The Metaphysics Experiment
Modern Physics and the Politics of Nature

by

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BA, Concordia University, 2003
MA, Simon Fraser University, 2005

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Supervisory Committee

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Supervisor: Dr. Arthur Kroker (Department of Political Science)

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Abstract

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The Metaphysics Experiment attempts to explicate a theory and history of universalism in modern physics, through an analysis of its conception of nature. Understood as an axiomatic and hegemonic metaphysical premise through four hundred years of scientific and political history, universalism is defined in terms of its general and persistent claim to nature or truth as an ahistorical reality. Thus, I argue that universalism is directly implicated in, not opposed to, the (Christian) monotheistic conception of God. Moreover, universalism constitutes the logic according to which nature is differentiated from history, culture, and politics. It thus constructs both sides of the same ostensible oppositions in the so-called science and culture wars that determine much of today's politics of nature.

The scientific and political dominance of universalism is demonstrated through a history in five acts. Using the current Large Hadron Collider experiment in Geneva as a principal case study in Act 1, and drawing on contemporary philosopher of science, Isabelle Stengers, I consider four pivotal historical moments in the history of physics and metaphysics that determine the universalist claims of this contemporary experiment. In Act 2, the mid-20th century development of Albert Einstein's General Relativity framework and Big Bang Theory is read against Martin Heidegger's critique of identity logic. In Act 3, the mid-17th century emergence of the mathematical universe in modern science and philosophy, through Galileo Galilei and René Descartes, is read against Benedict Spinoza's univocal metaphysics. In Act 4, the late 19th century invention of particle or quantum physics is read against Henri Bergson's idea of mind-matter dualism. Finally, in Act 5, considering the contemporary use of natural constants in physics, the insights of Michel Serres, Bruno Latour, Peter Sloterdijk, Heidegger, Stengers and Spinoza are drawn together to problematize the modern historical role of physics and its metaphysical constitution of nature.

Beyond these historical event-scenes, I also offer a theoretical explication of five logics, demonstrated individually Act by Act, that comprise different dimensions of science in action. Thus, physics is considered historically both as theoretical and experimental practice and as a form of political mobilization.

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I thank physicists I met at CERN and University of Victoria for their patience with the questions of an outsider. Philosophically, I have learnt immensely from my many conversations with Seth Asch, who first led me onto reading Spinoza. Without my loving parents in Norway, I may never have had the freedom of physical movement to go so far away for an education. And without my loving muse and partner, Kelsey Nutland, I may never have had the stability to complete such a vertiginous project.

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Dedication

To an existential sentiment,
once expressed by F. Scott Fitzgerald:

One should be able to see that everything is hopeless
and yet be determined to make it otherwise.

PROLOG: Toward the Logic of a World-Object

Within the complex of machinery that is necessary to physics
in order to carry out the smashing of the atom
lies hidden the whole of physics up to now.

Martin Heidegger

Once upon a time, in the early 21st century, somewhere in the mountains, there was a giant machine…

The machine was not only bigger and better than any built before it. No, the machine had a special power. By recreating the conditions of universal creation, it could unlock the deepest secrets of the world, determining the origins of space and time, matter and energy. The machine could tell us how we have become who we are, why the cosmos is the way it is — and even foretell our universal destiny.

It was not without reason many people referred to the machine as a cathedral, for it did indeed seem to have a special connection to God. People working there said the machine could find the God Particle, the mysterious constituent responsible for the matter of the world. In fact, the machine was seen to be so powerful that some people feared it outright, saying it would not enlighten them but rather destroy the entire world. They tried to convince others it needed to be stopped. But in the end, those in charge decided there was only one way to find out who was right: to turn the machine on and put the rivaling claims to the test.

And thus the world would never again be the same…

Sounds too fanciful for a modern science experiment?

The Large Hadron Collider, built and operated on a roughly $10 billion budget, is certainly not your average laboratory apparatus. Even if the thousands of physicists involved with the project prefer to speak about their work in technical jargon, and even if their discourse is concerned with questions demarcated as scientific, the enormous operation currently taking place outside Geneva is in all relevant senses of the word a metaphysics experiment. Against conventional distinctions that put metaphysics at odds with scientific practice, the Large Hadron Collider is explicitly engaged in determining the scope of philosophical, cosmological, and theological problems. For all the debates inside and outside the physics community over its specific findings, the experiment will undoubtedly grant legitimacy to the grandest stories of modern science about who, what, how, where, when — and to some, even why — we are. And if the machine can't quite reach God, it will in the eyes of physicists give us an authoritative, truly scientific history of Nature. From the origin of time to the evolution of the very human beings capable of making such an experiment, contemporary physics circumscribes for us all there is — in a word, metaphysics.

In this sense, the Large Hadron Collider expresses what German philosopher Martin Heidegger called a world-picture, his concept for modern metaphysics as the fundamental ongoing activity of enframing the world. Most essentially, Heidegger argued, “metaphysics grounds an age, in that through a specific interpretation of what is and through a specific comprehension of truth, it gives to that age the basis upon which it is essentially formed.” (115) So if this experiment determines our world-picture of today, how can we make sense of its claims, question our conditions of enframing? How can we assess its presuppositions and conclusions when, as Heidegger put it, “physics itself is not a possible object of a physical experiment”? (1977: 176)

From the outset, we appear caught in a double bind of highly specialized disciplines that both confine metaphysical problems to the discursive margins of legitimate inquiry. On the one hand, physicists rarely, if ever, consider the metaphysical implications of their work, which means that their many and significant assumptions go unquestioned. On the other hand, philosophers, especially in the dominant analytic tradition, severely circumscribe metaphysics through its largely epistemological language. Thus, one discourse can determine metaphysical problems without being concerned with them, while another discourse can be concerned with metaphysical problems without being able to determine them. In either case, what most tacitly structures and determines both these discourses continues to revel in the obscurity afforded by a curious blindspot in the bifurcated institutional modes of knowledge production.

Such a bifurcation shows itself in many guises, not least of which is the conventional separation of what counts as ‘scientific’ from what counts as ‘political.’ For example, if we ask about the historical connection between this current experiment in nuclear physics and the nuclear bomb, we are immediately faced with two sets of histories that rarely, if ever, intersect. Browse any library catalogue on nuclear or atomic history, and you will overwhelmingly find of texts that discuss the most notorious invention of 20th century physics either in terms of the scientific work going into making it, or the politics of its creation and fall-out. As contemporary French philosopher Bruno Latour has demonstrated, a closer investigation of the complicated factors involved in the production of the atomic bomb will in fact reveal a deep intertwining of scientific and political matters. Yet despite their fundamentally shared history, a division persists that consistently purifies laboratory work and theory constructions from their political means of mobilization.[1] At most, an historical account that deals with both dimensions will strenuously try to separate them — and so, thus far, nobody appears to have written a history of nuclear physics in the same sense as a history of nuclear politics.

For Latour, this is no coincidence or mere scholarly oversight. Rather, it reflects the terms of what he calls the 'modern settlement': a consistently articulated division between nature as the object of scientific or physical inquiry on the one hand, and history as the object of cultural, social or political questioning on the other. In this precise sense, the conventional separation of politics and science is indeed metaphysical, because it expresses, in Heidegger's phrase, the grounding of the modern age through a persistent bifurcation between nature and culture, according to which its comprehension of the world, its world-picture, is formed. To put it more precisely, the institutionalized division of the scientific and the political, just like the division of physics from philosophy in metaphysical matters, is not a 'fact of nature' — rather, it expresses how nature is constituted in our culture. And in turn, as I will show in this dissertation, the constitution of nature and culture in modern thought is predicated on a distinctive conception of God. Against the conventional opposition of religion and science — yet another binary of the modern settlement — I will demonstrate how particle physics today is most essentially Christian metaphysics by other means.

From the same metaphysical bifurcation of culture and nature, politics and sciences, religion and science, follows the general structure of public and academic debates about the sciences. In the last few decades, this has often been called the 'science wars,' whose crux consists of an ultimatum: either you support some version of 'realism,' which means that 'nature' can be accessed by a modern scientific method, or you are forced to counter with some version of 'anti-realism,' which means that science is culturally or socially constructed. In either case, the same metaphysical relation between nature and culture endures. In this dissertation, I will attempt to circumvent both realism and anti-realism as merely two opposed dimensions of the same axis. As Latour has repeatedly argued, that the sciences always already operate within a history does not mean that their claims are 'just' cultural constructions, if we by 'cultural' mean something distinct from nature. As we shall see, there is indeed a way around this metaphysical ultimatum

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[1] See for example Latour's chapter on the French nuclear scientist Joliot, in *Pandora's Hope* (1999), which amply illustrates how tenuous this prevailing bifurcation is. That there are practical distinctions between the work of scientists and that of industrialists and politicians is one thing. To consider these distinctions fundamental to how history is constituted is quite another, and therein lies for Latour the metaphysical problem.

— though it comes at a steep initial cost, since the axiomatic nature-culture relation in effect determines many of our most entrenched and even cherished concepts, from humanity and society to science and the universe. Nevertheless, I argue that the problematic configuration of metaphysics in our contemporary political landscape, and its direct implication in the catastrophic planetary conditions of our time, warrants its radical rethinking.

Hence, the 'politics of nature' in my title has to be grasped primarily in such a metaphysical sense. While Latour, for example, has explicitly engaged with 'politics of nature' in a recent book (2005) that attempts to lay out a more democratic foundation for the current work of the sciences, my focus here is rather on how the ostensibly apolitical constitution of nature comes to be a political problem in the first place. In my view, before we can consider the various significant claims to nature in contemporary politics — from genetics to political ecology to resource management to energy policy — our cultural understanding of nature first has to be problematized, because it turns out to be essential to our problems today. In this sense, the historically tenuous relation between metaphysics and modern physics is highly relevant — not because it tells us about the fundamental constituents of an inorganic realm or about the evolution of time, but because it shows us how our understanding of nature or reality is directly implicated in our contemporary means of mobilizing, transforming and, arguably, destroying it. Against the proliferation of bewilderingly specialized articulations, we need to approach the most general problems that still determine all others. As Latour puts it, "no progress can be made in the philosophy of science if the whole settlement is not discussed at once in all its components: ontology, epistemology, ethics, politics, and theology." (1997: xii) In other words, the significance of a philosophy of science today hinges on a serious consideration of metaphysics.

Perhaps this is one reason why such a project could only be undertaken from between disciplinary perspectives. Institutionally speaking, I am trained in neither physics nor philosophy. Turning a source of potential weakness into an actual strength, this intellectual constraint has forced me to invent a new perspective from which ostensibly irreconcilable discourses can once again appear together. In this dissertation, I conceptualize metaphysics as a vanishing mediator between scientific, philosophical, and political matters of concern. Thus, to situate my perspective on metaphysics between physics and philosophy means neither an objective point of equi-distance to each discourse, nor (I hope) a doubling of their equally hermetic jargon. Rather, I situate metaphysics in between discourses as a means to open up hidden sets of shared problems, in the hope of reaching fellow thinkers today who are critically and constructively engaged with how our world works and how our history is made.[2]

Although this book opens as a philosophical case study of the Large Hadron Collider, it is not really about this specific experiment as such. Throughout my story, I will explain such mystifying theoretical and experimental constructions as supersymmetry, general relativity, blackbody radiation, quantum mechanics, and particle accelerators, to mention but a few — but my objective is not to consider their relative merits or their truth value, since such conceptions inevitably lead us back into the trenches of the science wars. Rather, I want to show the means by which these scientific expressions of truth actually come about and how they are metaphysically configured. Thus, I engage with this experiment and the history that made it possible because it embodies a more implicit and persistent metaphysical construction — an axiomatic configuration of nature that I call universalism. As I will demonstrate, it is to universalism we owe some of our most commonsensical notions about the world, including the idea of the universe as such. And all the key conceptions of universalism, I argue, have in the course of the last century proven to be most dubious, contradictory and problematic, even as they are still tenaciously enforced in our cultural practices. The LHC is but an expression of this.

In this sense, metaphysics is a premise that will be properly demonstrated and developed in the course of this dissertation. As an idea, it has a long and complicated history, though its history alone does not define it. I begin in Act 1 with Heidegger's classic conception of metaphysics as the configuration of 'what is,' or ontology. For as the German thinker puts it, "any metaphysical thinking is onto-logy or it is nothing at all." (55) This notion of metaphysics crucially pivots on being constituted according to a fundamental division of the sensory from the suprasensory, or the empirical from the ideal — a traditional faultline in the history of philosophy. As our investigation proceeds, it will quickly become clear that such a conception is too narrow, or even outdated, since the development of physics in the 20th century conspicuously moves beyond ontology in any traditional sense. And in the wake of increasingly impotent philosophical notions, such as the still

[2] By history, I here mean something perhaps more general than current academic practices of historiography. My principal concern is the unfolding and constitution of historical events and practices, not a detailed archival analysis of these specific events themselves, nor an account of alternative or minor genealogies. As I will briefly discuss in Act 3, I purposely move within a canonical, retroactively constituted history of well-documented actors and occurrences — not to confer upon them any further significance than they already enjoy, but to show the action at work in constituting them as historically significant. In this sense, the history I offer is a dramatization — and this is one reason why I conceive my chapters as textual character stories in a five-act structure.

operative distinction between ontology and epistemology, new conceptual tools are urgently needed.

Thus, I will in this dissertation attempt to pry the idea of metaphysics open by conceptualizing it as different dimensions of logic. If this sounds suspiciously Hegelian to some readers, it is only because in conventional philosophy, logic is derived from a matrix of two persistent principles structuring what counts as reason in Western thought: the principle of identity and the principle of reason. As I will show, in the historical movements of physics, these principles undergo several significant mutations that eventually put the discourse of physics at odds with modern philosophical strands of metaphysical thinking — and this is precisely what requires us to go about the problem in a more innovative manner.

In my argument for thinking metaphysics beyond these traditional confines of logic, this dissertation stands and falls on another principle, articulated by Heidegger as ontological difference — the fundamental philosophical difference between Being as given and beings as they appear to thought. From a conventional analytical or epistemological point of view, ontological difference cannot be 'proven' any more than it can be demonstrated — it can merely be posited as an historically extant mode of thinking in Western thought. Methodologically speaking, it is based on the principle of 'general ontological difference' that I will differentiate and delineate five discernible logics constituting the metaphysics of scientific practice today. From the principle of ontological difference, then, I eventually derive a logical five-fold.

With this conceptual invention, I take seriously the suggestion by French philosopher Michel Serres, that thinking in terms of 'prepositions' is a means to get beyond the most enduring philosophical stalemates. As he puts it:

> Traditional philosophy speaks in substantives and verbs, not in terms of relationships. Thus, it always begins with a divine sun that sheds light on everything, with a beginning that will deploy itself in history (finally standardized) or with a principle — in order to deduce, through logic, a generalized logos that will confer meaning on it and establish the rules of the game for an organized debate. And if this doesn't work, then it's great destruction, suspicion, dispersal — all the contemporary doom and gloom. (1995b: 101)

Prepositionally, the logic of this 'generalized logos' is marked by being 'under' — under the divine sun that sheds light on everything, under the rules of reason, and under the concepts of debate. Drawing on the Greek prefix, I therefore call this 'hypological' reasoning. Act 2 will elaborate on this concept as itself the logic of conceiving things as things under the regime of reason. Each of the five Acts in this dissertation explicates its own logic in the history of the (meta)physics experiment, and each logic is differentiated relationally, by different prepositions. I begin in Act 1 with the analogical, the relation of ‘with’ or ‘along’ — in an active, verbal sense, analogy as the logic of connecting. Following the deconstruction in Act 2 of the hypological as the logic of conceiving, Act 3 concerns the autological, the relation of ‘through’ or ‘by’ (in the sense of ‘through itself’), as the logic of mediating. In Act 4, the metalogical expresses the relation of ‘beyond,’ as the logic of proliferation. And finally in Act 5, I discuss the catalogical as the relation of ‘against’ — the logic of constraining, which acts in direct concordance with the analogical, the logic of connecting. And although it does not formally belong to the main body of the text or the logical five-fold, this prolog is by the same reasoning pro-logical — that is ‘before’ or ‘in front of’ the logics (if not also pro as ‘in favor of’ them).

In this dissertation, each logical dimension acts like a frame around a key historical moment in which physics and metaphysics intertwine in significant ways. Hence, Act 1 introduces the contemporary situation of the metaphysics experiment, along with Heidegger’s thoughts on metaphysics as well as Isabelle Stengers’ concept of ‘invention’ in modern science. Thus, I identify four critical inventions in the history that made the Large Hadron Collider possible. Act 2 discusses the mid-20th century invention of ‘singularity’ in the form of Einstein’s General Relativity, the Big Bang, and black holes — that is, the origin story of the universe — in conjunction with Martin Heidegger’s critique of identity logic. Act 3 concerns the 17th century invention of ‘universality’ in the sense of a mathematical universe as articulated by Galileo and Descartes, read against Benedict Spinoza’s metaphysics of univocity. Act 4 tackles the late 19th century invention of ‘particularity,’ the discontinuous atoms and quanta that inhabit the universal spacetime of physics, along with Henri Bergson’s fateful idea of continuity between science and metaphysics. Finally, in Act 5, we return to the early 21st century and consider the invention of ‘constancy,’ the fundamental mathematical constants that keep the rift in the universal fabric together. Here, Michel Serres, Bruno Latour, and Peter Sloterdijk join Stengers and Spinoza for a final meditation on an alternative metaphysical configuration in the politics of nature.

Thus, the five-fold logical and historical image I offer is something akin to what Latour describes as “the mobilization of the world” — the means by which the material world is loaded into the discourse of physics, or the logics by which a scientific practice is constituted.[3] (1999: 99-102) Although this is not a piece of 'science studies' following an empirical actor-network analysis of the actions and alliances of scientists and other actants at the Large Hadron Collider, my dissertation can be said to follow Latour's work in a double sense.

First, my critical stance toward the metaphysics of universalism is enacted constructively, in that I'm making allies out of historically disparate thinkers.[4] For all the differences one can posit between, say, Spinoza and Heidegger, or Bergson and Latour, my principal interest lies in demonstrating their shared and perhaps unexpected metaphysical kinship. For my dramatization of history, I turn them into a protagonist ensemble against an antagonist axis of history. Certainly, on many other levels than the ones offered here, their kinship can be made to fracture and their friendship may be problematized — but I happily leave such lines of flight up to the reader.

Second, I follow Latour in regarding the configuration of nature as a fundamental, and fundamentally urgent, problem in Western thought. How we understand nature determines how we act into it — with serious consequences. Implicit in how nature is comprehended is the configuration of the sciences that seek to understand it. And the configuration of the sciences — how our systems of knowledge production are mobilized — is just as fundamentally a political problem. As already intimated, in foregrounding the notion of the political, I do not mean to suggest this dissertation is about practical policy implications for conducting physics experiments like the Large Hadron Collider. Rather, my political objective is more generally to show how metaphysics, like the sciences, is a cultural construction and thus, in the end, a matter of collective concern. As the

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[3] In *Pandora's Hope*, Latour describes the 'mobilization of the world' as one of the five dimensions in the 'circulatory system of scientific facts.' Although there is some logical overlap with my own five-fold construction here, I do not offer it as a correlation or extension of Latour's version.

[4] In my perspective, Latour as a thinker has multiple allies. One of them, not surfacing in my text, yet still pivotal to my construction of history, is Gilles Deleuze. For all their discursive divergences, Latour and Deleuze share a metaphysical premise, and I will demonstrate this through my reading of Spinoza. Briefly, Deleuze's conception of difference is similar to what I will here call the autological, the initial given of thought, while the identity imposed by thinking corresponds to my notion of the hypological, like a retroactive folding. Metaphysically, this implies continuous creation, a crucial implication of both Latour's actor-network theory and Deleuzian ontology. In this sense, every moment or every event, or every relation, is given as different from another, and only retroactively constituted as continuous, same, and identical. Rather than using Deleuze directly, I employ Heidegger in Act 2 to think the problem of identity as a principle that inverts reality — and this introduces inversion as a pivotal trope in thinking science, world and thought itself. To put this in terms of history of thought, this dissertation tries to show how Latour and Deleuze are mutually implicated in a metaphysics expressed by Spinoza and further articulated by Bergson.

sciences today create our new givens of tomorrow, it is perhaps a timely reminder that the sciences do not make themselves according to criteria that escape history.[5]

Insofar as the Large Hadron Collider is capable of accelerating particles up to the speed of light, and insofar as it promises to thereby reach conclusions about the ultimate nature of things, it is by French philosopher Michel Serres' definition a 'world-object.' A world-object, he argues, is a tool that is commensurable with one of the dimensions of the world — like "a satelllite for speed, an atomic bomb for energy, the internet for space, and nuclear waste for time." (2006) In this sense, the Large Hadron Collider may not be quite the fanciful fairytale machine of popular lore — but it is most certainly a world-object of multiple dimensions.

Hence, I propose to investigate this world-object as an expression of history, whose own history can tell us about the world-picture that grounds our age. Governed by a set of axiomatic claims to truth, nature, and reality, this world-object will reveal the different logics of a scientific practice that for at least a century, amidst its myriad incredible inventions that promise ever greater transformations of the world, has been charting its own collision course with the very same nature it is set to explicate. In other words, while the Collider may not itself unleash catastrophe upon the planet, the logic of this world-object, as constitutive of our world-picture, is deeply implicated in, and expressive of, the catastrophic times in which we live.

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[5] This is among many conceptions I owe to the remarkable work of Belgian philosopher Isabelle Stengers. This dissertation was completed by the time her magnum opus, *Cosmopolitics,* was finally rendered into English. From my cursory understanding of this work, Stengers touches on several strands of physics and metaphysics history comparable to my own. While I align myself in philosophy of science with Stengers' intellectual orientation as espoused in *The Invention of Modern Science* in particular, I cannot speak directly to this 'cosmopolitical' dimension of her work.

ACT I — ANA

Physics, that is, God:
The Invention of the Large Hadron Collider

God is dead:
but such as humans are,
there may for millennia yet
be caves where they will point
to his shadows.

Friedrich Nietzsche

1. Geneva, 2008

All the physicists I meet assure me: the underground accelerator tunnel is perfectly soundless. But somewhere in the beaming, spinning vortex of particle collisions, I believe the word of Nietzsche still resonates.[6] As an untimely echo, perhaps, reverberating through my own pilgrimage to the Large Hadron Collider (LHC), this glorious cathedral of contemporary physics. God may indeed be dead — but he is nonetheless lurking in the shadows of the cave.

Situated at the river mound of the greatest body of water in the Alp region, Geneva is a nestled oasis on the mountainous fault line that has shaped European history. While the Roman line extended through Geneva and made it a critical border town, it has remained a site of political exceptionalism ever since. The legacy of Geneva as a modern city-state is deeply entangled with the Reformation, through which it became known as Jean Calvin's 'protestant Rome'. And if Calvin is widely regarded as the spiritual father of the city, perhaps its greatest historical son was Jean-Jacques Rousseau. Geneva was a principal source of inspiration for Rousseau's version of the social contract, whose utopian city-state came to stand for the idea of universal cosmopolitanism — its later banishment of Rousseau and his books notwithstanding. Today's Geneva, with less than 200,000 inhabitants yet a distinctly multicultural flair, can still be regarded as the actualization of this idea. This is the global pivot of cosmopolitan, humanitarian bureaucracy. A large private banking industry, multinational corporate headquarters, and a cluster of non-governmental organizations form a parasitical web around an array of United Nations agencies, the Red Cross, the World Trade Organization, and various official international organs — not least of which is my destination: the European Organization for Nuclear Research (CERN), the site of the LHC experiment.

Only a few weeks before my arrival, more than 300 international journalists have waded into the choreographed PR launch of the world's largest physics experiment, citing with awe from its press release kits.[7] The LHC is being hailed as

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[6] Front quote is from *Die Fröhliche Wissenschaft*, section 108, my translation. Both the existing Kaufmann and Evans translations miss the simplicity of Nietzsche's turn of phrase, as well as the indicative use of the verb 'zeigen'. Subsequent citations from this volume follow the Kaufmann translation and are cited by section number, not page number. I also use the term 'joyous science' instead of the 'gay science.' See Nietzsche, 1974 [1882].

[7] The references are to an array of international newspapers on and around 10 September 2008, which carried more or less the same story in slightly different versions. For one example, see Saunders 2008. Journalistic preludes to this coverage are exemplified by Hart, 2006, and Overbye, 2007 and 2008.

a Big Bang machine — the biggest machine ever built — a machine that recreates the origin of the universe. Set to unlock an ultimate secret of Nature, the so-called God Particle, it makes for a critical step toward the reunification of the Universe. In short, this is one hell of an experiment. Literally hellish, according to some dissident scientists. They claim the LHC will generate black holes that could swallow the entire planet from within — and surely give yet another ironic twist to the theory of the Big Bang. Predictably, the scientists involved in the experiment scoff at the idea and assure the public that everything is under control, that the work of science must go on.[8] The only way to know who's right is to put the claims to the test, even if the test in turn could claim us all as victims. In any case, there is no turning back now, since the experiment has officially begun. And so, like Minerva's Owl, the metaphysicist arrives too late.

But then it appears I'm also too early. Just two days before, barely registered as a blip in the same newspapers, an accident involving faulty magnets in the 27 kilometer long tunnel forced the collider to shut down for critical repairs. The beginning of the inquiry into the beginning of the Universe, or perhaps the beginning of the end of the Universe as such, is unofficially on hold. Particle physicists fret, doomsday prophets breathe a sigh of relief, and the rest of us don't know if we really ought to be concerned. There is still time, in other words — even for an untimely metaphysical investigation.

No doubt, German philosopher Friedrich Nietzsche, writing toward the end of the 19th century, would have been amused by the ironic reversal of today's priestly caste — the ostensible shift from the classical word of metaphysics to the contemporary world of physics. In every news story, cardinal physicists are cast to speak for nature in hermetic vernacular, all the while summoning against scientific gnostics and heretics. Nietzsche would be amused by the LHC story because its logic is so familiar, all too familiar: the claim to Universal knowledge always already opposed by a rivaling claim to Universal fate. Will scientists at the LHC solve the ultimate mystery of God's creation? Or are they rather playing God through technology, turning the LHC into a prosthetic God, potentially annihilating humanity itself in its will to knowledge? In other words: should Adam eat the apple? Particle physics is thus implicated in an origin story and an eschatology at once. Its logic is so familiar and worthy of Nietzsche's laughter because the ostensible opposition between reason and faith, between a knowing science and a believing religion, actually pivots on the same metaphysics.

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[8] I will return to the doomsday scenario of the LHC in more detail in Act 5.

For German philosopher Martin Heidegger, 'the word of Nietzsche' — the declaration of the death of God — signifies an overturning of Western metaphysics, the final stage of a history claiming two millennia of cultural activity. Developed during the late 1930s and 'delivered repeatedly' as a lecture to small groups during the darkest hours of World War II, Heidegger's meditation articulates a sense of irreversible historical folding. For him, Nietzsche's word, 'God is Dead,' means first and foremost that "there remains for metaphysics nothing but a turning aside into its own inessentiality and disarray." (1977: 53)

What is this fateful metaphysics that has entered its final stage? For Heidegger,

> metaphysics is thought as the truth of what is as such in its entirety, and not as the doctrine of any particular thinker. Each thinker has at any given time his fundamental philosophical position within metaphysics. Therefore, a particular metaphysics can be called by his name. However… that does not mean in any way that metaphysics at any given time is the accomplishment and possession of the thinker as a personality within the public framework of creative cultural activity. (54)

Metaphysics, then, as the truth of what is, in and through its immanent expression by this or that thinker at this or that moment of history. And in the activity that defines the modern age for Heidegger, metaphysics is formulated through the sciences, which provide us not only with a definitive (even if continually changing) picture of the world, but more fundamentally, with the projection of the world into a picture in the first place. In this framing activity, metaphysics stands revealed — not as this or that specific picture, but as the implicit structuring of the scientific means of articulation. "For the sciences," Heidegger says, "in manifold ways, always claim to give the fundamental form of knowing and of the knowable in advance, whether deliberately or through the kind of currency and effectiveness that they themselves possess." (56) For a science in action, the world of ongoing research is always already metaphysically constituted.

In this sense, metaphysics and science are essentially intervowen. In his own clarion call for a 'joyous science,' inspired by the brash, young physics emerging in his day, Nietzsche already recognized the impossibility of doing science without metaphysics. For a science or a physics to be cultivated, Nietzsche asks,

> must there not be some prior conviction, even one that is so commanding and unconditional that it sacrifices all other convictions to itself? We see that science also rests on a faith, there simply is no science 'without presuppositions.' The question whether truth is needed must not only have been affirmed in advance, but affirmed to such a degree that the principle, the faith, the conviction finds expression: 'Nothing is needed more than truth, and in relation to it everything else has only second-rate value.' (344)

In its configuration of truth, science and religion stand as obverse dimensions of another — or as Nietzsche puts it, we too, we 'joyous scientists', are still pious in our own ways. In our cultural practices of believing as well as in our cultural practices of knowing, what is at stake is truth — always already a single, unified expression of truth. One God, one Universe: in one and the same operation, this means most essentially God as the nature of truth, and science as the truth of Nature. As Nietzsche makes clear, this axis is precisely the axis of the divine, insofar as God constitutes the fundamental metaphysical guarantee for unified truth.

What happens to this metaphysical constitution when 'God is dead'? As Heidegger points out, the word of Nietzsche is not merely a declaration of unbelief or apostasy, but more profoundly a proposition of fundamental world transformation. For the God of Nietzsche is both the God of Christianity and the "suprasensory world in general," that is, the name for a transcendental realm. In this sense, God is dead — but nevertheless extant in his structure:

> If God in the sense of the Christian god has disappeared from his authoritative position in the suprasensory world, then this authoritative place itself is still always preserved, even though as that which has become empty. The now-empty authoritative realm of the suprasensory and the ideal world can still be adhered to. What is more, the empty place demands to be occupied anew and to have the god now vanished from it replaced by something else. New ideals are set up. (69)

In theology, God may be a being or a creator, but metaphysically, God first and foremost constitutes our dominant logical frameworks of meaning. In physics, as I purport to show throughout this dissertation, God in this transcendental and structural sense is the fundamental condition of the scientific universe. Marked by its axiomatic logical relation between truth and nature, the empty place of God is carried forth by the metaphysical movement that I will call universalism.[9] It befalls universalist physics today, exemplified in the LHC experiment, to set up ever new ideals in God's shadow.

Thus, Nietzsche can write of his call for a 'joyous science' that

[9] In theology, universalism usually signifies the belief in salvation of all humankind. I use the term in a broader sense, though I believe this dissertation will make clear how universalist theology is but one expression of the same metaphysical configuration that I called universalism, and which permeates the sciences as well as Christian theology.

> it is still a metaphysical faith upon which our faith in science rests—that even we seekers after knowledge today, we godless ones and anti-metaphysicians still take our fire, too, from the flame lit by a faith that is thousands of years old, that Christian faith which was also the faith of Plato, that God is the truth, that truth is divine...

And along with divine meditation on truth comes the inevitable obverse consequence, as Nietzsche suddenly turns to an apocalyptical thought:

> But what if this should become more and more incredible, if nothing should prove to be divine any more unless it were error, blindness, the lie—if God himself should prove to be our most enduring lie? (344)

Truth as the ultimate arbiter, lie as the worst of all fears: this bifurcation expresses for Nietzsche the metaphysical foundation of our culture. For against religion as against science, the common enemy is always untruth — error, blindness, the lie. The promise of truth entails the fear of the lie, and the reality of the lie reinforces the promise of truth, by a double constitution. As a hallmark of universalism, this metaphysics is what submits any different mode of understanding to an absolute criterion of truth versus falsity. According to this logic, any critical approach to a universalist mode of knowledge can always be dismissed as dangerous relativism, an open door to charlatans, a slippery slope to chaos — anarchy. As Nietzsche puts it, this idea hinges on truth 'affirmed to such a degree' that its axis makes every other value second-rate. What Nietzsche considers the metaphysics of modern science can therefore initially be defined as the axiomatic activity through which we claim to let nature speak as truth, and to let truth speak as nature. And its degree of affirmation is in effect uni-versal because it implies a veritable oneness of language against the world as it is given.

For Heidegger, metaphysics is therefore always a form of Platonism, because it relies on a notion of transcendental truth. In the Western canon of thought, however, the traditional understanding of the concept of metaphysics tends to follow the definitions of Aristotle.[10] *Phusis*, the ancient Greek word for nature, from which our 'physics' is derived, stands for 'that which changes' — that is, physics in its original sense is nature understood as change. In Aristotle, metaphysics, on the other hand, comes to stand for 'that which never changes,' or 'that which endures.'

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[10] In posthumously edited collections of Aristotle's work, the prefix meta- ('beyond') was attached to the chapters in Aristotle's work that followed after the chapters on 'physics.' This originally editorial distinction is often taken literally (and falsely) to mean that metaphysics is that which lies beyond physics. Such is the contingency of naming. See Aristotle, 2001, as well as Gaukroger, 1980. For general reference, see Copleston, vol 1, 1962.

Logically, this does not make metaphysics static or eternal or any kind of entity externally related to physics. Rather, it means metaphysics is most essentially a matter of constancy, that which endures throughout change. To Aristotle, we inevitably find ourselves lodged in physics, that is, in nature as a ceaseless flux, and constancy cannot therefore appear out of itself, as an externality, but only as a certain differentiation of change.[11] That which endures is the given foundation of both religion and science in our modern sense. Metaphysics is, in Nietzsche's analogy, 'the flame' that lights our search for truth and knowledge — and in this fundamental sense, both the Platonic and the Aristotelian conceptions are aligned.

As a point of departure, then, I define metaphysics as the shared axis of believing and knowing. Metaphysics is the vanishing point between religion and science as cultural practices, wherein all that is as such becomes expressed according to a basic division of the sensory and the suprasensory. For Nietzsche and Heidegger as for Aristotle, there can be no simple binary question of something either being metaphysical or not being metaphysical — for in this very act of positing, in the very attempt to differentiate and negate, metaphysics is already secretly at work.

For Heidegger, the word of Nietzsche marks a final historical stage because the metaphysical overturning of God implies the very destiny of Western history itself. (58) Insofar as Nietzsche is right, he contends, "other possibilities of metaphysics can no longer appear." (54) Here in Geneva, it is still too early to pronounce on either historical destiny or the possibilities of metaphysics. But in the following, my dissertation will implicitly wrestle with and against Heidegger's totalizing conception of metaphysics. We begin with this notion of metaphysics in order to pry it open, transform it, and possibly yield a different conclusion. As I understand it, we have no more reason to think we could abandon metaphysics (without thereby invoking a metaphysical argument) than to think that metaphysics constitutes one and the same idea, one and the same structure, without other possibilities. In the same sense as the flame stands to its appearance, or the light to the shadow, an idea stands to its expression or a logic to its configuration. In this asymmetrical relation, the latter always implies the former — but not necessarily the other way around. The flame of light, like an idea or a logic, becomes a given condition for being, thinking, acting — revealing the world only to conceal its own action. And what is never given is how the given is to be turned, how it is to be

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[11] In Aristotle too, there is a transcendental entity analogous to God, the 'unmoved mover,' which in turn determines how the idea of substance is understood — but this shall not concern us here.

modified and structured. Against Heidegger, I will tentatively argue that metaphysics could very well be a different configuration than the universalism of God and Nature. Thus, our starting definition implies an inverse corollary: insofar as the axis of universal truth constitutes a metaphysical configuration, metaphysics as such is irreducible to the configuration of universal truth.

In this sense, universalism is not what metaphysics is or must be — it is simply the dominant metaphysics, the hegemonic configuration of our believing and knowing, our religions and our sciences. And neither is its familiar logic what logic as such is or must be. In this dissertation, I will argue that what we traditionally consider to be logic, a set of root principles that structure our actions, is but one mode under which the world is made. But before we can consider this traditional sense of logic in Act 2, we need to situate ourselves in the actual world of shifting constraints and contingencies in which any claim to logic, reason, or truth is made.

In the history of Western thought, medieval scholastics conceived the primary logic by which we reach metaphysics, the means for reasoning our way to the existence of the divine from earthly matters, as the analogical. In the case of the LHC, for example, we find that its claim rests on a principal legitimatory link established between a local operation and a global validity. Before we believe physicists' conclusions, we must accept the strictly analogical relation between an experiment conducted in a specific place and time, Geneva in 2008, and the origin of the universe and possibly its end, and consequently everything in between. From machine to cosmos, from mathematical concept to catastrophe, from physics to God, from history to a truth beyond history: the imaginative power of analogy encounters only the constraints given at its moment of expression. As French philosopher Michel Serres puts it, "science is not a content but rather a means of getting about" (1990b: 104) — and in this sense, science is an analogical practice of translating the world by forging new links.

Analogy, in its proper etymological sense, is the logic of 'ana', the inclined tendency. It is the Greek word for 'proportion' — a relational measure, one thing expressed in terms of another. To set a proportion is to enable a leap between what is being differentiated, relating a part to a whole. As the means by which Thomists would reason their way toward God, analogy signifies in its essence an upward mobility — a leap from one thing in terms of another thing, anything to anywhere. Analogy, in short, reveals the world in its sheer connection. And while in turn many other means of reasoning are crucial to the operation of the LHC, its analogical scope is what confronts us first and foremost. Down in the cave below the sprawling campus buildings, a whole set of relations are enacted, between space and time, matter and energy, the universe and particles. These are relations whose exact configuration govern the world as we know it, the world in its naked truth, in its Nature — or what is to universalism the very same thing, the world as God made it. At least by analogy, then, God — dead or alive — may still be revealed through the technological shadows of 21st century physics.

2. Experimental Particles

Along a long avenue proudly lined with flagpoles and nation-state banners waving in the wind, I meet Damir, a Croatian postdoctoral fellow who shows me around the sprawling CERN campus. He's gracious and friendly, introducing me to people as we pass by the various sites, even participating in the daily madness of lunchtime in the cafeteria. Like everyone else here, Damir speaks an efficient, if broken English, occasionally navigating through a formalized French, every now and then passing through a conversation in whatever happens to be mother tongue — but all eventually brokered by the language of mathematics. I feel like a parasite crawling inside a large host — a lone metaphysicist in an ocean of physicists.

Given CERN's location, I'm not surprised to hear Damir and his colleagues evaluate the experiment by invoking the notions of humanity and freedom. To them, the LHC is not so much about truth as it is about human freedom in a human pursuit of knowledge. In Damir's image, the organizational complexity of the LHC prevents some of the autocratic dangers associated with any project mobilizing some 10 billion dollars and some ten thousand scientists. For despite the material unity of the experiment, despite the deep sense of common cause and language among scientists involved, the capital, the ideas and the work activating the LHC are clustered and decentralized. No manager at the top of CERN, Damir says, can tell the participating researchers in the groups below how to do their work, how to form their ideas, how to investigate data. We have a brief discussion about this, and it leads nowhere. To me, Damir's epistemological freedom necessarily hinges on tacit acceptance of a shared metaphysics that always already constrains the action of every physicist here. But then again, freedom is usually best enjoyed when its actual conditions remain beyond purview. And a parasite too only has the freedom to wander as long as he does not offend his host with critical questions.

We enter the control room for the ATLAS project, where the relaxed pace bespeaks the accident in the tunnel two days earlier. Damir's team is comprised of experimentalists, a breed of physicist whose work always involves the threat of unpredictable malfunction and practical constraints. Damir explains that since the operating temperature in the tunnel is about 2 degrees Kelvin, that is, minus 271 degrees Celsius, it will take about a month just to warm the area enough for engineers to enter and fix the problem — and another month to cool it back down before acceleration can resume. In the control room, however, the delay is not all bad news. It offers a chance to fine-tune and calibrate the complicated computer system that is set to capture the subatomic particle collisions generated in the tunnel. From inside, the control room faintly resembles a NASA movie set: six designated teams with each 10 to 20 computer screens all face a long front wall of projected images, data and command overviews. One team supervises security of the entire system, another controls data input and flow onto the storehouse of servers, and so on, in an integrated model of activities. Damir's team watches and tweaks information from the liquid argon unit, a central component of the complicated operation that allows particle collisions to be detected.

Formally, the LHC is not one but six loosely coordinated experiments of different scope, all of which are international collaborative efforts. ATLAS is the largest operation, centered on a massive, 7000-tonnes multi-purpose detector built around a section of the tunnel. Its painfully contrived acronym — originally short for 'A Toroidal LHC ApparatuS' — invokes the double historical sense of world mapping and, mythologically, bearing the weight of the heavens — either way, inspiration from the activity of giants. ATLAS is in indirect competition with CMS, a somewhat smaller detector with a similar scope in a different section of the 27 kilometer circular LHC tunnel. Both ATLAS and CMS will provide overlapping data, partly for the purposes of cross-reference and correction and partly to double the extent of possible testing. Four smaller and more specifically focused experiments contribute to the range of work here.[12]

Whereas most accounts of the LHC focus on the most glaring material aspects, such as the sheer enormity of the physical objects and forces involved, scarce notice is given to the critical process of differentiation through which the experiment is actually rendered to the physicists themselves. Under what terms and conditions do the thousands of organized researchers come to interpret, analyze

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[12] For more detailed description and images from a physics perspective, see http://atlas.ch and http://cern.ch

and understand the physics displayed before them? Here too, an analogy is the first logic posited. Damir's Canadian team leader, Michel, who has been involved with ATLAS from its inception in 1992, describes the detector as a giant microscope. Like a microscope, the ATLAS detector is built for 'seeing into the unknown' of whatever happens in the collider tunnel.

However, whereas the purported object of the microscope, the collisions, occur 100 meters below, the observing scientists are in fact deciphering highly computerized rendering on digital monitors. In what sense does this constitute 'seeing into the unknown?' Ian Hacking, a Canadian philosopher of science, reminds us that from the very beginning of experimental science in the classical Baconian sense, "observation was associated with the use of instruments." (1993: 168) The microscope plays a unique role in the history of scientific observation and experimentation for drastically extending the range of scientific inquiry. As a general term for a kind of instrument whose character has changed remarkably over the centuries, the microscope has a history that, as Hacking tells it, is marked by three significant, identifiable shifts — veritable technological jumps. If we use as our indicative scale the limits of resolution that a microscope is designed to provide, we could draw a graph of development that would make its first leap around 1660, then continue along a slowly ascending plateau until a second great leap around 1870. And then, the final major leap, with which the immediate forerunners of the LHC can be directly associated, begins before World War II and continues through the 1950s and 60s. (194) Insofar as the LHC is a microscope, then, it's a third-order invention.

Although I do not want to exaggerate the importance of these leaps — which are not to be confused with historical 'breaks' — I consider them instructive key markers in the complex web of variables that constitutes the modern history of physics. The mid-17th century development of optical instruments, principally based on the principle of light absorption, coheres with the era that is usually thought of as the birth of modern science, eventually leading into the Newtonian synthesis of the early 18th century. The late 19th century invention of diffraction microscopes coheres with the growing range of experiments questioning the predictions of the Newtonian paradigm at lower levels of resolution, eventually leading to what we call quantum physics. And finally, the mid-20th century brought about a plethora of highly specialized microscopes able to exploit many different aspects of light borne out of extensive nuclear research, as physics became increasingly mobilized into a greater military-industrial expansion. Practically, this meant that microscopes could be engineered at ever increasing levels of energy, such as the particle accelerator first prototyped in the 1930s, and built at ever greater scales from the 1950s onwards. In subsequent chapters, we will consider each of these historical moments in terms of how their physics and metaphysics contributed to making up the experiment of the LHC today.

Despite the vast changes in the range and application of microscopes, some fundamentals of its experimental practice endure. Most importantly in Hacking's philosophical view, both a 17th century Baconian and a contemporary experimentalist such as Damir do not, as the common image would have it, see *through* a microscope — they see *with* it. In the complicated range of images generated by the ATLAS detector, the goal is to observe a track, or a set of tracks, from a collision of particles in the tunnel. This is what physicists call an 'event.' How do they see an event with the microscope? In a sense, they map it. Hacking puts it more generally:

> When an image is a map of interactions between the specimen and the image of radiation, and the map is a good one, then we are seeing with a microscope. What is a good map? After discarding aberrations or artifacts, the map should represent some structure in the specimen in essentially the same two- or three-dimensional set of relationships as are actually present in the specimen. (208)

Note the essential ambiguity of this statement. A 'good map should represent' what is 'actually present', even though the map is all that we know about what is actually present. This bespeaks a problem that permeates and to some extent defines the modern history and philosophy of science. How does the image, the 'good map' generated by the microscope, indicate an underlying reality? In what sense is an event really an event? The traditional answer, hinging on its shared commitment to the same metaphysical truth claim, bifurcates into two irreconcilable positions. Hacking refers to them as realism and anti-realism, others call them realism and instrumentalism, yet others prefer realism and constructivism. Any nominal coherence merely glosses over a bewilderingly fractured discourse. Not only is there is a large variance of more ostensibly nuanced positions articulated within this bipolar spectrum — from 'structural realism' and 'entity realism' through 'moderate' and 'strict empiricism' to 'social constructivism.'[13] Moreover, the entire discourse of what could be called scientific realism is historically entangled with an old philosophical faultline between materialism and

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[13] Hacking (1983) provides a pragmatic overview of this debate. For a more rigorous account of realism in direct relation to physics, from a neo-Kantian perspective, see Falkenburg, 2007, especially Chapter 1.

idealism, which in turn is implicated in the post-Kantian epistemological divide between rationalism and empiricism. And to make matters even more complicated, in the 20th century in particular, these debates become inseparable from the highly influential attempts in philosophy to separate the empirical from the metaphysical.[14] Under the guise of logical empiricism, or logical positivism, the objective of philosophy was to derive clear rules by which the truth generated by physics could be positively demarcated as scientific. According to this positivist fault line, metaphysics is conflated with theology and thus nominally separated from the stated goals of scientific practices.

As should already be clear, this dissertation rejects such a principal distinction and will seek to circumvent it. My evasion has less to do with an oppositional definition of metaphysics than two related practical concerns. First, even if we were to sound out a coherent position within the historical echo chamber that is philosophy of science, we would inevitably be concerted with the pragmatic inconsistencies that prevail in the sciences today. Hacking, whose reading of scientific practice pays particular attention to the significance of experiments, is among a wave of more recent philosophers who rejects any positive ontological demarcation of science.[15] As he puts it, "the realism/anti-realism debates at the level of representation are always inconclusive." In his view, this is because, "whereas the speculator, the calculator and the model-builder can be anti-realist, the experimenter must be a realist." (1983: xii-xiii) For physicists like Damir and Michel, the event is a fundamental and indubitable operational unit, and there is no sense in questioning its reality status. Second, my argument is that the event speaks truth before its exact extent — a real collision? a digital simulation? — can be debated. What matters to this dissertation is the means by which physics generates what it calls truth, not whether the claims of physics are 'really' true as such. As Nietzsche has already intimated, the deeper presupposition of truth as a pivotal axis of that which exists, and that toward which all questions are directed, means that the problem of whether the 'good map' is a 'real map' is already effectively circumscribed.

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[14] Generally, I have in mind here the 'revolt against metaphysics' associated with A. J. Ayers, as well as significant contributions by Moritz Schlick and Rudolf Carnap among others. For an account of the 'event' at Davos in 1929 that could be seen as the splitting point of analytic and continental philosophy (involving Carnap and Martin Heidegger), also from a neo-Kantian perspective, see Friedman, 2000.

[15] To mention only a few besides Hacking, see Nancy Cartwright's work on phenomenological physics (not to be conflated with philosophical phenomenology), Donna Haraway, Bruno Latour, and as I will discuss below, Brigitte Falkenburg and Isabelle Stengers.

So rather than questioning whether the good map is a true map, we could ask, how does a map become a good map? How are events rendered? The microscope as analogy will elude us if we think about calibration as something like two focal planes between a 'specimen' and an instrumental lens brought together in a sharp image. The principal role of the microscope as detector system is to digitally rebuild events for analysis after they occur — to provide a detailed image that is a 'good map' of interactions involved in the event. And perhaps its most foundational feature is selection — what Hacking calls the discarding of 'aberrations and artifacts.'

Whereas the ATLAS detector comprises several components designed to track and measure the momentum of specific types of particles, its heart is the 'inner tracker', where all the charges on the various detector surfaces are gathered and converted into binary signals. With an estimated roughly one billion collisions per second, however, the data flow encounters a powerful constraint. This is why the true invention of ATLAS lies in its data selection system, referred to as different levels of 'triggers.' The Level 1 trigger, working directly on a subset of information from the other detector components, needs 2 microseconds to make its contingent selection of events — around 100 of the billion collisions per second. That is to say, 99.9999% of the potential events are immediately discarded upon detection. The Level 2 trigger further selects and gathers events from the inner tracker, based on Level 1 results, and feeds them into a data acquisition system, where individual events can be reconstructed. According to ATLAS specifications, the final level of data acquisition stored for subsequent analysis and reconstruction amounts to about one billion events per year. That is derived from an estimated one billion collisions per second. There are almost 32 million seconds in a year. These are rough numbers but they intimate the astonishing rate of selection: the storehouse of servers at CERN, upon which a highly advanced multi-tier global grid system of distributed computing will be drawing to visualize the microscopic details of each potentially interesting collision, retain only about 1 in every 32 million events. The trigger system, in other words, is designed to filter through only what are considered liminal events. The event appearing on screen to the physicist is in this sense already exceptional — among the chosen ones. As an analogical step toward making sense of the role of the experiment, then, we could say that ATLAS is not just "the world's biggest microscope"— no more than the LHC is the "world's biggest machine" — but first and foremost an interface for regeneration of exceptional events. The LHC, in essence, is an event machine.

However, what physicists question is one event versus another event — never the event itself. Even if we, following Hacking, pragmatically accept its reality status, we are still left with the problem of what makes an event an event, separable and discontinuous from any other? As pragmatic realists, physicists will tell us that each event technically corresponds to a particle collision in the detector. The event, in other words, directly concerns the ostensible nature of particularity.

In Act 4, we will return in depth to the historical invention of discontinuity in physics. But as a contemporary introduction, we can briefly turn to a recent study, *Particle Metaphysics,* by Brigitte Falkenburg, a contemporary German philosopher of science in the neo-Kantian tradition. Falkenburg shows how the straightforward definition of a particle in Newtonian physics, and even in Einsteinian relativity, turns into a paradox under quantum physics.

> The 20th century history of the particle concept is a story of disillusion. It turned out that in the subatomic domain there are no particles in the classical sense… a generalized concept of quantum particles is not tenable either. Particles are experimental phenomena rather than fundamental entities. (209)

Through the rise of experimental accelerators, particularity has therefore principally become a mode of proliferation, a moving and mutating target. Under the dominant paradigm of physics since the 1970s, called the Standard Model, the number of different particle types have increased to a bewildering constellation, from neutrinos to muons, baryons and gluons, Z and Ws, with many more expected to appear with the LHC.

As a comprehensive framework, the Standard Model effectively bifurcates the material content of the universe into two different kinds of subatomic particles: 'matter' and 'interactions', or in the vernacular, fermions and bosons.[16] Physicists differentiate them according to their respective statistical frameworks: bosons follow 'Bose-Einstein statistics,' fermions follow 'Fermi-Dirac statistics.' Philosophically, they can be distinguished according to what is known as the Pauli exclusion principle, which lies at the heart of quantum physics. Several bosons, or interaction particles, can occupy the same quantum state — but only one fermion, or matter particle, can occupy the same state, or have the same energy, at any given time. Schematically, this means that the appearance of a boson is non-exclusionary to another boson of the same energy, while a fermion is by principle exclusionary

[16] For a comprehensive overview of the Standard Model besides Falkenburg, see also Pickering, 1984.

to another fermion of the same energy. In quantum physics, the exclusion principle ensures the proper distribution of matter particles into solid bodies (fermions) on the one hand while allowing for different interactions (bosons) across them on the other. The steady proliferation of new quantum particles, which lack any conceptual coherence that could unite them with the classical expectation of fundamental entities in nature, effectively means that, as Falkenburg puts it, “the unity of physics is a semantic rather than an ontological unity.” (38)

Classical particles, Falkenburg posits, can be described by a list of nine definitive predicates: they carry mass and charge; are independent of each other; pointlike in interactions; subject to conservation laws; localized; completely determined by the laws of mechanics; moving on trajectories in phase space; spatio-temporally individuated; and able to form bound systems. Only three of these descriptors can be said to carry into a quantum realm of bosons and fermions: pointlike interaction, conformity with conservation laws, and a certain independence — but all in a very conditional sense. First, contemporary theoretical physics, as I will discuss shortly, is focused on breaking up the point-ness of the particle, into an extendable range of tension known as a string. Second, conservation laws at the quantum level can only be inferred from one logical dimension of the exclusion principle. And third, particle independence — the pivotal metaphysical condition for a particle being a particle and thus an event being an event — is defined in the most hypothetical terms. Specifically, independence refers to the *possibility* that particles *may be* in non-interacting or uncoupled states, and that their initial conditions *can be considered* statistically uncorrelated.[17] Particle independence, in other words, is a nominal feature whose reality, just like the event, is a rather pragmatic affair.

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[17] See Falkenburg, pp. 235-248. The situation is further confounded by the production of quantum particle concepts whose reality status is even more obscure — notably ‘virtual particles’ and ‘quasi-particles’. Virtual particles are formal tools within quantum field theory. Emerging through perturbation, they do not exist on their own but only through interaction — that is, they break with the independence criterion of even the most generalized particle concept. Nevertheless, virtual particles produce in experiments very real collective effects, which can be calculated and measured with high precision. Quasi-particles too directly betray any real independence criterion and belong only to collective effects, as states of excitation in some quantum systems. However, here the relation between cause and effect is turned around: “Virtual particles do not have separable effects. A superposition of many of them generates a collective effect… Quasi-particles, however, are the collective effects of all charges…” (238) This tendency against classical assumptions of localized independence and rather toward dynamic collective appearance leads Falkenburg to the following analogy: “Quasi-particles are as real as a share value at the stock exchange. The share value is also due to a collective effect, namely to the collective behavior of all investors… Indeed, both concepts have a well-defined operational meaning, even though their cause cannot be singled out by experiments or econometric studies.” (245)

For an experiment to work, a particle must exist, and to show this particle, an experiment is necessary. This fundamental circularity characterizes the development of quantum physics from its initial conception by Albert Einstein and Max Planck. The mathematical inference that light consists of discontinuous quanta, or photons, means that the classical expectation of being able to localize any particle phenomenon is now extended into a generalized discontinuity. Any quantized property derived through Planck's constant *h* — the quantum of action in radiation — may therefore under the new regime count as a particle. But, as Falkenburg notes, such a particle is strictly speaking only operational, which in turn gives rise to increasing incommensurability between operational, referential and axiomatic aspects of quantum concepts.

As will be made clear in Act 4, in the quantum realm of bosons and fermions, connections to individual existence are indiscernible insofar as they are governed by an order of statistical reason. This wholesale epistemological and ontological breakdown of any stable particle concept, along with the rise of probability concepts corresponding to interacting, collective phenomena, substantiate Falkenburg's conclusion about the nature of physics today:

> The reality of subatomic particles and quantum processes is not a reality in its own right. Rather, it is relational. It only exists relative to a macroscopic environment and to our experimental devices. The quantum entities [in the microscopic world] are processes, dynamic structures, conserved physical properties, and event probabilities in the macroscopic world. (XII)

Here, a relational ontology implies the metaphysical idea that particles are constituted by that which precisely defies particularity as such — that which reveals itself to us as 'processes, dynamic structures, conserved physical properties, and event probabilities.' Such a dramatic folding of the Newtonian world is the consequence of what Falkenburg calls 'particle metaphysics.' Against the prevailing understanding of particle physics, she maintains that metaphysics in fact structures physicists' activity in decisive ways. For instance, metaphysics shows itself in untestable assumptions about the rational order of phenomena that give rise to methodological principles of unity and simplicity. Moreover, metaphysics shows itself in operational idealizations of physics that clearly rely on a notion of nature as independent substance. (28) Thus, whereas from a positivist point of view the rather provocative concept of 'particle metaphysics' may seem to imply that there is, in a strictly classical sense, no longer any 'real' particle at the core of particle physics, the thrust of Falkenburg's concept actually runs equally in the inverse direction: it refers to the nominal endurance, or constancy, implicit in the destabilizing changes to particular reality as such. The further physicists destroy the particle, the more they need it to give meaning to their act of destruction. The operational definition of the particle, which tacitly stabilizes it as a referential phenomenon, is in this sense conceptual feedback from the experimental process by which particularity is simultaneously presupposed and precluded.

Particle metaphysics, then, signifies that physics and metaphysics are deeply intertwined in scientific practice. It is Falkenburg's proclamation of death to the inherited faultline — physics on one side, metaphysics on another — that ruled the 20th century. This demarcation, she argues, results historically in conceptual failure on both sides of the limit. "Epistemologically, empiricism cannot cope with the methods of 20th century physics, whereas ontologically, traditional metaphysics cannot cope with the structure of quantum theory." (3) Thus, she says, the relation between philosophy and physics today is therefore best conceptualized as a "two-fold mismatch." Suspended along the axis of a doubling error, metaphysics occurs neither on one nor the other side of a divide but rather within this divide itself — as an instability field giving rise to a proliferation of paradoxical constructions through event machines like the LHC.

3. Stengers' Event of Invention

Thus, like the particle, the notion of an event takes on a double meaning.

Physically, the event is significant for its local isolation within space and time. Damir and Michel, for example, may not know which discrete event their work will detect — but they know which event most of their colleagues are hoping to generate. The most highly anticipated event at the LHC is also the most anticipated particle — the God Particle. Popularized by the Nobel Prize-winning physicist Leon Lederman in the early 1990s, the term has stubbornly caught on outside the physics community.[18] In fact, when I mention it to Damir, he laughs awkwardly. Physicists themselves only refer to the God Particle as a 'Higgs' or 'Higgs boson,' named after the Scottish physicist who predicted its existence under the Standard Model. The stakes for the successful generation of a Higgs event is the stability of the Standard

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[18] Lederman's book serves as a humorous (and humorously revealing) introduction to a conventional, self-serving history of physics from the point of view of an experimentalist committed to the universal truth of his endeavor. See Lederman, 1993.

Model itself. Without the Higgs, or some event like it, the Standard Model is unable to account for the rather fundamental physical phenomenon of mass.

Metaphysically, the event is not significant for what (or where, or when) it is — but rather for what it does. To ask what makes the event an event is then rather to ask, how is the event differentiated from other events, and how does this differentiation make a difference? For example, even the nominal distinction between a God Particle and a Higgs boson fulfills a practical function of reinforcing the constitutive division between science and non-science. To speak of a Higgs event rather than the God Particle is to situate oneself on the safe side of an external limit to the discipline of physics. At the same time, in the same expression, an internal limit is also articulated, between the various contenders for what would count as a proper Higgs event. In the constitution of both this external and internal limit, the experiment itself thus plays the role of the pivotal event — not merely as a particle in space-time but as a dynamic unfolding of history.

Isabelle Stengers, a contemporary Belgian philosopher of science, suggests that such a perspectival shift allows us to see that the experiment is itself the event that effectively singularizes modern science. Most significantly, she shows how the universalist axis of truth and nature can be inversed. The power of the experiment does not principally lie in its capacity to speak truth but rather in its ability to abolish what Stengers calls the power of fiction. This is "the idea of a negative truth: a truth whose primary meaning is to resist the test of controversy, unable to be convinced that it is no more than a fiction among others." (2000: 90) In other words, truth is not differentiated according to that claim which is in itself scientific but rather negatively, according to the claims that are deemed non-scientific. In this sense, Stengers shows how the influence of logical empiricism did not so much constitute a positive account of empirical science as a negation of that which it was not — which was called metaphysics. This differentiation of truth, today as in the early 20th century, bespeaks a political problem:

> The decision as to 'what is scientific' indeed depends on a politics constitutive of the sciences, because what is at stake are the tests that qualify one statement among other statements — a claimant and its rivals. No statement draws its legitimacy from an epistemological right, which would play a role analogous to the divine right of politics. They all belong to the order of the possible, and are only differentiated *a posteriori*, in accordance with a logic which is not that of judgement… but that of the foundation: 'Here, we can.' (80-1)

The experimental statement itself is therefore in principle mute with regard to its positive scope. Only retroactively is it made to speak as the privileged axis of nature and truth. In this sense, the experiment is precisely pivotal in that it plays on a double register of revealing and concealing: it makes the phenomenon 'speak' in order to 'silence' the rivals. The constitution of the event is therefore more circuitous and counter-intuitive than it is later made to appear. In effect, Stengers argues, it's a double constitution: "This is the very meaning of the event that constitutes the experimental invention: the invention of the power to confer on things the power of conferring on the experimenter the power to speak in their name."[19] (89)

In this precise sense, the event too is an invention. If we follow it retroactively through its historical unfolding, we can see that there is significant analogy between the physical and the metaphysical senses of the event — between micro-events on Damir's screen and the macro-event of the LHC itself. On both ends of the scale, the event signifies not only a discontinuity, but a discontinuity whose significance grows through repeated reference to itself — defined, in other words, by its continuing effects rather than its first locus of appearance. It's a difference that makes a difference through a process of differentation.[20]

Indeed, such is the logic of the Higgs event for which so many ATLAS physicists already, in a gesture of hope, brace themselves. As soon as the collider begins producing its chosen data, scientists involved will work to further select their collision-event, by differentiating it within a set of theoretical predictions with which they have already engaged. They will rebuild the event digitally, they will analyze it. They will produce publications through reference to it, which will become echoed in more publications. They will encounter rival claims and rival interpretations, based on other events analyzed along divergent lines. And as they succeed in garnering interest for their event, as the event engages more physicists who tacitly confer power on the experiment and its discovery, a complex reverberation process develops, which extends to the news stories, the popular science articles, the blogospherical controversies, by generating public interest and assigning roles, according to what Stengers refers to as the ongoing double

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[19] This is perfectly congruent with Heidegger's observation that "explanation is always two-fold. It accounts for an unknown by means of a known, and at the same time it verifies that known by means of that unknown." (1977: 121)

[20] Gregory Bateson once defined a unit of information as 'a difference that makes a difference,' which characterizes well the event in the purely physical sense, while differentiation relates to the metaphysical sense of an event as a process of unfolding.

demarcation of fiction from non-fiction and non-science from science. On the one hand, the successful event works to abolish other stories, such as the black hole doomsday theory of the LHC, as fiction. And on the other hand, it works to differentiate the event into a commonly accepted reference point among colleagues. Perhaps even one day, after innumberable repetitions and shifting interpretations, it could become clear to sufficiently many physicists that the Higgs event is nothing of the predicted sort but rather something so exceptional and anomalous as to constitute a veritable paradigm shift within the field of physics. From its conception as a theoretical possibility or an isolated appearance on a screen, the event beckons a messy yet institutionalized path to scientific glory. Pivoting around the experiment and the experimenters' mutual empowerment to speak in the name of nature and truth, it heralds the potential for a future moment in which it could be made the positive foundation for having 'changed our understanding of physics.' Through its effects, the event becomes retroactively constituted as exceptional and conceived as an origin, a foundational point in space-time.

A key concept for the successful creation of an event is therefore interest. As Stengers points out, there is an essential ambiguity to the notion of interest that bespeaks the paradoxical practice of the modern sciences. On the one hand, the denunciation of interest, often defined in economic terms, is what singularizes scientists in the common view. Their 'disinterest' as regards 'outer' influence is critical to their status — in direct analogy to the external limit that marks non-science from science. On the other hand, the movement of scientific invention, the creation of events that make history, depend precisely on interest in a more direct sense, in analogy to science's internal limit. In their action, physicists must succeed in generating interest for their microscopic event as differentiated from others.

Etymologically, as Stengers reminds us, to have or enact interest is to be *inter-esse* — situated in between. The paradoxical practice of science entails two different ways of understanding what it means to be 'in between.' In the former interpretation, which I in the next chapter will call hypological, interest is defined as a position in an 'external' political-economic situation, which scientists must strenuously seek to avoid. In this sense, to be in between means being an intermediary, caught in between existing forces or things. Hypologically, scientists are conceived as independent points, or a cluster of points, whose exceptional status relies on being able to step outside the field of forces within which they act — much like, as we have seen, the quantum operational definition of particles or events themselves.

In the latter interpretation, which I will call autological, interest is defined as making a link between forces or things in the 'internal' socio-political situation that acting scientists necessarily are in. Here, to be in between means being a mediator that opens up new relations.[21] Metaphysically, a mediator differs from an intermediary in the same sense that the autological differs from the hypological: it cannot and does not exist independently. Whereas the conceived intermediary is in a symmetrical relation to its surrounding forces, equi-distant to either side, the mediator maintains an asymmetrical relation to its constitutive forces, insofar as it is itself constitutive of its external relation. Interest in this autological sense is therefore not really a position as much as a movement, an initiation, that changes the relations through which it becomes expressed.

The logic of mediation will preoccupy us more thoroughly in Act 3. For now, we can say with Stengers that besides its asymmetrical character, the defining feature of mediation is its double power, or its double movement of power,

> which not only creates the possibility of translation but also 'that which' is translated, insofar as it is capable of being translated. Mediation refers to the event, insofar as its possible justification by the terms between which it becomes situated comes after the event, but even more so insofar as these terms themselves are then expressed, situated, and make history in a new sense. (100)

Specifically, this means that the physicists who become 'interested' in a particular pre-selected event proposed by an 'interesting' experimenter accept the hypothesis of a link that engages them. Herein lies the double constitution of the hypological intermediary. As Stengers puts it, "this link is defined by a very precise claim, which prescribes a duty and confers a right." (95) The duty consists of maintaining, or implicitly testifying, that the link is purely one of disinterest in the hypological sense — that a physicist's interest in another physicist's work does not signify a relation of dependence to anything other than this disembodied proposition in itself. The right, working in the opposite direction, enables the newly interested physicist to preserve a position of independence from the outcome of the experiment. Through their mutual relation of interest, the interested physicist recognizes and confers on the interesting physicist the ability of the experiment to speak for the phenomenon under investigation and therefore constrain the way in which the phenomenon henceforth must be described. A negative origin is thus

[21] Here, Stengers references Latour who develops the metaphysics of Serres. For a vivid account of the 'parasitic' logic of mediation, see Serres, 2007 [1980], to be further discussed in Acts 3 and 5.

created — a mute event whose historical unfolding will retroactively make it speak in favor of a certain alignment of interests.

In other words, the simple opening of an experimental controversy, such as the black hole doomsday scenario for the LHC, or the nominal division between a Higgs and the God Particle, is already in principle a success: a statement has succeeded in interesting colleagues who are equipped to put it to the test, who accept the possibility of a new practical engagement in relation to its terms. By reinforcing both the external dividing line between science and non-science and the internal line between fiction and non-fiction, interested scientists directly participate in the experimental process through which the double power is invented to allow for scientists to speak in the name of nature as truth, truth as nature. The event, in other words, as a difference that makes a difference through differentiation, takes on the metaphysical character of asymmetrical doubling.

Although Stengers describes interest largely in human terms, as emerging between practicing physicists, the principle of mediation readily extends to all non-human engagements, such as the experimental apparatus itself. In this sense, the computer system of ATLAS, wired through the control room before me, is an actor along with the physicists acting on it. When the ATLAS system saves one event on its servers for every 31,999,999 that it obliterates, interest is here too precisely the mediating force of selection. Various practical and technical constraints, forged along with the direct interests articulated through predictive models and theories, come to determine the designation of the event worthy of a name, the event worth saving for potential analysis — such as the Higgs Event (which could even become, to non-scientists, the God Particle Event). Both in its discontinuity and its reality, the ambiguity of the event speaks to the power of mediation, which reveals itself on and across all levels of definable scales, from the micro to the macro, quantitative and qualitative. In the case of the LHC, the mediating operation of the experiment, which provides scientists with their foundation to speak in the name of nature, is hardwired into the machine, into its various levels of triggers, switches and data capacities, and it stretches into years of continuous operation — all of which could be seen to constitute one event or many, depending on the perspectives of that possible future to which the event properly belongs.

Thus, to further make history from the event in its contingent unfolding, it is up to the interested scientists and their interpreters to differentiate the event more precisely and posit it into new constellations of meaning. And whereas most sciences today follow this logic of practice into various universalist claims, it is physics that has most clearly and distinctively made universalism constitutive of its operation. As Stengers defines the singularity of physics:

> On the one hand, this is clearly the science where the relation between theory and experience is the most rigorous and demanding... But, on the other hand, this is a science that always appears to involve the project of *judging* phenomena, of submitting them to a rational ideal. More precisely, we are dealing with the only science that makes the distinction between what physicists call "phenomenological laws" and "fundamental laws." The first may well describe phenomena mathematically in a rigorous and relevant way, but only the second can claim to unify the diversity of phenomena, to go "beyond appearances." (1997: 22)

In the endeavor to go beyond appearances and submitting the world to a rational ideal, Damir and Michel, and the thousands of experimentalists working around them, need to join forces with that other brand of physicist: the theorist.

4. Universalism on a String

Before he goes back to his monitors, Damir introduces me to Oleg, a young Russian employed as a CERN fellow. A lone theoretical physicist, unattached to busy shift schedules and group tasks, Oleg happily wanders out for an afternoon coffee.

The institutionalized internal divide between theorists and experimentalists in physics entails stories about two different creatures of physicists, conditioned by their different functions in the total enterprise. As both Stengers and Hacking agree, there is no sense in asking which comes first in physics, theory or experiment, because the two mutually reinforce each other. Einstein, for example, would famously determine experimentalist inquiry with his self-described thought experiments. And for contemporary physics, experimentation is as much mathematical as physical. Physics, in short, is a theoretico-experimental hybrid. In the case of ATLAS, its interest in selecting events is much determined by theoretical predictions, which are themselves drawn from experimental inventions that no theory had foreseen. CERN's current staffing imbalance between experimentalists, of whom there are thousands, and theorists, of whom there are hundreds, merely reflects that after decades of theoretically predicting events that require high-energy machines like the LHC, the experimentalists have now taken center stage. Meanwhile, the theorists try to stay ahead of the curve. Oleg explains that while some of his current work has been involved in clarifying exact criteria for such predicted events as the Higgs boson and its couplings with other events, most of his time is devoted to thinking beyond the Standard Model. His work consists of mathematizing the possible reunification of the 20th century disciplinary divergence — that is, a reunification of fundamental forces as they are known to physics.

Force is itself a metaphysical construct. As a certain definitive presence, it appears in physics as a problematic given. In ancient, medieval and early modern thought, force was conceptualized as substance — that which is cause of itself, existing in itself and through itself. With thermodynamics and relativity theory, force became energy — and energy is, as German physicist Werner Heisenberg once pointed out, only a different name for the same thing:

> Energy is in fact the substance from which all elementary particles, all atoms and therefore all things are made, and energy is that which moves. Energy is a substance, since its total amount does not change, and the elementary particles can actually be made from this substance as is seen in many experiments on the creation of elementary particles. Energy can be changed into motion, into heat, into light and into tension. Energy may be called the fundamental cause for all change in the world. (63)

As we have seen, the Standard Model turns force into bosons — the 'interaction' dimension of the physical universe. As such, the model operates with a concept of force differentiated as four separate phenomena, in order of increasing strength: the gravitational, electromagnetic, weak, and strong forces. Effectively, they are distinguished through incommensurability between micro and macro levels of energy. Gravity, once the Newtonian universal constant, simply disappears from the range of microscopy involving quantum mechanics. In turn, the two differentiated nuclear forces — the strong and the weak force — are incompatible with the macroscopic range of cosmology, where Einstein's general relativity plays out. Not only do the four forces fail integration into the same quantitative parameter — they also differ qualitatively. Electromagnetism, for example, exhibits both an attractive and a repulsive quality, whereas gravity, as it's known under General Relativity, is purely attractive and hence accumulative, increasing with greater mass in a non-linear relation that inevitably tends toward collapse.[22] As for the nuclear forces, these are explicated by the Standard Model in terms of its own set of particles. For instance, the name hadron, for which the collider is named —

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[22] On this point in particular, see Bal, 2010. Lindley also has an instructive discussion of gravity, to be continued in Act 2.

drawing on the Greek word for 'heavy' or 'thick' — refers to subatomic particles bound by the strong force, in analogy to how, at a less microscopic level, atoms are held together by the electromagnetic force. At the LHC, the experimental invention of the Higgs event would mark the consolidation of the strong force with the previously combined electromagnetic and weak force. This would make the Standard Model into a Grand Unified Theory of physics, what is known by acronymically inclined physicists as a GUT.

But a GUT is not the same as a TOE, a Theory of Everything. The GUT still leaves the problem of gravity — the operational constant of the classical Newtonian system and Einsteinian relativity — which does not as yet cohere with the Standard Model. Here, it is not only a matter of quantitatively increasing the reach of a theory from three to four differentiated forces. Qualitatively, the very notion of a unified theory changes its scope too. Because gravity currently functions as the limit condition of the three forces of the GUT, a TOE effectively has to account for its own limit conditions within itself. As British physics writer and astronomer David Lindley puts it:

> The theory of everything should comprise not just the rules of interaction between particles but also boundary conditions for the application of those rules; it is supposed to dictate, of its own accord, the nature of the universe that the theory of everything will inhabit. (245)

While the specificity of these rules has changed, the general claim has not. If anything, Theory of Everything is only the current operational term in physics for what in the 17th century was termed *mathesis universalis* — the historically recurrent claim to express the entirety of what physically exists in a single mathematical formulation. Its paragon definition was offered by a character we will encounter in Act 3, French philosopher René Descartes:

> There must be a general science that explains everything that can be raised concerning order and measure irrespective of the subject matter, and (…) this science should be termed *mathesis universalis* — a venerable term with a well-established meaning — for it covers everything that entitles these other sciences to be called branches of mathematics. How superior it is to these subordinate sciences both in usefulness and simplicity is clear from the fact that it covers all they deal with…" (19)

Against the Aristotelian division of knowledge into, on the one hand, physics — concerned directly with *phusis*, that which always changes — and on the other hand, metaphysics, along with mathematics — concerned with that which does not change — Descartes' project could be described as a major philosophical reconfiguration. As we shall see, it was an attempt, in the words of Australian historian Stephen Gaukroger, "to 'mathematize' physics and to 'physicalize' mathematics in one and the same operation…" (1980: 98) And while Descartes is barely remembered in the discourse of physics today, his universal configuration has prevailed. As German historian and philosopher Ernst Cassirer wrote in his study of 'the problem of knowledge' in modern science, "the spirit of [Descartes'] method and its universalistic purpose have remained embedded in mathematics and in modern natural science, where they have held good as a permanent and effective force." (14) As a typical expression of universalism, consider how British physicist William Hicks viewed the goal of theoretical physics at the 1895 annual meeting of the British Association for the Advancement of Science:

> While, on the one hand, the end of scientific investigation is the discovery of laws, on the other, science will have reached its highest goal when it shall have reduced ultimate laws to one or two, the necessity of which lies outside the sphere of our recognition. These ultimate laws — in the domain of physical science at least — will be the dynamical laws of the relations of matter to number, space, and time. The ultimate data will be number, matter, space, and time themselves. When these relations shall be known, all physical phenomena will be a branch of pure mathematics.[23]

As we shall see in Act 2, Hicks' universalism has been most cogently expressed in the late 20th century by celebrated British physicist Stephen Hawking. In a famed 1980 lecture, he argued the end of physics was near, by which he meant "a complete, consistent, and unified theory of the physical interactions which would describe all possible observations."[24] To Hawking, such a unification only hinges on a decisive experiment in the order of magnitude of the LHC.

For Oleg at CERN in 2008, what is at stake in the reunification of physical forces is therefore precisely the universalist act of making all physical phenomena conform to ultimate laws authoritatively described by the sovereign branch of pure mathematics. And from a purely mathematical perspective, this has already been accomplished. The universalization of physics, Oleg says, is a matter of who wins out among a large pool of internally consistent TOE contenders.[25] As always, the problem is to put the math to the test. By one calculation, a machine powerful enough to generate data for some predicted constituents of a TOE would require 15 times the electron-volt magnitude of the LHC; by another, several thousand times

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[23] Quoted in Kragh, p. 5.

[24] Quoted in Boslough, 131, which also contains Hawking's lecture.

[25] According to Kolbert, by 2000, there were over 10,000 published papers on string theory.

the energy will be needed. Still, theoretical physicists hope to come up with events in the LHC that could lend some support to their conjectures beyond the Standard Model.

In this endeavor, the God Particle plays a double role. On the one hand, as we have seen, the Higgs boson is the condition of completion for the Standard Model. On the other hand, the Higgs boson is not simply a missing piece of a static puzzle of particles — rather, it is itself produced as a consistent theoretical prediction by the mathematical invention upon which the Standard Model is predicated: symmetry breaking. Higgs' principal invention was a mechanism by which different particles can be explained in terms of the fundamental oscillations of a single system, thus leading toward a unified theory. Astronomer Lindley explains the process this way:

> What is wanted is an underlying device with some elegance or symmetry to it, and then some mechanism that disguises the symmetry and generates from it a set of different-looking forces. This is what symmetry breaking is all about: in the interior of a unified theory is a system in which all forces are equal or symmetrical in some way, but the symmetry is then broken, so that the outward appearance of the forces becomes different. (170-1)

In other words, the movement of explanation in contemporary physics runs from an initial global symmetry encompassing everything to local conditions for symmetry breaking. Symmetry begets asymmetry. But in the process, new and unintended features appear, which require further means of explanation and testing, to the extent that the overall movement of the physics enterprise appears rather as a constant mutation and proliferation of broken symmetries. Thus, everywhere in the Standard Model the Higgs Mechanism is employed, a mysterious new entity appears in the calculations — the Higgs Boson — whose experimental discovery becomes one of the primary research motivations for building the LHC. If the Higgs boson is the God Particle of the Standard Model, symmetry breaking is its God Mechanism.

This is why, besides the Higgs boson, the ATLAS team is also hoping to generate signs of Supersymmetry, a theoretical model that predicts a hidden coupling, or symmetry, between bosons and fermions. Supersymmetry posits a universal doubling, in which every known boson and fermion has a hitherto unknown superpartner. Effectively, Supersymmetry would allow the paradoxical relationship between bosons and fermions — as particles that essentially obey both axes of the exclusion principle — to be restabilized under a new and expanded regime. In turn, Supersymmetry is the sufficient condition for what is called string theory, currently the most popular mathematical framework beyond the Standard Model. In name, string theory derives from a 1970s attempt to shift the definition of the smallest constitutent of nature from a point-like particle to something like an extendable range of tension. Since then, the idea of the string, and its mathematical and metaphysical implications, have changed considerably. Physicists now prefer to speak of branes, leaving the term ‘string’ to tacitly demarcated non-scientists.

The complications of string theory discourse are reflected in how, if you ask physicists what a string ‘really’ is, you are likely to get very different answers.[26] To Oleg, the string is not an actual object but a purely mathematical abstraction. He illustrates with reference to three paradigmatic conceptions of a physical object such as a particle. In the classical picture, associated with Newton, the particle is a firm, actual thing. In the ‘semiclassical’ picture, developed under quantum physics, the particle is defined by a range of mathematical points expressing the uncertainty, or inherent change, of the observed object — which is only a thing in a probabilistic sense. As a set of fluctuations, the experimental object could be expressed as a wave or an energy state or a particle, depending on theoretical and experimental circumstances. As Oleg puts it, in a semiclassical picture, it is still possible to infer, through probability reasoning, back from the range of slight fluctuations toward some form of actually existing particle-object, in semi-coherence with the classical model. String theory transcends the semiclassical model by way of a logical folding. The range of slight fluctuations in quantum theory now constitutes the particle-object under investigation. According to string theory, any subatomic particle named under the Standard Model is ‘really’ — that is, if you could conduct an experiment at the appropriate level of energy — nothing more than string-like fluctuations, or states of tension.

In itself, the ‘string’ in string theory is therefore nothing. Nonetheless, the nothingness of the string is a finite nothing, for it requires a quantitative expression in order to be mathematically operational. Its finitude is provided by what is called the Planck length, the smallest possible one-dimensional unit according to the laws of quantum physics: 10^{-35} m. This length[27] is derived by mathematical inference from the Planck constant — the fundamental limit of quantum physics. We shall

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[26] I base my account of string theory in part on lecture notes by MIT physicist Barton Zwiebach provided to me at CERN as well as personal communication there. Additionally, articles by Witten (2002), Veneziano (2004) and Chalmers (2007) have been helpful. Lindley (1996) has a less updated but insightful and spirited discussion.

[27] That is, 0.00000000000000000000000000000000001 meter.

return to Planck's quantum in Acts 4 and 5, but for now we can glean that the metric finitude of the string is not so much an expression of an actual physical size as a lower conceptual threshold toward which string theory must be mathematically coherent in order to properly constitute a Theory of Everything. String theory is an idea, in other words, for deriving everything from nothing, quality from quantity, of expressing the nature of existence at the absolute limit of physical knowledge.

Thus, if string theory can be characterized as a mathematical transgression of the semiclassical picture of quantum physics — and a veritable inversion of the classical Newtonian picture — it is also a procedure that profoundly changes the course of asking questions about nature. Such an inversion bears some relation to the aforementioned historical 'leaps' of microscopic technologies. Well into the 20th century, the physicist used microscopes in conjunction with mathematics to ask what fundamental physical entities actually exist within a tacit universe. Around the turn of the 19th century, for example, the dominant problem of physics concerned whether the ultimate constituent of nature was an atom or an omnipervasive field of ether.[28] With the later emergence of particle accelerators and high-energy microscopy, as we have seen, new kinds of particles derived through experimental invention proliferated and effectively undermined any semblance of ontological unity. Today, the role of the theorist is in effect to ask: what are the mathematical conditions under which universality is possible?

String theory emerges as a response to this conceived problem, which takes the universalist imperative as its given — that ontological unity can be mathematically expressed — and makes symmetry breaking its principal mechanism. But its stipulated conditions are far more extensive than in the case of the Higgs mechanism. The original string theory invented in the 1970s required the world to consist of 26 dimensions. In a later version called M-theory, which links supersymmetry with quantum field theory, the dimensions have been compacted into 11, defined as 10 spatial and 1 temporal. Obviously, we do not live in such a world in any phenomenological sense. This is why, in order to explain it, the global symmetrical perfection of string theory must be broken up under all kinds of local conditions of symmetry breaking, in order to reduce 11 dimensions to four, give the particles mass and differentiate physical interactions. In one and the same operation, physics has to explain the nature of the perfect symmetrical world and

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[28] For a good overview of physics around the turn of the 20th century, see Kragh, 1999, pp. 3-12.

the means of its ostensible imperfection.[29] For an entire enterprise to leap across such a profoundly counter-intuitive divide requires considerable institutionalized faith in the metaphysics of universalism.

When theoretical physicists thus propose a model of string theory, it effectively becomes an event that follows a similar dynamic to the experimental event, and eventually converges upon it. Insofar as theorists can garner interest among peers for their formulations, they contribute to a complex collective movement that ensures, if successful, a shifted practical course for newly interested physicists. For experimentalists, the task is now to generate events that may indicate the existence of, say, 7 dimensions and an entire order of symmetries heretofore unknown. For theorists, the task becomes to further calculate how these 7 dimensions dictated by the theory are actually compacted so as not to appear. Analogously, they have to describe the vexing problem of how symmetries, necessary to the unification of the theory, are constantly broken in the experiential 4-dimensional universe — how, in a paradoxical kind of doubling, the universe is symmetrical even when it is not. A vast range of new kinds of tests, criteria and parameters are invented. Hence, as a complicated reverberation of multiple events, the theory, just like the experiment, is eventually poised to make history: a history in which interests are effectively mobilized to create the conditions under which a new phenomenon can henceforth be implicated.

Thus, in the logic of theoretical physics, a new reality is invented in order to become retroactively 'discovered.' To scientists and to the public, an experiment has succeeded in putting a theory to the test and proven it to be true, creating grounds for new theories and experiments, in a seemingly never-ending cycle of escalation. More caves, more shadows, more God. And so the story goes.

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[29] In another prominent version of string theory, the idea of the universe is replaced by the multiverse, a cosmos consisting of different ontological realities. For mathematical physics to speak of a multiverse is easily confusing, because even a multiverse implies mathematical universality. As I will show in Act 3, the uni-verse is by definition, if not in common parlance, that extensive realm in which a single, unified language rules, and the multiverse is defined by the same criterion. Thus the multiverse too is a product of universalism.

5. Beyond the Cave

At first glance, string theory, as only the latest in an array of contenders for all-encompassing modern world-pictures, fits neatly into Heidegger's history of metaphysics. In this sense, the brane or the string becomes the necessary mathematical condition for upholding the structure of universalism itself. Whatever takes the place of God after his death — whatever fills the void of the suprasensory — will in Heidegger's view necessarily "be variations on the Christian-ecclesiastical and theological interpretation of the world... whose fundamental structure was established and given its ground through Plato at the beginning of Western metaphysics." (64) In this general sense, Heidegger can claim that "metaphysics is history's open space" in which the destiny of a deeper cultural drive plays itself out — a nihilistic drive to render all suprasensory ideals null and void.

However, Heidegger's metaphysical construction is itself circumscribed in advance, because he argues that the metaphysics of our history is always already Platonism — even when it explicitly moves against the rule of the suprasensory or outright denies it. Thus, Heidegger sees this or that metaphysical expression in this or that historical era, but always one and the same metaphysical essence. Crucially, this totalizing claim hinges on metaphysics not being grasped as individual doctrine or philosophy but rather as "the fundamental structuring of that which is, as a whole, insofar as that whole is differentiated into a sensory and a suprasensory world and the former is supported and determined by the latter." (65) Thus, if today's physics is doubly constituted according to this universalist division, its metaphysics is, for all its myriad expressions, always already the same and destined to remain so until the entire cultural-historical project reaches its catastrophic completion.

In a 1954 lecture, Heidegger contextualizes his thesis in relation to physics, trying to grapple with the fundamentally different characteristics of classical Newtonian physics on the one hand and atomic physics on the other. These two forms of physics, he observes, indicate an epochal shift within modern physics itself, wherein it constitutes and determines nature in two incommensurable ways. And yet, as he points out, "what does *not* change with this change from geometrizing-classical physics to nuclear and field physics" is the way nature has to be already set in place as knowable "object-ness" — in a manner that we in the next Act will consider in terms of the framework, or enframing, of nature. Whether physics is understood in terms of geometry or statistics, nature is always encountered as an object, even if, as in the case of quantum physics, it is retroactively constituted in its trace. In his few pages of overview, Heidegger's analysis is consistent with the more rigorous reviews of scholars such as Falkenburg. Then he adds a rather curious remark:

> However, the way in which in the most recent phase of atomic physics even the *object vanishes also*, and the way in which, above all, the subject-object relation as pure relation thus takes precedence *over* the object and the subject ... cannot be more precisely discussed in this place. (1977: 173)

The vanishing object and the pure relation — this is as good a description of the mathematical string as any. In cryptic brackets, Heidegger intimates that this pure 'relational' ordering of subject and object, thinker and thing, is now itself taken up as standing-reserve — that is, it becomes a new part of the way the world is enframed for scientific inquiry, but he does not elaborate further. Perhaps Heidegger can say little about this kind of relational ordering, not simply because it is the 'most recent phase of atomic physics,' but more fundamentally, because it challenges the critical concept of 'object' and 'object-ness' of Heidegger's own metaphysical analysis. String theory, in other words, pushes toward the very limit of metaphysics — even as it reconstitutes metaphysical universalism in new terms.

Thus, within Heidegger's total claim to metaphysics as Platonism, and physics as the total enframing of nature, maybe there is still a little room to maneuver. What we require in the following is a means to grasp the metaphysics of today's scientific practice without collapsing back into the same universalist structure. To better understand the historical implications of contemporary physics, then, I propose we first of all need to move simultaneously with and against it. And although it may seem strange at first, string theory, as the apotheosis of contemporary universalism, serves as an exemplary logical precursor for its own critical inversion.

In the perspective to be developed in the following Acts, the historical unfolding of the event that constitutes modern science works inversely to the explanatory movement of contemporary physics. Rather than moving from global symmetry to local asymmetry, the very process of invention itself, as we have seen, has the character of asymmetrical doubling. Schematically, beginning from a negatively constituted origin, an asymmetrical event, it is mediated into a two-fold mismatch: an internal and an external limit, at once demarcating fiction from non-fiction and science from non-science. Let us first consider string theory in this sense as discursive case.

Internally, in physics networks, string theory has caused controversy among those who remain faithful to the 20th century positivist distinction and thus denounce as 'metaphysical' any theory that cannot be tested. As I have tried to show in this chapter, the denunciation of metaphysics as fictional and non-scientific is misplaced — not least because the separation upon which such a denunciation rests is itself metaphysically constituted. While the idea of a theory finding believers without empirical support certainly violates the established practice of modern science, the metaphysical thrust of such theories lies not principally in their unverifiable predictions, but rather in the implicit way they make truth and nature stand in a universalist configuration. The claim may appear to be that the world actually consists of 11 dimensions — and the controversy around this statement is part of the event's 'effects,' its unfolding. And these effects only reinforce the structural core of a much more circuitous, precedent claim: a universal reach whose guarantee rests upon the successful mobilization of physicists and computers to confer upon nature the power to confer upon the theory to speak in its name. The theory, like the experiment, is a pivot concealing its principal axis — a field of explanation already constrained and structured. This circumscription defines how the role of a pivotal event in the making of history, like the ATLAS system selection, is also, in one and the same double movement, involved in making history disappear. Writes Stengers:

> The actors in the history of the sciences are not humans 'in the service of truth,' if this truth must be defined by criteria that escape history, but humans 'in the service of history,' whose problem is to transform history, and to transform it *in such a way that their colleagues, but also those who, after them, will write history, are constrained to speak of their invention as a 'discovery' that others could have made*. The truth, then, is what succeeds in making history in accordance with this constraint. (2000: 40)

Thus, theoretical physicists are not primarily believers in a theory, but actors set to solve a problem according to a configured field of history. Their task is not to investigate the axiomatic conditions of their configurations, let alone their own implication in the articulation of theory. In this precise sense, the axiomatic constraint of the TOE is that it does not and cannot take into account the event of its own emergence. A theory never derives positively from the experimental event but is rather constituted by the negative constraints of its own pivotal conception, wherein the universalist alignment of nature and truth is already an axis of theoretical projection. Only retroactively and through a logical reduction — a double constitution turned into a single event — does a theory, like a fact, appear as its own isolable claim to truth. Disconnected from its own history, it conceals its own conditions in order to reveal itself.

Externally, in popular scientific discourse, the loudest internal claims of physicists reverberate incessantly. Nietzsche can laugh and Heidegger can lament because string theorists and their followers in so many ways fit the familiar Platonic-Christian image — a 21st century priesthood of physicists, proselytizing a higher-dimensional world whose access is explicitly contingent upon accepting their metaphysical configuration of *mathesis universalis*.[30] Here, the enduring power of universalist metaphysics is not primarily revealed in explicit transcendental claims, but first and foremost through its implicit operation in today's scientific practice. For as soon as we, along with so many other physicists, attempt to reject the claims of string theorists as fiction, we risk finding ourselves on a short-circuitous path, back toward a positivist claim to science — a more realistic or more truthful science, in opposition to flagrant metaphysical speculation.

Thus, debates that seek to dispute or contest some specific discovery always tend to reinforce the underlying logic of scientific practice, and thus, universalist metaphysics. As contemporary French philosopher Bruno Latour argues, structurally, our sciences today still operate in the very same sense as Plato's famous allegory of the Cave. In a brief analysis, Latour shows how the story of the Philosopher-Scientist, who breaks free from the prisoners' shackles to stare directly at the sun outside the Cave, determines the role of the sciences in a decisive double constitution. In the first movement, "the Philosopher, and later the Scientist, have to free themselves of the tyranny of the social dimension, public life, politics, subjective feelings, popular agitation — in short, from the dark Cave — if they want to accede to truth…" In the second movement, "the Scientist, once equipped with laws not made by human hands that he has just contemplated... can go back into the Cave so as to bring order to it with incontestable findings that will silence the endless chatter of the ignorant mob." In both movements, inversely to each other, there is "no possible continuity between the world of human beings and access to truths 'not made by human hands.'" (10-11)

In this double rupture between the Cave and its exterior, between fictional shadows and the light of truth, between the social world and the world of nature,

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[30] For a prominent contemporary example of this universalist stance, see Richard Dawkins' 2006 lecture, where he argues that while our everyday existence takes place in a 'middle world', science has access to a 'higher world' of understanding the universe. http://www.ted.com/index.php/speakers/richard_dawkins.html. Without semblance of conscious irony, the lecture was delivered the same year as Dawkins published his atheist bestseller *The God Delusion*.

the scientist plays a singular role: he “can go *back and forth* from one world to the other no matter what: the passageway closed to all others is open to him alone.” (ibid.) And while the practice of the Philosopher-Scientist has obviously changed in myriad ways since Plato, the same double rupture expressed in the Cave allegory shows itself in the bifurcations according to which the sciences operate. As Latour puts it, “the belief that there are only two positions, realism and idealism, nature and society, is in effect the essential source of the power that is symbolized by the myth of the Cave.” (34)

In turn, the two opposed positions make for the bullhorns of a now familiar dilemma. Metaphysically, the Cave of modern universalism is an apt expression of Heidegger’s claim to metaphysics as the double constitution of the sensory and the suprasensory. Physically, this double structure is analogous to the paradox facing physicists chasing after a TOE — the incommensurable conceptions of a physical particle-object. In string theory, the pivotal invention is in effect a means to circumvent this double structure by turning the incommensurability — the very inconsistency plaguing the stability of 20th century physics discourse — into the mathematical object of explanation. Thus, the unstable particle is pried open, revealed as an extendable range of tension, and subdivided into however many dimensions it takes to reconstitute its physical object. In a word, the string is the particle inside-out: it goes ‘beyond the particle’ through a logical inversion. In the very same sense, I propose that the only way to evade the iron grip of universalist metaphysics whilst wrestling with its history, is to move ‘beyond the Cave.’ In this sense, beyond the Cave does not mean to seek a higher ground for ultimate truth — already implied in the Cave analogy — nor does it mean denouncing universalism as a fiction. Rather, moving beyond the Cave means to pry it open from within. If, by living under the regime of universalist metaphysics, we are effectively still living in the Cave, the bullhorns of our dilemma dictate that we cannot leave the Cave any more than we can afford to stay. Thus, taking our cue from the logic of string theory, the only way out is in.

In effect, the theoretical move of this dissertation is to pry the history of universalist metaphysics open and show how today’s physics in action is itself constituted by a five-dimensional logic. Analogy is but the opening gambit in the different logical means by which the sciences operate. How the analogical, as the logic of connection, itself connects to the other logics is a matter for explication as the story goes on. But as I conceive it, each of these five logics contribute a significant dimension to the complex process that constitutes, in Stengers’ phrase, the making of history — and specifically, the making of universalist history itself. In turn, the purpose of employing such a tactic is not to create ‘string metaphysics’ for yet another cosmology — but rather, inversely, to explicate the historical and political stakes of modern physics as exemplified by the LHC experiment.

Thus, to get beyond the Cave entails flipping the cave inside-out — to theoretically construct an inverse experiment that will allow us to better explain the history of this history-making event. The operative problem for the following Acts is to elucidate the metaphysical conditions for emergence of the LHC physics experiment. Given that the possible range of such historical conditions extends far beyond the bounds of any dissertation, I propose to tell the history of the LHC by analogy. Just as physicists require high-energy accelerators for their work, the metaphysicist needs an accelerator of history. Perhaps it could be called a Large History Collider — smashing events, actors and thinkers together in order to differentiate their means of connection. Metaphorically, at least, the metaphysics experiment that constitutes this dissertation is a history of the invention of the Large Hadron Collider, conceived as its own experimental invention. Here, we won’t belabor the technical details of such undoubtedly sophisticated machinery, but suffice to say a metaphorical history collider comes complete with its own experimental detector — a triggering and switch technology capable of capturing the most interesting among the near infinite contingent events and rebuild them before us, stringing them out in their different logical dimensions.

Running the analogical accelerator in historical reverse, then, I will in the following Acts identify some of the brightest stars in a constellation of inventions that enabled the idea of this physics machine, the world’s largest microscope. Already, as we have seen, the history of the microscope suggests three historical leaps in the change of extended vision, and we will consider these moments in turn. In Act 2, we will continue the exploration of physics’ universal reach by turning to cosmology, analyzing the 20th century confluence of General Relativity and the singular origin of Big Bang theory. In Act 3, we will move back to the event-origin of modern science itself, to the 17th century invention of the universe through Galilean kinematics as a decisive condition for Newtonian physics. In Act 4, we will encounter the late 19th century invention of quantum theory and atoms beyond the limit of optical microscopy. And finally, in Act 5, spinning back into a contemporary landscape, we will consider the pivotal role of so-called Planck constants in articulating the boundary conditions of the universe. A history of universalism, then, as a four-fold configuration: singularity, universality, particularity, and constancy. For all the spectacular modes of change in the history of physics, for all its ever-increasing ranges and scales of theoretico-experimental probing, its universalist configuration as I will uncover it appears remarkably consistent. All the pivotal theoretical and experimental events to be considered here eventually come to form retrospective part of an event-history that makes and remakes itself in the same structural arrangement. That is, these events change physics in its proliferation, whilst conserving its axis of movement.

To truly get beyond the Cave, then, we need to, as Latour puts it, "accept the risk of metaphysics" and recover a different configuration of truth, nature, God and science. (232) Throughout the following chapters, I will explicate an alternative undercurrent to the dominance of universalism. This inverse configuration is expressed through a set of thinkers that may not usually be considered in conjunction — in fact, critical differences undoubtedly feature between them. Nonetheless, as my emphasis is here on construction rather than critique, on aligning disparate ideas against a common configuration, these are all pivotal thinkers in the most metaphysical sense, because they endeavor to change the very terms under which we come to ask questions, to do science, and to make history. Along with the physicists and philosophers associated with their respective historical moments, then, my protagonists in this dissertation comprise Martin Heidegger on the problem of ontological difference in Act 2; Benedict Spinoza on the problem of univocity in Act 3; Henri Bergson on the problem of dualism in Act 4; and an ensemble cast in Act 5 comprising Latour, Stengers, Michel Serres and Peter Sloterdijk, among others, on the problem of nature itself. In this sense, our story moves between God and Nature as it charts the making of history.

Back in Geneva at the LHC, however, Oleg is not very hopeful that he or his colleagues will succeed in making history according to their proposed terms. He says he does not believe the collider will yield sufficient signs to verify or falsify string theory, which will probably remain untestable at the micro level. The Standard Model, likely tweaked and updated, will be shown to prevail at the specific levels of energy for which it was tested. And that, he thinks, will be the end of particle physics as we know it. Oleg's prediction, apparently common in physics circles today, is that a large group of bright young theoretical physicists now involved with string theory will eventually, once the LHC experiment is winding down, move from the micro to the macro level — to cosmology.

For if the particle accelerator is a Big Bang machine, the Big Bang universe is the ultimate particle accelerator, able to provide the energies, temperatures, and densities high enough to probe the experimental depths of string theory. This movement toward the study of the stars, as the next Act will dramatize, signifies the conjoined nature of contemporary physics and cosmology, which in the course of a few decades have become paradoxically intertwined in an intensified quest for the Theory of Everything. As Lindley puts it:

> The hopes of cosmologists and particle physicists have become the same method: on both sides of this joint effort there is absolute reliance on the notion that a single theory will explain everything, and that when such a theory comes along it will be instantly recognizable by all. This might be called the messianic movement in fundamental science. (206)

If God is dead, he lives on in the hunt for universalist expressions. Insofar as it can mediate the requisite interest for a Theory of Everything, then, the LHC is a universal event machine. It produces the conditions for fashioning the entirety of what is as the universe of metaphysics, in structural accordance with God as suprasensory creator. But in order to bear out its proper potential, the LHC must be aligned with the event of the universe itself. The inward gaze must be complemented by an outward scope. The underground shadows of God must be turned back into the heavens. With physics and cosmology as hegemonic scientific practices, creation promises once again to meet its creator in his shadows.

Behind the scenes of the largest experiment in science history, under the alpenglow over CERN's Geneva campus, physicists are already engaged in the transition beyond the Large Hadron Collider — though not, as it were, beyond the Cave.

ACT II — HYPO

General Ontological Difference: Being, Beings, and the Big Bang

Not the capabilities of man,
but the constellation
which orders their mutual relationships
can and does change historically.

Hannah Arendt

1. Long Island, NY, 1953

It begins under Janus.

As the imperial Roman God of beginnings, gates, doorways — the God for whom our first calendar month is named — Janus transcends history by looking in two temporal trajectories at once. His face sees both past and future. As beings inevitably caught in between his doubled gaze, we find ourselves standing under his reach every time we conceive a new beginning.

Yet what about that very moment when the beginning, or that which will become the beginning, appears — what about the moment that is always 'between past and future?' This is German-American philosopher Hannah Arendt's question in a collection of essays written in the 1950s, taking Janus as leitmotif. For Arendt, the two-faced interval between past and future indicates not simply the continuing present of a linear time but rather a volatile moment of thought itself, the gap in which thinking occurs, pressured between temporal forces on two sides. A rare, if not singular event. Historically, she writes, such an odd in-between period in our culture inserts itself from time to time, "when not only the later historians but the actors and witnesses, the living themselves, become aware of an interval in time which is altogether determined by things that are no longer and by things that are not yet." (9)

The no longer and the not yet — this is the inversion of what philosophers after Hegel would call the 'always already.' The no longer marks a rupture in an ostensibly cyclical time, but does not yet appear clearly to the actors and witnesses of history. The 'living themselves' recognize in their thinking that the past is no longer, that something is changing, but they are not yet able to determine its charge. In this moment between past and future, the retroactive unfolding of history, in which what is will always already be, has yet to take place.

Arendt's words presciently, if unintentionally, describe their own historical moment of utterance. In the wake of two calamitous World Wars, yet barely at the beginning of that extensive technological escalation to be known as the Cold War, the 1950s appears today as precisely such an odd historical interval between past and future. The cultural shock of an apocalyptic war machine ravaging the planet ensured, as shocks tend to do, fertile ground for new beginnings. This was no less true in science, where the grandest of all possible beginnings was to be decided and made into history through the transformation of modern cosmology.

Occurring through a constellation of multiple events, this transformation found its exemplary site, politically and historically, in the United States, which in the postwar era definitively took over the mantle from Germany as the leading power in nuclear physics. In 1947, Camp Upton, a surplus army base on Long Island, New York, was transferred from the US War Department to the Atomic Energy Commission, a forerunner of today's Department of Energy. It provided the initial funding for Brookhaven National Laboratory, a collaboration between nine major northeastern universities that comprised several individual laboratories and giant machines for extended research in physics, chemistry, biology, and engineering. In 1953, Brookhaven's most spectacular machine reached its peak capacity. Based on a prototype developed in the 1930s, it was the most powerful machine of its kind ever built, capable of accelerating protons to previously unheard of energy levels, into the "giga" range of more than one billion electron volts, or GeV. For the first time, a particle accelerator could exceed the energy of cosmic rays showering the earth's outer atmosphere. The machine at Brookhaven thus inaugurated an era of high-energy physics venturing far beyond naturally occurring physical phenomena.[31] It was able to produce some of the first particles that defied existing quantum frameworks, resulting in the Standard Model. And in the course of its decades in operation, it would set nuclear physics squarely on a path toward elucidating stellar phenomena. It was not without reason it was called the Cosmotron.

In retrospective physics history, the Cosmotron signifies a critical turning point within the transformation of cosmology that largely took place in the period from the late 1940s to the early 1960s. Through a scientific battle of rivaling metaphysics inside and outside the burgeoning community of cosmologists, two distinct hypotheses of the universe were articulated and pitted against each other — the (losing) Steady State Theory and the (winning) Big Bang Theory — and in the wake of the battle, universalism was reinvented as a scientific cosmogony.

What was 'new' about the Big Bang? In the 'old' conception of the cosmos, what Arendt calls the modern idea of history, the world had neither beginning nor end — no great creator, no great beyond. Instead, humans invented a strictly secular realm of enduring permanence. Its foremost expression is the pervasive idea of infinite process, signified by the modern calendar, established in the late 18th century with the birth of Christ as its degree zero marker. Not simply a definitive

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[31] For more description of the significance of the Brookhaven lab, which was just the first in a lineage of particle accelerators in the following few decades, see Pickering, esp. pp. 33-34.

origin for a Christian accounting of time, as had already been the practice for centuries, the modern computation of history makes the birth of Christ into a pivot for a Janus-faced chronology. Henceforth, history stretches into, as Arendt puts it, "the twofold infinity of past and future." (75)

A sense of lament in Arendt's text bespeaks the passing of an era. Written just at the moment of a modern cosmos that was no longer reigning but a reinvented cosmos that was not yet established, her musing on the history of the modern universe would soon become anachronistic. For the new universe forged during her time of writing would once again, much like a Christian cosmology and a stable structure, have a beginning, a moment of creation, and therefore quite possibly an end — a finitude that could, with sufficient research investment in machines like the Cosmotron, be calculated with the utmost precision.

In Act 1, I introduced the idea, inspired by Isabelle Stengers and Bruno Latour, that the unfolding of scientific truth has the distinctive character of asymmetrical doubling. Singularly constrained by the negative origin of the experimental event, positive truth is retroactively constituted and reinforced through the ongoing double internal and external demarcation of science. The cosmological transformation, as we will see in this chapter, is an exemplary case of such an unfolding. This is not least because the ostensible subject matter exists so far away from the realm of the sensible that faith in universal mathematics becomes foundational. As I will argue, the Big Bang hypothesis did not win out because it is 'true' in any positive sense but rather because it most effectively gathered and mobilized interest in the scientific community for its explication of the fundamental constraints inherent to the formation of the discipline itself. Arendt, in the same essay on history, offers a very precise conception of this logic at work:

> What was originally nothing but a hypothesis, to be proved or disproved by actual facts, will in the course of consistent action always turn into a fact, never to be disproved. In other words, the axiom from which the deduction is started does not need to be, as traditional metaphysics and logic supposed, a self-evident truth; it does not have to tally at all with the facts as given in the objective world at the moment the action starts; the process of action, if it is consistent, will proceed to create a world in which the assumption becomes axiomatic and self-evident. (88)

The hypothesis is a conception: it offers itself as a beginning — which is, in a sense, an invented beginning, insofar as it grows out of the consistent action of those who work to make it come true. In this sense, a conception is analogous to Janus — a gateway through an already constructed wall, a first calendar month in a cyclical time. January is the beginning of the year because through consistent action in our cultural history, we have come to structure our lives in such ways as to make January the self-evident beginning of that natural cycle we call a year. It is so because we make it so. We conceived it and so it is. Thus, the hypothesis constitutes a tacit framework within which the world can be reinvented. The logic of a hypothesis that is made historically true in this sense must therefore not be confused with a tautology. For the hypothesis is not by itself a self-circular proposition. Rather, it is made circular, and thus foundational, through a forgetting of its conditions of emergence: the consistent action to which the axiomatic claim now owes its hegemonic existence.

This logic, which I will attempt to unpack in the following, I propose to call *hypological*. As a logic, it can be nominally differentiated in terms of its relative movement. In our language, relative movement is signified by prepositions, which, in a first approach, can be taken literally: pre-position. A preposition affords in a sense the 'before' picture of your current position of expression, from which you can infer the movement to the 'position' of utterance. The differential movement that is hypology is therefore essentially a relation marked by 'hypo', the Greek prefix for 'under.' Hypology is the logic of positing something as under itself, in the manner of a framework, which is established through the retroactive unfolding of a transformative movement that comes to make its terms self-evident. In this precise sense, hypology also constitutes a logic of under-standing. To under-stand is, most properly, to stand in an experiential relation of 'under' to conditions that have always already been enframed for me. I understand when I participate in the idea that orders my existence. I understand the Big Bang, as I understand January, first and foremost when I recognize my belonging to the ambiguous practices of the culture within which I find myself. It is so because we have made it so — and as long as we understand, we will keep making it so.

Thus, hypology shows itself as essentially Janus-faced. Conceiving signifies at once the revealing of a necessary beginning for thought — a beginning that looks simultaneously to the past and the future and thus enframes history — and the concealing of its inverse meaning: the critical action that remakes history under a new regime. Like the pivot concealing its axis, hypology hides its own contingent moment of conception. And what is at stake in the thematic of this chapter is precisely conception, creation, and the terms of its revealing and concealing. The parallel discourses of relativistic cosmology and continental philosophy in the 1950s both circle around the problematic relation to our own origin — as the Big Bang or as Being. In the following sections, I will discuss two distinct hypologies that are both in their own ways regarded as foundations for universal explanation: Albert Einstein's invention of the equation of relativity, $E = mc^2$, and Martin Heidegger's critique of the principle of identity, A = A. Einstein's invention leads to the hegemonic mathematical framework of General Relativity. Heidegger's critique leads to my invention of an inverse philosophical framework, General Ontological Difference, within which the hypological foundation of physics can be revealed. Through this double gaze, I offer the methodological means by which we may distinguish the universalist framework of our culture from that which we take to be tautological, that is, most self-evidently true. Through General Ontological Difference, in other words, it becomes possible to differentiate our conceptions from our acts of conceiving.

2. Einstein's General Relativity

The eventual victory of Big Bang Theory in the 1960s relied on three major factors: the acceptance of General Relativity as theoretical framework; a limited set of astronomical observations derived through new telescopic and computerized technology; and an explosive growth in the field of nuclear physics. Both the latter two variables were deeply conditioned by enormous military-industrial budget increases of the mid-20th century, which enabled large-scale experiments like the Cosmotron, foreshadowing the LHC of today. As Danish science historian Helge Kragh notes, through most of the postwar era federal US money was to a large extent "synonymous with military money," a vast capital flow sustaining an era of Big Science, a new and unprecedented constellation of research, government, military, and industry. The rise in spending was staggering. In the period between 1938 and 1953, federal funds for basic science research, adjusted for inflation, increased by a factor of 20 — that is, by 2000 percent. And through the 1950s, the budgets were maintained at roughly the same peak level. In the structural economic terms that Kragh outlines, the postwar period was later marked by a 25 percent decline in basic funding between 1960 and 1965, plateauing for the next 15 years, only to again climb significantly during the Reagan years. Still, whether counted in real term dollars or as proportion of federal spending, American basic research funding for science in the 20th century would never again reach its 1953 apogee. In more than a political economic sense, the cosmological reinvention, which would offer the Western world a new beginning for its own self-conception, was therefore inextricably related to the political, social, and cultural cataclysm known as the World Wars.

In turn, the political economic variables of scientific experimentation were related to the framework of General Relativity. The exemplary machine at Brookhaven demonstrates this connection.[32] As we have seen, what interests the postwar high-energy physicist is not so much particles freely existing in nature as subatomic constitutents generated through intensified experiments. The pivotal principle of accelerator technology dictates that the higher the energy or momentum, the lower the wavelength, that is, the deeper into the nucleus the microscopes are able to probe. Increase the electron voltage a thousand times, the linear proposition goes, and you will be able to see 'nature' at a thousand times smaller wavelengths. To produce a particle of a certain mass, in other words, a corresponding energy is required. As an experimental expression of this exact quantitative relationship — a relational constancy between speed, energy increase and mass decrease — the particle accelerator is therefore metaphysically rooted in the most famous physics equation of the 20th century: $E = mc^2$.

In conventional history of science, Einstein's formulation of mass-energy equivalence typically plays the role of a revolutionary break with the classical Newtonian universe. Yet it would be more correct to say that Einstein's theory of relativity is a direct extension of the classical universe, insofar as it saves the universalist configuration in a new and more simplified expression.[33] For even if its extensive field equations are forbiddingly complicated, and even if its exact implications are still disputed, the metaphysics of General Relativity essentially emerges from a constellation of three hypothetical principles. The first two, combined in Einstein's Special theory of Relativity (1905), are the principle of relativity and the principle of constancy of the speed of light. The third, which enables the General theory of Relativity (1917), is the principle of equivalence. While the second of these can be considered a critical invention of Einstein's age, the first and the third are new versions of principles put forth by Galileo and Newton in the 17th century.

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[32] As remarkable as the mid-century rise in American science funding was, the increase in energy levels of physics accelerators was even greater. Whereas the first so-called cyclotron in the early 1930s put accelerators in the "mega" range of energy, over one million electron volts, the LHC has today entered the "tera" range of trillions of electron volts. At 14 TeV, the LHC is on this scale 4,200 times more powerful than the Cosmotron, which in turn was roughly 3,000 times more powerful than the first accelerator.

[33] Arendt also emphasizes this continuity, as does Ernst Cassirer. See Arendt, 1998, 264.

In what is now taken as the earliest version of the modern relativity principle, Galileo argued that the laws of physics are the same "in all inertial frames," which is to say in all cases of uniform motion, such as a moving earth. As Einstein puts it, "the laws of nature perceived by an observer are *independent* of his state of motion."[34] (1987v6: 3) To physicists, the term relativity refers to the relative motion within which an observer is situated — something moving faster and slower than herself — and from which any chosen movement thus can be considered 'at rest' relative to other movements. The Newtonian system made inertia this absolute foundation for measuring relative movement, and the principle of relativity enabled the constitution of space as a system of coordinates in three continuous dimensions. But, argues Einstein, "this relativity had no role in building up the theory. One spoke of points of space, as instants of time, as if they were absolute realities."[35] (30) The crux of the theory of Special Relativity is to extend the principle to time itself, now conceived as a fourth dimension of the new construction called space-time.

An immediate consequence of Special Relativity, which will be extended in General Relativity, is that space and time are no longer to be considered as real physical entities but rather as derivative geometrical functions of what henceforth becomes the pivotal concept of modern physics, the event. Writes Einstein: "It is neither the point in space, nor the instant in time, at which something happens that has physical reality, but only the event itself." (30) This new physical conception of an event — Einstein's 1905 paper uses the word 11 times in a page and a half — thus functions as a bridge between two sets of symmetries embodied in the $E = mc^2$ equation — between matter/energy and the derivative space/time.

However, this symmetry hinges on a specific condition in which the relative measure of matter and energy is invariant for any frame of reference. For this reason, Einstein's preferred term for his invention was the 'invariant theory', since 'relativity theory', which was first used by Max Planck in 1906 and quickly became the accepted term, often leads to misunderstanding.[36] To ensure the invariance

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[34] Note that when expressed this way, the principle of relativity is not actually relative at all. What it posits is rather an absolute and independent physical reality, irrespective of local conditions of understanding. The principle of relativity says, most essentially, 'it is so,' notwithstanding how it comes to be taken as so.

[35] This and all following Einstein quotes taken from his comprehensive *The Meaning of Relativity*. See Einstein, 2005.

[36] For more on the circumstances on the naming and uptake of relativity theory, see Kragh, 1999, pp. 90-94.

between relative coordinates within the posited system, some constant reference was required in place of what in the Newtonian system had been absolute time. The new absolute of the theory of relativity, suggested by a few 19th century experiments, is expressed by the letter *c* for 'celeritas' — the speed of light in a vacuum. Einstein explains the principle of constancy this way:

> In order to give physical significance to the concept of time, processes of some kind are required which enable relations to be established between different places. It is immaterial what kind of processes one chooses for such a definition of time. It is advantageous, however, for the theory, to choose only those processes concerning which we know something certain. This holds for the propagation of light *in vacuo* in a higher degree than for any other process which could be considered… (28-9)

When Einstein chooses the constancy of the speed of light as the invariant that enables his new system, he therefore explicitly seeks recourse to a hypothetical concept that can maintain a high degree of certainty. His use of the word 'immaterial' in this quote is apt. A vacuum in physics is sometimes called 'free space', because it corresponds to a set of idealized conditions that strictly speaking do not exist outside an experimental setting.

Metaphysically, then, the absolute independent physical reality conceived under the principle of relativity implies a parallel independent non-physical reality, or physical non-reality, in the conception of a vacuum. That which absolutely exists independent of local conditions requires the guarantee of that which does not and cannot exist in the actual physical world other than as a thought experiment. In this general sense, being and thinking formally exist on independent planes that nonetheless are symmetrically aligned so as to mutually constitute the complete identity of the system. The principle of constancy posits that, if the speed of light is the *same* under the *same* hypothetical conditions, energy and matter can be considered equivalent in the independent physical reality posited by the principle of relativity. To put it in terms that make the planes of being and thinking come together in complete identity, physical reality is independent because the speed of light in a vacuum is constant. If something is constant within conditions guaranteed to be constant, that constancy can be said to be constant. It is so because it is so. But how did it come to be so? The perspective that allows for this symmetrical identity is precisely Einstein's invention, and it hinges directly on the principle of constancy, which could therefore be called the 'god principle' of relativity theory.

However, as Einstein makes explicit, the point is not what the constancy *is*, or whether it actually exists, but rather what it *does*. The 'god principle' of relativity enables the mathematical construction of a new point of view through which the world can be reinvented. Einstein's reasoning is therefore perfectly hypological. Whether the assumption of a constancy of the speed of light is an objective fact in the given world or not at the time of conception does not matter, for it will eventually, through consistent action, be turned into an axiomatic and self-evident truth. Wherever we look in the body of physics literature, we will not get further insight into the speed of light than that it is constant first and foremost because it is defined as constant. And from this foundation a whole process of scientific action in the 20th century has unfolded. With the scientific hegemony of relativity theory, both in its Special and General versions, the hypothetical speed of light has become a given — most notably as the absolute measure of the internationally standardized metric system.[37] Thus, the modern structure of the world, its system of identity through which all its key measures are expressed, is hypologically constituted.

From a physics perspective, why is the principle of constancy and thus the identity of physical reality itself made contingent on an idealized, fictional space of thought? In the first place, half a century before Einstein's theory it was well established that the speed of light varies with actual physical conditions. Air slows down light, water and glass even more so — a phenomenon known as refraction, which, to be sure, can be calculated, but again only with recourse to either specific local conditions or generalities derived from idealized conditions in the same hypological manner. In the second place, actual physical conditions also inevitably involve some kind of force, such as gravity. This would take us beyond the reach of the Special theory, which is Special in the sense of being restricted, in the use of both its principles. Whereas the principle of constancy is explicitly hypothetical, the principle of relativity is restricted to uniform, linear motion (inertia) and does not account for non-uniform motion, such as acceleration due to gravitation.

As Einstein was looking for a way to generalize his Special theory, he once again turned to a postulate of Galilean-Newtonian mechanics in order to modify it for his own needs. As he describes it:

> The ratio of the masses of two bodies is defined in mechanics in two ways which differ from each other fundamentally; in the first place, as the reciprocal ratio of the accelerations which the same motive force imparts to them (inert mass), and in the second place, as the ratio of the forces which act upon them in the same gravitational field (gravitational mass). (56)

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[37] 1 meter was in 1983 redefined by the International System of Units, the SI, as the distance traveled by light in free space in 1/299,792,458th of a second.

These two concepts therefore appear in classical mechanics as asymmetrical, but for no reason that can be explained in terms of the phenomena themselves. In characteristic fashion, Einstein develops hypothetical thought experiments to argue for a perspective from which the difference could be perceived as symmetrical and thus equalized. The most common example goes like this: if a person standing inside an elevator in free space — ie. a hypothetical vacuum — is being lifted upwards by the same speed as the force of the gravitational pull on Earth, she would not be able to distinguish between acceleration and gravitation. And inversely, if she stands in an elevator located on Earth that is in free fall, she would not feel the gravity that is now practically canceled out by its symmetrical opposite, the acceleration of the elevator. Einstein argues that this illustrates what he calls the principle of equivalence, which "signifies an extension of the principle of relativity to coordinate systems which are in non-uniform motion relatively to each other. In fact, through this conception we arrive at the unity of the nature of inertia and gravitation." (58)

It is the principle of equivalence that makes Special Relativity 'General', which is here to be understood as universal — for it enables an entire universe through a simple set of explanatory symmetries. In this sense, the principle of equivalence is a generalized identity principle. That it (independent physical reality) is so because it (constancy) is so now also means that it is so for all space and time. Put differently, the truth of relativity contingent on a hypothetical construction is now considered valid beyond its own local moment of emergence — it has become acultural and ahistorical, even 'a-planetary'. That which can be posited here and now is the same as that which can be posited anywhere and anytime. It is so because it is so, always already so.

In arguing for his General theory, Einstein once again demonstrates hypological reasoning of the shrewdest order, alternating between appeals to empirical facts and to hypothetical scenarios. In his thought experiment, he simultaneously argues from experience — the person in the elevator would not 'feel' the difference of the motions — even as the premise itself — an elevator in a vacuum? — is entirely hypothetical. As in the case of Special Relativity, the consistency of reasoning matters less than constructing the perspective that allows for an ingenious theoretical simplification. In one and the same operation, the principle of equivalence dispenses with the restriction to the inertial systems of Special Relativity and the persistent problem of gravity in classical physics. Newton's solution was to turn gravity into a universal constant of his cosmology, analogously to what Einstein does to the speed of light. Einstein's solution was to make gravity a geometrical spatio-temporal property of mass-energy equivalence itself. Again appealing to known experience, Einstein goes on to justify the metaphysical downgrading of inertial systems by arguing that they constitute a very limited case of actually known properties of the universe. In fact, he points out, inertia is itself a dubious concept.

> The weakness of the principle of inertia lies in this, that it involves an argument in a circle: a mass moves without acceleration if it is sufficiently far from other bodies; we know that it is sufficiently far from other bodies only by the fact that it moves without acceleration. (58)

In the Newtonian system, then, inertia proves a secure foundation insofar as it guarantees no external interaction. As Einstein exposes it, inertia refers only to itself — it is tautological. But does Einstein therefore do away with this tautological 'weakness' in his own system? On the contrary, the upshot of the principle of equivalence is rather to extend the tautology to the non-uniform field of gravitational movement, which under the new regime directly governs the relationship between body and force in an interaction. From a physical point of view, the problem with such a conception is that when a body is itself involved with a force, some feedback necessarily happens. As David Lindley explains it:

> When two bodies are pulled apart against their gravitational attraction, energy must be expended, and if they come together energy is released; but energy, as Einstein so famously proved, is equivalent to mass, and mass is subject to gravity. Therefore, the energy involved in a gravitational interaction between bodies is itself subject to gravity. Gravity, if you like, gravitates. (1993: 217)

Herein lies one consequence of Einstein's principle of equivalence, which implicitly assigns to force a self-reinforcing tendency. Gravity gravitates. Insofar as force, as I put it in the previous chapter, appears as a given in modern physics, its problematic nature becomes a classic aporia: the given gives.

But what does the given give? The quantitative dimension of this problem has preoccupied much of physics discourse. In the 1930s and 40s, for example, the development of quantum mechanics was consistently stymied by the inevitable appearance of mathematical infinities whenever calculations of force were attempted. This problem was only formally circumvented in the 1950s with the invention of a pragmatic mathematical trick called 'renormalization,' in which the troublesome infinities were effectively cancelled out of the calculations altogether. But while renormalization was a crucial step in the quantum field theories that ventured to unify the strong, weak, and electromagnetic forces, gravity turned out to be much more complicated. Partly due to its pervasiveness, whenever the gravitational force between two bodies is calculated, there is an immediate and recalcitrant feedback into the calculations that no established mathematical tricks have been able to cancel out. In this sense, the difference between gravity and the three other differentiated forces of today's Standard Model bespeaks the bifurcation at the heart of contemporary physics, between explanations on a quantum scale and on the cosmological scale of General Relativity.

Metaphysically, however, the problematic asymmetry that so vexes physics is intimately related to the fact that both gravity, as the tautological dimension of General Relativity, and the speed of light, as the hypological constant that holds the framework together, are fundamental limit conditions of scientific experimentation. Considered separately, they both constitute essential asymmetries in a universal cosmic symmetry: gravity refuses 'normal' mathematical integration; the speed of light resists assimilation to actual physical conditions. But the doubling of these asymmetries on one another — mobilizing the limit condition of light in terms of the limit condition of gravity and vice versa — constitutes the truly problematic horizon of General Relativity and it makes the theory exceedingly difficult to test experimentally.

From a physics perspective, consider that in Einstein's universalization of $E = mc^2$, the axiomatic relationship between mass and energy means that gravity curves space-time and thus also bends the path of light. But could gravity actually influence the speed of light itself? A photon, the 'particle' of light, is technically considered to have zero resting mass, and would therefore, according to General Relativity, not be affected by gravity.[38] But here the theoretical and experimental limits overlap in a self-reinforcing movement. Not only is the concept of resting mass itself hypothetical, if not meaningless, for a particle that is by definition the apotheosis of movement. Moreover, it has proved impossible to ascertain from experiments whether the photon, as it is understood by modern particle physics, actually has zero mass, let alone if such a value could ever be shown.

Ultimately, the masslessness of light is not so much a matter of an empirically founded truth as a necessary conception stipulated by the very theoretical framework it upholds. Necessary in what sense? If light were not massless, then its speed could not technically be constant. The very exception of the photon from the

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[38] Einstein's invention of the photon belongs to the story of quantum physics, to which I will return in Act 4.

physical distribution of mass among elementary particles is what guarantees the stability of the system within which it has meaning. If light were to have even the slightest mass — and from an experimentalist position, this cannot be ruled out — the entire framework of modern particle physics and cosmology, and the entire structure of unit standardization derived from it, would come unhinged.[39] In this sense, the constancy of the speed of light is not pivotal for its actual, calculable speed under hypothetical conditions but rather for expressing the limit condition of physics itself — a threshold for the perception and detection of any and all movement. As with any experimental invention that purports to lay the hypological foundation for an unfolding scientific discourse, the principle of the constancy of the speed of light is a negative truth in Stengers' sense — a truth whose primary meaning is to resist the test of controversy against other possible fictions.

As it unfolded, General Relativity did eventually prove more convincing than any of its rival conceptions. After a sensational public breakthrough immediately following World War I, and then three decades of attracting little to no interest, Einstein's theory would, for reasons that we will soon consider, eventually become the hegemonic, if not dogmatic, matrix for all theoretical and experimental work in cosmology. As Lindley summarizes it,

> General Relativity remains even today one of the least well tested of physical theories. It has passed all tests to which it has been put, and it is more elegant than any rival theory of gravity, but its predominant position in physics rests largely on its power to connect in a coherent and beautiful theoretical framework a handful of experimentally reliable facts. (11)

What singularizes the theory of General Relativity is its scope — the ability to predict a universe beyond what we perceive as our own solar system. To believe that one could reach universal conclusions about the entire cosmos based on laws derived solely from our planet requires a deep faith in universalism. As such, General Relativity is perhaps the most ambitious metaphysical project ever undertaken. In a popular account of the theory of relativity published in 1922, the French mathematician Emile Borel put it this way:

> It may seem rash indeed to draw conclusions valid for the whole universe from what we can see from the small corner to which we are confined. Who knows that the whole visible universe is not like a drop of water at the surface of the earth? Inhabitants of that

[39] The concept of variable light theory, drawing on experimental results that indicate the variability of several pivotal physical constants including the speed of light *in vacuo* and the Planck length (as discussed in Act 1 and to be elaborated in Act 5), has gathered some interest on the margins of the scientific community. For a helpful albeit technical overview, see Uzan, 2003.

drop of water, as small relative to it as we are relative to the Milky Way, could not possibly imagine that beside the drop of water there might be a piece of iron or a living tissue, in which the properties of matter are entirely different. (Kragh, 2007: 138)

Borel's objection speaks to the almost unimaginable scalar difference between what we know as the universe and our specific place in it as actors and observers — a difference that today, according to General Relativity, amounts to many billions of light years. Given that what is called the universal laws of physics emerge within the unique planetary conditions belonging to a tiny speck of this inconceivable vastness, how could we possibly claim the cosmos in our frame?

Nevertheless, Borel's point was largely rhetorical, because he eventually came to the conclusion, as most practicing physicists have done before and after him, that if science was to progress on its own terms, it would have to keep expanding along its universalist axis. Constituted by General Relativity as its hypological foundation, and consistently applied through theoretical and experimental action, the invented ground of contemporary cosmology thus makes $E = mc^2$ its foremost expression: the mathematical formula for the identity of the universe.

But in this sense, for the formula to express its symmetrical equivalence, it relies on a deeper metaphysical principle of identy itself. When something is so because we make it so, what does it mean that something is what it is? To engage with this essential question would take us back to the mid-century postwar moment, to Arendt's interval of thought, in which the physics of no longer encounters the metaphysics of not yet.

3. Heidegger's Ontological Difference

In a set of two lectures he first gave in 1957, published in English as *Identity and Difference,* Martin Heidegger attempts to articulate the limit condition of metaphysics in Western thought. He considers this limit condition as itself constitutive of the planetary danger claiming the living world — a danger for which the very emergence of Big Science is symptomatic. "What claim do we have in mind? Our whole human existence everywhere sees itself challenged — now playfully and now urgently, now breathlessly and now ponderously — to devote itself to the planning and calculating of everything." (34-5) To this historical challenge Heidegger addresses his concerns about "the Atomic age." His characteristic way of questioning can be described as a method of immanent rationalism. In this lecture in particular, Heidegger thinks from within thought, out toward thought's own condition — toward a beyond that he argues always already dwells within. It is this inversal dimension of Heidegger's thought that makes him a profound critic of the metaphysical character of modern science and an indispensable foil for the universal claim of physics.

In analogy to how the postwar cosmological transformation concerned the origin and destiny of the universe as such, Heidegger's metaphysical shift concerns the origin and destiny of Being. The nature of the relationship between the universe and Being will become clearer in the following, but in either case — cosmology or metaphysics — we are implicitly faced with ontological and theological questions. Heidegger provides us with a hypothesis for thinking how these questions are related:

> When metaphysics thinks of beings with respect to the ground that is common to all beings as such, then it is logic as onto-logic. When metaphysics thinks of beings as such as a whole, that is, with respect to the highest being which accounts for everything, it is theo-logic. (70-1)

Beings as such, and beings as a whole — this is generality in its double sense of generative, that from which something comes, and generalized, that to which something pertains. The onto-theological bespeaks a divergence within a shared relation — metaphysics as an instability field. In essence, metaphysics concerns the configuration of an alpha and an omega — the beginning and the end, the ground and the highest being — and thus, by deduction, everything in between. Insofar as cosmology today is considered the science of the universe, of the all-encompassing realm in which unified logical explanation is possible, it is always already a certain configuration of metaphysics. Yet, as I put it in Act 1, metaphysics is not reducible to universalism.[40] In this sense, the two terms are not interchangeable. Both metaphysics and cosmology are 'onto-theo-logical' in that they speak of the origin,

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[40] Act 3 will try to demonstrate this difference, which is also indicative of the slight divergence between Heidegger's use of the term metaphysics and the way I have defined it for this dissertation. It would require a separate study, which I have no intention of doing here, to trace the meaning of metaphysics throughout Heidegger's work -- from "the nihilation of the nothing" in the late 1920s to the hyperbolic equation of metaphysics with Platonism in the early 1960s. I consider the selected text for this chapter exemplary of Heidegger's inclination to turn metaphysics on itself -- that is, to immanently expose metaphysical foundations from invented, or reinvented, metaphysical principles. Insofar as Heidegger too acknowledges that there is no outside to metaphysics, because this would in itself be a metaphysical idea, I therefore find myself generally aligned with Heidegger's definitions.

the extent, and the fate of that which is. But in this dissertation, I use metaphysics as a broader term for that which reveals something like a cosmology in the scientific sense — as emerging within its own cultural and historical configuration.

In his first lecture, Heidegger argues that the universalist configuration of Western metaphysics, for which modern cosmology stands as the apotheosis, is revealed in a single logical principle which functions as the general pivot of logic, "the highest principle of thought." Sometimes called the principle of non-contradiction, or the principle of contradiction, Heidegger analyzes it as the principle of identity. A = A. The principle governs how something comes to be some thing, discernible and distinct — that is, the representation of Being.

At first glance, A = A is a perfect tautology. It says that A is the same as A and that every A is everywhere the same, in the sense of the Greek *to auton*, from which the Latin 'idem' for 'identity' derives. A = A bespeaks self-sameness. But more fundamentally, Heidegger says, A = A also means that

> every A is itself the same with itself. Sameness implies the relation of 'with', that is, a mediation, a connection, a synthesis: the unification into a unity. This is why throughout the history of Western thought identity appears as unity. (25)

In his text, Heidegger interrogates this mediation in unity, the self-relation that the principle of identity expresses. For insofar as the principle expresses what something is by virtue of what it is to itself, it also speaks to the conditions for how a being comes into being, when that being is hypothesized as distinctive and clearly differentiated. In this sense, the principle of identity appears in Western thought both as an ontological ground, insofar as it is the given point of departure, and a theological whole, insofar as it sets the goal for arrival.

> What the principle of identity, heard in its fundamental key, states is exactly what the whole of Western European thinking has in mind — and that is: the unity of identity forms a basic characteristic in the Being of beings. Everywhere, wherever and however we are related to beings of every kind, we find identity making its claim on us. If this claim were not made, beings could never appear in their Being. Accordingly, there would then also not be any science. For if science could not be sure in advance of the identity of its object in each case, it could not be what it is. (26)

The self and the relation of self to itself — that is, what A is with respect to A — is therefore properly a 'belonging together.' What A is said to be belongs together with what A is. But in what sense? The limit of the scientific understanding of identity, Heidegger argues, is that it effectively effaces the mediating relation to itself. ‘Belonging together’ is determined by the word ‘together’ so as to assure its unity. To belong in this sense means “to be assigned and placed in the order of a ‘together’, established in the unity of a manifold, combined into the unity of a system, mediated by the unifying center of an authoritative synthesis.” (29)

However, Heidegger points out, belonging together has a potentially inverse meaning that is effectively concealed to representational thinking.

> How would it be if, instead of tenaciously representing merely a coordination of the two in order to produce their unity, we were for once to note whether and how a belonging to one another first of all is at stake in this ‘together’? (30-1)

By inverting the guiding sense of ‘belonging together’ from together to belonging, Heidegger is in effect expressing the metaphysical inversion of an ‘ontology’ to a ‘theology,’ in which unity is not found on condition of a unified origin but rather on condition of the vast belonging of everything to everything else. What is lost to the modern scientific mind, Heidegger says, is precisely this inverted world, the in-folded horizon of Being, which foregrounds how something connects to everything rather than how something is some single thing for itself. The principle of identity understood as the basis of Western logic enables the physicist to encounter the world as an agglomerate of already differentiated particles first, and this necessary connection to the whole second. Fundamentally, it means that a relation is thought in terms of its particles rather than the other way around. In this precise sense, every revealing is to Heidegger simultaneously a concealing — for what A = A seems to disclose only works to hide its inverse proposition.

The principle of identity, in other words, harbors the essential tension in modern thought between science and religion, within which metaphysics is directly implicated. For Heidegger, as well as for the other protagonists in this dissertation, it is never a question of favoring one ‘side’ over the other, taking science or religion as a more fundamental truth, but rather always a matter of understanding how their source of tension is implicit in their own being, that is, in their identity as such. In order to perceive this tension more clearly, it is according to Heidegger necessary to make a leap away from the prevalent attitude in modern physics whereby what is being represented is unified with that which is.

Here, we could also make a leap — out of Heidegger’s 1950s text. The logic of representational thinking is closely connected to what he two decades earlier had analyzed in terms of ‘mathematical projection.’ In *What is a Thing?*, a work on the metaphysics of modern science, with particular emphasis on the modern change in physical world-view from Aristotle to Newton, Heidegger demonstrates that the mathematical is in etymology and essence a mode of learning — that which is learnable. *Mathesis universalis* in its original sense means the learning attitude by which things are taken up in modern knowledge. The common interpretation of mathematics as dealing with number is only an expression of the mathematical in this deeper sense.

> The mathematical is that evident aspect of things within which we are always already moving and according to which we experience them as things at all, and as such things. The mathematical is this fundamental position we take toward things by which we take up things as already given to us, and as they must be and should be given. The mathematical is thus the fundamental presupposition of the knowledge of all things. (1993: 277-8)

If the mathematical stance implies a configuration of the world such as to reveal itself in terms of learnable things, the principle of identity guarantees the fundamental non-contradiction necessary for this learning. As a mathematical principle, it is what "rules and determines the basic movement of science itself." (273) Just as in the principle of inertia and the speed of light, in A = A we have the appearance of an absolute identity grounded in tautology. In general, this means: A is the same to itself, it is *to auton*, tautological. Yet, as we have also seen, the ostensible sameness belies its hypothetical nature — it masks the conditions for its internal self-relation, that is, its essential belonging to the moment of its expression. Inertia is the axiomatic movement because we make it so. The speed of light is the universal constant because we have defined it so. Equally, the principle of identity is the highest principle of logic because we have taken it to be so. Neither of these propositions was originally self-evident but required the consistent action that constitutes our history by making them retrospectively appear as tautological foundations. In all such cases, what matters is to naturalize the hypothetical beginning — make it into something that follows from itself, that just is the way it is — a given.

But the given gives. Like mathematical infinities that resist cancellation tricks, the decisive hypological invention that naturalizes itself as tautological cannot for long conceal its essential difference from the very condition it attempts to define. For Heidegger, the crucial problem with the principle of identity is that whereas it clearly means to "speak of the Being of beings" — of what *is* in the sense that A *is* A — it does not appear to speak of the necessary difference between Being and beings. That is, insofar as identity is a first principle of thought, through which belonging is understood in terms of unified togetherness, it essentially disregards ontological difference as the necessary condition for its own emergence.

What is ontological difference? As a consistent theme unearthed from Heidegger's many meditations on ancient, medieval and early modern thought, the concept was most clearly delineated as a beginning for philosophy in *Basic Problems of Phenomenology* (1929):

> We must be able to bring out clearly the difference between Being and beings in order to make something like Being the theme of inquiry. This distinction is not arbitrary; rather, it is the one by which the theme of ontology and thus of philosophy itself is first of all attained. It is a distinction which is first and foremost constitutive for ontology. We call it the ontological difference — the differentiation between Being and beings. Only by making this distinction — *krinein* in Greek — not between one being and another being but between Being and beings do we first enter the field of philosophical research. Only by taking this critical stance do we keep our own standing inside the field of philosophy. Therefore, in distinction from the sciences of the things that are, of beings, ontology, or philosophy in general, is the critical science, or the science of the inverted world.[41] (17)

In this 'science of Being', then, ontological difference is not a particular, local difference but rather a general, constant, nonlocal distinction — the necessary condition for entering 'the field of philosophical research'. This general ontological difference can then be recognized as a foundation for all 'ontic' sciences, such as physics. Ontological difference, in other words, marks the hypological origin of a 'science of the inverted world.'

A science of the inverted world, or an inverted science? As Heidegger would be the first to note, inversion is not negation, but rather the immanent folding of a framework onto itself. The concept of ontological difference only establishes a primary position of metaphysics to a secondary position of physics relatively speaking, on account of inverted reason, not on terms it can claim as absolute. Thus, ontological difference offers a distinction that allows us to look critically at how our systems of knowledge are constituted — a method for revealing what is normally concealed.

Specifically, ontological difference allows us to invert the prevailing framework of mathematical science — General Relativity. If the principle of constancy, in the form of the speed of light in a vacuum, expresses the limit condition of mathematical science, we find the constancy of ontological difference

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[41] In this earlier phase of Heidegger's writing, Being is written with a lower-case b. I have capitalized it in this quote in order to maintain nominal continuity with the later text.

to express the limit condition of inverted science, beyond which immanent reason is unable to go. Ontological difference, then, functions as a pivotal constant — another 'god principle' — through which the relative axes or symmetries of philosophy and science, metaphysics and physics, can be expressed. According to the principle of constancy, the inverted scientist and the mathematical scientist work from the same metaphysical pivot — that is, a principle of constancy — even as it is tilted in different directions. From this foundation, we might further conceive two principles that constitute the inverted framework.

The first axis runs through an inverse principle of relativity. Whereas the mathematical expression of this principle asserts the independence of the physical world from its conditions of observation, its inverted expression would rather claim a fundamental dependence between any truth claim and its local conditions of utterance. We have already seen this principle at work in the previous chapter on experimental and theoretical invention. As singular events, experiments are pivotal to the unfolding of scientific truth insofar as they effectively constrain the mediation of interest inside and outside the scientific community. To make or transform scientific history always means to act within a field configured by those inventions that have already successfully been mediated as discoveries, to which any new experimental and theoretical phenomenon must henceforth refer. In this sense, the inverted principle of relativity would hold that no thought or expression can be considered metaphysically independent of what actually constrains it into being.

Further, in Einstein's theory, the principles of relativity and constancy conjoin in a special theory of relativity — a mediating loop of identity between thinking and being whose unified togetherness determines the ontological ground of the framework. What then of its belonging, its theological horizon? This is another way to think of the principle of equivalence, which extends the ontological ground of the special theory to a generalized, higher limit. The principle of equivalence determines that every thing, insofar as it is a thing, ultimately belongs to the universal claim of identity. In its inverted sense, the principle of equivalence — thus, inequivalence — conceives of every thing as generated out of the differential constraints that determine history. As Arendt already described it, the moment of thinking that is both no longer and not yet always occurs *in* time, *in* history — it is always pressured between past and future — never outside it. Hence we can say with Heidegger that there is a fundamental inequivalence, or asymmetry, within identity itself — between what something is and its actual conditions for being. This inequivalence bespeaks ontological difference because what something is — Being as Being — is ultimately so because we — beings as beings — make it so.

As an inverted scientific framework, I propose to call this constellation of principles General Ontological Difference. According to General Ontological Difference, the difference between the mathematical and the inverted science is relative to its own foundations. This means that there is no universal perspective from which an inverted science can be seen as primary to a mathematical science or vice versa — only that either perspective will tend to conceal its conditions for emergence relative to its own set of logical rules. As with Einstein's invention, the point of General Ontological Difference is therefore not what it is but what it does. In its juxtaposition with mathematical science, it opens up a space within which the metaphysical conditions of our own cultural history may henceforth be interrogated. In this sense, General Ontological Difference, insofar as it emerges and exists through an inverse relation to General Relativity, is a theory of asymmetrical doubling. That is, it effectively renders the relation between physics and metaphysics as divergent, inverse movements within the same. Such a theoretical invention may be considered a response to Heidegger's call for a critical science of Being, a science of the inverted world.

However, if we now leap back to Heidegger's 1950s text, we would find the most incisive critic of my invention in Heidegger himself. By the time of his identity lecture, his thought had turned explicitly against some of his earlier proclamations. Evidently, Heidegger had become disenchanted with the thought of conducting anything like a science of ontology. In the postwar text, the open claim to science has disappeared, and the almost technical distinction between 'Being and beings' is now reconfigured as a relation between 'man and Being.' In a crucial passage, Heidegger suggests the problem is that by juxtaposing one form of science with its inverted 'other', we merely perpetuate the logic of representation as such:

> We stubbornly misunderstand this prevailing *belonging* together of man and Being as long as we represent everything only in categories and mediations, be it with or without dialectic. Then we always find only connections that are established either in terms of Being or in terms of man, and that present the belonging together of man and Being as an intertwining. We do not as yet enter the domain of the *belonging* together. How can such an entry come about? By our moving away from the attitude of representational thinking. (32)

Does a doubling that allows both Being and man to be articulated in terms of each other still correspond to the representational logic of either-or that is governed by the principle of identity? Ostensibly, it only enables connections in terms of either framework — and we would not in any direct sense enter a properly theological domain of belonging. What Heidegger seeks is to "experience authentically the *belonging* together of man and Being" and this, he argues, cannot be done through representational thinking any more than through the metaphysical structure of language itself.

Nevertheless, if the objective is a closer link between thinking and the actual experience of Being, perhaps a scriptural reading of Heidegger's words is bound to miss his most crucial insight altogether. At the outset of the lecture, he characteristically implores the listener "to pay attention to the path of thought rather than to its content." (23) How are we to understand this? Heidegger here articulates a distinction that in fact is emblematic of his philosophy as a whole, insofar as it bespeaks the very idea of ontological difference. To pay attention to the implicit movement of thought rather than to its explicit content is analogous to focusing on the ontological dimension of Being rather than the ontic dimension of beings as such. The path of thought belies its content, and to "dwell properly upon the content" blinds us to the sense in which it actually emerges. If we then rather dwell upon the unfolding of Heidegger's text, its twists and turns, we come to recognize that even if Heidegger no longer speaks about an inverted science, he is clearly still performing and practicing a string of logical inversions. Essentially, Heidegger's text reveals that in the self-mediation of identity, in the movement of the same, there can ultimately only be that which is necessarily different from itself. In this sense, Heidegger's path of thought, as much as its content, is directed at unconcealing that which appears to us in daily life as most clearly and self-evidently present.

Ontological difference, then, still appears implicitly in the text as the 'relation between man and Being.' In fact, Heidegger appears to think the problem of the relation of man and Being precisely according to the principles of General Ontological Difference. What is at stake in moving away from representational thinking is not causality between man and Being taken in unified togetherness. Rather, Heidegger says, it is the "constellation of Being and man" in its differential relation that reveals the essential character of the modern, technological world. How do they belong together? How do they challenge one another in their constellation? This is for Heidegger the real question, and precisely what General Ontological Difference purports to reveal.

This constellation is for Heidegger governed by *Gestell,* his neologism for the essence of technology — usually translated as 'the framework' or 'enframing.' In the same manner as the 'mathematical' in its originary sense prefigures today's actual mathematical science, Heidegger argues that the essence of technology is something that prefigures the actual technologies of modern science. A final lengthy passage clarifies Heidegger's stance:

> The name for the gathering of this challenge which places man and Being face to face in such a way that they challenge each other by turns is 'the framework.' That in which and from which man and Being are of concern to each other in the technological world claims us in the manner of the framework. In the mutual confrontation of man and Being we discern the claim that determines the constellation of our age. The framework concerns us everywhere, immediately. The framework, if we may still speak in this manner, is more real than all of atomic energy and the whole world of machinery, more real than the driving power of organization, communications, and automation. Because we no longer encounter what is called the framework within the purview of representation which lets us think the Being of beings as presence — the framework no longer concerns us as something that is present — therefore the framework seems at first strange. It remains strange above all because it is not an ultimate, but rather first gives us That which prevails throughout the constellation of Being and man. (35-6)

Insofar as the relation between man and Being is governed by ontological difference, Heidegger's concept of the framework is first and foremost the configuration, or "constellation," of this differential relation. The framework expresses the particular way in which 'man' comes to stand toward Being, and thus toward 'himself' — and this historical relationship constitutes the essence of modern technology, for which modern science and its universal mathematical structure is but a grand expression. What Heidegger calls the framework is in its mathematical sense precisely governed by the principle of identity, as a representational equation of that which is with that which can be thought — a symmetrical equivalence between man and Being, between being and thinking. The mathematical framework is a configuration of ontological difference that renders it opaque to its own conditions of emergence, to Being as such.

In the terms I propose here, this means that enframing, as Heidegger's concept for the essence of modern technology, which is embodied in the principle of identity, is hypological in character. As a contemporary expression of the essence or active nature of modern technology, Einstein's General Relativity is exemplary. Like Heidegger's enframing, General Relativity is the hypologically constituted system by which we come to understand our relation to the world. The framework is thus Janus-like: it sets the terms under which we stand toward the past and the future. Hypology posits, as Heidegger describes it, an essential relationship between 'man' and 'his' origin that has become so self-evident as to make the actual concept appear strange. In this sense, the hypological "is not an ultimate, but rather first gives us That which prevails throughout the constellation of Being and man." The essence of technology, as unified togetherness embodied in the principle of identity, has become the ontic, or hypological, ground for man's relation to Being.

To invert the relation between man and Being into a problem of belonging is therefore to open up the framework toward its ultimate, or theological, rather than its primary, or ontological, dimension. But before we can address how General Ontological Difference configures its ultimate horizon, we must make a brief historical excursus through 20th century cosmology, in order to see how the development of Einstein's mathematical framework comes to determine the absolute origin and the fate of the universe.

4. Hawking's Big Bang

As a modern scientific endeavor, the history of cosmology is characterized by its limited experimental horizon. Besides the many practical difficulties involved in inventing workable tests, the technology for experiments on a galactic order of magnitude requires enormous capital investment. Before the field was settled into its current paradigmatic configuration, cosmology was only tangentially connected to the sciences thriving on the major capital influx in the 1940s and 50s. In other words, until cosmology became scientific enough to term itself Standard Cosmology, in concordance with the Standard Model of physics, successful experimental observations were few and far between — and thus all the more significant in structuring the terms of discourse.

In fact, the mid-century period in which cosmology would be transformed into a scientific discipline can be defined as the interval between two history-making events of astronomical observation: the expansion of the universe in 1929, and the cosmic microwave background radiation in 1965. Neither case was strictly an observation as such but involved a complex interplay of theoretical and experimental predictions based on massive machines and pliable parameters, in order to become mediated as scientific discoveries. The discovery of universal expansion unleashed a flurry of competing cosmological theories in the 1930s in particular, which eventually became narrowed down to two main rivals. The discovery of microwave background radiation marks the critical turning point in which one theory eclipsed the other, and alternative explanations were forgotten. Since 1965, there have been many capital-intensive experiments, largely designed and interpreted to reinforce the existing paradigm. But as I will try to show in the following, the story of how the field became so decisively configured is really a story about the configuration of General Relativity itself — the framework within which cosmology's limited experimental horizon takes place.

When Einstein worked out his complicated set of field equations for General Relativity, he was developing the first theory capable of making broad generalizations about the universe beyond our own solar system. As we have seen, the metaphysics of General Relativity rests on a constellation of three principles — relativity, constancy, and equivalence. However, the theory still lacks a fourth principle by which it would be complete and bounded. In analogy to classical philosophical doctrines of causality, this could be called its teleological dimension — or more properly, its boundary condition. To Einstein, General Relativity was a field theory. But what kind of field? How would the theory of the universe, and thus the universe as we know it, be circumscribed? The cosmological battles of the mid-20th century pivot on the rivaling answers to this fourth principle of General Relativity.

Whereas the classical Newtonian theory of the universe considered space an infinite void, Einstein rather favored a "space-bounded, or closed, universe," for which he provided three arguments. First, pragmatically, "from the standpoint of the theory of relativity, to postulate a closed universe is very much simpler than to postulate the corresponding boundary condition at infinity." Second, epistemologically, "it is more satisfying to have the mechanical properties of space completely determined by matter, and this is the case only in a closed universe." Third, probabilistically, "an infinite universe is possible only if the mean density of matter in the universe vanishes. Although such an assumption is logically possible, it is less probable than the assumption that there is a finite mean density of matter in the universe." (107-8) To the question of mean density, later denoted **Ω** for the Greek letter omega, Einstein could only reason by assumption — but later in the century, as probabilistic reasoning became more entrenched, it would be of key parametric importance in experiments and theoretical predictions.

Nonetheless, the elegance of making space determined by matter turned out to have a troubling consequence when calculations were performed. Due to the auto-like, reinforcing quality of gravity through the distribution of matter under General Relativity, the spacetime of the universe would be expanding at great distances. Because Einstein's understanding of the universe at the time was in concordance with what Arendt calls the modern idea of history — a continual process without beginning or end — he decided to counteract his undesirable mathematical answer by introducing what he called a cosmological constant, a negative pressure equal to the positive expansion predicted by the field equations. Einstein admitted that this new constant, for which there was "no physical justification," would complicate the theory and thus reduce its logical simplicity — yet it appeared to him a necessary circumscription. In this sense, the cosmological constant constitutes the fourth principle of the original theory of General Relativity, in which the universe was guaranteed to be unchanging in its boundary state.

The modern view of the cosmos, however, began to change by the end of the 1920s after the American astronomer Edwin Hubble published the findings from his telescopic research on the galaxies beyond our own solar system.[42] By identifiying individual variable stars as 'standard candles' for measurement, Hubble claimed to "establish a roughly linear relation between velocities and distances among nebulae for which velocities have been previously published" — a linearity that would later become known as 'Hubble's Law'. Hubble's measurements were based on the perceived redshift of the stars, that is, the shift of its light toward the less energetic part of the light spectrum as it moves away from an observer — a phenomenon known as the Doppler effect, demonstrated in electromagnetic physics in the 19th century. To what extent the Doppler effect would pertain to outer galaxy stars, and to what extent outer galaxy stars can be used as 'standard candles' for measurement would be subject to much argument, observation, and theorization in the following decades. Hubble's general conclusion, however, succeeded in mobilizing interest among astronomers within only a few years. Insofar as his observations were correct, outer galaxies were moving away from us with a speed proportional to their distance. The farther away they were, the faster they appeared to be moving, at a linear rate denoted by the Hubble constant.

In the wider interpretation of Hubble's findings, the retroactive constitution of scientific history would eventually recover a set of solutions to Einstein's relativity equations from the early 1920s, in which the cosmological constant was omitted and universal expansion made possible. The solutions were worked out independently of each other, first by the Russian mathematician Alexander Friedmann and a few years later in similar fashion by the Belgian theoretical physicist Georges Lemaitre. In place of the cosmological constant, Friedmann made

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[42] The following pages of overview of Big Bang cosmology up to the work of Stephen Hawking condenses a history that is told in a myriad of books in remarkably similar ways. For my brief account of this standard history, I have found the most comprehensive and properly detailed resource to be Kragh, whose 1996 work is the authoritative study of the Steady State vs Big Bang battle. For quotes, I have largely relied on the more concise 2007 work. Throughout, these books have been complemented by insights from Narlikar, Lindley and, to a lesser extent, Seife.

the fundamental assumption that the universe as a whole is spatially homogenous and isotropic — that is, the same in all directions, from any perspective within it — but temporally variant.[43] Lemaitre, also a Catholic priest, most eagerly pursued this mathematical inference of cosmic expansion through time. In 1931, he published the first in a series of papers touting the 'primeval atom' hypothesis, which based itself partly on new developments in quantum mechanics. It suggested that,

> we could conceive the beginning of the universe in the form of a unique atom, the atomic weight of which is the total mass of the universe… [and which] would divide in smaller and smaller atoms by a kind of super-radioactive process. (Kragh 2007:153)

Lemaitre's boundary condition on General Relativity, in other words, implied an evolutionary field of finite age. Throughout the 1930s, however, the attempt at explaining creation through physics was resisted by much of the community, which was still dominated by astronomical observations.

It took a nuclear physics research programme in the United States from 1940 to 1953, enabled by the spike in federal science funding, to develop a theory of early-universe cosmology that would draw the explicit link beween an expanding universe and a finite origin of this process within the framework of General Relativity. The key figure in this field was Russian-born George Gamow, who, without knowledge of Lemaitre's earlier work, outlined the theory of an explosive nucleo-synthesis at the beginning of space-time. To be precise, the theory, and all its variations since, does not concern the actual moment of creation but rather the immediate aftermath of an explicitly hypothetical event. A 1953 paper by Gamow's colleagues offered calculations for the emergence of elementary particles starting at .0001 seconds after "t = 0", corresponding to a temperature of 10 trillion degrees Kelvin, and for the following 600 seconds. What their work described was the limit condition of the universe, the point at which the theoretical framework breaks down, formulated as an absolute alpha point for nuclear expansion.

In a BBC radio broadcast in 1948, Gamow's conception was first christened the 'Big Bang' theory. Ironically, the British astronomer Fred Hoyle intended it as a derogatory moniker to distinguish Gamow's model from his own alternative

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[43] From this premise, which alters the original four-dimensional space-time of the special theory of relativity, Friedmann was able to derive three possible models of the universe: positively curved, negatively curved, or, as the boundary condition between either of these two possibilities, flat. Temporally, these universes differ in their movement. Positive curvature implies a full closure — it expands, grows to a maximum size, then contracts. Both flat and negatively curved universes are open and expand forever, albeit at different rates.

cosmology called Steady State theory, proposed in the same year. As the name implies, Steady State theory is aligned with the modern expectation of a cosmos unchanging in its boundary condition. The metaphysical premise for Hoyle and his colleagues was thus closer to Einstein's original sense of relativity theory as constituting a four-dimensional space-time. Instead of a cosmological constant as teleological circumscription, Steady State theory introduced the 'perfect cosmological principle', which holds that the universe is homogenous and isotropic in all dimensions including time. That is, its apparent expansion in one place is supplemented by the continuous creation of matter at the heart of stellar constellations, a so-called C-field, which ensures universal isotropy overall.

In Britain in particular, the Steady State challenge spurred a public debate that brought out latent onto-theological concerns. Hoyle attacked the Big Bang theory not only on its scientific terms but for its political, ethical and religious consequences. Hostile to organized religion, Hoyle suggested links between Christianity and Big Bang theory that he found preposterous and argued that Steady State theory left no metaphysical room for Christian belief. Any suspicion against the Big Bang theory's reliance on a miraculous event was certainly not quelled by Pope Pius XII, who in 1951 declared that the theory was in perfect harmony with Christian belief and that modern cosmologists thus had arrived at the truth theologians had known for more than millennium. Meanwhile, on the other side of the iron curtain, communist leaders declared the Big Bang theory an ideological enemy of materialist science, in which the universe, following the modern view, must be infinite in both space and time.

Inside the scientific community, the ongoing discourse turned into a battle of competing metaphysical principles. Opponents of the Steady State theory dismissed the conception of the C-field as a violation of the principle of energy conservation, whereas proponents argued that the perfect cosmological principle had to hold more absolute than a probabilistic law of thermodynamics. The tenuous dividing line between science and non-science was further reinforced by debates on whether cosmology as such was properly scientific. Steady State theorists repeatedly invoked the British philosopher of science, Karl Popper, to argue that their theory was more open to 'falsification' through astronomical observation than the rival, and they were repeatedly countered with the claim that their cosmology was predicated on aesthetic preferences that lacked support in existing physical data. In both cases, the charge of overreaching empirical knowledge was leveled at the other side and 'metaphysics' routinely hurled as a term of abuse. The cosmological contest of the 1950s, in other words, played out as a great clash of positivist universalisms.

As the story goes, the event that tipped the scales in favor of the Big Bang was the discovery of the microwave background radiation. Around 1965, two radioastronomers in New Jersey were conducting tests on a large microwave receiver designed for satellite communications. They inadvertently found that all their tests exhibited the same constant background noise in all directions. Having no idea what it could mean, they were eventually connected to a group of theoretical cosmologists at Princeton who happened to be seeking experimental support for their own prediction that, given the hypothetical Big Bang event, the universe today should be filled with feeble radiation. [44] Once the connection was forged, there was a three-way retroactive reinforcement: experimental observation, mathematical projection and metaphysical grounding converged on the Big Bang theory in much the same way as inferences of the expanding universe had coalesced with Einsteinian relativity in the late 1920s. As Kragh describes it, by the end of the 1960s, the Big Bang theory,

> consisting of a large class of models sharing the assumption of a hot, dense beginning of the universe, had become a standard theory accepted by a large majority of cosmologists. In fact, it was only from this time that cosmology emerged as a scientific discipline and 'cosmologist' appeared as a name for a professional practitioner of a science, on a par with terms such as 'nuclear physicist' and 'organic chemist'. Although rival cosmologies did not disappear, they were marginalized. Not only was the Big Bang now taken to be a fact, rather than merely a hypothesis, it was also taken for granted that the structure and development of the universe were governed by Einstein's cosmological field equations of 1917. (2007: 200-1)

To some extent, the differences between the Big Bang and Steady State theories were correlated to the theories' respective disciplinary grounding. The Big Bang theory grew out of nuclear physics and initially found scarce support among astronomers. The Steady State theory, on the other hand, showed strong correlation with prevailing astronomical observations but its account of matter creation failed to convince many physicists. In this sense, as both theories in the 1950s and 60s

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[44] In a critical review of the discovery, American cosmologist Geoffrey Burbidge argues that the ostensible conjunction of predictions and observational data in the discovery of the microwave background radiation was very much 'ad hoc.' Examining the original calculations, he shows how it adopts a key numerical coefficient in order to make the calculated value agree with the observed value. "This is why the Big Bang theory cannot be claimed to explain the microwave background… It is only an axiom of modern Big Bang cosmology, and the supposed explanation of the microwave background is a restatement of that axiom. Thus in no sense did the Big Bang theory predict the microwave background." See Burbidge, 4-5.

went through several reinventions and readjustments, the structural increase in research funding for nuclear physics certainly played in favor of the Big Bang theory in the longer run. Above all, the Big Bang offered a lucrative and productive convergence with nuclear physics experiments, because the theory essentially made the universe itself into the ultimate particle accelerator. Today, relativistic cosmologists study the skies like nuclear physicists study particle collisions — looking for debris from which they can deduce the inner structure of matter. In both cases, the assumption of an initial hypothetical event is the same, as is the standard set of parameters from which calculations can be made. Cosmology and physics, in other words, mediated in self-unifying togetherness.[45]

In the following decades, scientists and historians would continue to retroactively constitute and streamline the history of the Big Bang theory as one of inevitable discovery. To this consolidating process belongs the notable work of British theoretical physicist Stephen Hawking, whose brash drive toward theoretical unification of physics succeeded in capturing the imagination of scientists and non-scientists as the late 20th century inheritor of Einstein. In fact, Hawking's brilliance is analogous to Einstein's in that he was repeatedly able to mobilize the limit condition of the theory as an operational feature of the framework itself. In this regard, his most significant work revolved around the mathematical concept of a singularity — the point at which mathematical prediction breaks down. A singularity functions as an exception to the very system within which it is given meaning.[46] In the Friedmann-Lemaitre equations of General Relativity from the 1920s, singularities had kept cropping up, something Einstein had profoundly disliked and Lemaitre had circumvented in his theory of the 'primeval atom.' Hawking, however, found a way to capitalize on it, by drawing on the work of fellow mathematician Roger Penrose, who first applied the singularity to the universe. In 1965, Hawking writes, Penrose showed that according to General Relativity,

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[45] What happened to the Steady State theory after the microwave event? Caught off guard by the sudden shift in the discipline, a few of Hoyle's followers began working on models that could account for the observed radiation phenomenon within the existing framework. Some were able to reproduce the same predicted results without inferring an evolving universe. A later version of the non-evolutionary cosmological model is now called the Quasi-Steady State theory. Championed by Hoyle's student, the Indian cosmologist Jayant V. Narlikar, it postulates a cyclical model of the universe which claims to better explain existing astronomical data along with various persistent discrepancies and anomalies in the Standard Model.

[46] In this sense, the light-particle, or the photon, is also a singularity, though it is usually considered a physical rather than mathematical construct.

> a star collapsing under its own gravity is trapped in a region whose surface eventually shrinks to zero… All the matter in the star will be compressed into a region of zero volume, so the density of matter and the curvature of spacetime become infinite. In other words, one has a singularity contained within a region of spacetime known as a black hole. (52)

Thus, the singularity that appeared as an anomalous condition in the Friedmann-Lemaitre equations resurfaces with Penrose as a particular cosmological state. The metaphysical essence of the black hole argument is that light and gravity, both limit conditions of the framework itself, can be mathematically recombined to predict a physical phenomenon. Insofar as General Relativity is true, in other words, black holes must necessarily be present in the universe.

However, from both an experimental and a philosophical perspective, the problem with the singularity is that it cannot be represented. As Hawking puts it, “the singularities produced by gravitational collapse occur only in places, like black holes, where they are decently hidden from outside view by an event horizon.” (91) Nobody had seen a black hole, because it could not be seen. But drawing on blackbody theory from quantum physics, Hawking was able to infer that a black hole would emit radiation and particles in a way that might make it detectable in its trace.[47] Soon, Hawking’s influential work sent experimentalists and astronomers off to verify the theory. More than three decades later, several contenders have been suggested, and many strange cosmic phenomena such as ‘quasars’ and ‘pulsars’ have been cataloged, but no black holes decisively declared.

This empirical challenge did not quell belief in the mathematical theory of singularity, for the idea fit all too perfectly with the emergent cosmological model. Hawking’s decisive invention was to turn the temporal direction of the black hole postulate around. As he writes, “Penrose’s theorem had shown that any collapsing star *must* end in a singularity; the time-reversed argument showed that any Friedmann-like expanding universe *must* have begun with a singularity.” (52-3) In this way, Hawking was able to formulate how the framework of General Relativity itself predicts the event of the Big Bang as an absolute alpha point. As a singularity, the Event of the Big Bang marks not only the limit condition of the universe where “the laws of science and our ability to predict the future would break down,” but simultaneously the constitutive origin of the universe as such. In this sense, the singularity becomes in General Relativity a new kind of ‘god principle’ insofar as it confers hypological meaning upon a framework that it by definition transcends.

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[47] The story of blackbody radiation as the origin of quantum physics will be told in Act 4.

Thus, from Einstein to Hawking, we can draw the hypological circle of General Relativity: a retroactive historical unfolding through which the complex constellation of events leading to the scientific discovery of the Big Bang became constituted as always already inherent in the theory itself. Whereas Einstein hypothesized the framework of the universe, Hawking mathematized the singular event of its becoming — the Event of the universe. Thus, the fourth principle of General Relativity was reinvented. In place of the original cosmological constant that acted against the expansive inclination of the model, Hawking had derived mathematically a ground for evolutionary circumscription.

Henceforth, cosmology becomes a matter of 'puzzle-solving.' According to General Relativity, the spatio-temporal structure of the universe can now be determined by two key variables: its rate of expansion, the Hubble constant, and its mean density, **Ω**, which indicates whether the universe would be positively or negatively curved, or flat. Omega, like the last letter of the Greek alphabet, determines the balance between expansion and contraction in the universe and thus signifies its fate. In 1998, an experiment based in the Antarctica known as Boomerang attempted to make a fine-tuned reading of the cosmic microwave background radiation.[48] The idea was the same as Hubble's approach in the 1920s: given the hypological constancy of the speed of light, one can measure distance in the sky by locating 'standard candles' — objects of known size or shape. For Boomerang, the standard candles would be a set of identifiable hotspots within the microwave background radiation — by now turned into a given of Big Bang theory. By comparing microwave hotspots, it would be possible to compare their observed size to their calculated size, and the positive or negative discrepancy between theory and observation would in turn indicate the critical density of **Ω**, the universal boundary condition. As it turned out, Boomerang found no discernible curvature, meaning the universe of General Relativity is neither positively nor negatively curved but flat. The findings cohered with contemporary observations of supernovas, whose measurement indicates that the expansion rate of the universe, the Hubble constant, is in fact accelerating. Both these experiments appear to confirm the teleological fate of our cosmos: the universe will expand forever, faster and faster, and eventually suffer 'a death by ice.'[49]

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[48] A contrived acronym for Balloon Observations of Millimetric Extragalactic Radiation and Geophysics.

[49] The term is Charles Seife's, whose hyperbolic account of the 'third cosmological revolution' nonetheless includes a helpful overview of several contemporary experiments, including the two mentioned above.

However, such a sensational conclusion is only as certain as the hypological foundation of the framework within which it is expressed. An obvious shortcoming of relativistic standard cosmology is that it can only directly account for 5 percent of the "ordinary matter" in the universe. Ordinary matter means matter as we know matter to be according to established physical principles on planet Earth. To make sense of the enormous discrepancy between observable matter and the predictions of General Relativity, new forms of matter have since had to be invented to ensure the coherence of the model. Thus emerge concepts like "exotic dark matter," "cold dark matter" or plainly "dark matter" — meaning that which has to be present in 95 percent of the universe, according to the framework within which we understand it, even if it remains invisible and undetectable to us as observers.

To confound matters further, the experimental conclusion that the universe is accelerating means that General Relativity has to be modified to account for a mysterious, negatively acting pressure that would contribute to flattening the universe more than the distribution of matter would allow. The new term for this invisible force is "dark energy," which along with dark matter has become the latest chapter heading in the unfolding scientific truth of the universe. According to present calculations, dark energy would have to account for between 60 and 70 percent of the overall critical density of the universe. This has led to the reinstatement of a cosmological constant, which Einstein first posited and which was later withdrawn, to account for the widening gap between theory and experiment.

Paradoxically, the increasing complication of observable and experimental phenomena appears to have only intensified the faith in a logically simplified theoretical framework within which the entirety of celestial phenomena can be represented. As I showed in Act 1, the thrust of explanation — the 'path of thought' in Heidegger's phrase — has actually been inversed through the century: cosmologists today are predominantly experimenting to yield phenomena or facts that might fit their hypothetical framework rather than the other way around. Without the definitively calculated Event of the universe, derived from the mathematics of General Relativity, cosmologists and physicists would not only be unable to express their findings but incapable of formulating a meaningful experiment. So while the physics of Big Bang cosmology becomes more unstable and precarious, its actors work ever more ferociously toward its final mathematical unification. This might be called the hypological movement of universalism.

Hawking's guiding idea was that in the concept of singularity, from which the Event of universal becoming could be derived, lay also the solution to the contemporary problem of incommensurability between relativity and quantum frameworks. After his initial breakthrough, Hawking devoted much time to working out a quantum theory of gravity, which could properly reunify the universe of the micro and macro levels of phenomena — work that has since been superseded by the emergence of string theory and other models. In 1980, he delivered a lecture in which he suggested that the end of physics, that is, its reunification was in sight and that large-scale experiments such as Boomerang and the LHC would likely complete the major pieces of the physics puzzle. Since then, he has toned down his rhetoric. Yet he makes it clear that the stakes of reunifying the universe are far higher than securing the operational ease of physicists. For Hawking, the question of the universe is explicitly onto-theological in character. In the final paragraph of his 1988 bestseller, *A Brief History of Time*, he writes that if physics discovers a complete theory of the universe, it would be a crucial step to "the question of why it is that we and the universe exist. If we find the answer to that, it would be the ultimate triumph of human reason — for then we would know the mind of God." (191)

Along with the ostensible self-completion of General Relativity, then, Hawking's conception at the tail end of the 20th century leads directly to the question, as he puts it, of why it is that we and the universe exist — that is, to the question of Being as such. Most fundamentally, what does it mean that 'we' as beings have learnt the identity of the universe, the spatiotemporal realm of Being? Have we thus finally identified the relation of man and Being in its true constellation? The question of our existence, in other words, returns us to General Ontological Difference.

5. The Onto-Theo-Logical Event

Looking back at the 20th century, we may now better understand in what sense the Cosmotron at Brookhaven, as the exemplary experiment in a postwar era characterized by exponential growth in capital and energy, is a Janus-faced machine. Under the regime of mass-energy equivalence, the higher the energy the smaller the wavelength under observation — that is, the deeper into nature at its smallest scales are we able to probe. The circumscribed framework of General

Relativity crucially adds a temporal dimension to this relationship. The higher the energy the further into the early universe physicists can claim to see. In this sense, the particle accelerator signifies the pincer movement of nuclear physics and cosmology in the 20th century, whereby underground experiments can recreate the original conditions of the universe and astronomical observations can be used to determine the character of nuclear physics.[50] The experimental gaze of the particle accelerator thus cuts two ways: toward the beginning and the end of the universe at the same time.

General Relativity now stands revealed as a complete, four-dimensional framework within which reinforcing experiments can take place — but a framework that nonetheless conceals its own foundation. What is the relation between the universe as a mathematical realm and its mathematizers? As we have seen, this is essentially the problem Heidegger addresses in terms of the framework, as the name for the gathering of how 'man' and 'Being' come to challenge each other — that is, the hypological constitution of history.

To Hawking, the question of the relation between man and Being is in principle identical to the question of the human relation to the universe — that is, it is governed by what has become known as the anthropic principle. Coined by his Australian physicist colleague Brandon Carter in the 1970s, the anthropic principle says most essentially that, as Hawking puts it, "we see the universe the way it is because we exist." (128) To physicists, the anthropic principle prescribes how one is to account for the relation between our particular situation as observers in a universe and the universe as a whole when considering small data samples within it. Its explicit function, in other words, is as a probabilistic weighting of the bias inherent in any observation. Carter argues that the anthropic principle emerged in response to two existing contenders for describing the human-universe relation. On the one hand is the "pre-Copernican dogma" of the autocentric principle, which places human terrestrial observers at the center of the universe. On the other hand is the perfect cosmological principle espoused by Steady State Theory, which holds that the universe has no privileged center, is homogenous and isotropic, and that our local area can therefore be considered a typical random sample. For Big Bang theory, neither of these principles would work, because while our planet is clearly

[50] In 1993, results from an experiment at CERN in Geneva appeared to confirm predictions about the neutrino particle that were derived from cosmological argument. An American physicist involved in the experiment, David Schramm, argued that "this was the first time that a particle collider had been able to test a cosmological argument, and it also showed that the marriage between particle physics and cosmology had indeed been consummated." (Kragh, 2007: 222)

not at the center of the General Relativity universe, it is nonetheless considered to be in a very particular stage of an evolutionary process that distinguishes it temporally from other parts of the universe. Explains Carter:

> As a reasonable compromise between these unsatisfactory over-simplistic extremes, the anthropic principle would have it that (…) the a priori probability distribution for our own situation should be prescribed by an anthropic weighting, meaning that it should be uniformly distributed, not over space-time (…) but over all observers sufficiently comparable to ourselves to be qualifiable as anthropic. (174)

He contends that the anthropic qualification is not simply an identification of the human and thus a restatement of earth-biased autocentrism, because the principle is intended to encompass "extraterrestrial beings with comparable intellectual capabilities."[51] Moreover, Carter argues that because it involves probability distribution and not absolute values, the properly formulated anthropic principle is not actually tautological in character. Technically speaking, he is correct. The anthropic principle does not validate itself directly but rather works to circumscribe the framework within which it was first constituted. In this sense, the principle is precisely not tautological but hypological — made historically true through the effacing of its own historical contingency. For whatever its possible practical uses to physicists, the anthropic principle has immense metaphysical implications, since it effectively completes the hypological circle between man and Being within the universalist framework. Hawking reasons that the anthropic principle explains why the Big Bang occurred about ten thousand million years ago, because this is the time it would take for 'intelligent beings' to evolve. This is how he describes the process of universal formation:

> …an early generation of stars first had to form. These stars converted some of the original hydrogen and helium into elements like carbon and oxygen, out of which we are made. The stars then exploded as supernovas, and their debris went to form other stars and planets, among them those of our solar system, which is about five thousand million years old. The first one or two thousand million years of the earth's existence were too hot for the development of anything complicated. The remaining three thousand million years or so have been taken up by the slow process of biological evolution, which has led from the

[51] Physics convention is now to distinguish between the 'weak' and the 'strong' versions of the anthropic principle. Their difference is reducible to the range of universal models in consideration. The weak version limits itself to saying that in an infinite or very large universe, conditions for 'intelligent life' will only be met in very limited regions of such a universe. The strong version says that of all possible universes, only one like ours could produce such conditions. Whereas the weak anthropic principle is commonly accepted among physicists, the strong version has its detractors. See Carter, and Hawking, 1998: 128-9.

simplest organisms to beings who are capable of measuring time back to the Big Bang. (128-9)

In other words, within one and the same theoretical framework, the mathematical derivation of a singular event origin is given physical meaning within the context of a universal history, and this universal history is in turn justified in terms of the beings who invented it. In essence, this amounts to a forward and backward movement of the same reinforcing logic. We, at this moment in history, can explain our own cosmogony, and this cosmogony is verified by our very existence at this moment in history. Thus we have made our own history transparent to ourselves in a complete framework within which our only remaining task is to fit a few pieces of a predetermined puzzle. Our enframing, it appears, is total.

Heidegger's work, however, shows us a way out — and that way is in. That is, the way to open the hypological circle of General Relativity is not to tarry with its expression but to invert its essential structure. Pivoting on a shared principle of constancy — speed of light in a vacuum in one, ontological difference in the other — General Ontological Difference also shares with General Relativity the hypological invention of an Event. Within the framework where we find ourselves claimed by modern technology, Heidegger says, "there prevails a strange ownership and a strange appropriation. We must experience simply this owning in which man and Being are delivered over to each other, that is, we must enter into what we call *the event of appropriation."* (36) The event of appropriation is a laborious translation of Heidegger's term *Ereignis*, a German play on both the concept of an event and of ownership or belonging. For what Heidegger wants to call an Event — and this is how I will modify the translation of *Ereignis* henceforth — is intimately related to the theological horizon of metaphysics insofar as it offers to thought a key term for thinking the ultimate belonging of man and Being. Heidegger writes:

> As such a key term, it can no more be translated than the Greek *logos* or the Chinese *Tao*. The term Event here no longer means what we would otherwise call a happening, an occurrence. It now is used as a *singulare tantum*. What it indicates happens only in the singular, no, not in any number, but uniquely. What we experience in the frame as the constellation of Being and man through the modern world of technology is a prelude to what is called the Event. (36-7)

As we can see, to conflate Heidegger's Event with the Event of the Big Bang is not merely word play, for in both cases the logic of singularity, that which exists uniquely and outside any hypological framework, remains the essential invocation. When Heidegger describes the Event as "that realm, vibrating within itself, through which man and Being reach each other in their nature," he goes far toward describing the Big Bang event in metaphysical terms. In the singularity of the Event where the laws of physics break down, human explanatory power and the universe insofar as it can be explained reach each other at their respective limits. Analogously, the Event that Heidegger describes is the limit condition whereby the ontological difference between man and Being ceases to exist.

According to General Ontological Difference, the crucial distinction between the Event of the universe and what we by analogy could call the Event of Being does not lie in their respective discursive formations but rather in their metaphysical orientation. Whereas the Event of the universe is posited as an ontological ground from which the character of the universe can be determined, Heidegger's Event speaks inversely toward the theological event horizon of that to which our future belongs. In the Event, Heidegger says, "the possibility arises that it may overcome the mere dominance of the frame to turn it into a more original appropriating." In this sense, the Event is a promise of a future in which man reaches, in his thought and in his being, into the conditions for his being and thinking: the dimension of Being that does not let itself be captured hypologically by the principle of identity.

However, Heidegger warns us about understanding the futural sense of the Event as existing on something like a universal spatio-temporal horizon.

> It seems as if we were now in danger of directing our thinking, all too carelessly, toward something that is remote and general; while in fact what the term Event wishes to indicate really speaks to us directly from the very nearness of that neighborhood in which we already reside. (37)

The futurally oriented Event, in other words, is that which is always already closest to man in his Being. In this sense, the Event, if we were attempting to think it as a representation analogous to Heidegger's 'self-vibrating realm,' is precisely not some point in space-time but rather something continually present throughout it, sustained by the act of thinking itself, of being in language. "To think of appropriating as the Event means to contribute to this self-vibrating realm… We dwell in the appropriation inasmuch as our active nature is given over to language." (37-8)

What does this mean for identity? While the constitution of a hypological framework sets the conditions for what Heidegger calls the modern world of technology, it configures the "*belonging* together of man and Being in which the letting belong first determines the manner of the 'together' and its unity." Through this inversion, Heidegger can posit that the "question of the active meaning of [the]

Same is the question of the active nature of identity." (38-9) Heidegger's thesis is that the principle of identity fails to capture what can only be represented as this persistent realm, within whose 'vibrations' the active nature or continual presence of the Sameness of the Same resides.

As differentiated from the hypological constructions rooted in the principle of identity, I propose to call this 'self-vibrating realm' *autological*. The concept of autology designates that active dimension of Being upon which beings rely, or through which they dwell, but which is nonetheless concealed to their thinking, insofar as this thinking is governed by hypological constructions. Thus, 'autology' differs from 'tautology' in that the latter, as a linguistic concept, strictly speaking concerns the retroactive identification of a hypological construction — a logical short-circuit of sorts — and not the action of it being expressed, which is always already autological.

The Event, then, designates Heidegger's inversion of the principle of identity that opens up to the autological realm — to the question of what is necessarily different from the claim inherent in the Western understanding of identity. Such an autology, he argues, cannot be thought in terms of a spatialized relation but rather as a "perdurance" — a perdurance that is really "the circling of Being and beings around each other." (69) In other words, the difference of the Sameness of the Same from itself — that is, the ontological difference — is a recurring dimension of Being. Within a universal horizon constructed upon a singular Event, Heidegger's inversely singular Event could only be represented as omnipresence, as what is always already there. "We represent Being in a way in which It, Being, never gives itself. The manner in which the matter of thinking — Being — comports itself, remains a unique state of affairs." (66) Historically, the Event becomes itself expressed in different hypological constructions of Being, in the recurring activity of thinking Being. Thus, "there is Being only in this or that particular historical character: *Ousia, Logos, Hen, Idea, Energeia*, Substantiality, Objectivity, Subjectivity, the Will, The Will to Power, the Will to Will." (ibid.) And perhaps, we could add, General Ontological Difference.

In the very act of thinking Being, in all its historical configurations, we find its Event persisting through the making of history itself. This sense of action at the heart of Being carries a very close resonance to Arendt's concept of action as a pervasive force of sheer, unpredictable invention. As she puts it in *The Human Condition:*

> Action has the closest connection with the human condition of natality; the new beginning inherent in birth can make itself felt in the world only because the newcomer

> possesses the capacity of beginning something anew, that is, of acting. In this sense of initiative, an element of action, and therefore of natality, is inherent in all human activities.[52] (9)

Again we are reminded of Heidegger's advice to pay attention to the path of thought as much as its content. For in the activity of thinking itself, not in thought as already expressed, lies the deeper connection to the autological dimension of Being. But to reach into this dimension, into the origin of the Event where the thinking of Being and Being coincide, where identity and difference align, simultaneously takes us to the limit of metaphysics — it "springs into the abyss." The Event, in other words, marks the limit condition where the hypological and the autological are simultaneously identified and differentiated in a process of asymmetrical doubling.

In Act 3, we will look more closely at the idea of the autological. For now, its relation to the hypological could be explicated thus: just as General Ontological Difference does not imply that beings are in any way a 'false' expression of a 'true' Being concealed underneath it, the hypological is not some 'untruth' masquerading over the 'truly' autological. Like Heidegger's conception of the onto-theological, these are not two concepts unified in togetherness but rather differentiated in their essential belonging. Insofar as there is ontological difference, there is no way to discern, in the manner of identity, the actual nature of the autological without thereby differentiating it and thus rendering it different from itself. What is 'truly' autological, always and everywhere the same in itself, can only be rendered hypologically. As far as our technical vocabulary allows us passage, then, we can define the hypological as the enframing of the autological in its constant differentiation from itself.

Moreover, when we think the Event of Being as constituted in, by, and through action, we arrive somewhat closer to a sense of, on the one hand, the complex, relational web of constraining mediations that continually make history into its current configuration, and on the other hand, the precarious dynamic by which the

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[52] Arendt writes about the action of scientists that it "lacks the revelatory character of action as well as the ability to produce stories and become historical" because "it acts into nature from the standpoint of the universe and not into the web of human relationships." I believe Stengers effectively shows that Arendt's conception of scientific action is here very limited. Specifically, in the terms deployed in Act 1, Arendt limits scientific action to intermediation through theoretical models and experimental machinery, and does not take into account the sense in which interest is directly mediated among scientists. Generally, I take Arendt's concept of action to be closely akin to Stengers' description of the mediation of interest — and this political dynamic does not exclude scientists.

configuration is constantly prone to change. As Arendt puts it, it's not human capabilities that change through history — what changes is the constellation that orders their mutual relationships. (2006: 66) As a metaphysical concept, the Event bespeaks precisely this constant capacity for historical reordering and change against all existing conceptions. As itself a hypological invention, the crux of the Event is the action it enables: the inversion of thought from its universalist identity configuration. As Heidegger puts it, "on its way from the principle as a statement about identity to the principle as a spring into the essential origin of identity, thinking has undergone a transformation." What kind of transformation? Now, Heidegger says, "thinking sees the constellation of Being and man in terms of that which joins the two — by virtue of the Event." (39-40) In this sense, if Einstein is the 20th century's greatest universalist, Heidegger is its true inversalist. The Event of Being marks the singular — that is, non-representable — dimension of belonging, whereas the Event of the Universe marks the singular — that is, non-calculable — dimension of togetherness in unity.

In conclusion, what the asymmetrical doubling of metaphysical frameworks suggests is that the 20th century cosmological problem is deeply related to this essential constraint of oneness in explanation. With General Relativity, Einstein offered us the most logically coherent means by which the cosmos could be unified — and Hawking consolidated these means for the age of Big Science — yet persistently eluding the framework is its actual unification. Not only is the Standard Model of physics, as we saw in the previous chapter, split between two phenomenal scales reconcilable only through violent mathematical inventions such as an 11-dimensional string-based universe. Moreover, Standard Cosmology is forced to concede that the vast majority of its predictions rely on constructions whose truth is entirely contingent on a deeply rooted belief in mathematical universality as such.

In this Act, I have argued from General Ontological Difference that the universe in its modern scientific sense is hypologically constituted, on account of a certain constellation of man and Being. The next turn in our investigation will be to elucidate the idea of the universe further by examining its historical conception. That is, we will turn to the the 17th century and the origin of modern physics. In the history of metaphysics, it was with thinkers like Galileo and Descartes that the idea of the universe was born — and it was with thinkers like Spinoza that this idea was inverted in its structure. With Spinoza, then, Heidegger's question of enframing will be given its appropriate tilt: not *if* we are enframed, or *if* we can un-enframe ourselves, but rather *how*, or in what sense, we are enframed. By what principles and on what grounds can our world be said to be configured, and with what consequences?

As both the conceptual invention by which the thesis of this chapter could be expressed, and as the logic by which our world is enframed, the hypological is Janus-faced metaphysics. In one and the same double movement, it constitutes history as our invention and invents history as our constitution. The making of history is in this sense also the making of truth. As Arendt puts it, what was originally nothing but a hypothesis will in the course of consistent action always turn into a fact, never to be disproved — in fact, the consistent action will eventually proceed to create a world in which the hypothesis becomes axiomatic and self-evident. As a final twist, then, Arendt first derived this logic from her study of totalitarian political regimes. That it should so accurately describe the history of 20th century cosmology and the development of General Relativity, as well as technological enframing in Heidegger's sense, is far from coincidental. For in all these cases, we are not merely concerned with regimes of knowledge that rely on a degree of totalization. Most fundamentally, what is at stake is the way in which a culture invents its own origin story.

ACT III — AUTO

God, that is, Nature:
The Invention of Universalism

I should wish to demonstrate

by certain reasoning

things that are contrary to reason.

Benedict Spinoza

1. Amsterdam, 1633

Autology has no end — nor, therefore, a beginning. But as we have to begin somewhere, we have hypology. In this case, the conception of a pivotal event.

In 1633, a promising young French natural philosopher called René Descartes was living in the Netherlands. He had recently finished writing what he considered a revolutionary treatise called *The World*, which presented a bold hypothesis on the nature of light, motion, and the dynamics of what he would call the universe. As Descartes had written to his long-time correspondent Marin Mersenne just a few years earlier,

> instead of explaining a single phenomenon, I have decided to explain all natural phenomena, that is, the whole of physics. And the plan gives me more satisfaction than anything previously, for I think I have found a way of presenting my thoughts so that they satisfy everyone, and others will not be able to deny them.[53] (219)

One day in late fall, after a trip to his regular bookseller in Amsterdam, Descartes' aspiration to such an 'undeniable' natural philosophy took a sudden and unexpected turn. Anguished, he wrote back to Mersenne:

> I had intended to send you *The World* as a New Year gift… but in the meantime I tried to find out in Leiden and Amsterdam whether Galileo's *World System* was available… I was told that it had indeed been published, but that all copies had been burned at Rome, and that Galileo had been convicted and fined. I was so surprised by this that I nearly decided to burn all my papers, or at least let no one see them… I must admit that if this view [that the earth moves] is false, then so too are the foundations of my philosophy, for it can be demonstrated from them quite clearly. And it is such an integral part of my treatise that I couldn't remove it without making the whole work defective. But for all that, I wouldn't want to publish a discourse which had a single word that the Church disapproved of; so I prefer to suppress it rather than publish it in a mutilated form." (290-1)

This event at the bookseller, Descartes' crossing of paths with the fate of Galileo Galilei, had some dramatic consequences, for himself as well as for the history of metaphysics. As his distraught quote intimates, Descartes was plunged into a crisis of character. He held off on publishing his grand work, recoiling instead into a renewed and intensified search for methodological justification. With Galileo now an official heretic of the Catholic church, Descartes needed a way to assuage his own universal faith.

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[53] Descartes' correspondence is quoted from Gaukroger, 1995.

Meanwhile, outside Florence, a convicted Galileo under house arrest was also spurred toward methodological justification. Here, he secretly wrote his final work known as the *Discorsi*, the *Discourses Concerning Two New Sciences*, to be smuggled out of Italy and published in the Netherlands in 1638.[54] The book laid out the novel kinematic rationale that would become the explanatory basis for Newton's dynamics and in turn ensure, in no small way thanks to his legendary clash with Pope Urban VIII, Galileo's canonical place in the history of modern physics as its true 'father' figure.

For Descartes, a Catholic still living in protestant Northern Europe, the intense thinking process would culminate in the theory of the *cogito*, the mental subject at the basis of what would become modern epistemology, in turn ensuring Descartes' role as the 'father' of modern philosophy. In the remote encounter between these two characters, then, we find a mutual origin story for what we now call modern science and philosophy.

However, this neatly symmetrical story ends on a note of discord — a foreshadowing of future complications. For if we imagine a tormented Descartes walking the streets of Amsterdam in search of the answer to his excruciating dilemma, at some point he would, probably, be passing the birthplace of a newborn child. A child who would become the local heretic, an ex-communicated Jew, as well as the heretic of the new natural philosophical order. A heretic of heretics, Baruch (later to be Benedict) Spinoza would, as we shall see, invert the metaphysics of both Descartes and Galileo in the name of autological reasoning.

If, as the previous chapter argued, hypology constitutes the logic of the invented origin — the hypothesis that through concerted historical action becomes a cultural truism — we will in this chapter clearly be involved with the hypology of the event that is called modern history. Although Amsterdam in 1633 may seem as arbitrary a starting point as any, Descartes and Galileo are already conventional characters in prevailing narratives of this modern emergence. They are not short of company. We have plenty of invented origins to choose from, events that in one way or another make rivaling claims to being the decisive break that marks 'early modernity' or the beginning of the modern age. How about, in the name of technological revolution, the invention of the microscope and the telescope in the

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[54] Confusingly, two of Galileo's works today are translated with the term dialog: *Dialogue Concerning Two Chief World Systems*, the 1632 publication that had him face papal inquisition, and *Dialogues Concerning Two New Sciences*, the clandestine 1638 text. Following classical convention, I will refer to the former as *Dialogo* and the latter, my key Galilean text, as *Discorsi*. I will use similar classical shorthand for Descartes and Spinoza.

Netherlands just around the turn of the 17th century?[55] Or, rather glancing through a political lens, the treaty of Westphalia in 1648? Perhaps the English Civil War of 1640-60, where property laws were established?[56] Although we could go on, the many different origin stories of modernity belie their essential similitude.[57]

Two complementary points must therefore be made clear from the outset. On the one hand, if we walk in such an historical loop, it is partly because the demarcation of historical breaks and discontinuities in terms of modern and pre-modern (and postmodern) is itself characteristic of modern historiography. In effect, this identity loop, the hypological circle *par excellence*, ensures the stability of the modern story, in spite of its many rivaling interpretations. For in every alternative story of modernity, the identity of modern history itself, as differentiated from some other kind of history, is always already structurally guaranteed.[58] In other words, the more scholars challenge each other over the origin of modern history, the more they work to actualize an invented break into historical fact.

On the other hand, inventions are not imaginations. A beginning or not, mid-17th century Europe constituted on almost all accounts a remarkable historical contraction that gave rise to a proliferation of new phenomena. The Thirty Years War (1618-48), a war of imperial power and religion fought partly by navies and in

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[55] In a possible subplot to the event-story, Antonie van Leeuwenhoek was born just a month before Spinoza in 1632. He would become known as the greatest microscope inventor of the early modern world, perfecting the art of lenscrafting for centuries to come — thus continuing Galileo's legacy.

[56] Even more conventional historiography would pull out of the 17th century altogether, back to the fall of Constantinople in 1453, or Columbus 'New World' landing in 1492, or Martin Luther's nailing of theses in 1517 — or push forward to the first commercial steam engine in 1712, or even the French revolution.

[57] A possible exception could be made for someone like Bruno Latour, whose *We Have Never Been Modern* tries to move away from modern origins altogether. However, for all his glibness, Latour too is involved in the same procedure, since his argument rests on a reading of the now legendary dispute between Hobbes and Boyle as an origin story of modernity. Only by revisiting an origin story and ruling claims about the modern is Latour able to hypothesize that what we take to be modern is in fact only one dimension of what being modern would have to mean. Insofar as he is concerned with the logic of mediation, there is some convergence between Latour's approach and what I present in this chapter, though I do not share his thesis on modernity.

[58] Fredric Jameson makes this point well in his book, *A Singular Modernity*, which contains an even longer list of historiographic candidates for the modern break: "Indeed, the trope of modernity may … be considered as self-referential, if not performative, since its appearance signals the emergence of a new kind of figure, a decisive break with previous forms of figurality, and is to that extent a sign of its own existence, a signifier that indicates itself, and whose form is its very content. 'Modernity,' then, as a trope, is itself a sign of modernity as such. The very concept of modernity … is itself modern, and dramatizes its own existence." (34)

colonies, with eight million casualties from at least three different continents, can make a plausible claim to being the first real 'world war.' This violent age saw the emergence of, among other things, revolutionary military mobility in the form of musketeer artillery forces; the first stock market; a commercial banking system; currency inflation; an international legal system for the absolute sovereignty of the nation-state. And not to be forgotten, probability reasoning and statistics, to which we shall return. In other words, in the mid-17th century, we find a familiar political clustering of war, capital, and science in a distinctive historical configuration. In a time and place that was by all measures still dominated by such 'pre-modern' features as absolutism, alchemy, astrology and magic, the epicenter for this new configuration can plausibly be located in the first modern nation-state, the Dutch Republic.[59] And this would bring us full circle back to the story of Descartes at the Amsterdam bookseller in 1633 — or some equally exemplary event.

I foreground these considerations in order to circumvent them. By selecting Galileo, Descartes, and Spinoza as characters in this Act, I am obviously moving within a retroactively constituted history. I make no historiographic pretensions to conceiving an alternative history or genealogy of modernity. Rather, in setting the scene for this chapter, I want to transition from the hypological principle of identity explicated in Act 2 — that is, in what sense the modern is modern and when the modern therefore begins and ends, and so on — toward considering a different principle at the heart of Western metaphysics. For the German philosopher G.W.F. Leibniz, a character with his own eventful linkages to Spinoza[60], if the principle of identity (which he called the principle of contradiction) is the most fundamental principle of thought, its necessary complement is the *principle of reason* (or principle of sufficient reason). That is, "nothing happens without a reason that one can always render as to why the matter has run its course this way rather than that."[61] The principle of reason is a principle of thought as much as a principle of causality. In either case, it becomes a metaphysical determination, or constraint, for physical explanations. As the cases of Galileo, Descartes, and Spinoza will make clear, the principle of reason lies at the core of modern metaphysics because it

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[59] General historical reference and insight on the military revolution of the Thirty Years War comes from Davies and Dyer, passim.

[60] For a lucid reading of Leibniz' personal and philosophical relationship to Spinoza, see Matthew Stewart, *The Courtier and the Heretic*, 2006.

[61] This particular quote comes from Heidegger's close reading of Leibniz' correspondence in *The Principle of Reason*, p. 119. Leibniz outlines the difference between the two principles several places, most succinctly in the *Monadology*, Principles 31-32.

spurs thinking about the reason for any ostensible truth or fact as it comes gathered under the principle of identity. And this means that the principle of reason can be made to ask for something even more profound: the reason for identity as such.

In *The Birth of Physics,* the 20th century French philosopher Michel Serres crystallizes the relationship between these two principles thus:

> If we had only the principle of identity, we would be mute, motionless, passive, and the world would have no existence: nothing new under the sun of sameness. We call it the principle of reason that there exists something rather than nothing. From which it follows that the world is present, that we work here and that we speak. Now this principle is never explained or taken up except in terms of its substantives; the thing, being and nothingness, the void. For it says: *exist rather than*. Which is almost a pleonasm, since existence denotes a stability, plus a deviation from the fixed position. To *exist rather than* is to be in deviation from equilibrium. Exist rather. And the principle of reason is, strictly speaking, a theorem of statics. (21)

In other words, rather than the hypological constitution of identity as appearing out of itself, like the modern in modern historiography, there is always something deviating from it, a given. Toward this positive existence gestures the principle of reason, as an axiom of thought. Leibniz' Latin formulation, *Nihil sine ratione*, nothing without reason, could therefore be inversely restated along Serres' lines as, *Semper sic* — always something on the condition of something else, always this rather than that, always a given. This given, which we may not be able to know, but for which there is necessarily a reason, is the *autological*, the self-positing logic of that which gives itself in and for itself, but which is not itself given as a self — that is, not already given under the principle of identity as a clearly differentiated thing. Although the autological is discernable in all classical, 'pre-modern' philosophy, it is with Spinoza's *Ethica* that it will be most distinctly expressed, as simultaneously the logic of substance, God, and Nature. From the perspective of hypological reasoning, the autological constitutes a limit condition, that which is evidently present yet refuses to be integrated into identity. From the perspective of autology, hypological reasoning occurs when the given — that which intitiates, mediates or enables reason — is turned under identity, that is, when it is conceived.

In the history of thought, autology thus occurs in a myriad configurations. In physics, the autological becomes primarily expressed as the concept of force, a foundational problem of dynamics. In scholastic philosophy, which provides the hegemonic vocabulary of the 17th century, the autological is principally substance, the *causa sui*, the self-causing cause. In theology, it is often expressed as the logic of the soul, that which animates us as thinking beings. In turn, this ensures the autological a dubious status from the perspective of modern science and epistemology. Following Heidegger, we can think of autology as outlined by the structural gap of general ontological difference, between the ontological and the ontic, between Being and beings — or, in another tradition, following Bergson and Deleuze, as an infinitely small, vanishing, intensive difference. To philosophy on the whole, as Serres observes, the problem easily becomes a matter of nouns that purport to explain everything — thing, being, void, difference — even if what they explain is precisely that which cannot be adequately conceptualized. Logic encounters its own limit. This is not to say that philosophical concepts such as being, difference, and so on, are essentially identical — for that would again reduce the question to the principle of identity. Rather, according to the principle of reason, which will steer us in this chapter, such concepts share one pivotal characteristic: they gesture toward a lived, experienced dimension of reality. An epistemic principle, in other words, connects to an ontology — in Heidegger's sense, an onto-theology.

In this Act, I will try to demonstrate the significance of the autological for how the modern scientific universe first becomes configured. Through a small set of texts by Galileo, Descartes, and Spinoza, I am offering, in effect, a structural analysis of the onto-theological constitution of metaphysics. I follow this distinction in Heidegger's original sense, as laid out in Act 2: ontological for beings as such, theological for beings as a whole, both constituting one another metaphysically, in the principles that govern our logic. As a neologism, autology offers no primary distinction between Nature and God. Rather, it is a logical distinction derived from the principle of general ontological difference, between the hypological and that from which we showed it must logically differ. What began in Act 2 as a methodological conception must now be demonstrated, put into action. This is why the autological, by way of our hypological story about it, belongs to the very middle of this dissertation — for it is the nature of mediation itself.

2. Galileo's Void

To engage with the principle of reason beyond which reason cannot go is inevitably to encounter metaphysics as the vanishing point between Nature and God, science and religion, knowing and believing. For this reason too, the mid-17th century constitutes a remarkable historical contraction. For in this moment we find an almost total convergence, under the twin signs of natural philosophy and natural theology, between what for centuries had been — and centuries later would again become — an instituted disciplinary divergence between physics and metaphysics, science and religion. As contemporary historian Stephen Gaukroger puts it in his impressive study of the emergence of modern scientific culture:

> A good part of the distinctive success at the level of legitimation and consolidation of the scientific enterprise in the early-modern West derives not from any separation of religion and natural philosophy, but rather from the fact that natural philosophy could be accommodated to projects in natural theology: what made natural philosophy attractive to so many in the seventeenth and eighteenth centuries were the prospects it offered for the renewal of natural theology. Far from science breaking free of religion in the early-modern era, its consolidation depended crucially on religion being in the driving seat: Christianity took over natural philosophy in the seventeenth century, setting its agenda and projecting it forward in a way quite different from that of any other scientific culture, and in the end establishing it as something in part constructed in the image of religion. (23)

In the context of natural philosophy and theology as the very axis of modern scientific culture, the autological becomes imperative. Whether it was understood as natural force on the one hand or as divine presence on the other, these two dimensions — physics and metaphysics — were to all the pivotal thinkers of the era mutually indispensable in making sense of the same positive reality.

In a retrospective history of the conditions for emergence of the current scientific universe, we inevitably encounter Isaac Newton's *Philosophiae Naturalis Principia Mathematica* from 1687, which within a century of its publication had managed to become the veritable touchstone of modern physics. Newton's picture of the cosmos is the quintessential expression of a new mathematical universe: in one and the same logical operation, one and the same configuration, it yields a complete and unified realm of quantitative explanation. And it is from Newton's *Principia* onwards, through the conceptual extension and simplification that Einstein offers it under General Relativity, that the universe becomes a commonsensical idea, as a name for the totality of the cosmos within which humans find themselves. However, the concept of the universe involves a profound metaphysical idea about the relation between God and Nature. And in order to grasp the precise nature of this relation, we will need to better understand how the universe of modern scientific cosmology was forged.

Newton's universe was predicated on "Rational Mechanics", which, as he put it in his preface,

> will be the science of motions resulting from any forces whatsoever, and of the forces required to produce any motions, accurately proposed and demonstrated… And therefore we offer this work as mathematical principles of philosophy. For all the difficulty of philosophy seems to consist in this — from the phenomena of motions to investigate the forces of Nature, and then from these forces to demonstrate the other phenomena. (lxvii)

The statement intimates the spectacular rise of mechanics from the low ranks of the Aristotelian hierarchy of the sciences, where it was categorized as practical mathematics, to becoming the *de facto* metaphysical foundation for a wholly new cosmological framework. In the Aristotelian system, the theoretical sciences at the top of the hierarchy were divided in terms of two factors: mutability and dependence. First philosophy, or metaphysics, concerns that whose nature is unchanging, relative to physics, whose subject matter is the ever changing. Mathematics, like metaphysics, concerns the unchanging, or the constant. But whereas Aristotle considered both physics and metaphysics independent of humans, mathematics was for him dependent on human thought.[62] Mathematics and physics, in other words, were in a mutually exclusive relationship: physics concerned the changing nature of a world existing independently of us, mathematics concerned the unchanging nature of a world dependent on us. With the hegemony of Newton's work, this entire explanatory structure was turned around. To grasp dynamics mathematically is now simultaneously to understand physics, that is, the fundamentals of the world — and this grasping occurs on new metaphysical conditions.

In the lower part of the Aristotelian system, the discipline of mechanics consisted of three areas. *Kinematics* deals with bodies already in motion, *statics* with bodies in a state of equilibrium, and *dynamics* with forces responsible for motion. Dynamics was, as Gaukroger puts it, "the ultimate prize of 17th century physics" because it had to, like Newton's work, encompass both a theory of motion and of forces.[63] But in order to accomplish this in quantitative fashion, the development of dynamics had to move through the two other areas that would turn out to be mutually exclusive. Statics, well-developed through antiquity, deals with

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[62] In the Platonic schema, however, mathematics is afforded an independent existence that makes it indistinguishable from metaphysics in this sense.

[63] See Gaukroger, 2007, p. 413. The relation between mechanics and mathematization has been part of his research since *Explanatory Structures*, 1978, as well as his many books on Descartes.

forces but not with motion. Kinematics, on the other hand, deals with motion but not with forces. To natural philosophers seeking to pursue a complete dynamics, statics and kinematics therefore offered two different routes to the same ostensible goal. But as each route implies different metaphysics, it also implies different realities. Thus, in historical practice, only one of the routes allowed for the quantification necessary to constitute a mathematical universe. As retrospective history would enframe it, after decades of working with models from statics that proved unsuccessful, Galileo eventually blazed the 'right' trail through kinematics.

Galileo, who in so many stories plays the true scientific revolutionary, found his historical significance in a shifting institutional context. As historian Mario Biagioli points out, the break that Galileo makes with scholastic thought is also a break with a scholastic institution, in favor of his extended networks of patronage as a courtier in the aristocracy of Italian city-states. In these circles, social status came with more authority than what would later be termed scientific credibility. Indeed, as Biagioli shows, Galileo's success as a courtier is contingent on his ability to mediate interest within a newly emergent domain for natural philosophy. Thus, Galileo the Courtier is both enabled and compelled to frame his problems in novel ways that can differentiate him from the hegemonic structure of knowledge.[64] In history of science, the short-lived period of patronage would mediate between the traditional, scholastic order of knowledge and the later order emerging through scientific academies.

Thus, arising in this intermittent historical position, Galileo comes to play a crucial double role in the making of scientific history. In effect, as we shall see, Galileo is both the enactor of the experimental observation and the inventor of the conditions for the mathematical framework within which this observation can be explained and legitimated. Galileo the Experimenter and Galileo the Mathematizer. This mutuality constitutes his metaphysical constancy in modern history and makes him axiomatic to the history of modern thought in a way that neither Descartes nor Spinoza can rival.

In physics, Galileo's constancy finds mathematical expression in his principle of invariance that underlies both the Newtonian and Einsteinian universe. Under this conception, the laws of physics are the same in all inertial frames. In philosophy, Galileo's constancy is effected through his ability to fascinate countless later thinkers — among them, Hannah Arendt and Isabelle Stengers. Their

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[64] See Biagioli's interesting account of Galileo's self-fashioning in *Galileo, Courtier,* 1993, esp. pp. 6-17, 59, and 357.

perspectives, which both contribute to a sense of Galileo the Experimenter, hinge on each of Galileo's decisive demonstrations taking place in 1608: the telescope and the inclined plane. As demonstrations of celestial and terrestrial mechanics respectively, they both turn explicitly on the problem of movement and implicitly on the critical new role of experiment in natural-philosophical matters.

For Hannah Arendt, Galileo is foremost the Telescoper. The invention of the telescope and the development of a new science that considers the nature of the earth from the viewpoint of the universe constitutes, she argues, a pivotal moment in the irreversible and paradoxical modern process she calls "world alienation." The more humans increase their surveying capacity, the more the actual place from which this surveying takes place disappears to them. What Arendt describes is like a cultural blindspot. Referring to a general phenomenon of the modern age, the thesis of world alienation holds that "any decrease of terrestrial distance can be won only at the price of putting a decisive distance between man and earth, of alienating man from his immediate earthly surroundings." (1998: 251) Despite all the previous philosophical musings on the nature of the heavens and the earth, including Copernicus' hypothetical treatise on a heliocentric universe, Arendt argues that supreme significance must be attached to Galileo's demonstration of the telescope in 1608 as a world-historical event.

> What Galileo did and what nobody had done before was to use the telescope in such a way that the secrets of the universe were delivered to human cognition 'with the certainty of sense-perception'; that is, he put within the grasp of an earth-bound creature and its body-bound senses what had seemed forever beyond his reach, at best open to the uncertainties of speculation and imagination. (259-60)

This actual shifting of human perspective, pivotal to a Newtonian universe, still holds dramatic sway. As Arendt points out, well before the age of satellite earth mapping would make her insight almost prosaic, Galileo's telescopic event effectively demonstrated an 'Archimedean point' through which it becomes possible to act within terrestrial nature as though we are disposing of it from the outside. It is the invention of outward leverage, a transcendental turning that changes everything:

> Whatever we do today in physics — whether we release energy processes that ordinarily go on only in the sun, or attempt to initiate in a test tube the processes of cosmic evolution, or penetrate with the help of telescopes the cosmic space to a limit of two and even six billion light years, or build machines for the production and control of energies unknown in the household of earthly nature, or attain speeds in atomic accelerators which approach the speed of light, or produce elements not to be found in nature, or disperse

radioactive particles, created by us through the use of cosmic radiation, on the earth — we always handle nature from a point in the universe outside the earth. (262)

The event of the telescope, of course, is also pivotal to the legendary cosmological clash between religion and science in modern thought. At stake in Galileo's contradiction of Catholic Church geocentric doctrine (a condemnation the Pope officially withdrew in 1992) is the movement of the earth in relation to the planets and stars, all of which could be inferred from the telescope.

Yet precisely in this sense it could be argued that Galileo the Telescoper is something of an incidental character, inscribed in a history he does not actually constitute. As Isabelle Stengers argues, that Galileo happened to be in a privileged position to use this new instrument and garner interest for its observations in his extended patronage circles is not what truly singularizes his role in modern history. To Stengers Galileo is foremost the Inventor — creator of the demonstrative device known as the inclined plane. Upon this plane, which modern eyes will recognize as an abstract representation of space and time, Galileo aimed to demonstrate his theory of motion: an analytic reduction of motion into separable elements.[65] Crucially, these elements happen to be precisely those demonstrable by the inclined plane. As we saw in Act 1, Stengers argues that the constitutive role of the experiment in modern science is its ability to play on a double register — it makes the phenomenon 'speak' in order to 'silence' the rivals. In a close reading of Galileo's device as the proto-experiment of modern science, she points out that, contrary to the conventional understanding of the experiment as a positive demonstration of truth, the inclined plane, as a *de facto* laboratory rendition of the world, first and foremost establishes a negative truth that only retroactively, through the hypological constitution of the experiment as factual and truthful, comes to appear as a positive statement about nature. In fact, because the apparatus allows its author, Galileo, to withdraw, to let the premeditated motion testify in his place, it appears as though nature is made to 'speak' directly through the experiment, even though the logic of the experiment is considerably more circuitous. Thus, as Stengers puts it,

the 'law of motion' is not linked to observation but is relative to an order of created 'fact', to an artifact of the laboratory. But this artifact has a singularity: the apparatus that

[65] The actual plane itself, Galileo describes as "a piece of wooden moulding or scantling, about 12 cubits long, half a cubit wide, and three finger-breadths thick" with a grooved channel "a little more than one finger in breadth" cut along it — upon which he would roll, multiple times at multiple degrees of incline and lengths measured by a water clock and a pendulum, "a hard, smooth, and very round bronze ball." (*Discorsi,* 136-7)

creates it is also able, certainly not to explain why motion lets itself be characterized in this way, but to counter any other characterization. (85)

In the case of Galileo, the primary rival fictions to be countered were prevailing versions of Aristotelian physics. These rivals were defeated not simply by conducting an experiment as such, but rather by reconfiguring the role of the experiment in the overall explanatory structure, in order for physical problems to be posed mathematically.[66] Consequently, the explanatory structure itself shifts. Here Galileo the Experimenter, on which both Arendt and Stengers focus, is complemented by Galileo the Mathematizer.

In Galileo's 1638 text, the *Discorsi*, the experimenter and mathematizer show themselves as mutually constitutive for the emergence of quantitative kinematics, the *post facto* route to a Newtonian dynamics. The rather strange text is constructed as an ongoing dialogue spread out over four days (or chapters) between three characters — Salviati (the interlocutor), Sagredo (the skeptic), and Simplicio (the Aristotelian) — interwoven with blocks of dense prose by the Author (Galileo), to whose prepared text the characters refer. In the course of days three and four, Galileo provides the first modern kinematic rationale for treatment of motion. In the prevailing Aristotelian view, motion is itself an irreducible physical reality underlying time as a mental, that is, human abstraction. Galileo, however, treats motion purely as a local change of spatial location in time. With explicit reference to the inclined plane, both as a thought experiment and an actual demonstration, he divides motion into three independent forms. First, uniform motion "is defined by and conceived through equal times and equal spaces (thus we call a motion uniform when equal distances are traversed during equal time-intervals)." (123) Uniform motion is similar to what we after Newton would call inertia, straight rectilinear movement along a horizontal plane, like a billiard ball. Second, naturally accelerated motion is a motion "uniformly accelerated… starting from rest, it acquires, during equal time-intervals, equal increments of speed." (124) This is, in other words, the separable case of free fall or vertical motion toward the ground. Third, projectile motion, or projection, is, Galileo argues, a compound of uniform and accelerated motion, both of which are demonstrable through the inclined plane. His novel thesis is that "a projectile which is carried by a uniform horizontal motion compounded with a naturally accelerated vertical motion

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[66] Contrary to an enduring myth of modern science, experiments were common practice also before Galileo, albeit with a different explanatory function.

describes a path which is a semi-parabola," that is, a perfectly sloping curvature. (190)

Given their turn, Sagredo and Simplicio counter with three objections to the Author's geometrical argument. First, Sagredo points out that the semi-parabola, which is in theory perpendicular to a horizontal surface, cannot account for the tendency of a falling body toward the center of the earth, which the geometrical abstraction could never reach. That is to say, in post-Newtonian language, gravity would in some way intervene on the perfect geometrical path by drawing it to earth, and "the path of the projectile must transform itself into some other curve very different from the parabola." Second, as Simplicio now weighs in, the Author supposes "the horizontal plane, which slopes neither up nor down, to be represented by a straight line as if each point on this line were equally distant from the center, which is not the case; for as one starts from the middle (of the line) and goes toward either end, he departs farther and farther from the center of the earth… Whence it follows that the motion cannot remain uniform… but must continually diminish." That is to say, Galileo's demonstration cannot take account of the sphere of the earth. Finally, Simplicio adds: "I do not see how it is possible to avoid the resistance of the medium which must destroy the uniformity of the horizontal motion and change the law of acceleration of falling bodies." (194) In other words, Galileo's demonstrations are universally valid insofar as the universe is a flat, forceless, friction-free space — that is to say, a void.

The first two objections, retrospectively viewed from General Relativity, both concern some aspect of gravitation, insofar as the curved shape of the earth is directly implicated in the tendency for bodies to fall to its center. In this sense, they could both be corrected in a more mathematically complicated theory. The latter objection concerns force too, though more immediately. Singularly characteristic of the kinematic approach to dynamics, the wholesale removal of the medium in which bodies move is fully extant in contemporary physics. For what is at stake here is nothing less than the ability to mathematize physics.

Faced with his critique, Salviati, on behalf of the Author, admits "that these conclusions proved in the abstract will be different when applied in the concrete and will be fallacious to this extent…" (ibid.) Nevertheless, he counters — and herein lies the essential invocation that makes the Newtonian universe possible —

> in order to handle this matter in a scientific way, it is necessary to cut loose from these difficulties; and having discovered and demonstrated the theorems, in the case of no

resistance, to use them and apply them with such limitations as experience will teach. (196)

Not unexpectedly, Sagredo and Simplicio are appeased by this concession and allow Salviati's interlocution with the Author's subsequent theorems and demonstrations to continue. And so, incidentally, does scientific history.

From the discussion in Act 2 of how Einstein turned the speed of light in a vacuum into a physical constant, Galileo's invention will be recognizable. First, his kinematics privileges the fundamental relativity of motion, wherein rest and uniform motion (inertia) become identified as equivalent states. In kinematics, differences of motion are never an absolute difference between moving and not-moving but rather relative differences between moving-less and moving-more. These can be mobilized to express ratios, or relations of change, for speed, momentum, weight and so on. Insofar as Newtonian dynamics is established on the mathematical basis of kinematics, relativity becomes already with Galileo an axiomatic concept.

Second, by arguing through the condition of a void, Galileo is immediately able to generalize his relative problem in a deeply transformative way. By way of an extended principle of identity, the universal similitude of all bodies, regardless of their mediated situation, is first of all established, and under this hypological framework — that is, another 'Archimedean point' — the world as it exists, autologically, can be treated as simple mathematical differentiations. No longer is it a question, as in the Aristotelian doctrine, of different bodies under different conditions, but rather a matter of any bodies with any weight or any speed, since all their worldly imprecisions and impediments have been, in a foundational gesture, stripped and subsequently redressed to vouch for the stubborn, if negligible discrepancy between thinking and its actually existing conditions — between the hypological and the autological. Enframed as a constant, Galileo's claim becomes valid in all 'inertia frames' precisely on account of the hypological void, which provides a stable referent to the quantification of movement. Inventing the void is effectively 'world alienation,' though perhaps in a more immediate sense than Arendt's, since it now becomes the necessary condition for quantification and thus for the rational mechanist universe as such.

However, we cannot therefore simply dismiss Galileo's work as idealizations or empty abstractions. On the one hand, the experiment itself is now autological insofar as it is a mediating act, taking place in the world. On the other hand, Galileo's invention is a matter of carefully reconstituting the problem in a retroactive, that is, hypological fashion. In a sense, the void is not so much invented as the force of the given, the mediation that makes mathematization so problematic, is effectively circumscribed. In its place, the experiment is set to speak. Earlier in the *Discorsi*, for example, Galileo takes us through a painstaking reconstitution of the relative weight of air to bodies — the very medium his generalization needed to remove — and through these sequential experiments, piece by piece reconstituting what was initially removed, Galileo is able to make a plausible claim to having established, or re-established, as real the very situation that is by definition impossible to submit to experience. Whereas the medium was once considered constitutive of the physical problem as such, it has now been redefined exclusively in terms of 'resistance' to a universalized motion.

Thus, the explanatory structure of physics is transformed: rather than beginning from the autological, mediating force in which the natural philosophers find themselves, the "new science" of Galileo begins in the hypological circumscription of the world. Galileo's invention is not merely recourse to an experimental device, nor simply the *a priori* hypothetical generalization to which this device is put, but rather a mutual construction, a doubling: the inclined plane, be it in the form of a thought experiment or an actualized contraption, directly mediates Galileo's analytic breakdown of motion into constituent parts, which it in turn demonstrates through the synthetic reconstruction of the circumscribed reality. If this double logic appears bewildering, it is only because it takes a lot of contortion to circumvent the autological force of the world as it is given to our experience.

In other words, it is with Galileo that modern physics first appears as we described it in Act 1, a theoretico-experimental hybrid. And it is with Galileo that this reality becomes, as we described it in Act 2, a new hypological constitution.[67] Galileo the Experimenter and Galileo the Mathematizer are mutually constitutive: in short, the experiment is the enacting of the framework within which it is given meaning. The singularity of this double power coheres with Stengers' thesis on the circuitous nature of the experiment in modern science: the invention of the power to confer on things the power of conferring on the experimenter the power to speak in their name. However, now we also see this loop on its inverse: the invention of

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[67] As Michel Serres describes the political implications of this move, "Galileo is the first to put a fence around the terrain of nature, take it into his head to say, 'this belongs to science,' and find people simple enough to believe that this is of no consequence for man-made laws and civil societies... The knowledge contract becomes identified with a new social contract. Nature then becomes global space, empty of men, from which society withdraws... The experimental sciences make themselves masters of this empty, desert, savage space." (1995: 84-5) The consequences for our understanding of nature and culture along this line of thought will concern us in Act 5.

the reality of things to which the conferred power now speaks. Henceforth, the work of modern science becomes determined by the discrepancy between these two logical dimensions — the hypological and the autological — by the blindspot between the world as thinking invents it and the world as it becomes revealed to thought. Developing on multiple, specialized fronts in proliferating disciplines and discourses, circumscription becomes a matter of minimizing the 'auto-hypo discrepancy' within a certain framework — until the framework itself becomes so incoherent it requires reinvention in order to account for the same stubborn discrepancy, albeit from a different historical perspective. The autological, then, becomes the excluded middle.

3. Descartes' Vortex

Until Galileo's kinematics became the basis for Newton's mathematical universe, the most influential modern enframing of nature was the Cartesian universe, predominant among natural philosophers well into the 18th century. It would attempt to arrive at dynamics through a different route — statics. And if it appears to retrospective history as a detour, it nonetheless turned out to be rather productive, for Descartes would in the meantime provide the new scientific universe with a significant metaphysical legitimation.

As we have intimated in the opening event scene in Amsterdam, Descartes' conception of the cosmos clearly converged with Galileo on the question of heliocentrism. Moreover, as a natural philosopher, Descartes was aligned with Galileo in the general project of forging a mathematical physics that would overturn the traditional hierarchy of the Aristotelian sciences. Certainly Galileo would not object to Descartes' stance that "the only principles which I accept, or require, in physics are those of geometry and pure mathematics; these principles explain all natural phenomena, and enable us to provide quite certain demonstrations regarding them." (*Principia*, IIP64)[68]

Nevertheless, when Descartes went back to the bookseller to pick up Galileo's *Discorsi* in 1638, his response, discernable in another letter to Mersenne, was an unqualified dismissal of the Italian philosopher's kinematic rationale. For Descartes,

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[68] In referencing the *Principia*, I will quote principles, following the convention for citing Spinoza's *Ethica*. II refers to Part II, P to Principle, and 64 for the principle number.

who had spent much of the two previous decades grappling with dynamics, Galileo's work was problematic for two fundamental reasons that partly echo the objections of Sagredo and Simplicio. First, it provides no account of causality — that is to say, it deals with motion in itself but not with the forces that cause motion. Second, Descartes considered the existence of a void both logically and physically impossible. For Descartes, the presence of force becomes a necessary condition that precludes thinking in terms of its absence. That is, in Cartesian physics, the autological appears as an included middle.

Descartes' universe was first coherently explicated in the principal part of *The World*, the "Treatise on Light." The book opens by conceiving, in effect, a general ontological difference. There is a difference, Descartes says, between the sensation we have of light, or between "the idea we form of it in our imagination through the intermediary of our eyes, and what it is in the objects that produces the sensation in us, that is, what it is in the flame or in the Sun that we term 'light'." (3) Logically, this difference enables Descartes to ask, employing the principle of reason, about the cause of our sensations. To ensure his starting point is taken in the most general way, he also offers an aural analogy replete with classical overtones:

> Do you think that, when we attend solely to the sound of words without attending to their signification, the idea of that sound which is formed in our thought is at all like the object that is the cause of it? A man opens his mouth, moves his tongue, and breathes out: I see nothing in all these actions which is in any way similar to the idea of the sound that they cause us to imagine. (4-5)[69]

In scholastic vocabulary, the general ontological difference that Descartes invokes is between the *vocal* and the *versal*, between utterance and meaning, or between voice and speech. Vocal is derived from voice and signifies an initiation of sound. Versal, a Latin word closely associated with text, often denoting ornate lettering, stands etymologically for 'turning'. The word 'versus' still carries this original sense of 'turned' (past participle of 'vertere') in the everyday sense of 'against' — as in, Galileo, 'turned' on or against Descartes. In other words, the general ontological difference between the vocal and the versal is that between a logic of initiation and a logic of turning — between a primary presence and a

[69] Incidentally, the third analogy Descartes uses is haptic. Even with touch, he says, there can be a difference between a physical sensation and what caused it. Example: a soldier on the battlefield has been injured, but has no recollection from the maelstrom of battle how it happened. Yet a doctor can still reason his way toward the likely cause.

secondary folding — between, as it were, the autological and the hypological.[70] The ostensible paradox of the principle of reason is that only through the logic of turning, through hypological enframing, could we express our understanding of the autological. Thus, what is in one frame a logical sequence — autology begets hypology — conceals its inverse relation — now hypology in order to grasp autology. Which quickly turns this relation, of thought to being, turning to initiation, into a swirling dance of mutally constitutive logical movements.

As a natural philosopher, it is the autological dimension of reality, what appears to act on us immediately, that Descartes wants to explain. Having distinguished it by general ontological difference in his opening chapter, he proceeds to argue that the phenomenal qualities of light can be explained in terms of motion. In the third chapter, he further argues that the generalized phenomenon of motion extends to all that we know as Nature, that is, the ever-changing realm of physics. Henceforth, pure mechanism. Descartes defines Nature in terms of a metaphysical supposition that closely resembles the traditional Aristotelian distinction between the changing and the unchanging:

> …By 'Nature' here I do not mean some deity or other sort of imaginary power. Rather, I use the word to signify matter itself, insofar as I am considering it taken together with the totality of qualities I have attributed to it, and on the condition that God continues to preserve it in the same way that He created it. For it necessarily follows from the mere fact that He continues to preserve it thus that there may be many changes in its parts that cannot, it seems to me, properly be attributed to the action of God, because this action never changes, and which I therefore attribute to Nature. The rules by which these changes take place I call the Laws of Nature. (25)

Here, Descartes' elegant analogical unraveling — moving from phenomenal sense perception to light to motion to all of Nature — encounters a puzzling ambiguity. God for Descartes is, in a traditional sense, the self-causing cause and thus the cause of Nature — that is, God is autological. Yet if the world we perceive

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[70] Giorgio Agamben analyzes such a difference in some detail in *Language and Death*, 1991 [1982]. He argues that this fracture in the field of being, between indication and signification, between showing and saying, "traverses the whole history of metaphysics, and without it, the ontological problem itself cannot be formulated. Every ontology (every metaphysics, but also every science that moves, whether consciously or not, in the field of metaphysics) presupposes the difference between indicating and saying, and is defined, precisely, as situated at the very limit between these two acts." (18) Agamben raises the ontological difference between what he calls Voice and speech to its apotheosis: "As it enacts the originary articulation of phone and logos through this double negativity, the dimension of the Voice constitutes the model according to which Western culture construes one of its own supreme problems: the relation and passage between nature and culture, between phusis and logos." (85)

is constituted by the diversity of motions whose changes, as Descartes puts it, cannot be properly attributed to God, does this make the pure presence of Nature — the starting point of his inquiry — autological in the same sense? Are the physical phenomena we call gravity or light, for example, to be considered as the action of God insofar as he preserves Nature or as the action of a constantly changing Nature insofar as God's action is not attributable to it? How do we account for God's presence, if not through Nature? Herein lies a foreshadowing of a deeper problem that Descartes will have to face in the wake of his character crisis. For now, however, Descartes' explication of *The World* abandons God and moves to his hypothesis, the three Laws of Nature, all of which are dynamical postulates. And contrary to Galileo, these laws are modeled on hydrostatics.

In statics, the paradigmatic instrument is the *equilibrium* — the scale or beam balance that will incline in one or other direction depending on the weight distributed on either side.[71] As a mechanist discourse, then, what statics most essentially measures is deviation from a constructed equilibrium, and this procedure has implications for the kind of questioning it enables. Logically, statics first defines a rest position, a degree zero, then a movement as an absolute difference from this initial position. We can see the principle of identity and the principle of reason here operating in tandem, as though in different directions. On the one hand, through the rest state of balance, identity is defined so that we may ask about the reason or cause of the motion. Thus through the principle of identity, we reinforce the classical, Aristotelian divide between motion and rest as absolute categories — at the pivot, either the scale is moving or it's not, one or zero.

On the other hand, what we find when we employ the principle of reason on this difference between rest and motion is not, strictly speaking, motion itself but rather the limit condition of motion, the point at which motion begins. In classical

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[71] Already a well-established domain, statics in the 17th century actually comprised two quite different traditions — one based on the Aristotelian *Mechanica*, which meant that it formed part of Aristotle's natural philosophy, and another based on the purely mathematical work of Archimedes, notably pursued in the early 17th century by Simon Stevin. In the Aristotelian tradition, the scale measurement works in terms of a proportionality between weight and speed. In the Archimedean tradition, by contrast, bodies on a beam balance are treated as points along a line according to their center of gravity — that is, their physics is transformed into a mathematical model. Galileo's early work had dabbled in Aristotelian statics by trying to abstract physics from it but eventually abandoned it and rather pursued kinematics. Descartes drew more closely on Archimedean statics by trying to reintroduce physics into the mathematical model. For the general situation discussed in this chapter, however, this internal division of statics has little significance. Serres' *Birth of Physics* treats hydrostatics in the Archimedean vein and its relation to vortical motion in poetic detail. Gaukroger's account in *Emergence* is more technically precise and leans more on the Aristotelian aspect.

thought, as well as in Descartes, this limit condition will be understood as tendency to motion. Force will now be conceived in terms of weight. Increase or decrease the weight, and the scale tends in either one or another direction. When we ask about why the scale moves or not, or why it moves in this case but not that, we are asking about force, about what is directly bearing, through its presence, on the identified difference. From the point of view of a hypological equilibrium, we are inquiring into the reasons for that which appears as autological, as cause of itself, that is, cause of the identity of equilibrium.

As Michel Serres puts it, in statics, "everything begins with balance, but on condition that it tilts." (20) The deviation from equilibrium, which is both the precondition and the object of statical analysis, is in this sense for Serres directly analogous to the principle of reason: nothing without reason, something always on the condition of something else. *Semper sic*.

> If things exist and if there is a world, they are displaced in relation to zero. And if there is a reason, it is this inclined proportion. If there is a science, it is its evaluation. If there is a discourse, it speaks of inclination. If there is a practice, it is its tool. We do not exist, do not speak and do not work, with reason, science or hands, except through and by this deviation from equilibrium. Everything is deviation from equilibrium, excepting Nothing. That is to say, Identity. (21)

Identity is the premise whose reason is in constant question, because identity, like a rest state, by principle occurs on the condition of something differing from it, something moving. It is in this sense that we also must understand the concept of equilibrium itself. By 'librium' we can readily grasp the notion of balance. But by 'equi' we do not mean sameness and therefore identity as oneness. Equality is never oneness other than through mathematical operations. If the sameness of equality was fundamental to statics, we could call the scale a 'uni-librium'. Rather, equi- signifies most properly a relation of difference, of more than one. The equilibrium posits a potential symmetry on account of deviation from the one, that is, on account of the asymmetrical.

Consequently, the ostensible tension between the autological tendency toward deviation in a system of equilibrium lies at the core of physics in *The World*. Descartes' model of dynamics thus determines his three Laws of Nature. The first law posits that "each particular part of matter always continues in the same state unless collision with others forces it to change its state." (25) The ostensible similarity between this law and Newton's law of inertia is limited to describing a generalized case of uniformity, for in Newton's case, inertia is derived from the absence of the force that Descartes is in fact attempting to describe. This becomes a bit clearer with the second law, which resembles a law of conservation: "when one of these bodies pushes another it cannot give the other any motion except by losing as much of its own motion at the same time; nor can it take away any of the other's motion unless its own is increased by the same amount." (27) Descartes, in other words, is trying to account for a universe in which the sum total of motions never changes. The differentiation of movement within this plenum, in which all parts of matter move and are moved by others, is then fully realized with the third law:

> when a body is moving, even if its motion most often takes place along a curved line… it can never make any movement that is not in some way circular. Nevertheless, each of its parts individually tends always to continue moving along a straight line. And so the action of these parts, that is, the inclination they have to move, is different from their motion. (29)

We find, in other words, a distinction, which will become more explicit in the *Principia*, that whereas the tendency toward motion is rectilinear, actual motion is always circular. That is to say, we are dealing with two mutually constitutive forces or tendencies derived by way of difference: one that strives to deviate from being kept in place by the other. Nature, insofar as it is experienced within itself, fundamentally operates in a circularity, whose constant change emerges in, as it were, a deviation from itself.

At this point, we could recognize some contours of the logical flip necessary to constitute the Newtonian universe. Whereas Descartes attempts to explain how straight motion is possible within an autological universe of force and circular motion, Newton rather inverts the problem and asks how force intervenes to turn kinematically straight movements back into the circular motion of the cosmos. This retroactive constitution of the problem is pivotal to making the universe quantifiable. But it comes with a strange discrepancy: the dimension of reality that is most intimately and immediately felt — that which we call gravity — is now conceptualized as an external and mysterious force acting at a distance. Left as a circumscribed constant that makes calculations work but which cannot be explained, gravity only becomes with Einstein's General Relativity more thoroughly integrated into the scientific universe. And then, as discussed in Act 2, the problem is simply shifted to a different level of explanation, reconstituted as the limit condition between relativity and quantum physics. Such is the case also with light, which neither Newton nor his successors can account for other than in exceptional terms. Its 20th century hypological constitution as a natural constant — speed in a vacuum — is a stabilization that belies, as we shall see in Act 4, its essential instability — at once particle and wave phenomenon — within the modern framework. Gravity and light, in other words, as expressions for the autological given, already constitute the limit conditions of Newton's kinematically derived dynamics and stand for the problematic kernel of modern physics on the whole. Their exclusion predicate the entire framework, and their subsequent inclusion causes its general instability.

Descartes' account of light and gravity, on the other hand, makes immanent sense to his model, because he has already defined matter autologically. The Cartesian universe is fundamentally mediated, as a chunky kind of soup — an infinitely extended substance within which we are lodged, a substance differentiated solely in terms of the different motions of its parts. In terms of light, it is now transmitted through extensive matter in what, after the work of Descartes' successor, Christiaan Huygens, will be thought of as waves. Descartes' considerable contributions to optics and the first phase of microscopic technological innovation owes much to his conception of light as a fundamental continuity. In terms of gravity, for Descartes, it cannot be conceptualized as a separable or abstract force but rather as a direct consequence of the pressure caused by the swirling nature of matter — a vortical gravity.

> I want you to consider what the weight of this Earth is, that is, what the force is that unites all its parts and makes them all tend toward the center, each more or less according to the extent of its size and solidity. This force is nothing but, and consists in nothing but, the parts of the small heaven which surround it turning much faster than its own parts about its center, and tending to move away with greater force from its center, and as a result pushing the parts of the Earth back toward its center. (47)

The hydrostatic influence on Descartes can here also be understood as an extension from the elemental quality of water, insofar as his universe is constituted by omnipervasive fluid matter, whose flux is the essential representation of the cosmic order. Descartes' essential idea of the world is perhaps most eloquently expressed in the later *Principia*, in a formulation that also clearly reveals his terrestrial analogy:

> The whole of the celestial matter in which the planets are located turns continuously like a vortex with the sun at its center… The parts of the vortex which are nearer the sun move more swiftly than the more distant parts, and… all the planets (including the earth) always stay surrounded by the same parts of celestial matter. This single supposition enables us to understand all the observed movements of the planets with great ease, without invoking any machinery. In a river there are various places where the water twists around on itself and forms a whirlpool. If there is flotsam on the water we see it carried around with the whirlpool, and in some cases we see it also rotating about its own center;

further, the bits which are nearer the center of the whirlpool complete a revolution more quickly; and finally, although such flotsam always has a circular motion, it scarcely ever describes a perfect circle but undergoes some longitudinal and latitudinal deviations. We can without any difficulty imagine all this happening in the same way in the case of the planets, and this single account explains all the planetary movements that we observe. (IIIP30)

The solar system, then, as flotsam in a whirlpool. This ability of Descartes' single account to explain planetary movements was certainly instrumental in mediating interest among his contemporary natural philosophers. The vortex theory of planetary motion, conceived by Descartes and developed by his disciples, soon became the dominant cosmology in the mid-17th century.[72]

Yet despite Descartes' many achievements in quantifying natural phenomena in the realm of practical mathematics, he could provide no such quantitative extension to his natural philosophical system as a whole. The dream of a *mathesis universalis* on his philosophical terms — as an alignment of the three theoretical sciences of Aristotle: physics, mathematics, and metaphysics — could not be actualized.[73] Gaukroger provides detailed analyses of some fundamental anomalies that appear when Descartes' postulates, especially his dynamical rules for collision, are worked out mathematically. In at least two sets of cases, Gaukroger concludes, the problems appear because Descartes' dynamics tended to use models from hydrostatics to provide the forces from which he then tried to fill out the kinematics necessary to constitute a complete dynamics.[74]

This [problem] arose, for example, where the kinematics that Descartes needed to resolve a question, and the statical concepts in terms of which he tried to pursue the resolution, were in conflict, so that when he should have been thinking (kinematically) in terms of inertia he was in fact thinking (statically) in terms of equilibrium, and when he should have been thinking (kinematically) in terms of how unequal bodies behave when they collide, he was actually thinking (statically) in terms of how unequal bodies behave when they are placed on a balance. (412-3)

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[72] A thorough account of the vortex theory and its historical rise and fall is provided by Aiton, 1972.

[73] As Gaukroger puts it, whereas Galileo's approach was to make physical questions amenable to mathematical treatment, "Descartes, by contrast, wants both to 'mathematize' physics and to 'physicalize' mathematics in one and the same operation. He does not simply want to use mathematics in physics, he wants to unify mathematics and physics in certain crucial respects." (1980: 97-8) For a close reading of Descartes' early project of universal mathematics, see Schuster in Gaukroger, ed., 1980, pp. 41-96.

[74] This analysis corresponds to what Martial Gueroult calls "an insoluble problem" in Cartesian physics, namely the relationship between forces. See Gueroult in Gaukroger, ed., 1980, pp. 196-229.

Although Gaukroger's analysis on the whole is thorough and convincing, its retrospective (or 'presentist') history is problematic for suggesting that the "right" way to develop an account of dynamics is a matter of what Descartes "should have been thinking" in order to become Newton — that is, turning Newtonian dynamics into an inevitable outcome. What must rather be emphasized is that Descartes could not think in terms of inertia of the Galilean kind because it was wholly alien to his metaphysics, in which everything is mediated and no kind of void is possible. Indeed, the two modes of mechanical thinking appear mutually exclusive: Descartes' "failure" to provide a thoroughly quantitative system hinges on the very same metaphysical idea of infinite extension, which made his system so qualitatively cogent in the first place.

As the kinematic case of Galileo indicates, in order to quantify something, we need both a discontinuity — that is, an identifiable difference — and a stable reference point. The concept of a particle, which was to become the foundation for Newton's dynamics, serves this function well, as does a notion of absolute space or time. But as we saw in Act 2, Einstein could make do with only a generalized principle of relativity derived from kinematics — enabling ratios and differential equations — and the invented concept of the speed of light in a vacuum as a referent. In the case of Descartes, he does find discontinuity in the "real, perfectly solid body, which uniformly fills the entire length, breadth, and depth of this great space" — the autological plenum with which his story begins. Conceptually, extension is indefinitely divisible into identifiably different parts through its immanent diversity of motions. Descartes' identification of extension as the essence of physical susbstance is thus designed to allow for geometrical, that is, mathematical treatment. However, when it comes to a stable reference, Descartes' physics in *The World* has only one — and it lies, as we have seen, ambiguously outside Nature: that is, God.

However God is defined, it makes for a poor mathematical constant. Operationally, we require something that exists within Nature, not outside it. After the condemnation of Galileo, Descartes was hard at work on this problem. Because he held back publication of *The World,* his natural-philosophical work therefore actually first appeared, essentially unchanged but arranged more systematically and succinctly, with the 1644 publication of the *Principia*, or *Principles of Philosophy*. Crucially, the physics of the *Principia* is preceded by a first part on 'the principles of human knowledge', explaining the relation between the human mind, nature and God in a manner that for Descartes reconciles a mathematical dynamics of the universe with the Church's ban on heliocentrism. As he puts it in a principle that determines the fundamental relativity of positions between bodies in the world,

> if we suppose that there are no… genuinely fixed points to be found in the universe (a supposition which will be shown below to be demonstrable) we shall conclude that nothing has a permanent place, except as determined by our thought. (IIP13)

A novel idea has emerged: thought as constitutive exception. In the course of the first eight principles of the *Principia*, Descartes establishes what now becomes an attempt, in Arendt's phrase, "to move the Archimedean point into man himself, to choose as ultimate point of reference the pattern of the human mind itself, which assures itself of reality and certainty within a framework of mathematical formulas which are its own products." (284) The discrepancy between the hypological and the autological, in other words, is now internalized, into the *cogito*. Descartes' first principle of human knowledge is that "the seeker after truth must, once in the course of his life, doubt everything, as far as possible" — an attempt at "freeing ourselves" from our preconceived opinions. (IP1) As in the case of Galileo's method, the world first needs to be removed. In Descartes' metaphysics, then, the autological once again becomes the excluded middle.

Under the second principle, the mental circumscription of the world is conceived: whatever can be doubted should be considered false. That is, thought independent of the world, thought without mediation, can be fundamentally bifurcated, into truth on the one hand and falsity on the other — or in the pervasive analogy throughout Descartes' work, light versus darkness.[75] Principles three, four, and five function as elaborations and qualifications for this stark procedure, arguing that while such doubting should not be attempted in the course of "ordinary life", in which we require our senses, it is precisely the senses that can deceive us and therefore warrant removal. What Descartes is building up is a *de facto* experiment, which he argues can be replicated by anyone. What the experiment first requires is analogical to the procedure of statics — a definition of rest state (everything in doubt), from which we can employ the principle of reason to infer the cause of our doubting.

However, for Descartes, the cause of our doubting has an identity. Presumably by the fact that we can choose to undertake such an experiment, Descartes

[75] In the *Meditations*, Descartes makes the relationship between light and darkness, clarity and confusion, even more explicit than in the *Principia*, where the analogy surfaces only in the explanatory texts of each principle.

deduces an important sixth principle: “We have free will.” The ‘fact’ of free will, Descartes argues, is what enables our doubting, for we can thus freely withhold our assent in potentially false matters. Given this freedom, and given the removal of the senses, through which a fundamental distinction between the true and the false can be made, Descartes famously concludes in his seventh principle of mind: “It is not possible for us to doubt that we exist while we are doubting; and this is the first thing we come to know when we philosophize in an orderly way.” To philosophize in an orderly way means, as we have seen, to first remove the mediation of our existence and, as a corollary, submit to the principle of identity. “For it is a contradiction,” Descartes warns, “to suppose that what thinks does not, at the very same time when it is thinking, exist.” (IP7) The essence of the cogito, in other words — “the natural light of our soul” — is that whatever is thinking must be understood, per identity, as a thinking thing. Logically speaking, the crucial hypothesis of Descartes’ procedure is therefore not the undeniable existence of thought in principle seven, but rather the conclusion of principle eight: “In this way we discover the distinction between soul and body, or between a thinking thing and a corporeal thing.” The explication of the principle follows:

> For if we, who are supposing that everything which is distinct from us is false, examine what we are, we see very clearly that neither extension nor shape nor local motion, nor anything of this kind which is attributable to a body, belongs to our nature, but that thought alone belongs to it. So our knowledge of our thought is prior to, and more certain than, our knowledge of any corporeal thing. (IP8)

The constitution of Descartes’ reasoning is revealed in that the first supposition — that we can remove ourselves from the world through an absolute division between truth and falsity — already implies the absolute distinction or division between mind and body. Indeed, in the French version of *Principia*, the supposition reads, “if we who are now thinking that there is nothing outside of our thought which truly is or exists…” Descartes, in other words, derives his conclusion from his hypothetical premise, both of which are constituted by appeal to the principle of identity.

Having clearly set up this new equilibrium between two identities, mind and body, Descartes now turns to the principle of reason to argue for the prior certainty of the mind, its natural light of truth. In principle 11, he says that

> we should notice something very well known by the natural light: nothingness possesses no attributes or qualities. It follows that, wherever we find some attributes or qualities, there is necessarily some thing or substance to be found for them to belong to;

and the more attributes we discover in the same thing or substance, the clearer is our knowledge of that substance. (IP11)

Nothingness has nothing, so there must be something. Nothing without reason — nothing has no reason — so insofar as we find something, this something clearly belongs to an identified thing. There is a deft logical interplay at work throughout Descartes' text, in which the principle of reason is always employed in the service of an ultimate identity. And this is how Descartes now approaches the problem of substance itself. For if the mind can come to know itself as a thinking thing, distinguished from the world as a corporeal thing, how do we know that this certainty is not merely a mental delusion? In principle 13, he concedes that knowledge of things "depends on the knowledge of God": "the possession of certain knowledge will not be possible until it has come to know the author of its being." But God can be ascertained, he argues in principle 14, from the fact that in the mind "there is one idea — the idea of a supremely intelligent, supremely powerful and supremely perfect being — which stands out from all the others." This is the idea of necessary existence, that which must exist in order for anything else to exist. What is this necessary existence? Logically, a postulate of the principle of reason — nothing is without reason — determined by the principle of identity. For Descartes is very clear that God as the necessary reason for existence is a being, or most properly, a thing, the Thing of all things. And insofar as God is both the necessary reason for our thought and for that which we distinguish as matter, this Thing of things is the constitutive relation for our knowledge of the world.

Thus, the search for a proper grounding of his natural philosophy takes Descartes in two simultaneous directions — a double movement between mind and God on the one hand and God and matter on the other. The stable referent for Descartes' autological universe is now constituted by looping together God and the human mind, through which Nature is conceived within human grasp. That is, whereas Galileo, and Newton by extension, could effectively predicate the project of a mathematical physics on the invention of a void within the field of inquiry itself, Descartes obliges us to conceive his project metaphysically, by recourse to theology on the one hand and epistemology on the other, in a mutually reinforcing framework.

However, in order for theology and epistemology to properly reinforce one another, the constitutive relation between God and Nature must be of a certain configuration. In the *Principia*, as Descartes moves from the individual mind in doubt to the conditions for mind to know with certainty, his alignment with scholastic discourse finally brings him to the concept of substance.

> By *substance* we can understand nothing other than a thing which exists in such a way as to depend on no other thing for its existence. And there is only one substance which can be understood to depend on no other thing whatsoever, namely God. In the case of all other substances [i.e.. mind and body], we perceive that they can exist only with the help of God's concurrence. Hence the term 'substance' does not apply *univocally*, as they say in the Schools, to God and to other things; that is, there is no distinctly intelligible meaning of the term which is common to God and his creatures. (IP51)

Within the discourse to which Descartes here refers, this relation between God and Nature is therefore defined as *equivocal*. As explained, 'equi' most properly signifies a relation of difference, of more than one, and 'vocal' signifies initiation, primary utterance. That is, God as autological being is said in a different sense than that of his creation — or put differently, nothing can be said of Nature or of a creature in Nature that is simultaneously said of God in the same sense. Pivotally, then, the equivocal logical relation expresses an absolute distinction between creating and created substance. In turn, this means that created substance is unified under the concept of "things that need only the concurrence of God in order to exist." So even though mind and body for Descartes are distinct substances, they are unified, identified as one, in their turning, that is, in their constitutive relation to God.

Effectively, like the logic of initiation in relation to its turning — the vocal in relation to the versal — this conceptual unification constitutes the Cartesian concept of the universe. As with equivocity and univocity, the concept of the universal is implicated in a complex history leading up to the 17th century, involved in century-long scholastic arguments on, among other things, nominalism versus realism. Yet for all the nuances of this history and the various meanings these concepts take on, the universe that we find in Descartes — like the universe of Newton — is defined as universal in a whole new sense. A universal mathematical physics is possible, Descartes argues, because the mind is in such a privileged position that it can, insofar as it "reasons in an orderly way" — that is, on account of the hypological *cogito* — clearly perceive the attribute of extension, that is, the nature of matter. The mind, in other words, is like a calm eye in the storm, a fixed Archimedean point within the relentless vortex of Nature that can grasp the movement surrounding it without itself being carried away.

The crux of Descartes' universe is this absolute difference that is nonetheless a unified grasping — like a plane of mind perfectly aligned with a plane of extension, or thought extending itself to extension — explicitly occuring on the condition of an equivocal relation between God and Nature. *Equivocity* becomes the necessary condition for *universality*. In Descartes, the concept of the universe is a direct logical consequence of the configuration of God and Nature. Or to put it differently, the scientific universe follows from the logical structure of the Christian doctrine of creation: the creator-being separated from the being of creation, the theological distinct from the ontological.[76] The principle of reason submitted to the rule of identity.

In the case of Descartes, his constrained balancing act between the dictates of his reason and his faith produces a cleverly compromised solution in his account of whether, as Galileo so heretically held, the earth moves or not. In establishing that the whole universe is a vortex of motion from which the Earth could not be excepted, Descartes nonetheless argues that the earth itself, strictly speaking, cannot be said to move, only the heavens. To say that the earth moves is an improper way of speaking, "rather like the way in which we may sometimes say that passengers asleep on a ferry 'move' from Calais to Dover, because the ship takes them there." (IIIP28-9) Thus, Descartes' *Principia* concludes in characteristically sly deference. Although his reasoning, he says, is of "absolute certainty," insofar as it rests "on a metaphysical foundation, namely that God is supremely good and in no way a deceiver," nevertheless — "mindful of my own weakness, I make no firm pronouncements, but submit all these opinions to the authority of the Catholic Church…" (IVP206-7)

Although the Galilean-Newtonian route to dynamics veers methodologically from Descartes' path, their overturning of Aristotelian natural philosophy nonetheless makes them close kins in the emergence of the modern scientific universe. Their difference can perhaps be described as the mathematical universe versus universal mathematics. In the ensuing divergence of natural philosophy through the 18th and 19th centuries, into philosophy on the one hand and science on the other, the Cartesian and the Galilean-Newtonian inventions will turn out to be mutually reinforcing legitimations. Read against each other, whereas Newton explains the mathematization of the physical universe, Descartes explains the universal grounding of this mathematization in thought. Both accounts of

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[76] For a concise philosophical argument on the direct implication of the Christian doctrine of creation for the possibility of a science on the modern model, see Michael B. Foster's articles from the 1930s, collected in Wybrow.

universality rely on God as the equivocal author of the universe. And both accounts rely on the constitutive circumscription of the autological. Whereas Galileo excludes mediation in physics through the void, Descartes excludes it in metaphysics through the cogito, making their universe, strictly speaking, a hypological constitution. In other words, both Galileo and Descartes can thus be said to mutually constitute a universe that turns the autological inside-out — a universe that becomes, in Hegel's famous phrase, "the inverted world."

Thus, when Heidegger, as we saw in Act 2, muses about ontological difference as the basis for a science of the inverted world, he is in our terms here rather arguing for an inversion of an inverted world, a re-inversion — effecting a return to the world of being that modern science and epistemology has circumscribed. In a sense, Heidegger wants to put the autological back into thought, even if the autological precisely marks the limit condition of thought itself, where thinking must submit itself to conceptions like ontological difference that mark a cut within being. Such a geometrical folding of thought is precisely what leads us to Spinoza.

4. Spinoza's Voice

For Spinoza the lens-grinder, as for Descartes the optical theorist, the presence of light bespeaks God most clearly and distinctly. But in Spinoza's *Ethica*, published posthumously in 1677, it does so in a very different sense than Descartes' ontological bifurcation of light and darkness, truth and falsity. Says Spinoza: "As the light makes both itself and the darkness plain, so truth is the standard both of itself and of the false." (IIP43S) In one turn of phrase, Descartes' world premise is turned inside-out, his ontological bifurcation turned into unity. Light not as the opposite of darkness but rather its condition. In the metaphysics of light, as the autological limit condition of the world, stands exposed two different world configurations, like positive and negative images of each other.

The passage from Descartes to Spinoza thus goes from the inverted world of universal mathematics to its logical re-inversion through the autological as thoroughly included middle. This turning is clearly reflected in the relationship between the *Principia* and the *Ethica*. On the surface, the works appear similar in construction and in categories, as both adopt the style of explicated principles, logically following from another "in an orderly way," draped in a scholastic vocabulary of substance, attributes and modes. Yet upon closer reading, Spinoza's "geometrical exposition" of metaphysics appears almost in jest of Descartes, for the *Ethica* reads like an inverted *Principia*, in structure as well as in idea. Whereas Descartes begins with the individual thinker and then reasons his way toward God and Nature, Spinoza begins with God and reasons his way to the individual thinker in Nature. And whereas Descartes' individual is a lonesome doubter in self-imposed isolation from the world, Spinoza's individual finds itself embedded in a culture where other individuals are constantly affecting and being affected by one another in multiple ways.

In the text, Spinoza's inversion of Descartes becomes discernable from the very first definition, which is that of the autological itself. "By cause of itself I understand that whose essence involves existence, or that whose nature cannot be conceived except as existing." (ID1)[77] A following definition elaborates: "By substance I understand what is in itself and is conceived through itself, that is, that whose concept does not require the concept of another thing, from which it must be formed." (ID3) *Causa sui* and substance are thus aligned: substance is the concept for that which is not determined by, or caused by, any other concept, and therefore is cause of itself. This means two things for the autological: first, that the logic of substance is that of an active presence, an existence, and second, that it cannot be conceived in any other way, by any other concepts, through any kind of determination. In other words, the autological is not governed by the principle of identity — it is not, as Descartes explicitly put it, a thing. What Spinoza rather is trying to define is a limit condition — "that which does not require the concept of another thing" — governed by the principle of reason. Because it is not determined by identity, the autological is in a subsequent definition further aligned with God as "absolutely infinite" substance. Causality equals substance equals God.

In turn, these definitions of the autological, in which the principle of reason overdetermines the principle of identity, provide Spinoza with his general concept of causality. In the first definition of the *causa sui*, we see that essence and existence are aligned. This marks a constitutive exception, because subsequently, Spinoza will say that the essence of something — a man or a thing — is not its existence, "that is, from the order of Nature it can happen equally that this or that man does exist, or that he does not exist." (IIA1) "For example," Spinoza argues, "a

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[77] Following convention, I reference Spinoza by book number and principle number. D is for definition, A for axiom, S for scholium, C for corollary. Thus, ID1 equals book one, definition one.

man is the cause of existence of another man, but not of his essence, for the latter is an eternal truth. Hence, they can agree entirely according to their essence. But in existing they must differ." (IP17) The 'eternal truth' of essence can be logically grasped by seeing that "to the essence of any thing belongs that which, being given, the thing is necessarily posited and which, being taken away, the thing is necessarily taken away." (IID2) What is essential about any thing, in other words, is not any identifiable form, but rather how it is connected or caused or determined by any other thing to be a thing in the first place.

In Heidegger's distinction from Act 2, essence for Spinoza concerns the 'belonging' of belonging together. 'Onto-theologically' speaking, essence thus speaks to a theological dimension, differentiated from the ontological dimension of what things are, that is, their existence. Simultaneously general and generative, the ontological difference is for Spinoza essentially productive, because it equals what we would call efficient causality.[78] The divergence between essence and existence is what determines, in accordance with the principle of reason, something to be the cause of something else. In this sense, God is not the infinite creator of everything. Rather, God is a name for that which determines a cause to have an effect. God is the apotheosis of the principle of reason — the Principle of Necessary Reason. Contrary to Descartes' creator-God constituted by the principle of identity, then, Spinoza's God is mediated by the principle of reason. Thus Spinoza will say, in a turn of phrase often repeated through the *Ethica*:

> The idea of a singular thing which actually exists has God for a cause not insofar as he is infinite, but insofar as he is considered to be affected by another idea of a singular thing which actually exists; and of this God is also the cause, insofar as he is affected by another, and so on, to infinity. (IIP9)

In other words, for Spinoza, God is the essence and existence of the self-causing, the autological, which determines not things or beings in terms of their existence but in terms of their essence. That is, God does not create — rather, God determines how things or beings are related and thus become what we perceive them to be, as individuated.

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[78] This point is also emphasized by Gilles Deleuze: "Traditionally, the notion of cause of itself was employed with many precautions, by analogy with efficient causality (cause of a distinct effect), hence in a merely derivative sense; cause of itself would thus mean 'as if by a cause'. Spinoza overturns this tradition, making cause of itself the archetype of all causality, its originative and exhaustive meaning." Deleuze, 1988 [1970], p. 53.

Crucially, this sense of relation or belonging that essence bespeaks is not merely some external arrangement of passively existing things. Rather, it is double, for essence is also intrinsic to how a thing exists — that is, its 'conatus' or striving. As Spinoza argues, "the striving by which each thing strives to persevere in its being is nothing but the actual essence of the thing." (IIIP7) We note again a determination by the principle of reason, in that the essence of a thing is not itself a thing. Rather, the essence is a striving — a tendency, that is, a limit condition in the statical sense. If we conceive of how a thing is a thing, then, we must attribute both its 'external' relation to all other things — its causal chain of determination — and its 'internal' striving to persevere in this relation as simultaneous expressions of the same essence. The thing may be considered passive in that it is acted upon and determined by other things, but it is nonetheless active insofar as it maintains its determination, that is, insofar as it is mediated to exist in this way rather than that. The striving tendency of the conatus thus expresses an autological dimension of every thing and being: the logic by which it posits itself as a self-existing thing. And by this autological striving, it relates or belongs to all other things insofar as they are causally determined in the same way — that is, determined by their essence that is the self-causing causality Spinoza calls God.

Thus, Spinoza's scheme appears paradoxical: we exist on account of the general ontological difference between the ontological and theological — but from the point of view of self-causing substance, the theological equals the ontological. Two mutually constitutive perspectives thus coincide in the same conceptual alignment. From a hypological perspective, God is the constitutive exception, the deviation from equilibrium. From an autological perspective, God is the logic of mediation itself.

Consequently, we find the first part of the *Ethica* devoted to reasoning against the Christian conception of equivocal substance.[79] From his definitional premise, Spinoza derives the only logically coherent argument, that there cannot be more than one substance. If there were several substances, as in Descartes, their relationship would have to be determinate, meaning that the determined substances are not really substances at all, for they would not then be cause of themselves but of others. And if there is only one substance, there cannot be any difference in sense between creator and created. That is, the relation between God

[79] On the coherence of the first 15 principles in Spinoza, see in particular Deleuze's article on Gueroult's structural analysis of Spinoza (Gueroult's voluminous work has not been translated to English). *Desert Islands*, pp. 146-155.

and Nature is *univocal* — God is said in the same sense of 'himself' and his beings. Here, the uni- of univocal is an indicative prefix only, since the logic of initiation cannot be turned into oneness in a mathematical sense.[80] In fact, from Spinoza's perspective, it would be enough to say that God is vocal, that is, Voice itself, for it implies the same kind of necessary unity. "Whatever is, is in God, and nothing can be or be conceived without God." (IP15) Which means that "God is the immanent, not the transitive, cause of all things." (IP18) And in turn, this means that God is another name for Nature. Such is the heretical crux that inverts the hegemonic configuration of Christian theology and modern science: *Deus sive Natura* — God, that is, Nature. Theo, that is, onto, constituted by ontological difference.

As emergent from this productive difference — indeed, as expressive of this difference through the striving of our being — how do we stand toward Nature? In an early definition of part one, Spinoza has precluded immediate knowledge of substance, because this would mean that we, as finite human beings, have infinite knowledge, which is, as he would put it, 'absurd.' Rather, we can know substance in existence through its modes or in essence through its attributes. A mode is "the affections of a substance," that is, any expression of causal determination in the world. A scale tipping in one or another direction is a mode of substance, as is the hand placing a weight on it, as is the weight itself, insofar as these all manifestly involve change. An attribute, on the other hand, is "what the intellect perceives of a substance, as constituting its essence" — that is, its unchanging nature (ID4). Spinoza argues that, although in principle substance has infinite attributes, we can only know the two that Descartes claimed as indefinite substances in their own right — mind and body. Like Descartes, Spinoza defines mind in terms of thought, or ideas, and body in terms of extension. Yet, as we would now expect, his explication of the mind-body relation in part two of the *Ethica* essentially inverts the Cartesian doctrine.

Whereas Descartes' famous seventh principle of mind is, I think therefore I am, Spinoza's seventh principle of mind is no less pivotal to his own metaphysical configuration: "The order and connection of ideas is the same as the order and connection of things." This ostensible isomorphism follows from the principle of reason: if there must be a cause for every effect, as determined by the necessary

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[80] French philosopher Pierre Macherey is therefore quite correct in observing that God in Spinoza's philosophy "is not 'one', any more than he is two or three, or that he is beautiful or ugly. Contrary to a tenacious tradition, it must be said that Spinoza was no more a monist than he was a dualist, or a representative of any other number that one wants to assign to this fiction..." See Macherey in Montag, ed., p. 88.

existence of univocal substance, then insofar as mind and body are attributes of this same substance, their order must essentially be the same. In the scholium of the same principle, Spinoza elaborates:

> a mode of extension and the idea of that mode are one and the same thing, but expressed in two ways… For example, a circle existing in Nature and the idea of the existing circle, which is also in God, are one and the same thing, which is explained through different attributes. Therefore, whether we conceive Nature under the attribute of extension, or under the attribute of thought, or under any other attribute, we shall find one and the same order, or one and the same connection of causes, that is, that the same things follow one another. (IIP7S)

Two common misunderstandings easily follow, both constituted by letting the principle of identity overrule the governing principle of reason in Spinoza's thought. The first is to consider mind and body, insofar as they are two different attributes of the same substance, as independent of one another — as though the circle and the idea of the circle are two wholly different things. The second is to place the attributes themselves in a relation of accord, of identity — as though the presence of the circle guarantees the simultaneous presence of the idea of the circle, or that one contains the other, or that the two modes can be directly compared. Rather, their sameness in order and connection is a feature of their essence, that is, it follows from the nature of substance. The attributes themselves, Spinoza argues, are strictly incomparable and reciprocally irreducible. They do not stand in any extrinsic relation of homology or correspondence but each is rather identical only to itself insofar as it includes everything under itself.[81] Contrary to Descartes, there is no 'interaction' between mind and body, other than in their necessary relation determined by substance. Thus, the mind-body problem that riddles modern philosophy of science does not exist in Spinoza.

However, if mind cannot grasp body in a relation of independence, or stand to body in a relation of symmetry, what happens to the concept of the universe? To better understand this pivotal implication, we first have to look more closely at Spinoza's inverted order of knowledge. As a point of differentiation, let us consider Spinoza's reenactment of the experimental Cartesian *cogito* — the mind affirming the existence of its own thinking. From Spinoza's perspective, "the first thing which

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[81] Macherey puts it succinctly: "To understand the nature of the attributes is precisely to rule out considering them term by term, so as to compare them… it is one and the same order, one and the same connection carried out in all the attributes, and that identically constitutes them in their being: substance is precisely nothing but this unique necessity that is expressed simultaneously in an infinity of forms." Ibid., 89-90.

constitutes the actual being of a human mind is nothing but the idea of a singular thing which actually exists." (IIP11) This singular, actually existing thing is expressly not the cogito. Rather: "The object of the idea constituting the human mind is the body." (IIP13) In other words, Descartes' idea of his own thinking affirms nothing but the existence of that from which he believed his mind to be independent. Instead, his thought is affected as his body is affected, in the same order and connection: "The human mind does not know the human body itself, nor does it know that it exists, except through ideas of affections by which the body is affected." (IIP19) From the perspective of univocal substance, mind and body appear symmetrical in that they constitute the same order and connection — that is, they are the same in essence, in how they belong to one another. But from the perspective of the existence of the individual mind, the mind is dependent on the body — thus, their relation is asymmetrical. As Spinoza puts it, "the present existence of our mind depends only on this, that the mind involves the actual existence of the body." (IIIP11S)

In later interpretations, this bodily dependence is often taken as the materialist basis of Spinoza's thought, heralded in stark contrast to Descartes' idealist conception of the mind as an Archimedean point. As such, it is true — yet to call Spinoza a materialist betrays a limited perspective that conceals a critical complication of the mind. For just as an idea is the idea of the body insofar as it is affected, there is also in the mind an idea of this idea — thought thinking itself — and it too is related to the mind in the same way, that is, by the same order and connection, as the mind is related to the body. This does not mean that the thinking of thinking is its own attribute — rather, it is a mode of the attribute of thought. As Spinoza puts it, "the idea of the mind, that is, the idea of the idea, is nothing but the form of the idea insofar as this is considered as a mode of thinking without relation to the object." (IIP21S) In other words, at work here is a mental doubling, which ensures that "the human mind perceives not only the affections of the body, but also the ideas of these affections." (IIP22) That is, thought is asymmetrically related to the body insofar as it depends on the body for its existence, and through this asymmetry, thought is doubled on itself.

Thus, in the asymmetrical doubling of Spinoza's mind, we encounter the emergence of the differentiation between the autological and the hypological. Insofar as thought is the idea of the body as it is affected, both mind and body are in this sense autological — they emerge out of the plenitude of affections of the same substance, in the same order and connection. But insofar as the idea of the idea is "a mode of thinking without relation to the object", it thus gives rise to a turning, to the possible inversion of the autological. Spinoza's subsequent principle states, "the mind does not know itself, except insofar as it perceives the ideas of the affections of the body." (IIP23) For Descartes, as we have seen, the mind knows itself better than it knows the body — but in Spinoza's terms, what Descartes claims to know is not the idea as bodily affection but the idea of this idea — thought turned against the thought of bodily affections. Once this idea of the idea — e.g. that the mind is independent of body, or that man is a category of being — is turned into a common notion, that is, constituted by the principle of identity, it is also turned into a possible foundation for thought. It becomes hypological. Thought thinks itself, without relation to its constitutive affections. It thinks, hypologically.

A paradoxical God thus implies a paradoxical reason: logic turning on its mediation to mediate itself. Spinoza is concerned with delineating this process of thought, as he finds himself refuting widely held ideas of things that are considered 'universals,' such as the Christian (and Cartesian) freedom of the will. From Spinoza's perspective, universals are really "metaphysical beings," formed from that which the body encounters and, through the idea of these affections, turned into something without relation to the object. Thus, such hypological notions, he says, tend to be "confused in the highest degree. Those notions they call *Universal*, like Man, Horse, Dog and the like" all derive from the limited capacity of the body and the ideas of its affections:

> For the body has been affected most forcefully by what is common, since each singular has affected it. And the mind expresses this by the word *man*, and predicates it of infinitely many singulars… But it should be noted that these notions are not formed by all in the same way, but vary from one to another, in accordance with what the body has more often been affected by, and what the mind imagines or recollects more easily.

Thus, Spinoza says, "each will form universal images of things according to the disposition of his body." (IIP40S1) In this sense, the disposition of the body, that is, its affections, constitute the limit condition of reason. Plainly, there is nothing about the structure of the human mind or its relation to the body that guarantees clear and distinct ideas. On the contrary, due to the dependence on the affects, the tendency of the mind would rather be toward the "mutilated and confused knowledge" that arises from encounters with singular things, from signs, opinion and imagination. As the basis for belief, this is generally what Spinoza refers to as the "first kind of knowledge," the inadequate knowledge that easily leads us astray, or lets us be determined by the forces acting upon us — in a word, our "human bondage." Because we can never speak without affection, because we are always 'bound,' we are precluded from actually attaining universal knowledge.

Nevertheless, Spinoza posits, “there are certain ideas or notions common to all men” that makes us capable of having “adequate ideas of the properties of things.” This argument, which establishes what Spinoza calls reason, “the second kind of knowledge,” is expressly demonstrated from physics. And here he directly follows Descartes’ autological physics, without inversion. For Spinoza, from the mechanist premise that motion is common to all things and is equally in the part and in the whole — that is, in singular things as much as in the world overall — we must submit that “all bodies agree in certain things, which must be perceived adequately, or clearly and distinctly, by all.” (IIP38C) By adequate, Spinoza understands “an idea which, insofar as it is considered in itself, without relation to an object, has all the properties, or intrinsic denomination of a true idea… I say intrinsic to exclude what is extrinsic, namely, the agreement of the idea with its object.” (IID4) In other words, an adequate idea, such as the universe, is precisely hypological, constituted by the principle of identity, because it is conceived without relation to an object. It is movement grasped through statics, through the absolute difference between motion and rest as constituted by the equilibrium. Adequate ideas of reason are thus divided from their essence, that is, their connection to other things insofar as they are causally or autologically determined.

Beyond reason as second knowledge, Spinoza argues for a third — intuitive knowledge. Intuition is distinct from reason insofar as “this kind of knowledge proceeds from an adequate idea of the formal essence of certain attributes of God” — that is, from the kind of reasoning that grasps thought and extension as the essence of mind and body — “to the adequate knowledge of the essence of things.” To have adequate knowledge of the essence of things means to understand the idea of God, or Nature, under the principle of reason, as a self-causal determination for which everything in the world is an expression. In other words, the passage from reason to intuition as a ‘higher’ kind of knowledge involves belief. In fact, it reinvolves the belief of first knowledge, the affects, through its differentiation from reason. Now, this is coherently expressed as belief in God, or Nature, as the axiomatic connecting principle of all things for which reason only provides us with limited, hypological knowledge. In Heidegger’s terms, the metaphysical passage goes from the ontological as the ground of all things — grasped by reason — to the theological as the whole of all things — grasped by intuition. As Spinoza lays it out, through intuition, we finally comprehend two simultaneous truths. On the one hand, the ontological and the theological, or existence and essence, are one and the same in substance. On the other hand, the differentiation of the ontological and the theological in our encounter with the world is the cause of all things. The ostensible contradiction between these two "essential truths" is resolved by the fact that God, or Nature, is not constituted by the principle of identity, but rather is an alignment through the principle of reason.

As with all ostensible hierarchies, the three kinds of knowledge connote a sense of continual refinement, from the bottom snake pit of affective knowledge to the elevation of reason, and further onto some paramount idea of God, which allows us what Spinoza calls freedom and the highest blessedness of the mind. In form, this appears as yet another paean to the divinity of human knowledge. Nevertheless, if we follow the logical differentiation of these three kinds of knowledge in Spinoza, the picture that emerges is precisely the inverse of a linear progression. The first kind of knowledge, insofar as it is affective and thus emerging from the constant force of things pressing on other things, from the self-positing insistence of the world, is autological in nature. The second kind of knowledge, logically corresponding to the difference between the minds' affections (that is, the idea of the body) and the idea of these affections, emerges as a turning from the autological — the hypological constitution of reason. As we have seen, when the idea of the idea turns away from its autological object, that is, the affections of the body, it takes the principle of identity as its fundamental metaphysical axis. What happens with the differentiation to the third kind of knowledge is not some further refinement of reason, but rather the overturning of hypological reason against the autological difference from which it sprang. In this sense, intuition as the third kind of knowledge emerges as a logical grasping of the auto-hypo discrepancy. In Spinoza, this loop takes the distinctive form of a questioning of the reason for reason, by the principle of reason. Intuition does not remove itself from the autological, but rather cycles back through it by its differentiation from hypological reason. The linear hierarchy, in other words, is more like a circular folding — from level one to level two and back through their difference to a level three in which they all become aligned in mutual participation.

Thus, the discrepancy between the hypological and the autological, which in Galileo is external to nature, and which in Descartes is internal to the mind, becomes in Spinoza reflected into the conception of God as such, that is, it becomes internal to Nature. The autological is the included middle — and this is precisely the condition that makes the modern scientific universe impossible.

In the fifth and final part of the *Ethica*, this becomes particularly evident. Here, Spinoza defines human freedom and the ability to form clear and distinct ideas of the essence of things in relative rather than absolute terms. Such is Spinoza at his most joyfully empowering: “Each of us has — in part, at least, if not absolutely — the power to understand himself and his affects, and consequently, the power to bring it about that he is less acted on by them.” (VP4S) Or as a subsequent principle puts it: “So long as we are not torn by affects contrary to our nature, we have the power of ordering and connecting the affections of the body according to the order of the intellect.” (VP10) Yet it necessarily belongs to Spinoza’s perspective on the human condition that we can never have any certainty of whether we are not in some way “torn by affects contrary to our nature.” In fact, without the intuitive alignment of our thinking with our affects through a principle of necessary reason, Spinoza’s world — as we shall see in the final section — is rather governed by a kind of constitutive uncertainty, against which reason alone is no guarantee. Which is to say, as Spinoza puts it most essentially against Descartes, light is both the condition of darkness and itself.

In turn, the analogy with truth sheds light on some political implications of Spinoza’s logic. If truth is the standard both of itself and the false, this means that “all ideas, insofar as they are related to God” — that is, insofar as they are expression of the same substance — “are true.” (IIP32) Contrary to Descartes’ initial division of the world into truth and falsity, “there is nothing positive in ideas on account of which they are called false.” (IIP33) From the perspective of reason, this comes with the rather perplexing insight that truth is mediated by belief. If today’s prevailing debates on realism and anti-realism turn on the question of whether there are some statements about nature that are really true, or only relatively true, or that there is no such thing as truth, Spinoza rather argues that, as a matter of principle, everything considered in itself is true. In this sense, he is simultaneously the opposite of a relativist and a foundationalist. Here is Descartes’ cogito of reason turned into a principle of faith: “He who has a true idea,” Spinoza says, “at the same time knows he has a true idea, and cannot doubt the truth of the thing.” (IIP43) In the same way, a believer of something believes it because he believes it, with or against external verification. Generally speaking, we argue, justify, and demonstrate not in order to find the right belief, but rather, belief is the initial spur in the turning that becomes our arguments, justifications, and demonstrations. Thus, the relationship between believing and knowing is analogous to the difference between the logics of initiation and turning. The role of the third kind of knowledge is, as an overturning of reason’s difference from itself, to align belief and reason in such a way as to make knowledge intuitive. That is, by way of the logical circuit of intuition, we immediately discover what we always already knew.

If reason is mediated by belief, how can we distinguish between true and false conceptions in science? Crucially, for Spinoza, since there is no positive, extrinsic criterion of falsity, the distinction between truth and falsity is rather intrinsic to scientific practice. That is, the distinction of truth and thus its constitution, is a matter of power. Spinoza's work, in other words, coheres with Stengers' picture of the political dimension of the sciences in Act 1. Here, interest for truth claims must be mediated and mobilized among rivals and divergent actors whose own ideas, insofar as they are autologically derived expressions, that is, conditioned by their belief in the hypotheses, are in principle as true as any other. Their falsity will be established secondarily, in accordance with prevailing criteria for making history — that is, as we put it in Act 2, criteria that have succeeded in the hypological constitution of truth.

On the whole, then, Spinoza's theory of knowledge is predicated on the insight that thought always occurs on the condition of something different than itself — and that it is itself therefore differentiated. *Semper sic*. Whereas Descartes' equivocal God guarantees the human mind its independence by which it can have universal knowledge of the world — in other words, that equivocity implies universality — we find through our textual encounter with Spinoza the inverse conclusion, namely that a univocal God implies a conditional knowledge, what I will call *equiversal* knowledge.

The logical argument for equiversality is mediated by the principle of general ontological difference, which we identified in Chapter 2. Insofar as there is a difference between voice and speech, between initiation and turning, that is, between the *vocal* and the *versal*, this difference can be marked by the indicative prefixes of *uni-*, one, and *equi-*, different than one. By general ontological difference, these dimensions are mutually implicated, meaning that we cannot have, for example, a univocal universality, because this would precisely efface the signifier of ontological difference. Rather, we can have an equivocal universality, as in Descartes, Newton and modern science in general, or in its inverse form, as Spinoza shows us, a univocal equiversality. In this difference, where we put the relation of difference, the equi-, makes all the difference. Equivocal universality means, by the *a priori* differentiation of God from Nature, that knowledge of Nature can be universally grasped. Univocal equiversality means, by the *a priori* alignment of God and Nature, that knowledge of Nature can be equiversally grasped, that is, on account of its own conditions for emergence.

Ultimately, Spinoza's inversion of Descartes conjures up an image of thought for the emergent modern world. Insofar as the order and connection of things and ideas are the same, and insofar as an autological physics grounds a claim to reason, then Spinoza's mind is itself a vortex. Constantly swirling in various directions by the diversity of thoughts affecting it — now inclining with affective joy, now declining with affective sadness — but always in propulsion from the striving, the conatus, the autological that constitutes its essence, the mind only finds relative stability and calm within the constant presence of potential turbulence. For Spinoza, to seek blessedness of mind, that is, to discover human freedom, is precisely to act in such a way as to spin along with the forces acting upon us, to streamline ideal momentum, to mitigate mental turbulence, to keep thinking from imploding on itself, from being sucked into the maelstrom whose existence continually threatens the life of the mind.

Perhaps this is something like the sense that Heidegger gives thought when he quips: "Philosophy is the opposite of all comfort and assurance. It is turbulence, the turbulence into which man is spun, so as in this way alone to comprehend existence without delusion."[82] After all, it is the same Spinozist principle, that the order and connection of things and ideas is the same, that enables the inverted scientist to engage in analysis of the differential relations between ideas and their logical constitution.

Thus, in the passage from Galileo to Descartes on the one hand, and Descartes to Spinoza on the other, we come to see the onto-theological constitution of metaphysics expressed as two mutually exclusive modes of thinking. Whereas the constitutive exclusion of the autological makes the universe as conceived by Galileo and Newton a resolutely quantitative realm, Spinoza's thorough integration of the autological produces an 'equiverse' that is utterly qualitative. Featuring neither a void nor a stable referent — even worse, revealing the hypological constitution of so-called universal notions — Spinoza's autological thought becomes not only heretical to the predominant idea of biblical revelation, but also dangerous to the emergent natural philosophical project of universality. With the relative obscurity of Spinoza to modern philosophy of science, the autological too disappears from modern thought. Autology becomes, as Heidegger would later say of Being, forgotten — in spite of, or perhaps precisely due to, its immediate self-evidence.

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[82] In Heidegger, 1995, p. 19.

5. Beyond the Principle of Reason

In our retrospective history of the late 17th century as the early consolidation of a new scientific culture in Western Europe, it is Descartes, despite his brief period of influence, whose ultimate fate is most tragic. In his attempt to overturn the metaphysics of the Aristotelian order, Descartes showed ambitions that were too Aristotelian for the new science. On the one hand, his hydrostatical model of the universe proved immensely difficult to quantify and thus failed to constitute a coherently mathematical framework for physics. On the other hand, after Newton's rise, and especially after Kant's reconfiguration of metaphysics, by the 19th century, the natural philosophical project was no longer in need of its own metaphysical grounding. If Descartes' method initially served as a legitimatory philosophical narrative for bridging the fraught relationship between a new kind of science and an old church order, the new bifurcated order of modern scientific culture would eventually turn Descartes himself into the excluded middle.

In the new political constellation, in which natural philosophy and natural theology became mutually reinforcing, what was to be called science could effectively circumvent philosophical considerations and, on account of the Christian doctrine of revelation, inquire directly into nature. As Gaukroger describes it, "the idea that natural philosophy is a means of seeking evidence of God's activity in nature would become widespread in the 1680s and 1690s, particularly in England, and Newton for example would consider the stability of planetary orbits to be evidence of God's constant intervention." (505) Natural constants became evidence for God's constancy. With increasing force, natural philosophy and revelation combined in the pursuit of what it saw as a shared truth — with theology as its initiatior. Writes Gaukroger:

> The kind of momentum that lay behind the legitimatory consolidation of the natural-philosophical enterprise from the seventeenth century onwards, a momentum that marked it out from every other scientific culture, was generated not by the intrinsic merits of its programme in celestial mechanics or matter theory but by a natural-theological imperative. (507)

Logically speaking, they were a perfect match, insofar as both pivot on the fundamental principle of identity. The God of natural-theological revelation is the identifiable creator — the being who produces Nature as universal. Natural philosophy, with Newton as its paradigmatic thinker, inquires into Nature as a creation of given, identifiable things — of particles. Thus, God gives us the universe, natural philosophers examine its parts, in ideal harmony.[83] In the metaphysical configuration of equivocal universality, theology guarantees the ontology that natural philosophy can reconstitute hypologically. The onto-theological constitution of metaphysics thus occurs by way of logical, symmetrical division. The universe in its modern scientific sense is a symmetrical proposition that becomes axiomatic to scientific practice, because henceforth, modern scientists can substitute or complement their belief in God with the belief in the universe, in mathematical universality — a belief which in turn legitimates the universality of the enterprise as such.

Nevertheless, as I have tried to demonstrate, the distinguishing trait of this universal symmetry is precisely the circumscription of its asymmetrical condition. For Spinoza, who follows this logic of mediation through every aspect of his thought, the universe, both in its Galilean-Newtonian and its Cartesian form, is a fiction — or, as he would put it, a metaphysical being, a being of reason, which is confused for a real being. Yet, as Spinoza would have to admit, this confusion is not therefore simply an untruth. In fact, as metaphysical beings become taken for real beings, they are enacted into existence and thus in turn act into Nature. That is, like an undercurrent, they come to change the autological conditions for hypological reasoning. In the case of the emergent modern world, this leads to a very real problem whose implications the *Ethica* is unable to account for. For what happens when the logical confusion between the autological and the hypological is not resolved by the 'blessed mind,' but rather becomes generative of new logical forms?

In the stubborn discrepancy between hypological universality and autological reality, which will govern scientific practice for the next few centuries, something new is also mediated into existence. As a new kind of metaphysical being, it will come to exacerbate the tension in the onto-theological unity of 17th century natural philosophy and make the legitimatory circulation between science and religion much more complicated.

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[83] Although a similar 'harmony' was crucial to previous natural philosophical orders, such as the Thomist synthesis under the Catholic church, post-Reformation science profoundly rearranged this order according to a shifting faith. For instance, Gaukroger points to the Protestant inclination of the experimental natural philosophy that would become dominant with Newton, especially in its general emphasis on witnessing over received knowledge. "It is a core part of Protestant understanding... that unmediated access to the testimony of witnesses who were present at miraculous or otherwise holy events is to be preferred to the interpolations of generations of theologians..." (2006: 378)

Spinoza's philosophy occurs at the very margin of this historical development, and we can only retrospectively find it foreshadowed in his inverted onto-theological constitution of Nature, that is, the internal division of Nature itself. In the first part of the *Ethica*, Spinoza makes a distinction between what he calls *Natura naturans* and *Natura naturata*, between 'naturing' and 'natured' nature. Loosely translated, this is a difference between active and passive nature, and it runs in direct analogy to the general ontological difference between essence and existence. By active nature, Spinoza understands substance itself and its attributes of expression, that is, "God, insofar as he is considered as a free cause" — Nature as essence. By passive nature, Spinoza understands nature as modes, the effects of God as free cause, that is, "whatever follows from the necessity of God's nature" — Nature as existence. (IP29S) Crucially, the distinction is drawn in a principle demonstrating that "in nature there is nothing contingent, but all things have been determined from the necessity of the divine nature to exist and produce an effect in a certain way." (IP29) As we have seen, God, or Nature, is the apotheosis of the principle of reason, whereby it becomes necessary reason. It is because of God, or Nature, as an active essence, that everything is determined. However, if we only consider Nature insofar as it is existent, that is, passive nature, or *naturata* in itself, we encounter a realm in which the axiomatic, autological principle of necessary reason is not only circumscribed but entirely removed. We are left with a realm of pure contingency and chance.

In 1657, Christiaan Huygens, on encouragement from the French philosopher Blaise Pascal, published what today stands as the first textbook on probability reasoning, *Calculating in Games of Chance*. It's as good an origin marker as any, if only because it appears to be the first of historically preserved texts to make it to the printer. As Ian Hacking points out in his concise study, the emergence of probability as a historical phenomenon has no clear, singular origin but rather seems to spring up independently in textual records around the same time, both in the Netherlands, in Paris, and in England. Besides Huygens, Pascal worked on an early conception of probability in a different vein, as did Leibniz independently of anyone else. And in London, statistical records were compiled from which mathematical patterns were inferred — all in the course of the 1660s. From this general emergence to the 18th century formal problematization of induction (David Hume) and statistical reasoning (Thomas Bayes), there appears no clear path —

which, ironically, makes the emergence of probability itself historically akin to a statistical phenomenon.[84]

As a contemporary of Huygens, Spinoza participated in study circles that were discussing, apart from natural-philosophical subjects like optics and physics, the reasoning and mathematization of chance. In correspondence with Huygens in the mid-1660s, in the same time period as he was at work on the *Ethica*, Spinoza dabbled with some of the problems in Huygens' book, and some time in the same period, he wrote a short treatise on the subject himself, *Calculation of Chances* (published only posthumously). Much like Huygens, Spinoza approaches the calculation problem in a statical way. First an equivalence is established (Huygens calls it 'equivalent gambles') — in every coin toss, for example, there is an equal chance of yielding heads or tails — from which a series of generalized equal chances can be inferred and thus calculated. But theirs were only two of many divergent approaches to understanding the new, autologically circumscribed realm of chance.

From its inception, Hacking tells us, drawing on a commonly held thesis, probability has been Janus-faced. "On the one side it is statistical, concerning itself with stochastic laws of chance processes. On the other side it is epistemological, dedicated to assessing reasonable degrees of belief in propositions quite devoid of statistical background." (12) He provides a brief overview of the history of this problem, which has preoccupied students of probability reasoning for centuries. Various attempts have been made to either distinguish the two aspects by name — for instance, chance on the one hand, credibility on the other — or, going the opposite way, to claim that one aspect of probability is a subset of the other. As Hacking relates, none of these approaches have succeeded, and clearly two families of reasoning remain analytically distinct, even as their origin is shared.

> Philosophers seem singularly unable to put asunder the aleatory and the epistemological side of probability. This suggests that we are in the grip of darker powers than are admitted into the positivist ontology. Something about the concept of probability precludes the separation which, Carnap thought, was essential to further progress. What? (15)

Hacking's study is not devoted to answering his own question, though the suggestion that "we are in the grip of darker powers" is perhaps a more instructive

[84] Incidentally, there seems to be no clear etymological connection between statics and statistics. Statics comes from a Latin derivation of the Greek word for 'weighing', whereas statistics is traced to a German invention of the 19th century, Statistik, likely connected to the word state, in the sense of state records.

orientation toward the problem than he may have intended. After all, modern epistemology as an analytic branch of philosophy, like modern physics, operates within a logical space predicated on the circumscription of the autological. Without reference to logic as autologic, I would argue, the difference between the two dimensions of probability reasoning becomes difficult to identify. Let us therefore briefly consider the hypological and autological aspects of either side of probability.

On the epistemological side, the two dominant schools of thought are both concerned with the probability conferred on a hypothesis by some evidence, either conceived as a certain relation between two propositions, or as a matter of personal judgment subject to rules of internal coherence. As Hacking puts it, "no matter whether the logical or personal theory be accepted, both are plainly epistemological, concerned with the credibility of propositions in the light of judgement or evidence." (14) Epistemic probability, in other words, is concerned with the general scientific problem concerning the discrepancy between the autological and the hypological. Its objective is to find a way to measure a degree of correspondence between a hypologically constituted concept — an invented origin — and its experimental occurrence, or between a concept and its circumscribed reality. In this sense, an autological dimension is involved insofar as correspondence with a causal experiment is established. Moreover, autology is involved insofar as the analysis of the probability relation — be it extrinsic, between two propositions, or intrinsic, in terms of personal judgment — explicitly involves belief. Whether a hypothesis is considered believable in general or believed by the subject involved, we are still nominally tied to the autological dimension from which we attempt to remove ourselves. Epistemological probability, in other words, is concerned with a determinate hypological relation — and its determination consists in its causality.

On the aleatory side, the dominant theories either focus on the problem of randomness in infinite and finite sequences — in other words, on effects — or on the causes of frequency phenomena, conceived as the propensity or tendency for a test to yield one of several possible outcomes. "Clearly," Hacking writes, "none of this work is epistemological in nature… the stable long run frequency found on repeated trials is an objective fact of nature independent of anyone's knowledge of it, or evidence for it." (ibid.) Insofar as the work is mathematical in a general sense, aleatory probability is also clearly hypological. However, if it can be considered non-epistemological, as Hacking claims, it is not because it is 'objective' or 'physical' but rather because it does not involve a determinate relation between a concept and its reality. In statistical reasoning, we do not invent an origin whose reality we circumscribe — but rather inversely, we invent a reality within which an origin can be circumscribed. As students of statistics know, it only involves correlation, and all causality is indeterminate. And if no causality is involved, as per the principle of reason, neither is the autological.

In common practice, it is convenient to distinguish aleatory probability as involving large sets of numbers and referring to macro-level events. But the distinction between the two faces of probability is not quantitative in nature, nor is it strictly a matter of scale. There is no identifiable threshold or limit where epistemic probability ends and aleatory probability begins — nor is there, as the many historically unsuccessful attempts indicate, a way to make the two dimensions correspond. Rather, their distinction is logical — to be exact, defined by their relation to the autological. Thus, on one side, we find the autological is turned around, circumscribed by hypological reasoning. On the other side, the hypological overturns its own reason for determination and becomes predicated on total autological exclusion. In this sense, epistemic probability is still properly hypological, insofar as it involves causality. Aleatory probability, however, emerging hypologically, yet averting its gaze from the mediating logic of causality, I propose to call *metalogical*. In its difference from autology, hypology is therefore asymmetrically doubled. Hypology begets metalogy. Whether we think of meta- in denotative terms of 'beyond', 'after', or positional change, the metalogical signifies, as it were, a kind of reasoning able to turn away from its autological ground. A metaphysical overturning.

In any event, the invention of metalogy would turn out have most dramatic consequences for the modern world. In the 19th century, this becomes particularly evident through the new statistical order of government, which Hacking closely links to French philosopher Michel Foucault's notion of biopolitics. In physics, the new logic emerges first within the Newtonian framework in conceptions like the laws of thermodynamics. Yet eventually, with the emergence of quantum theory in the early 20th century, a new metalogical order of physics is forged. As I will show in the next Act, the 20th century of physics is defined by the deep metaphysical tension between hypological and metalogical conceptions, which experiments such as the Large Hadron Collider attempt to resolve.

Thus, in the origin story of the modern world, we witness not merely the new mode of reasoning that came to reconstitute the explanatory structure of metaphysics through experimental invention — but simultaneously a doubling.

Through the circumscription and exclusion of the logic of mediation, the hypological turned on itself, extending beyond itself, revealing new means of questioning, comprehending — and controlling. Metalogy implies an asymmetrical doubling of logic, a doubling of forces — of causes for change.

As always, this revealing was simultaneously a concealing. In its forgetting of the autological, the modern world lost its ability to conceive the forces by which it was continually affected, exponentially increasing the sense of world alienation. But forgetting does not mean foregoing. For autology, which has no beginning, does not come to an end. It remains in the middle, as the logic of mediation itself.

ACT IV — META

Asymmetrical Doubling:
Probability, Proliferation, Particularity

To philosophize means
to reverse the normal direction
of the workings of thought.

Henri Bergson

Shouldn't the irresistible urge to philosophize
be compared to the vomiting caused by migraines,
in that something is trying to struggle out
even though there's nothing there?

Ludwig Boltzmann

1. Jena, 1889

In the extension of modern history, the image of thought eventually reaches its limit. And in physics, the limit turns out to be the given itself — the limit of light.

As noted in Act 1, the historical development of microscopy undergoes three decisive jumps in resolution. Instrumental to the historical emergence of modern science, the first leap was exemplified by a contemporary and peer of Spinoza, the Dutch microscope maker and scientist Antonie van Leeuwenhoek. Although not its inventor, van Leeuwenhoek vastly improved a single-lens microscope that enabled magnification to the level of blood cells and bacteria, somewhere in the metric range of 30 micrometers — thus opening up a new world of phenomena to empirical investigation. In 1850s Jena, Germany, a young Carl Zeiss had perfected making a similar single-lens microscope and decided to tackle the greater optical challenge of producing compound-lens microscopes. Over the next two decades, Zeiss succeeded in manufacturing award-winning industrial microscopes that ameliorated its design, and by 1866, he had sold his one-thousandth apparatus. Yet in terms of magnification, these microscopes represented only partial improvements on van Leeuwenhoek's work two centuries earlier.

In 1872, Zeiss hired Ernst Abbe, a professor at the University of Jena to solve the problem. Aided by an advanced mathematical understanding of lenscraft and based on the prevailing wave theory of light, Abbe was able to calculate the theoretical limit condition of microscopy. According to his formulation, the physical limit of microscopic resolution amounts to half the wave-length of light, which for light in the visible spectrum corresponds to a maximum object resolution of around 0.3 micrometers.[85] Under a theoretically perfect lens, then, any two lines closer together than this limit will appear as one, and any object smaller than it will be invisible or indistinguishable. In effect, Abbe invented the theory of aperture that is still the basis of photography today — and Carl Zeiss' lenses are still industry-leading. In the following decade and a half, Abbe and Zeiss approximated this theoretical limit experimentally by producing a series of advanced compound microscopes. In 1889, Abbe made a lens with the highest numerical aperture ever manufactured. Capping out at roughly 100 times the magnification of

[85] In the biological realm, 0.3 micrometers translates into somewhere between the smallest forms of bacteria and the largest forms of virus. But, as we shall see, to render an atomic level of hypothetical matter constituents visible to the human eye would require at least another 100 times magnification. See Bradbury, pp. 240-57, and passim for a technical history of the microscope. See Egerton, pp. 5-6, for mathematical formulations.

Leeuwenhoek's microscopes, the optical light microscope had for all practical purposes advanced to a level of resolution it has never since been able to surpass. Abbe's microscope, in other words, stands as the technological paragon of late 19th century physics — at once maximizing the continuity of light and reaching its limit.

Faced with this profound constraint of its given conditions for 'seeing into the unknown,' where was physics to go? As this Act will relate, what was at stake for physics going into the early 20th century was inventing the means to proliferate past its own physical limitations — to go beyond its own metaphysics.

In the previous Act, we saw how the mid-17th century provided modern science and philosophy with its metaphysical grounding — and simultaneously, through the invention of probability, with the emergent conditions of its overturning. Within the first three decades of the 20th century, the explosive growth of modern culture had turned into consummate chaos. In the wake of the cataclysmic Great War, vertiginous reaction-formations were alternately turning against and clinging onto its own cultural foundations, all the while being mobilized anew for even more unfathomable modes of catastrophe. And through the clamor, a persistent metaphysical theme resonates — a critique of the canon of modern thought and the uneasy relationship between philosophy and science.

In set of public lectures in 1925, the British philosopher and mathematician Alfred North Whitehead warned that the progress of science had reached a critical turning point. "If science is not to degenerate into a medley of *ad hoc* hypotheses, it must become philosophical and must enter upon a thorough criticism of its own foundations," he said. (1926: 21) For Whitehead, what was at stake in the tumultuous times was the unifying vision of science, metaphysics and religion that for him precisely characterized the modern world. Thus, his criticism of scientific foundations led him to espouse a strong conviction in reason, which he characterizes as deeply rooted in an autological human experience:

> Faith in reason is the trust that the ultimate natures of things lie together in a harmony which excludes mere arbitrariness. It is the faith that at the base of things we shall not find mere arbitrary mystery. The faith in the order of nature which has made possible the growth of science is a particular example of a deeper faith. This faith cannot be justified by any inductive generalization. It springs from direct inspection of the nature of things as disclosed in our own immediate present experience. (23)

In his historical account of the development of this deep faith, Whitehead did not shy away from bestowing upon Galileo's legendary dispute with the Catholic church a religious quality as the origin marker of modern science itself: "Since a babe was born in a manger," he proffered, "it may be doubted whether so great a thing has happened with so little stir." (2)

French philosopher Henri Bergson was far more critical. For him, Galileo's modern science was founded on setting up movement and mobility as an independent reality, leading to "universal mathematics, that chimera of modern philosophy." (2007: 161) The problem as Bergson would see it, is that the reality of mobile experience cannot be grasped in terms of the immobilized creations of the mind — such a method is in effect, as we have put it in previous chapters, hypology effacing autology. This dimension of Bergson's critical analysis was replayed multiple times by philosophers with which he conceptually shared little. One prominent example is his contemporary Edmund Husserl, whose project of phenomenology can be paraphrased as a critique of hypological reason and its concomitant forgetting of the autological dimension of being — that is, a problematization of how mathematics substitutes logical formulae for the 'life-world'. Husserl also singled out Galileo, referring to him as "at once a discovering and a concealing genius" (118). Thus, Husserl's phenomenology set a philosophical keynote that would echo throughout the 20th century: a set of attempts to reinscribe some claimed mode of authentic lived experience as the true ground of thought — or posed in negative form, attempts to critique the predominance in modern culture of science developing on its own hypological terms. For all their considerable philosophical differences, then, an exemplary theme clearly resonates through Whitehead, Bergson and Husserl: science must be brought closer in line with its true autological being.

This Act is about how the general critique of hypological reason, by the time it gained serious philosophical currency in the early 20th century, had already become irrelevant to science. In 1927, Werner Heisenberg published his mathematical formalism since known as the 'uncertainty relation' of quantum mechanics. It expresses a fundamental indeterminacy in calculating both the position and momentum of a particle or waveform within the same system. In practice, one dimension can only be measured at the cost of the other, and reversing measurements cannot be combined without a discrepancy, that is, a degree of uncertainty. As the product of roughly six decades of new theoretical and experimental developments in physics, Heisenberg's quantum mechanics formally punctuated a new order of physics whose explanatory basis thoroughly excludes its autological being. Instead, as I will show, the new physics was, both in derivation and orientation, metalogical. In effect, the metalogical constitutes a different order of reasoning and understanding unfamiliar to the logical structure of modern philosophy and science. As its name implies — the Greek prefix 'meta' stands for a movement with, across and after its reference point — metalogy moves beyond the limitations of traditional logic.

In Act 3, I defined the metalogical in relation to the two aspects of probability, drawing on Ian Hacking's work. Whereas the epistemological aspect of probability involves reasoning inverted from an autological premise — such as degrees of belief that some specific event may or may not occur — its aleatory or statistical side effectively excludes the autological altogether through random sets of numbers. Insofar as the autological is consonant with a generalized principle of reason for itself — that is, not determined by hypological identity — epistemological probability clearly retains a connection of causality. Statistical probability, however, extends its reach by mathematical correlations through a disconnection of causality. In this sense, it is metalogical — a distinct shift in reasoning beyond the autological initiation and the hypological turning that mutually constitute conventional logic. Schematically, then, metalogy turns on hypology in the same sense as hypology turns on autology, as though removed by one degree.[86]

Hence, metalogy is acausal, that is, without cause in the generalized sense — or, as contemporary physicists put it, 'nonlocal', that is, not linked to a specifiable, localizable causal trajectory. But metalogy is certainly not without effect. Hacking's book, *The Taming of Chance*, is a general study of the spectacular rise of probability in the 19th century — and in particular its statistical side. Recounting what he calls an "avalanche of numbers" printed after the Napoleonic wars, from birth and death rates to insurance premiums and civil status, Hacking explicitly links the rise of statistical reason to French philosopher Michel Foucault's notion of biopolitics. (21) In this context, biopolitics is a term whose exact historical meaning may be unclear, but whose basic thrust involves the extensive mapping, control and manipulation of populations within bounded nation-states, based on what came to

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[86] The relations between auto, hypo and meta have a suggestive analogy in linguistics, in the use of metaphor. As one standard work defines it, by changing a word from its literal meaning to one analogous in meaning, metaphor involves "assertion of identity." The related trope of metonymy implies "substitution of cause for effect, effect for cause." Thus, if the logical matrix constituted by the principles of identity and reason find their analogy in the axiomatic relation between metaphor and metonymy, we can relate the metalogical to synecdoche, which involves "substitution of part for whole, or vice versa." These definitions are from Lanham, p. 189 — but of course definitional models for the relationships between tropes are contentious and do not necessarily correspond to some tripartite scheme.

be regarded as autonomous statistical laws — laws which in turn would deeply affect the modern world.[87]

> Statistical in nature, these laws were nonetheless inexorable; they could even be self-regulating. People are normal if they conform to the central tendency of such laws, while those at the extremes are pathological. Few of us fancy being pathological, so 'most of us' try to make ourselves normal, which in turn affect what is normal. (2)

In this sense, quantitative extension thus implies qualitative intension — a "feedback effect," as Hacking calls it. This feedback effect is crucial to the conceptual distinction of metalogy from statistics as such. For it is first and foremost through the aggregated feedback effect enabled by such statistics that something distinct from conventional logic occurs. No longer merely an initiation and its folding or its inversion, no longer merely the ceaseless ping-pong of being and thought — no longer just the differential interplay, in Spinoza's terms, between affects and the thoughts of these affects, as they incline or decline with joy or sadness, toward lesser or greater perfection of knowledge within a natural whole. Rather, emerging from the asymmetrical doubling of autological and hypological orders, and differentiated as a vector for itself, the metalogical signifies increased mobilization, acceleration, multiplication. Much begets more.

In this chapter, we will largely be concerned with metalogy as statistical reason in the domain of physics. But to intimate how the metalogical is not simply reducible to the effects of statistics, consider briefly a remarkable historical parallel to the rise of probability and modern science: the joint-stock company, today known as the corporation. Also invented in the mid-17th century Netherlands, corporations first became flourishing economic dynamos in Western Europe in the same 19th century period we are concerned with in this chapter.[88] As legal scholar Joel Bakan puts it, "the genius of the corporation as a business form, and the reason for its remarkable rise over the last three centuries, was — and is — its capacity to combine the capital, and thus the economic power, of unlimited numbers of people." (8) This combining capacity takes a very specific form. The decisive legal

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[87] Agamben's *Homo Sacer* (1998) argues that biopolitics, defined by constitutive exception of a biological from a political dimension of life, strictly speaking is an ancient Western idea. In my general reference to the biopolitical in the following, I have in mind its modern, 19th century appearance, since that is the purview of this chapter. However, this should not be read as a claim that biopolitics, or more specifically, metalogy, is necessarily a phenomenon exclusive to modern, Western culture.

[88] For general reference on the emergence of stock markets and joint-stock companies in 17th century Europe, see Niall Ferguson, 2008.

change that enabled the meteoric rise in corporate power throughout the Western world was first enacted in England in 1856: a statute of limited liability that simultaneously removed investor risk and constituted the corporation as a single juridical body. Thus: unlimited pooling of capital, combined in the legal entity of an individual, in which all causal connection between corporate owners and corporate actions has been formally removed. This new body is pure proliferation — the incorporation of leverage. Herein lies the essence of metalogy as I understand it.

How does such an extensional structure relate to the actual use of statistics? Take the familiar example of opinion polling in liberal democracies. In the most basic sense, if we want to know what people think about a specific issue, we do not have to go door to door across the country asking every single voter — rather, we ask a random sample of people and calculate a probability estimate for the population as a whole. Thus, we extend from part to whole under the principle of identity at the cost of causality, since there is no longer any way to determine the actual voting trajectory of any one individual. Now, whether this method is accurate is a quantitative concern that in itself has to be resolved by statistical means: the probability of a probability estimate being correct is itself subject to a probability estimate, and this paradoxical feedback effect bespeaks metalogy in its own way. But qualitatively, the statistical method provides us with relative leverage. Just as an opinion poll saves time, labor, capital, energy, and so on, the multiplier effect of statistics translates into a simultaneous compression of usual hypological measures. In the metalogical act of statistical reason, thinking extends beyond its own conditions — and in turn, changes them in its newfound reach.

As Hacking points out, such changes clearly occur in a social sense, as his example of the self-regulation of normalcy indicates. However, he then makes an important differentiation: "Atoms have no such inclinations. The human sciences display a feedback effect not to be found in physics." (2) Malleable humans — but permanent atoms? In the thematic context of biopolitics, the distinction of physical and human nature is commonsensical — yet, as the previous chapters would indicate, metaphysically questionable. Historically, it mirrors the hypological identity of human as differentiated from what we call nature. That is, it bespeaks the modern configuration of the universe itself: nature, as differentiated from culture, is the realm independent of human knowledge. In turn, the truism of atomic independence from human inclinations, as Hacking puts it, justifies precisely the metaphysical differentiation upon which modern philosophy and science are predicated in the first place.

In this chapter, I will attempt to break this hypological circle by, in effect, challenging Hacking's statement. I aim to demonstrate a fundamental feedback effect that appears to have gone unacknowledged in the history of modern thought. Perhaps this is partly because the feedback effect in physics runs inversely to its manifestation in the human sciences. Practically, this inverse feedback is what allows Abbe's limit to be transcended by different logical means. And it crucially relies on the concept of particularity — the idea of individual or independent identity. In his charting of the social conditions for statistical reasoning in the 19th century, Hacking makes a distinction he describes as "gross but convenient" to illustrate a general point of some significance:

> Statistical laws were found in social data in the West, where libertarian, individualistic and atomistic conceptions of the person and the state were rampant. This did not happen in the East, where collectivist and holistic attitudes were more prevalent. Thus the transformations that I describe are to be understood only within a larger context of what an individual is, and of what a society is. (4)

Why would statistical laws occur more readily in connection with individualism? Because without defined individuals — that is, discontinuous, identifiable units — metalogy is impossible. In our conceptual scheme, the reliance on particularity signifies the metalogical tie to the hypological principle of identity. When the identity of cause and effect is relinquished, the principle of identity remains as though it has been overturned, now existing only by implication, as a negative presupposition. In short, then, statistical reasoning presupposes individuals.[89] This is one reason why the example of opinion polling applies so readily to liberal democracies, in which the individual political subject, identified as an independent voter, was already invented and, through the subsequent rise of statistical reason, reinforced. In the case of physics, as I will show, the logic runs the other way, since what was required to implement statistical methods and go

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[89] In the academic literature on probability, this is a point that is curiously glossed over. Probably, this is because modern probability as a field of study and as a specialized branch of mathematics appears to take individual identity for granted. As in Hacking's work, there is no problematization of how this identity must be forged if it doesn't already present itself as a given. The general link Hacking makes between individualization and statistics provides one clue. In the detailed study, *Probabilistic Revolution*, the presupposition appears in common phrases such as, "...to permit the introduction of probability theory, he mentally subdivided that energy into little cells or elements..." (Kuhn 1987: 16) and, "...in statistical mechanics, probabilistic statements can be applied only to large aggregates of elementary systems, e.g. molecules or atoms..." (Krüger, 373). In general, the dearth of discussion of the metaphysical assumption of statistical reason is itself indicative of the argument I'm here presenting.

beyond physical limits most effectively was precisely a constitution of individual units — the invention of particularity.

My philosophical witness to this historical invention is Bergson, whose rise to prominence was predicated on the hopeful possibility of reconciling metaphysics and science — not in a unifying synthesis but as two halves co-existing in perhaps uneasy yet mutually necessary tension. At the turn of the century, as science and philosophy had come to grow ever more distant, this was already a monumental task. As Bergson remarked in his 1903 essay, "An Introduction to Metaphysics":

> The masters of modern philosophy have been men who had assimilated all the material of the science of their time. And the partial eclipse of metaphysics since the last half century has been caused more than anything else by the extraordinary difficulty the philosopher experiences today in making contact with a science already much too scattered. (2007: 169)

Bergson's *Matter and Memory* from 1896 can be considered the last major coherent attempt in the Western canon at making viable contact between physics and philosophy. His work combined a critical renewal of modern philosophy's premise with conclusions that proved remarkably convergent with the most advanced physics of his day. Yet within barely a decade, the metalogical shift of physics had rendered Bergson's Herculean efforts Sisyphean. In this sense, his work is a harbinger for the fate of metaphysics in the 20th century — in which the image of modern thought reaches its limit and doubles on itself.

2. Maxwell's Continuity

In the history of statistics, Hacking's "gross" cultural differentiation of East and West has a corollary in the story of 19th century physics. As historian Helge Kragh writes, it was mostly in Britain that "atomic models had their origin and were discussed. In Europe and in North America, interest in atomic structure was limited." (48) In Germany toward the end of the 19th century, one of the most influential programs for unification of physics was 'energeticism' and a rivaling conception of electromagnetic ontology founded on universal continuity. Similarly, concerted research programs in Britain led to J.J. Thomson's 1897 claim to having discovered the first particle, the electron, whereas in Berlin, Max Planck's mathematical result that light consists of discontinuous quanta — retroactively canonized as the foundation of quantum theory — can at best be said to have been discovered accidentally, indirectly, and retrospectively.

In contrast to the story of hypology in physics, which could be conveniently centered on a few pivotal thinkers, such as Einstein and Galileo, the story of metalogy has, as perhaps befits it, a rather proliferating plot. Even in the most streamlined, retrospective form that I will offer here, it runs through several intertwining concepts and thinkers. If this history can be narrowed down to a few pivotal characters, it is the Scottish physicist James Clerk Maxwell's work that comes to play a crucial double role — much in the same way that Einstein's work would make for a decisive double juncture four decades later. From Maxwell through Einstein and a few key physicists in between, we find the same paradoxical features that will bedevil physics for the rest of the 20th century: traces of the metalogical revolution in modern thought.

In historical terms, the development of probabilistic reasoning is perhaps better characterized as a revolution in application rather than in science.[90] As its documented historical emergence in the mid-17th century indicates, probability sneaks up on the modern world so slowly, and through such a multitude of separate events, that it can be considered revolutionary only in an extended century-long sense. In his overview of this long, quasi-revolutionary century, Hacking offers a heuristic division of the period 1820-1930 into four successive, partially overlapping stages. The first stage, roughly 1820-1840, is marked by the onslaught of printed statistical data in post-Napoleonic Europe. In turn, proliferation of data becomes the condition for a mid-century second stage, 1835-1875, characterized by "faith in the regularity of numbers." (1987: 52-3) This regularity within the 'avalanche of numbers' corresponds to an exponential vector. In concert with several biopolitical measures, population figures in Europe now take on their characteristic run-away effect. Within less than three generations, between 1850 and 1910, the great metropolitan centers of Europe roughly triple. London's population, estimated at barely one million by the beginning of the 19th century, rises in this period from 2,5 to 7,5 million. Paris' population spikes from 1 to 3 million, and Berlin maintains an even stronger tendency, from half a million to 2 million people. Joint-stock companies rising to dominate national economies occur alongside unprecedented mobility of labor for increasingly mechanized forms of

[90] This is e.g. I. Bernard Cohen's conclusion in his historical analysis, elaborating on Thomas Kuhn's notion of scientific revolution. See Cohen, 1987.

work.[91] Greater populations require greater metalogical measures, which improve conditions for increasing populations, in ever greater feedback correlations between a modern science and politics in ever increasing mutual alignment.

However, partly due to its deep mechanist inheritance, physics takes up statistics late, toward the end of this second period of 'regularity,' and then only as a secondary logical movement. Thus, to account for the metalogical rise of physics, we first need to better grasp its historical thrust into the late 19th century. In distinction from its 17th century hypological framework, we can characterize this movement most generally as a 'return' to the autological.

As we saw in the previous Act, the institution of Newton's hypological framework of dynamics was predicated on a foundational circumscription of that which by Descartes and other natural philosophers of the 17th century had been defined as force — the presence of a given. Through the invention of a kinematics in which motion was treated as taking place in a void, the problem of gravity was transformed into a proportional constant between two bodies, later known simply as G. In a retrospective sense, the development of physical science in the 18th and 19th centuries resembles an experimentally layered re-filling of the Galilean-Newtonian spatio-temporal container known as the universe. Yet in another sense, it is in the 19th century that natural philosophy properly becomes known as physics and takes shape into a recognizable, institutionalized discipline. Though internally diverse in its focal points, physics now becomes dominated by questions of the so-called 'imponderables' which Newtonian dynamics could only outline, from light, heat, and gas, to sound, energy and electricity — all of which brings forth new conceptual problems. Thus physics takes shape according to the increasing discrepancy between the hypological framework of dynamics and its actual conditions. And the decisive invention that will differentiate the 19th century movement of physics from its late 17th century framework becomes known as thermodynamics.

Developed from the physics of heat processes, thermodynamics establishes an equivalence between heat and work through the concept of energy. In 1865, the German physicist Rudolph Clausius formulated the two laws of thermodynamics in the way they since have become known. The first law states that "the energy of the universe is constant."[92] Thus, energy takes on a metaphysical meaning in direct analogy to the idea of substance — a name for that which does not itself change, but enables any process in the universe. In a conceptual distinction that harks back to Aristotelian metaphysics, energy becomes subdivided into potential and actual energy — actual energy later being measured and expressed as kinetic energy. Though hypological insofar is it is conceived under identity, energy, as this total of actual and potential, is fundamentally an expression of autologically mediating presence. In a radical inversion of the kinematic law for a falling body in a void, the first law of thermodynamics constitutes the world as a plenum. And the hypostasis of this fundamental axiom ensures the metaphysical constancy of energy.

For the second law of thermodynamics, Clausius proposed the Greek word for transformation, 'entropy,' to describe the ostensibly irreversible, directional character of heat flowing from hot bodies to colder ones. Thus, the second law proclaims that "the entropy of the universe tends to a maximum." In this way, entropy also expresses metaphysical constancy, because it is defined as a tendency toward a limit condition. Together, the two laws describe what Clausius, Maxwell and other physicists at the time took to be the fundamental features of energy, itself turned into a fundamental concept: conservation and dissipation. Everything is in equilibrium, on condition of disequilibrium — everything begins with balance, on condition that it tilts. In this precise sense, thermodynamics is a theorem of statics, as described in Act 3. Thus, it also replays the constitutive difference in dynamics between a kinematical void and a statical plenum. Rather than explaining motion in the absence of force, as Galileo did, statics and thermodynamics describe force without motion — tendency to motion, tendency to change. Moreover, the two laws of thermodynamics express the extensive relation between part and whole. The second law explicates the tendency of any part toward the whole that is constituted by the first law. That is, entropy is the qualitative extension of energy, from the dissipation of its part to the conservation of the whole.

For Maxwell, the physical promise of the concept of energy and its formulation through the laws of thermodynamics lay in its potential to replace the traditional but mathematically imprecise notion of force altogether. Several key works of the 1870s espoused the view that Newtonian 'abstract' dynamics could successfully be derived from thermodynamics as a new basis for physical

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[92] On the history of thermodynamics, see Harman, especially pp. 64-7, and passim for general historical context of 19th century physics. Critical discussion can be found in Stengers, and in Prigogine, passim.

explanation.[93] And in turn, energy was established with the same fundamental reality status as matter itself.

Subsequently, much of the development of 19th century physics revolved around the metaphysical problem of how to reconcile energy with matter. The atomistic conception of matter, as fundamentally constituted by indivisible particles, had its adherents, encouraged by developments in chemistry that theorized individual chemical elements as atomic. But chemical atoms, or elements, were an expression of the limit of chemical analysis, the point at which composite bodies break down. By contrast, a coherent physical conception of the atom would require something so fundamental as to be invisible to experiment. That matter could usefully be regarded as a composition of molecules was not by itself problematic — but whether such molecules were truly fundamental was a very different question. And the late century movement of physics converged toward an autological sense of the problem: if the Newtonian universe indeed consisted of bodies, or planets, in mechanistic motion, something was needed to mediate them. Irrespective of the molecular and quantitative models used to explain energy as a physical phenomenon, thermodynamics appeared to signify an absolute continuity of energy in the universe, both in terms of its totality (the first law) and its flux (the second law).

Foregrounded in Maxwell's work, a set of analogous key concepts reinforce the metaphysical axiom of continuity. Mathematically, modern physics since Newton was significantly shaped by the invention of differential calculus. Used to formulate the basis of rational mechanics, the characteristic derivative function expresses a fundamental differential equation between variables that, if unlimited by other factors, can be extended indefinitely. Accordingly, the concepts of mathematical physics would tend to express continuous functions. This was

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[93] Incidentally, this positive dimension of universal thermodynamics had a significant cosmological consequence. If the universe was, as the prevailing framework held, infinite, then its point of reaching maximum entropy would coincide with a universal stasis — all energy eventually passing into heat and thus precipitating an inevitable universal 'heat death.' In order to escape this metaphysical apocalypse while retaining logical coherence, there were broadly two options. Either one would have to assume a fundamental boundary condition by which the dissipating energy could cycle back through the universe — in analogy to the fourth dimension of General Relativity, as discussed in Act 2. Or one would appeal to theological arguments about divine mechanisms of design preventing such abominable effects. As American historian of science P. M. Harman puts it in his study of 19th century physics: "Appeal to theological arguments, not uncommon among British physicists, was a manifestation of the continued influence of the 'natural theology' tradition." (68-9) Indicative in this context is Maxwell's statement that the identity of molecules demonstrated their design by divine agency, a "manufactured article" of God. (ibid.)

particularly the case with Maxwell's electromagnetic field, his mathematical unification of the physical phenomena of electricity and magnetism. Based on Michael Faraday's proposition of lines of force, the general field theory allowed forces between individual bodies to be mediated by the continuous propagation of energy, for which the differential equation became the principal mathematical formalism. In this sense, Maxwell noted, the continuous field theory proved a direct correlate to the prevailing wave theory of light, first formulated in the mid-17th century by Christiaan Huygens, in part based on the metaphysics and optical theory of Descartes, and demonstrated through Abbe's microscope.

Thus, theoretical and experimental lines of inquiry converge in the coherence of mathematical equations, physical instruments, and metaphysical axioms, all leading toward the tantalizing ideal of explanatory unification. Now, in order to make the theory of light cohere with mechanics, electromagnetism, and the thermodynamic conception of energy, physics needed an autological medium to carry energy, light, and electromagnetic waves. It was known as the ether — a physical concept whose many varying interpretations belie its prominence in 19th century physics.

In 1878, Maxwell authored the entry on ether for the ninth edition of the *Encyclopedia Britannica*, arguing its case for explaining the propagation of light and related continuous phenomena: "The evidence for the existence of the luminiferous ether has accumulated as additional phenomena of light and other radiations have been discovered; and the properties of this medium, as deduced from other phenomena of light, have been found to be precisely those required to explain electromagnetic phenomena." (569) Maxwell further explains that in order to transmit energy, the ether would need to possess "elasticity similar to that of a solid body, and also have a finite density." (570) He cites conceptual problems over whether the ultimate constitution of the ether is molecular — that is, contiguous elements through which undulatory light is capable of passing — or continuous in itself. Nevertheless, his conclusion is emphatic:

> Whatever difficulties we may have in forming a consistent idea of the constitution of the ether, there can be no doubt that the interplanetary and interstellar spaces are not empty, but are occupied by a material substance or body, which is certainly the largest, and probably the most uniform body of which we have any knowledge. (571)

To the late 19th century British physicist, in other words, the existence of the ether was indubitable — a necessary presupposition — for without it, the prevailing concepts of physics would cease to make coherent, unified sense within the hypological framework of mechanics. Over the next two decades, the discourse of physics would become rife with proliferating mechanical, thermodynamic, gaseous, molecular, particulate, and fluid models to explain this necessary autological mediation. Among the theories Maxwell worked on was, notably, a version of Descartes' idea of the vortex. In fact, one of the most promising and influential theories in the 1890s for uniting the demand for particular discontinuity with a universal ethereal plenum becomes known as the vortex atom, advocated most prominently by William Thomson (later known as Lord Kelvin). Thomson's model, later developed and synthesized with the latest experimental phenomena by Joseph Larmor, conceives of matter itself as vortex rings in a primordial fluid medium. Consequently, as Larmor put it, "matter may be and likely is a structure in the ether, but certainly ether is not a structure made of matter."[94] The ether, in other words, is ontologically primary and constitutes the pure continuum within which particulate matter occurs.

Perhaps the most eloquent philosophical expression of this general tendency in physics was captured by Bergson in his *Matter and Memory*, first published in 1896. He summarizes both Faraday's conception of centers of force and Thomson's vortex rings as two different explanatory attempts that coincide in a metaphysical vision of universal continuity. Writes Bergson:

> In truth, vortices and lines of force are never, to the mind of the physicist, more than convenient figures of illustrating his calculations. But philosophy is bound to ask why these symbols are more convenient than others, and why they permit of further advance. Could we, working with them, get back to experience, if the notions to which they correspond did not at least point out the direction we may seek for a representation of the real? Now the direction which they indicate is obvious; they show us, pervading concrete extensity, modifications, perturbations, changes of tension or of energy, and nothing else. (266)

For Bergson, the contemporary trend in physics was highly encouraging, because concepts such as the ether signified the acceptance in physics of the philosophical distinction between the continuous movement of reality and the artificial divisions of the mind, such as the popular but as yet unfounded physical theory of atoms. As Bergson puts it,

> We shall never explain by means of particles, whatever these may be, the simple properties of matter: at most we can thus follow out into corpuscles as artificial as the corpus — the body itself — the actions and reactions of this body with regard to all others… But the materiality of the atom dissolves more and more under the eyes of the

[94] Quoted in Harman, 102. Kragh offers a concise discussion of the vortex atom and its significance, pp. 3-12.

physicist. We have no reason, for instance, for representing the atom to ourselves as a solid, rather than as a liquid or gaseous… (262-3)

He further cites two experiments conducted by Maxwell that effectively counter any conception of particles existing in a void. Thus, he concludes that modern science ends up with a concept like the ether to account for the autological mediation of its hypological particle concepts.

> We see force more and more materialized, the atom more and more idealized, the two terms converging towards a common limit and the universe thus recovering its continuity. We may still speak of atoms; the atom may even retain its individuality for our mind which isolates it; but the solidity and the inertia of the atom dissolve either into movements or into lines of force whose reciprocal solidarity brings back to us universal continuity. (265)

In this sense, the 19th century appeared to close on a dizzying note of advancement toward the limits of physical understanding. Prominent physicists began talking publicly about the end of physics, that is, the near-completion of physical problems. And Bergson rose to the occasion with a remarkable and, above all, hopeful proposition: that he could reconceptualize this metaphysical limit as the condition under which both philosophy and science could co-exist in conceptual alignment.

3. Bergson's Harmony

Despite its comprehensive attempt to reconcile the foundations of psychology, biology, physics and philosophy in one and the same work, it must be said that *Matter and Memory* is historically significant rather for abandoning pretension to the possible unification of thought. From the outset, Bergson calls for a dualism — but as soon becomes clear, it is a dualism with a metaphysical twist. In this sense, Bergson clearly writes both with and against the traditional current of modern philosophy, which in turn makes his thought eminently difficult to categorize.

In approach, Bergson's philosophy is reminiscent of Einstein's style of physical theory: inventing the perspective from which contradictory positions appear to mutually cancel each other out. *Matter and Memory* begins with the strictly hypological fiction called "pure perception" — an inversion of both Descartes' cogito and Kant's concept of 'pure reason.' Bergson invites us to think our experience of the world as an unlimited fullness: "In pure perception we are actually placed outside ourselves, we touch the reality of the object in an immediate intuition." (84) This world of pure perception consists only of what he defines as images. With this conceptual invention, Bergson explicitly intends to navigate between, on the one hand, the 'representation' of idealist thought, and on the other hand, the 'thing' of realist thought. In a manner analogous to how Descartes describes the world from the point of view of the cogito, Bergson says that when we look at the world from the perspective of pure perception, "all seems to take place as if, in this aggregate of images which I call the universe, nothing really new could happen except through the medium of certain particular images, the type of which is furnished me by my body." (3)

Of course, there is no such thing as pure perception, which Bergson in due course will acknowledge, since perception is always and everywhere mixed to some degree by bodily affection. But as a premise, it enables him to circumscribe the world in terms of a plenum rather than a void: matter consists of an aggregate of images, whereas perception of matter — that is, the interface of mind upon matter — consists of the same images as limited by that one particular, privileged image called my body. (8) In other words, Bergson submits us to a distinctly Spinozist premise, in which one and the same univocal reality is expressed equiversally. In Bergson's language, this is thought as two systems of images:

> Here is a system of images which I term my perception of the universe, and which may be entirely altered by a very slight change in a certain privileged image, my body. This image occupies the center; by it all the others are conditioned; at each of its movements everything changes, as though by a turn of a kaleidoscope. Here, on the other hand, are the same images, but referred each one to itself; influencing each other, no doubt, but in such a manner that the effect is always in proportion to the cause: this is what I term the universe. The question is: how can these two systems co-exist, and why are the same images relatively invariable in the universe, and infinitely variable in perception? (12)

With his use of the universe, Bergson readily illustrates its condition of dependence on the differential image system of the body — in my terms, that the scientific 'uni-verse' is in fact 'equi-versal.' Conceiving his problem thus, Bergson attempts to circumvent two related pitfalls of the universe in modern philosophy. The first concerns ontological bifurcation and the second revolves around epistemological predominance. In both cases, Bergson's tendency clearly correlates with Spinoza.

As my explication of Descartes in Act 3 made clear, a prototypical first move of modern philosophy is to create an ontological distinction of symmetry —

between interiority and exteriority, between subject and object, or what in Descartes amounts to the same thing, between mind and body. This difference in kind is predicated on the principle of identity, by which a discernible difference becomes a marker of separate identities — mind on one side, body on the other. And once this difference in kind is established, it leads to, as Bergson notes, a problem whose terms are strictly insoluble by themselves. Either we are left with a "mysterious correspondence" between the two symmetrical systems — for which a *deus ex machina*, such as a miracle or pre-established harmony, becomes necessary — or we disavow transcendental solutions altogether and instead forge from the relational question a causal explanation: how the outer physical world causes the inner mental world of the subject, or vice versa. As Bergson succinctly puts it, "subjective idealism consists in deriving the first system from the second, materialistic realism in deriving the second from the first." (14)

Instead, Bergson's premise simply proposes that inside and outside, or subject and object, are functions of image relations — not the other way around. And because the difference between the two systems emerges in the limitation of the body, their co-existence is not symmetrical but rather asymmetrical. It corresponds, he says, to the distinction between part and whole. (44) In this sense, Bergson's philosophy can be read as a double analysis of how the body moves from its own image system to the universe by extension, while simultaneously changing in itself by intension, or inextension.[95]

Generally, Bergson's equiversality differs from Spinoza's only in terminology. His two systems cohere with Spinoza's difference in attributes between a body and the idea of the body. That is, what Spinoza in proper rationalist form calls 'thought' is for the more empirically oriented Bergson 'perception.' For Bergson, "to perceive means to immobilize" (275) in much the same way that for Spinoza thought without relation to its object, that is, the idea of the idea of affection, is hypological. Their conceptual convergence becomes clearer through a metaphor that Bergson draws from microscopy and optical theory.

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[95] For Bergson, the relation between the extended and inextended was one of three related antitheses of perception, along with quality and quantity, freedom and necessity. (325) He avoided the term intension, as it was for him entangled with use in psychological discourse of the day. In Deleuze's reading of Bergson and in the modulation of his own philosophy drawing on Bergsonian concepts, intension and intensity play prominent roles. My use of intension here is meant to generally illustrate the inverse tendency of extension, thought in terms of the concept of metalogy alone, and is not offered in any necessary correlation with Deleuze's usage.

> When a ray of light passes from one medium into another, it usually traverses it with a change of direction. But the respective densities of the two media may be such that, for a given angle of incidence, refraction is no longer possible. Then we have total reflection. The luminous point gives rise to a virtual image which symbolizes, so to speak, the fact that the luminous rays cannot pursue their way. Perception is just a phenomenon of the same kind… This is as much as to say that there is for images merely a difference of degree, and not of kind, between being and being consciously perceived. (29-30)

Yet this reflection is, in Bergson's continuation of the metaphor, a kind of mirage, since the virtual image conceals the fact that rays still travel through it. Thus the effect is, from the perspective of the behavior of light rays, "that the real action passes through, and the virtual action remains." (32) In fact, the image trope here falls short, because the body, as the privileged image of both systems, does not "merely reflect action received from without; it struggles, and thus absorbs some part of this action." This absorptive capacity, Bergson says, stands for the source of affection. Thus, "while perception measures the reflecting power of the body, affection measures its power to absorb." (57) In mediating the body, in other words, light effectively doubles in its movement: in reflection, it is moved 'under' or turned on itself — hypo — and at the same time, continues through itself — auto. For Spinoza, idea is the thought of an affect — auto — and also, in a doubling, the thought of this thought, hypostasized, as though by a reflected, virtual image. This doubling corresponds logically to the two image systems that Bergson differentiates thus: "The first system alone is given to present experience; but we believe in the second, if only because we affirm the continuity of the past, present, and future." (15)

If we translate Bergson's scheme into our terms, then, we have a given system, which runs from autological initiation of the acting body to its hypological turning — auto-hypo — and a belief system, which runs inversely, from hypological turning back onto the acting body — hypo-auto. The two systems constitute a double movement, their loops feeding simultaneously forward and backward. By privileging one system, we get caught in a paradoxical reliance on the other, for which the philosophical divide between realism or materialism and idealism is an exemplary expression. If we assert that a logical movement 'really' or 'naturally' runs from autological given to hypological belief, we are soon forced to acknowledge that we can only make this claim on account of the inverse movement itself. Asserting the primacy of either system is precisely to efface general ontological difference, to flatten the double movement of mind and body onto a transparent plane — or put inversely, to render thought opaque to its own conditions.

In this sense, the evisceration of the double movement becomes itself a double error. The rivaling doctrines that attempt to explain one movement in terms of the other do not merely begin with a false ontological bifurcation, Bergson argues. Together, they also mutually constitute a false epistemological image — the second pitfall of modern philosophy. With regard to the perennially contested status of so-called subjective knowledge, he writes:

> The whole discussion turns upon the importance to be attributed to this knowledge as compared with scientific knowledge. The one doctrine (realism) starts from the order required by science, and sees in perception only a confused and provisional science. The other (idealism) puts perception in the first place, erects it into an absolute, and then holds science to be a symbolic expression of the real. But for both parties, to perceive means above all to know. (17)

Insofar as *Matter and Memory* attempts to reconfigure the relationship between philosophy and science, metaphysics and physics, it pivots on disputing the well-worn postulate of Western thought that knowledge is the telos of perception. In this sense, Bergson is properly aligned with Nietzsche's insight, with which we began our discussion of metaphysics in Act 1, that science is metaphysical in an axiomatic sense, because it is founded on the idea of knowing truth for itself — whether truth be understood in realist or idealist terms. For Bergson, however, as for Nietzsche and Spinoza — the mind is not geared toward knowledge or truth for its own sake — rather, its purpose or tendency is action.

In this context, much relies on how we understand the idea of action. As Bergson defines it, action is "our faculty of effecting changes in things," and he links it directly to the indetermination that he believes is "characteristic of life." (67) In fact, he says, living matter, or active perception, is defined by its ability to defy determinate expectation — in this sense, for the autological to resist the hypological turning back on it, to evade capture — and this constitutes its essential freedom.

> Perception arises from the same cause which has brought into being the chain of nervous elements, with the organs which sustain them and with life in general. It expresses and measures the power of action in the living being, the indetermination of the movement or of the action which will follow the receipt of the stimulus. (68)

The emphasis on life becomes a stronger motif in Bergson's later writings, most notably *Creative Evolution*, where the idea of action is developed into an account of vital tendency (*élan vital*). For Bergson, life is precisely what mechanistic thought misses — and in his careful distinction of action from affection, he appears to be distinguishing his own philosophy from Spinoza. The reciprocal dependence of conscious perception and cerebral movement — that is, the correspondence between mind and body — is for Bergson "simply due to the fact that both are functions of a third, which is the indetermination of the will." (35) At first glance, nothing could be further from Spinoza's infamous claim in the *Ethica* that people's common 'opinion' of having free will "consists only in this, that they are conscious of their actions and ignorant of the causes by which they are determined. This, then, is their idea of freedom — that they do not know any cause of their actions." (IIP35S) Certainly, in the Western canon, Spinoza is often considered the ultimate expression of 17th century rationalist determinism — a radically alien sentiment to Bergson's indeterminist philosophy of life.

Nevertheless, this common interpretation must be resisted, because it pivots on a fundamental misunderstanding of how Spinoza and Bergson come to solve the problematic relation between the two systems, that is, between mind and body. As we have seen, both thinkers share the univocal premise that the co-existent systems are expressive of the same reality — that mind and body are the same images expressed in irreducibly and qualitatively different modes. However, for Spinoza, this co-existence finds its ultimate alignment in God or Nature as an apotheotic principle of reason. That is, his perspective develops from the (theological) whole in order to explain how the individual body and mind participate in it. Bergson, on the other hand, approaches the problem from the inverse perspective — from the individually perceiving mind toward the greater whole. Thus it should not be surprising that their divergent stances yield different conclusions. Spinoza's determinism is strictly a function of his perspective, which sees in the autological striving of each individual body an expression of the logical principle by which the world is immanently connected. Considered exclusively from the point of view of this connecting principle, nothing could be indeterminate or unconnected by it, since the principle by itself expresses the whole. But this is very different from claiming that our actions are determined by an identifiable being — recall that God or Nature in Spinoza is not a function of the principle of identity — or that individual minds could ever grasp the order of this determination, since this is precisely what is precluded in the *Ethica*. Most significantly, as I showed in Act 3, if we were to only consider the world from within the ever-changing order of phenomena, *natura naturata*, the result is not iron-clad scientific determinism, but on the contrary, a world of absolute chance and contingency. From Bergson's hypological premise of an individual pure perception contemplating the relation of co-existing image systems, Spinoza too would become a radical indeterminist, for he would be deprived of the generalized causality principle upon whose inversion his philosophy is predicated.

Moreover, the attempt to distinguish action from a passive or determined affection only nominally differentiates Bergson's thought, since for Spinoza affect can be both active and passive. Underneath these terminological differences, Bergson and Spinoza effectively converge on the body as the limit condition of the mind. Through its very autological positing, or its conatus, the body acts into the world and strives toward increasing its power of acting. In Bergson's terms, the body functions as the constantly moving distinction between the two co-existing systems of images. Lodged within this double movement, as though in an electrical circuit, the individually perceiving body is at once active transmittor and passive conductor:

> It is then the place of passage of the movements received and thrown back, a hyphen, a connecting link between the things which act upon me and the things upon which I act — the seat, in a word, of the sensori-motor phenomenon. (196)

With his reorientation toward the prerogative of action, then, Bergson is not distancing himself from Spinoza but more importantly positioning himself against a hegemonic current of Western thought, running through Aristotle as well as Descartes and Kant, that posits rational knowledge for its own sake, as the distinguishing trait of human beings. Critiquing this stubborn ideal as misguided, Bergson denounces philosophical and scientific conceptions like Newton's and Kant's, in which space and time are constituted by something like pure reason:

> Homogenous space and homogenous time are (…) neither properties of things nor essential conditions of our faculty of knowing them: they express, in an abstract form, the double work of solidification and of division which we effect on the moving continuity of the real in order to obtain there a fulcrum for our action, in order to fix within it starting-points for our operation, in short, to introduce into it real changes. They are the diagrammatic design of our eventual action upon matter. (280)

Concepts like the universe, in other words, enable us to immobilize nature so as to increase our mobility, our capacity for acting upon and within it. In Bergson's view, the mind simply furnishes the concepts most useful for bodily action.

By implication, the prerogative of action means that knowledge has to be considered not in itself but rather within a political field — that is, a field in which any body and all bodies are necessarily engaged through the autological mediation of interest. The hypological order of discrete facts is equally conditioned by this mediation. As Bergson puts it, "that which is commonly called a fact is not reality as it appears to immediate intuition, but an adaptation of the real to the interests of practice and to the exigencies of social life." (239) In this sense, Bergson's philosophy, much like Spinoza's, implies a critical view of how the modern sciences are traditionally conceived. By refusing to accept an epistemological status for modern science that divides it from ontological concerns, both Bergson and Spinoza constitute significant undercurrents in modern thought that connect to later thinkers, such as Gilles Deleuze, Michel Serres, Isabelle Stengers and Bruno Latour. Metaphysically, we could say, both Spinoza and Bergson open up to fundamentally political considerations of scientific practice by developing a perspective on the modern sciences in terms of their action in the world rather than their knowledge claims about it.[96]

Yet neither Spinoza nor Bergson goes further in this direction. On the contrary, their key works unite in a concern for the potential reconciliation of metaphysical and scientific understanding. In turn, this raises questions about the status of the position from which they philosophize. Are we to understand metaphysics too under the predominant sign of action — or as distinct from the kind of practical knowledge the sciences offer? In other words, either we have to ask, in a manner uncomfortably close to both positivism and pragmatism, about the actual usefulness of metaphysics — or it appears we have to posit a purpose for metaphysics that differentiates it from scientific knowledge altogether. This pervasive ambiguity finds a tentative resolution in yet another conceptual overlap between Spinoza and Bergson that requires some consideration. If, as Bergson puts it, the body "has for its essential function to limit, with a view to action, the life of the mind," this limit condition is where mind and body eventually meet or align. (233) It is what both Spinoza and Bergson call intuition.

Within this convergent concept too, we find a significant perspectival divergence. For Spinoza, intuition is the kind of knowledge which leads to "the

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[96] We will return to this contemporary thread in Act 5 and show how it relates to the works of Serres, Latour and Stengers, and their articulation of a different relation between nature and culture. Philosophically, Deleuze is perhaps the foremost connecting point between Spinoza, Bergson and Nietzsche, partly through his monographs on these individual thinkers, and partly for articulating a differential ontology consistent with much of Latour and Stengers' philosophies.

perfection of the intellect," its "highest blessedness" and the condition of its freedom. The purpose of intuition is not to achieve universal knowledge — for as we saw in Act 3, this is metaphysically impossible for Spinoza — but rather to enact an alignment of the body's own striving tendency with its actual conditions. That is, through intuition, Spinoza suggests, we come to discover that connecting principle by which essence and existence are mediated: in a word, God or Nature. The overall movement of his five-part work is therefore once again significant: beginning with a concept of the whole — substance, God or Nature — moving toward the individual mind, in search of a stoic harmonization with the world as it is given to thought. Intuition in Spinoza thus becomes the ethical means for finding a kind of personal peace.

Moving in the inverse direction, Bergson's initial premise of the individual perceiving body opens toward the whole. Thus, intuition is not merely where the individual finds its continuity with the cosmos — no, much more spectacularly, it is universal continuity as such. To think intuitively, in Bergson's conception, is "to reverse the normal workings of thought," whose "invincible tendency" is always toward thinking states and processes as things. (2007: 160) This means to reintegrate oneself with the real movement of the world, to philosophize from within the mobility of life rather than from the immobility of perception. Consequently, intuition is where science and metaphysics converge. As Bergson most ambitiously puts it in his 1903 essay:

> A truly intuitive philosophy would realize the union so greatly desired, of metaphysics and science. At the same time that it constituted metaphysics in positive science (…) it would lead the positive sciences, properly speaking, to become conscious of their true bearing, which is often superior to what they suppose. It would put more of science into metaphysics and more of metaphysics into science. Its result would be to re-establish the continuity between the intuitions which the various positive sciences have obtained at intervals in the course of their history… (2007: 162)

The convergence toward positive, universal continuity in the sciences is for Bergson predicated on the very same reversal of thought toward which the intuitive method in philosophy leads. The differential calculus, he argues, is "the most powerful method of investigation known to the mind," because it "substitutes for the ready-made what is in process of becoming" by following the growth of magnitudes, seizing movement in its tendency towards change. (2007: 160) The abstract symbols of mathematics and the reality of physics thus stand toward one another as quantity to quality — not quite symmetrically nor identically, since "quantity is always nascent quality," but nonetheless in a mutually constitutive relation.

Toward the end of *Matter and Memory*, then, a rather lyrical Bergson attempts to articulate the close parallels between contemporary physics, mathematics and metaphysics, which in turn suggests a set of complementary practices for philosophy and science into the 20th century.

> …when we have placed ourselves at what we have called the turn of experience, when we have profited by the faint light which, illuminating the passage from the immediate to the useful, marks the dawn of our human experience, there still remains to be reconstituted, with the infinitely small elements which we thus perceive of the real curve, the curve itself stretching out into the darkness behind them. In this sense, the task of the philosopher, as we understand it, closely resembles that of the mathematician who determines a function by starting from the differential. The final effort of philosophical research is a true work of integration. (241-2)

True integration — founded on difference, co-existing in deep admiration and respect for the universal continuity of becoming. Moving far beyond the lonesome ethical prescriptions of Spinoza, Bergson offered the new century a compelling, if not magnificent, vision of harmony that succeeded in moving exalted crowds into lecture halls, engaging masses of readers, interesting philosophers and scientists from all over the continent — all by invoking the irresistible ideals of comprehension and coherence. With Bergson, the world was finally making sense.

And yet — within merely a few decades, the relation of philosopy and science had never been more thoroughly bifurcated, more deeply antagonistic — and the virtual image of philosophy itself never more splintered. What happened?

To glimpse the historical evanescence of Bergson's pronouncement that integration is the final true nature of philosophical research, it is instructive to juxtapose it with Heidegger's statement three decades later, as quoted in Act 2. The true nature of philosophical research, Heidegger says, begins with ontological difference — that is, it begins by asserting that philosophy and science are fundamentally different in nature — that science, including physics, is merely ontic, not truly ontological.[97] And as we have already seen, Heidegger's later works do little to reconcile this divide, upon which much of his own philosophy was predicated. Indeed, by the time Heidegger waded into a bitterly fraught philosophical scene in Europe, the vicissitudes of Bergsonism had revealed most clearly the incipient resentment of modern mass popularity, which turned the

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[97] See Heidegger, 1988, p. 17, also quoted in Act 2.

French philosopher from *cause célèbre* into *cliché*. As Whitehead later remarked, "a system of philosophy is never refuted; it is only abandoned" — and Bergson's fate during the world war decades illustrates it all too well.[98] Although perhaps no thinker had done more than Bergson to advance a philosophy of time, life, difference and experience in distinction from prevailing positivist and neo-Kantian currents, Heidegger made scant reference to Bergson in his own work. In a dismissive one-paragraph analysis, Heidegger first reduces Bergson's thought to simply a reversal of the Aristotelian conception of time, and then, as if the first punch were not enough, claims that Bergson misunderstands Aristotle anyway. Thus, the Frenchman who eagerly staked out a new orientation for philosophy was recast as yet another culprit in the history of thought from which the young German thinker, like so many others, sought to differentiate himself.[99]

In any case, to grasp what failed Bergson's vision at the turn of the century, we look in vain within the increasingly insular, fragmented and relentlessly fashion-cyclical discourse of philosophy itself. Instead, an historical answer lies in the rapidly growing disparity between Bergson's cogent account of his contemporary physics and some of its most novel and unpredictable inventions. In a span of merely three years after Bergson's 1896 publication, new experimental phenomena would boggle prevailing physical ideas: x-rays, radioactivity, electrons, canal rays — and sensational discoveries that would later be rejected and forgotten, including black light and etherions.[100] As we shall see in the following, the attempts to render these phenomena coherent with physical explanation would significantly alter the direction of physics in the 20th century, effectively overturning Bergson's conception of universal continuity.

Another related answer can be gleaned from considering Bergson's thought within the general historical context of his time. Something simply jars too much in the juxtaposition of a harmonic philosophy of continuity expressed amidst the explosive growth lines of a culture proliferating beyond human control. In this sense, I think, the strength of Bergson's philosophy inevitably turns out to be its weakness. For its conception of the equiversal relation between the individual body and the totality of the world, which so brilliantly enables the concept of intuition to

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[98] See Whitehead, 1979, p. 6. All subsequent quotations from Whitehead are taken from *Science and the Modern World*, 1926.

[99] See Heidegger, 1988, p. 231-2 for Bergson's alleged one-dimensionality, and p. 244 for the claim that Bergson misunderstands Aristotle.

[100] See Kragh, p. 37

express the universal continuity between part and whole, and which thus submits philosophy to the prerogative of action, simultaneously appears to have missed entirely the most discernible worldly effect of this action. Consider, for example, the consistent critique Bergson leveled against physics in particular and science in general: its inability to account for life — the relentless source of newness, change, singularity, of the irreversible flow of time. Life, in short, is that which escapes any quantitative science. Yet if we accept the general vitalist hypothesis, perhaps the most revealing problem in Bergson's analysis in *Matter and Memory* is that life is conceptually limited to the individual body in relation to a determinate totality. For what clearly arises in 19th century Western Europe as historically distinct is a dimension of life that is neither immediately discernible at the level of the individual body nor at the level of a universal totality — but rather, virtually everywhere in between. Qualitative intensification, quantitative proliferation. In a biopolitical order, life shows itself first and foremost as an intensely expansive, virally multiplying phenomenon — an order in which the causality of any one individual form of life is both practically and theoretically irrelevant. Beyond the autologically living and positing body that mentally perceives order in the universe according to hypological rules, the 19th century conceives life metalogically.

In other words, the explosive growth of the modern world does not conform to the mutual axis of a principle of reason constituted by the principle of identity. And in this precise sense, Bergson's analysis of the part-whole relation — for all its laudable efforts at reorienting thought — never takes him logically beyond hypological reasoning.

4. Planck's Discontinuity

Even as his subsequent philosophical work moved more explicitly toward biology, Bergson showed a deep and abiding interest in physics. He would claim, for example, that the second law of thermodynamics is "the most metaphysical of scientific laws" — that is, most aligned with Bergson's metaphysics — because it points out, without any artificial mediation, the direction the world is going.[101] In particular, he would draw on the concept of energy to explain his theory of the vital tendency, variously as creative energy and, as in his 1919 essay collection,

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[101] See Bergson, 1911, p. 243. For a brief discussion, see Capek, 368.

L'énergie Spirituelle, translated as mind-energy. Ostensibly, the positive thermodynamic assertion of the universal constancy of energy and its irreversible flow appeared to capture something confluent with life itself.[102]

Outside physics and philosophy, the idea of entropy tending toward a maximum appeared to be more than a theoretical construct. Along the same exponential vectors as population curves, the physical conceptualization of energy in the 19th century correlates with its increasing mobilization. By the 1880s, electricity had become widely available across Western Europe. And in turn, a new carbon era was ushered in, through the rapacious consumption of coal. Between 1850 and 1900, the British output of coal surged 355 percent, from 50,2 million tonnes to 228,8 million. And in this capacity too, it would soon be overtaken by Germany, whose run-away output in 1900 — 142,7 million tonnes — represented a 2700 percent increase on 1850 levels.[103] Thus, if we find Spinoza speaking from a culture fired by wood, Bergson evidently writes from a civilization of coal.

By vastly transforming the human condition at the expense of a nature from which it had hypologically differentiated itself, this modern scientific culture expresses its profound inner contradiction in the mobilization of energy. Conceptually, this contradiction was present in energy physics from its inception. Energy is the substantial idea underlying two pivotal constructs that together form the basis for the discourse of theoretical physics.[104] One, as we have seen, was Maxwell's electromagnetic field theory — the other was Maxwell and Boltzmann's kinetic theory of gases. In retrospect, these two theories turn out to be metaphysically irreconcilable because they rely on two different logics, expressed through different kinds of mathematics. Thus, the metalogical rise of theoretical physics is predicated on an internal bifurcation, which corresponds to the very

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[102] In this enthusiasm for energy, Bergson was certainly in line with the *zeitgeist*. In German physics, energy became a serious contender for replacing mechanics as the unifying framework of physics. Exemplary is the influential contribution of the Dutch physicist Hendrik Lorentz, who systematically treated the problematic relation between energy and matter and developed a completely foundational electromagnetic ontology. Lorentz claimed to explain the ether as an electromagnetic field and matter in terms of electrons, as discrete units of energy charge, and thereby put physics on new metaphysical ground. Along with other popular movements such as 'energeticism', the electromagnetic world-view typified the 'progressivist' orientation for physics, resisted by 'conservatives' such as Max Planck and positivists like Ernst Mach. See Harman, 115-19.

[103] See Davies, p. 1294.

[104] Thermodynamics as the basis for a new theoretical or mathematical physics is discussed in Lindley, p. 140.

same incompatibility we today see between general relativity and quantum mechanics.

For Hacking, the rise of probability in the 19th century develops, after the initial "avalanche of numbers" and a period of "law-like regularities," into a third recognizable stage, in which distribution curves and large number regularities are turned into what he calls "the autonomy of statistical law." Roughly situated from 1875 to the early 1900s, this stage corresponds well with the work of Maxwell, also the pioneer of statistical reasoning in physics. Already in the 1850s, Maxwell had read the work of Adolphe Quetelet, the doyen of statistics in the social sciences. Soon, he molded Quetelet's work into a 'statistical mechanics' for description of large-scale systems.[105] In dabbling with its physical application, Maxwell adopted a pragmatic attitude, writing in a letter:

> The true logic for this world is the calculus of probabilities… This branch of mathematics, which is generally thought to favor gambling, dicing and wagering, and therefore highly immoral, is the only 'mathematics for practical men.'[106]

In 1866, he applied this practical calculus to the problem of how gases change as they heat up. The radical invention of the kinetic theory of gases was to derive it from statistical reasoning: instead of conceiving a changing gas in terms of a continuous function or the presence of some imponderable property — in prevailing heat theory, this was called a 'caloric' — Maxwell assumed that heat rather consists of particles in motion, and, as a further mode of circumscription, that their changes can be described in terms of discrete states. In this conception, as the gas heats up, its myriad tiny molecules increase in velocity, banging about with greater frequency. The average pattern of grouped particle sizes turned into a generalized distribution model that would come to be known as the Maxwell distribution. Maxwell found that his average distribution could be used to derive experimentally verifiable results for the totality of the gas, even if the actual mechanics of the system itself — its causal chain — remained unknown. With probability calculation, in fact, there was no need to know the actual composition of the gas at all, as long as the assumption of particularity, necessary to perform the

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[105] This procedure, and the subsequent development of probability in physics, occurs in a markedly different way from the social sciences. Rather than accumulating large data sets for which inferential procedures can be invented, probability primarily becomes significant at the level of measurement on the one hand, and at the level of theoretical construction on the other — into both halves of the theoretico-experimental hybrid. See Krüger, 1987b, p. 373.

[106] Quoted in Lindley, p. 69. In 1859, Maxwell first applied probability to an astronomical problem, the nature of Saturn's rings. He explained mathematically how they could be considered particulate.

mathematical operation, eventually yielded the right results for the system as a whole.[107]

In 1872, the Austrian physicist Ludwig Boltzmann pushed Maxwell's work one step further. Whereas Maxwell's solution consisted of deriving a large number of possible gas states in order to find the most probable one for the variables given, Boltzmann found a simplified way to express all the probabilities in terms of one single system. The crux of his laborious investigations was his minimum-theorem, which later became known as the H-theorem.[108] The constant H functions as a quantitative threshold defined in terms of the velocity distribution of the hypothetical atoms. In one and the same operation, Boltzmann's mathematics showed that if the gas particles corresponded to the normalized Maxwell distribution, H would reach its minimum quantity — and conversely, that if the value was initially higher than H, the gas would over time move its velocity toward the Maxwell distribution and thus eventually reach the minimum, H. In other words, Boltzmann's theorem is a statistical expression of the two laws of thermodynamics, positing at once a given equilibrium — energy in average distribution, that is, in constancy — and a tendency toward this equilibrium, defined as maximum entropy. The quantity H thus becomes the mathematical fulcrum through which either energy constancy or entropy, both defined as states of equilibrium, can be expressed.

Boltzmann's H-theorem is an early example of the double constitution necessary to eventually align theory and experiment. In characteristic circularity, the theorem appeared to be mathematical proof of the laws of thermodynamics, and at the same time, it lent legitimacy to his calculation because it corresponded so well with laws based on observation. In fact, Boltzmann was convinced that he had derived conclusive proof for the absolute mechanical certainty of thermodynamics, and in particular, the law of entropy. His conviction too is exemplary of Hacking's second stage of the rise in probability reasoning, in which the law-like regularities of statistics mingled with existing mathematical laws in combinatorial forms.

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[107] This and the following general discussion of the statistical inventions of Maxwell, Boltzmann, and Planck is primarily drawn from a combination of Harman, Lindley, and Kuhn, 1978, and Krüger, 1987a.

[108] According to Lindley, it became the H-theorem when an English physicist misread Boltzmann's hand-written letter E (for 'element') as an H. Lindley, p. 75.

But Maxwell realized that something was wrong with the mix. In 1873, he mused on a contrast between "two kinds of knowledge" in physics, one of which was dynamical, the other being statistical and "belonging to a different department of knowledge from the exact science."[109] Specifically, Maxwell concluded, the laws of thermodynamics were statistical in nature — thus not absolutely certain, but rather, in a common phrase with distinctly biopolitical overtones, only 'morally certain.' The most popular illustration of this insight is now called 'Maxwell's demon' — a thought experiment that situates between two connected gas containers an observer (the 'demon') able to follow the individual causal distribution of molecules as they flow from one container to another, from hot to cold, in the direction stipulated by the law of entropy.[110] From the perspective of this demon, it is impossible, Maxwell concluded, to ascertain that some particles would not be able to move the opposite way. The best that could be said for the laws of thermodynamics is therefore moral certainty — highly probable with a constitutive degree of uncertainty. Or put differently, these are laws of tendency. If thermodynamics differs from Newtonian dynamics as statics differs from kinematics, then probability is really the classical autological concept of tendency reconstituted in metalogical form. What statistical laws most essentially tell us is the inclination of a phenomenon to occur, not the causality by which it actually happens.

Either way, in the late 19th century, Maxwell's logical distinction was far from obvious or commonly accepted. Boltzmann, for one, remained unconvinced. For years after publishing his H-theorem, which from Maxwell's perspective combined statistical and dynamical modes of calculation, he continued to insist that it proved irreversibility as an absolute, dynamical fact of nature. Although he many years later conceded the H-theorem was 'merely' statistical, he kept minimizing the practical importance of this logical difference, insisting that his proof was not merely based in probability — it was, he wrote, "extremely probable" and the chance it could be wrong was "extremely small."[111] For years, Boltzmann put his

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[109] Quoted in Krüger, 79.

[110] In this sense, Maxwell's fictional local observer — he never himself used the term demon — must be distinguished from the more famous Laplace's demon, the omnidirectional observer from which the entire universe can be causally determined. Some histories even place Laplace's demon in the same category as Spinoza's alleged determinism. However, I have already shown in section 3 how Spinoza's determinist perspective does not rely on an identifiable being. The idea of Laplace's demon, that a scientific observer could determine all movements of the universe, would be preposterous to Spinoza.

[111] Quoted in Kuhn, 1978, p. 61.

physical work aside and embarked on a lengthy personal study of philosophy to find ground for his original claim, only to be frustrated by its futility for his specific purpose. In 1905, he wrote poignantly to the philosophy professor Franz Brentano: "Shouldn't the irresistible urge to philosophize be compared to the vomiting caused by migraines, in that something is trying to struggle out even though there's nothing there?"[112]

Another skeptic was the German physicist Max Planck. Throughout the 1890s, he worked on a theory of blackbody radiation, which in effect combines three dimensions of Maxwell's work: electromagnetics, thermodynamics, and statistical mechanics. The physical parallel between kinetic gas theory and electromagnetic radiation was already established. Considered as systems, they both move irreversibly toward equilibrium, defined in terms of Maxwell's statistical distribution, which could be applied to wavelength size rather than molecules. Planck was a rather conservative respondent to the new progressive wave of energy-based physics. Like Boltzmann, he was concerned with reconciling the laws of thermodynamics with classical dynamics. To this end, Planck retraced many of Boltzmann's mathematical steps, year after year, eventually leading him in 1899, as American philosopher of science Thomas Kuhn relates, to the same frustrated conclusion as his Austrian peer: "Both men had initially sought a deterministic demonstration of irreversibility; both had been forced to settle for a statistical proof; and both had finally recognized that even that method of derivation required recourse to a special hypothesis about nature." (1978: 91)

Only after 1910 would the statistical understanding of thermodynamics become firmly established in physics discourse, and this around the same time as probability becomes an autonomous branch of mathematics.[113] The slow recognition of the metalogical mirrors the century-long historical rise of probability. According to Hacking's scheme, the discernible final stage of this development occurs roughly in the 1890s and onwards to the 1930s, when statistical reason becomes increasingly associated with a philosophy of indeterminism, ostensibly

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[112] Quoted in Lindley, p. 199.

[113] See Kuhn, 1978, p. 70. Jan von Plato discusses the difference between 'classical' and 'modern' probability, defined as the departure from the equiprobability theorem of Huygens and Spinoza in favor of more autonomous mathematical approaches to calculation. See von Plato, 1987, and his 1994 book on the subject, esp. pp. 4-18.

differentiated from deterministic laws associated with the paradigmatic mechanism of the 18th century.[114]

Yet for the next century, this differentiation would be as unclear in scientific practice as in philosophy. Already in the last three decades of the 19th century, when statistical laws were increasingly regarded as autonomous, the status of thermodynamics within the discourse of physics appeared paradoxical. On the one hand, the laws of thermodynamics were developed from observable physical conditions of actual phenomena — in contrast to the laws of Newtonian dynamics, which were abstract, mathematical and reversible. Thus, in experimental work, nothing appears more certain than the clearly visible fact that heat always flows from a hotter to a colder object. But on the other hand, Maxwell was arguing — and his successors would corroborate his point — that this phenomenal, irreversible reality is the one that could not be stated with certainty. To this day, theoretical physicists are trained to accept that the laws of mechanics are primary to the 'merely phenomenological' laws of thermodynamics, even if it is only the latter that can be witnessed and attested directly in the laboratory. Thus, the devolution of thermodynamics to a second-class natural law is often a main line of critique against a discipline that in the course of the late 19th century once again appeared to abdicate its physical common sense to mathematics.[115]

Metaphysically, however, there is more at stake in probability than common sense. In the case of thermodynamics, Bergson is among the thinkers who see in the irreversibility of entropy the physical correlate of time's arrow. Moreover, because the difference between mechanical and statistical explanation implies indeterminism, it also leaves a loophole in physical description for human freedom. In fact, in the same 1873 paper that distinguishes dynamics and statistics as two kinds of knowledge, Maxwell himself explicitly regards free will as a possibility

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[114] See Hacking, 1987, pp. 52-3. Hacking, 2006, contains a discussion of 'Cassirer's thesis' that the determinism of the 1870s is a distinctly different concept from the determinism retrospectively read back into 17th century mechanics. In this sense, the supposed indeterminism of the late 19th century would be less of an historical break than is easily supposed when determinism and mechanism are conflated. In either case, my reading of Spinoza, as the alleged arch-determinist of 17th century thought, along with my subsequent discussion below, suggests the common historical distinction of determinism and indeterminism is a conceptual red herring, at least as long as they are considered on the same logical plane.

[115] Nancy Cartwright has dedicated several books to this line of critique, including the arrestingly titled, *How the Laws of Physics Lie*. Ilya Prigogine's *The End of Certainty* is a direct attempt at reestablishing the laws of physics on the statistical basis of thermodynamics. Prigogine's critical work is also reflected in Stengers' work, esp. 1997, pp. 21-79.

within the framework of statistical knowledge. The probabilistic description of thermodynamics, in other words, appears to right the wrongs of Newtonian dynamics, to reinverse the inversion of nature — to once again include into physics the autological concepts which its foundational gesture so firmly excluded. And in turn, much like Bergson's sentiment in *Matter and Memory*, such a positive recognition would enable a measure of harmonization between physics and metaphysics.

Alas, the metalogical character of probabilistic thought is not so easily aligned with the prevailing logical system of either science or metaphysics. In his epistemological distinction, Maxwell does not differentiate the fallacy of one logical order against the positive possibilities of another. Most essentially, it bespeaks an irreconcilable relation. Maxwell's demon is not a real physical example of potential freedom to defy mechanist laws but an illustration of a logical limit condition. And the irreversibility of statistical mechanics and thermodynamics is not a positive statement of time but, strictly speaking, only a function of probability. In this sense, irreversibility as an ostensible physical fact must not be conflated with what is logically only non-reversibility. That is, insofar as statistical description is differentated from the reversibility of Newtonian dynamics, it is non-reversible. And insofar as the metalogical appears as a differentiation from predominant logic, it is not strictly indeterminate, if we by this intend some quality of the phenomenon itself, but properly speaking only non-determinate.

What does this difference mean? On the one hand, the hypological order of dynamics is reversible because it is predicated on an inversion of autological causality, meaning that every cause is identified with an effect. Under the principle of identity, A equals A, whose direct correspondence is the necessary condition for moving backwards and forwards between cause and effect without fault. Thus, the reversibility of rational mechanics is a function of its logical matrix. On the other hand, the metalogical order of statistical reason is predicated on the exclusion of autological causality, and thus relates to dynamics only by correlation. This lack of causal identity is why probability is non-reversible. Metalogically, a kinetic gas system, for example, is not irreversible because of the passage of time but because its mode of explanation is non-causal. In itself, then, the metalogical takes no positive account of time, freedom or becoming. Only by differentation from the established hypological order of reversibility does it take on positive meaning, precisely as a measure of that which the hypological cannot circumscribe. In turn, this difference all too easily becomes hypostasized by the principle of identity and employed in the service of attempts to fill the gaping absence of causal reason.

In this sense, the logical status of thermodynamics is a precursor to the problematic and ostensibly contradictory postulates of quantum mechanics. In the vast literature interpreting quantum physics, a common move is to reintroduce some positivized hypological concept into the logical absence of causal explanation. For instance, 'subjectivity,' 'mind,' or 'God' comes to explain the uncertainty relation as the power of subjective (or mental, or divine) intervention in objective calculation.[116] The nominal possibilities are endless.[117] But in either such case, the metaphysical problem is resolved like a *deus ex machina* — much in the same manner as the mysterious correspondence between image systems in Bergson.

Thus, the combination of hypological and metalogical reasoning involves a double movement. It can yield new solutions to old problems — resolving discrepancies between hypological and autological conditions, as in kinetic theory — and, as in the tendency just described, old solutions to new problems. The asymmetrical character of this doubling is perhaps best revealed in a profound perspectival shift on physical and metaphysical problems as such. Maxwell's epistemological distinction between dynamical and statistical knowledge leads him to formulate the branching of different solutions to physical problems into two general categories: predictable and unpredictable systems. According to the 'classical' postulate of equiprobability, which underpins statistical reason from Huygens in the 17th century to the early 20th century, for every mechanically possible motion that leads toward equilibrium, there is another equally possible motion that leads away from it and which would be incompatible with a dynamical interpretation of entropy. Whereas classical dynamics was exclusively concerned with stable, predictable systems, because this is what its causal logic favors, Maxwell suggests shifting this "prejudice of determinism" toward a study of "the singularities and instabilities, rather than the continuities and stabilities of things."[118] In this sense, Maxwell can be considered not only the grandfather of a metalogical physics that is exclusively focused on anomalies, but also a forerunner

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[116] See physicist Victor Stenger's scathing review of 'quantum metaphysics' for a list of contemporary examples.

[117] Consider that in the recent *Compendium of Quantum Physics*, the entry for "Interpretations of Quantum Physics" yields the following reference, p. 322: "See Consistent histories, Ignorance interpretation, Ithaca Interpretation, Many Worlds Interpretation, Modal Interpetation, Orthodox Interpretation, Transactional Interpretation." And these are only the canonical entries within physics, discounting popular and philosophical theories outside discursive bounds.

[118] Quoted in Krüger, p. 80.

of all analytical inquiries focused on exceptions, breaking points, singularities, limit conditions — a distant yet discernable echo of 20th century discourses involving critical theory.

As a scientist in the classical Newtonian and natural theology tradition, Maxwell contributed fundamentally and equally to both a dynamical and a statistical conception of energy, without ever trying to resolve their incompatibility. For him, metaphysical reconciliation would necessarily involve the transcendental order of God, not the mathematical universe of physics. Therefore, he limited his claim to epistemology. Yet he clearly understood that the difference between dynamical and statistical explanation implied the difference between a fundamentally continuous and discontinuous universe. In a hypothetical turn of phrase, he described the consequence of statistical reason this way: "if the molecular theory of the constitution of bodies is true, all our knowledge of matter is of the statistical kind."[119] For both Maxwell and Boltzmann, the kinetic theory of gases was still limited to this dependency clause that could not be tested: *if* matter is particulate. Certainly, kinetic theory lent some credibility to atomism, since it made individualized particles conceptually useful. But the actual constitution of matter was still far beyond Abbe's microscopic threshold. And more problematically, in Boltzmann's hypothesis, the actual size of the atoms was arbitrarily chosen and could vary in relation to the other mathematical variables. From the perspective of a coherent atomism, this was rather contradictory.

Then again, if statistical law is logically autonomous, how could one expect it to be combined with a different logic without resulting in contradiction? The answer, it would turn out, was to invert the contradictory logics into a case of mutual constitution within the same framework. And in turn, Maxwell's dependent clause could be made into an independent reality. As Einstein would later quip about his style of reasoning, only half in jest: "Turn the problem into a postulate, that's how you get by."[120]

In this sense, Maxwell and Boltzmann's kinetic theory reveals the actual effect of combinatorial approaches, by deftly moving between Newtonian dynamics and statistical reasoning. On the one hand, differential calculus provides an expression for the system as a whole. On the other hand, probability calculus can proceed from this whole by expressing it in terms of particularized components. Thus,

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[119] Ibid., p. 79.

[120] Quoted in Hentschel, 341.

Maxwell's two kinds of knowledge are mobilized in tandem, and their logical difference assimilated — under the reigning hypological assumption of universal mathematics. In other words, given that mathematics always speaks in the same language — always reflects a unified turning of an equivocal metaphysics — contradictory logics may be combined along the same fundamental metaphysical axis. In this sense, the absolute continuity of field theory and the axiomatic discontinuity of kinetics are practically unified.

Perhaps the most pivotal example of this approach is Planck's invention of the quantum in 1900. After years of futile research on irreversibility, a disappointed Planck shifts his focus toward deriving from the blackbody spectrum a radiation law that would hold up to already existing experimental results. A blackbody is a hypothetical space that functions much like Galileo's void or Einstein's speed of light in a vacuum, only in inversed form: not empty, but full — a pure plenitude of electromagnetic radiation. Kuhn formulates the premise:[121]

> If a cavity with perfectly absorbing (i.e.., black) walls is maintained at a fixed temperature T, its interior will be filled with radiant energy of all wavelengths. If that radiation is in equilibrium, both within the cavity and with its walls, then the rate at which energy is radiated across any surface or unit area is independent of the position and orientation of that surface. (1978: 3)

In other words, the blackbody is a classic hypology: if radiation in a specific thermal state is in equilibrium, then any local, mediating conditions can be ignored. In this sense, the formal problem is to derive a radiation formula in such a way, in accordance with the condition of equilibrium, that it can be extended to universality. By isolating local conditions and circumscribing temperature variation to a a single state (T), the question becomes: how does the wavelength of a heated body change with temperature? This formal similarity to the kinetic gas problem allows Planck to replicate Boltzmann's mathematical approach under the assumption that blackbody radiation is a system like any other.

However, this common physical assumption conceals a crucial metaphysical difference. Whereas Boltzmann operates with a distinctly bounded physical phenomenon — gas in a container — Planck is theorizing toward the very limit

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[121] The following discussion is largely derived from Kuhn's detailed study, 1978, with some supplementary insight from Hentschel. I do not, however, follow Kuhn's historical conclusions on the significance of Planck's theory, nor am I concerned with his more controversial argument about the specific later sources of Planck's own reinterpretation of his own theory, something that fits Kuhn's general story of a paradigm shift but whose interpretation some historians of physics dispute. See Kragh's note, p. 454.

condition of physics itself. He is trying, as it were, to derive a mathematical expression for a compound foundational concept: energy, radiation, light and electromagnetism. To even make his problem conceivable mathematically, Planck finds it necessary to insert an additional hypothetical premise: a set of 'resonators' that would absorb energy from, or be sensitive to, each wavelength frequency. Specifically, then, his problem is to calculate the frequency distribution of energy within a hypothetical space in terms of hypothetical individual resonators.

To satisfy the metalogical supposition of individuality, Planck subdivides the energy continuum into elements of finite size for purposes of calculation. In the process, he also strategically reverses the order of the problem. Instead of stipulating suitable initial conditions that lead toward equilibrium, as in Boltzmann's method, Planck begins by assuming equilibrium in order to find the initial conditions, which in this case corresponds to the relationship between resonators and wavelength. And unlike Boltzmann's variable-size atoms, Planck eventually finds that in order to make his energy elements correspond to the resonators, they have to be of a fixed size. Without this fixed discontinuity, the interaction between radiation and resonator would lead to an increasing dominance of oscillations over a diminishing frequency within the radiation field — that is, a run-away feedback effect. Hence, to preserve the statical equilibrium necessary to extend the problem to universality, any change in energy within the radiation spectrum would have to be expressed as multiples of the energy element *e*, in discontinuous jumps rather than continuous alteration. For Planck and the first physicists taking up his argument, there is no discernible physical reason why this should be so — it just happens to make the overall calculations cohere with experimental results.

Thus, we glimpse the contours of a double feedback cycle: no longer merely in the hypological sense of theory and experiment mutually constituting one another, but now also between the irreconcilable logics working in combination. In order to render the discrepancy between electromagnetic theory and actual experimental results coherent within a universal framework, Planck seeks recourse to a statistical, metalogical method whose sufficient condition is a discontinuous quantity. When Planck reverses the problem and assumes statistical distribution as his given, he reaches the point at which the mathematical continuity of electromagnetic radiation breaks down — the limit condition of the energy spectrum — and this too shows up as a discontinuous quantity. Calculating forwards and backwards, Planck is unable to eradicate this strange mathematical implication. Logically, then, Planck's combining hypological and metalogical reasoning yields the condition for achieving a mathematically unified formula for blackbody radiation, namely a limit on the universal continuity of light. What is at stake in Planck's result, in other words, is not initially the nature of light, but the metaphysical axiom of universalism itself.

As already intimated, Bergson's *fin-de-siècle* vision of hypological harmony between metaphysics and science was supported by some physicists who believed that the successes of frameworks for universal continuity spelled the 'end of physics.' As quoted in Act 1, a famous universalist statement from the 1895 British Association for the Advancement of Science exclaimed that the ultimate laws of nature "will be the dynamical laws of the relations of matter to number, space, and time. The ultimate data will be number, matter, space, and time themselves. When these relations shall be known, all physical phenomena will be a branch of pure mathematics."[122] This 'end of physics' sentiment, which has later been invoked by prominent figures like Stephen Hawking, plays a special role in the retroactive history of 20th century physics. As a typical example, Kragh's synoptic survey begins: "At the end of the 19th century, some physicists believed that the basic principles underlying their subject were already known, and that physics in the future would only consist of filling in the details. They could hardly have been more wrong."[123] Yes, clearly these poor, naive physicists, like Bergson, were proven wrong by history. Yet reducing the sentiment to something like an historical joke that affirms the genius of 20th century physics fails to capture the surrounding metalogical conditions for such a failed prediction.

At the turn of the century, the discourse of physics was burgeoning. From once being a creative juncture for experimental problem-solvers with general training in mathematics, related sciences — and sometimes even philosophy — it would now gather momentum as an institutionalized and professionalized discipline. Counting physics faculty including assistants in 1900, German universities hired 145 physicists, its British counterparts 114, the French 105.[124] The flurry of activity is

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[122] Quoted in Kragh, 5.

[123] This is the back cover text of Kragh's book, which effectively frames the history of 20th century physics as a radical departure from a foolhardy conception.

[124] Meanwhile, across the pond, American physicists already numbered over 200. But partly due to the long distance of communication from the European institutions, where new inventions would occur at an increasingly frequent pace, it would still take until the 1930s for the center of gravity in physics to shift decisively across the Atlantic. While the US produced around 20 physics PhDs in 1900, and still less than a yearly average of 30 by 1920, the curve turns exponential in the 1920s, reaching 100 by 1930 and pushing 200 by 1940. See Kragh, pp. 14-16, and p. 20.

indicated by prolific research output — nearly 1500 published papers between the three top European physics journals — with the average German academic physicist producing more than three papers a year. The discipline of physics, in other words, like the biopolitical and carbon vectors around it, was accelerating. And due to Abbe's maximization of the optical limit, the only way for physics to maintain momentum was to invent new ways of extending its reach into the invisible constitution of nature.

Most significantly, the universalist assumption of an 'end of physics' implies that the real movement and progress of physics as a scientific enterprise is governed by the knowledge and understanding of individual scientists themselves. If physicists in 1895 agreed that the 'end of physics' or the limit of mathematical universality were indeed reached, would we then assume the discipline to somehow halt in its tracks, to thwart its own momentum?[125] Such an implication is sustained by what we could call the metalogical illusion — the illusion that individual human beings are in actual charge of metalogical practices that extend exponentially beyond themselves.[126]

In this sense, the discrepancy between Planck's own understanding and the one that would become retroactively ascribed to his work is indicative. At first, as Kuhn relates, Planck appears to think he has merely produced a curious *ad hoc* result to a specific problem that he still views in classical terms. But five years later, Einstein and other physicists begin to consider Planck's theory significant in a different way. As Kuhn puts it, "without apparently having intended to do so, Planck had produced a concrete quantitative link between electromagnetic theory, on the one hand, and the properties of electrons and atoms, on the other." (1978: 112) Only upon this mediation of interest by his peers does Planck begin to describe his result as non-classical and change the terms of his discovery to reflect its new status. What had first been described as an 'element', in analogy to chemistry and Boltzmann's gas theory, he now baptizes the 'quantum of action' — quantum in German signifying discontinuity and separability — and the acoustic analogy of

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[125] To put this in a contemporary analogy, if only a group of great scientific minds gather in agreement to stop the world's consumption of carbon, the metalogical run-away momentum of global economic structures and practices could be stopped... As in Bergson's hopeful scenario, a notion of free will is not only posited, but extended from the particular to the universal.

[126] If Hacking's aforementioned correlation of the rise of statistics with Western conceptions of individuality is any indication, such a metalogical illusion would be more pervasive in liberal democracies, or any political system with a deeply rooted conception of individuality — that is, a profound mismatch between its functional ideals and its actual practices of mass mobilization.

'resonators' changes to the more binary term 'oscillators.' (1987: 17-18) Conceptually, then, Planck had invented a sufficient condition for physics to ground itself in the very discontinuity between its two irreconcilable logics. What remained was to forge the experimental link — from mathematical discontinuity to physical particle. At the turn of the century, in other words, the progress of physics becomes a matter of folding metalogical reasoning back into the hypological framework — reconstituting metalogical assumption as hypological fact.

5. The Invention of Particle Physics

At the end of the 19th century, the first evidence for particles was claimed. However, this did not occur in a determinate hypological manner, as a particle rendered visible and distinct under a microscopic lens. Rather, it happened in a metalogical proliferation of experimental tests that under highly specialized and qualified conditions appeared to mutually indicate a variety of mathematically stable phenomena whose implicit demand for unifying explanation would warrant invocation of a distinctly metaphysical particle concept. If that sounds complicated for experimental proof, it's only the simplified half of it. For what emerges as a physical particle is distinctly Janus-faced.

As Brigitte Falkenburg explains, the particle concept that extends into 21st century physics has fundamentally two roots. The first lies in the experiments of atomic, nuclear, and particle physics, relying on theoretical assumptions carried over from classical physics, and the second lies in the hypothesis of the light quantum. (220) In fact, the simple delineation of separable roots already conceals a complicated set of mutually constitutive relations whose intertwining complication grows exponentially for each decade in the 20th century. Focusing only on the nascent years of this theoretico-experimental hybrid, we can say generally that both aspects of the contemporary particle concept hinge on Planck's invention, both are extended and partially unified in Einstein's work — and both are decisively forged by novel, metalogical experimental means beyond Abbe's optical limit range of physical inquiry.

Unsurprisingly, the invention of the particle in modern physics occurs in an experimental vacuum. In 1897, the electron is derived from experiments with electric discharges in gases inside vacuum tubes. In these specially designed tubes, it had been shown years before, invisible cathode rays would shine forth upon contact with specific residue materials. British physicist J.J. Thomson, looking to prove the molecular structure of matter, finds a way to deflect the rays in the tube and thus measure, through differentiating electric and magnetic interference, its ratio of mass to charge. According to Maxwell's theory, electromagnetic waves do not carry a charge, and Thomson's result therefore indicates a discrepancy in the prevailing model. From framing his mathematical result in a model developed by Hendrik Lorentz a few years earlier, Thomson infers the existence of an isolated entity, which he first calls a corpuscle — partly because he thought his particle different from other electrons already theorized, and partly for its classical metaphysical connotations. Thomson eagerly pronounces the implications for atomic theory:

> We have in the cathode rays matter in a new state, a state in which the subdivision of matter is carried very much further than in the ordinary gaseous state: a state in which all matter… is of one and the same kind; this matter being the substance from which all the chemical elements are built up.[127]

Behold — substance in a test tube!

If only it were so simple. In a case study of the electron, Falkenburg analyzes the complicated intertwining of theory and experiment involved. As she points out, Thomson's "measurement did not in any way test the hypothesis that cathode rays consist of single massive charged particles. It only confirmed a consequence of this hypothesis," expressed in terms of Lorentz' mathematical model, which itself already implied atomism. (84-5) Neither of the properties Thomson ascribes to the particle — inertial mass, electric charge, point-like or local behavior, and a trajectory through classical space-time — was actually measured by him, nor are they subject to independent measurement. Rather, as Falkenburg puts it, "they are connected to each other by classical dynamics" in the same tacit particle concept. (85) By experimentally measuring the ratio of mass to charge in the observed phenomenon, Thomson thereby strictly imposes a dynamic structure onto his result.

As Kragh suggests, Thomson is celebrated as the discoverer of the electron less on account of his specific experimental findings than the boldness of his claim, which succeeded in attracting contemporary physicists to his work. Within the next few years, other isolated experimental phenomena with approximately the same mass-to-charge ratio were found in experiments of photoelectricity, beta

[127] Quoted in Kragh, p. 41.

radioactivity, and thermionics, and a similar quantity could be inferred from other fields of physics. (42) For believers in atomism, the mathematical stability of these results was strong indication of a discontinuous, identifiable phenomenon. But the ontological status of the electron would be impossible to discern from experiment alone. For one thing, by the 1920s, quantum mechanics would hold that electrons could be measured as both a particle and a wave. For another, as late as 2006, precision experiments in high-energy physics would conclude that the electron is only a so-called point particle — that is, it possesses no structure beyond what the theories of quantum mechanics and relativity demand for its coherence.[128]

Planck's quantitative link between particles and electromagnetism was forged most decisively by Albert Einstein in the first of his 1905 papers, "On a Heuristic Point of View about the Creation and Conversion of Light." After a pithy introduction remarking on the "essential formal difference" between the molecular assumptions of kinetic gas theory and the continuous spatial functions of electromagnetism — that is, what Maxwell called two kinds of knowledge — Einstein argues as his heuristic point of view that some contemporary experimental "phenomena involving the emission or conversion of light can be better understood on the assumption that the energy of light is distributed discontinuously in space." (91-2) Since the assumption of discontinuous distribution of energy is already embedded in Maxwell's statistical law of distribution, which itself implies discontinuity, Einstein's logical suggestion is effectively to reinterpret the discrepancy that is bound to result from the formal difference between the two kinds of knowledge in physics. Such a move allows for theoretical unification: a hypological understanding of the nature of light corresponding to metalogical constraints instead of autological, that is, continuous functions. In his paper, Einstein goes on to show mathematically how Planck's 'elementary quanta' can be considered independent of the theory of blackbody radiation as 'light-particles.'[129] In the canonized history of physics, it is with Einstein's paper that quantum theory, predicated on the assumption that light is particulate, is decisively born. Notably, it contains no positive ontological claim for the discontinuity of light — but rather a strategic, operational reorientation of the framework within which light can be understood. In subsequent work, Einstein extends Planck's results to establish stronger coherence with prevailing theoretical models and allow for testable

[128] See Milton, p. 455.

[129] As Hentschel observes, "the originality of this consideration lay in the new way of linking different chains of reasoning" — a characteristic feature of Einstein's thought. See Hentschel, p. 344.

predictions. Conceptually, the quantum henceforth becomes intertwined with the theories and experiments of atomism.

In fact, all of Einstein's four '*annus mirabilis*' papers of 1905 contribute to establishing atomism in their own way. In his second paper, Einstein theorizes the movement of small particles suspended in a liquid, a phenomenon known from early 19th century microscopy as Brownian motion. Einstein shows how tiny pollen grains seen to be randomly moving around without any apparent cause can be mathematically explained as a generalized case of the kinetic theory of heat. From this, he reasons by analogy: if kinetic theory, which assumes atoms colliding according to certain probabilistic rules, can be correctly used to calculate and predict the motion of visible particles, a correlation would hold for particles beyond the microscopic range, which are therefore subject to the same mathematical operation. Metaphysically, such an inference is by itself inadequate, since it does not preclude the physical possibility that atomic particles are mediated. In this respect, Einstein's third and fourth papers, which together establish the basis of special relativity, are significant, because they dispense with the prevailing conception of the autological ether through a simplification and integration of mechanist principles.

Meanwhile, in the experimental search for hypothetical atomic properties, new radiation phenomena were mobilized. Most instrumental were so-called scattering experiments, which measure the interaction of radiation and matter by counting the relative frequency of particles bouncing at specified angles.[130] Early scattering experiments are direct ancestors of particle accelerators such as the Large Hadron Collider, in which particles are presupposed as part of the probabilistic formula of measurement. Initially, they relied on kinetic theory, wherein energy is assumed to be distributed in particulate form. Gradually, they would grow to encompass more complicated statistical models that derive individual particle predictions from the observable level of collective effects. In this paradoxical sense, scattering presupposes the very particularity it is designed to measure.

Moreover, scattering is the basis for the metalogical extension of microscopy beond Abbe's limit into what becomes known as the electron microscope. This third historical jump in microscopic resolution occurs with the first prototypes in the early 1930s. Instead of using natural or electric light, the electron microscope is a closed system that focuses a beam of electrons within a tiny wavelength, thereby

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[130] A general analysis of scattering experiments is supplied by Falkenburg, 2009.

achieving, according to Abbe's formula, a theoretical limit of resolution close to 100 times the maximum of optical light microscopes. By simultaneously extending the mathematical framework of optics and breaking away from its limit, the electron microscope is a paradoxical construction that exploits both dimensions of the wave-particle duality in quantum physics. Insofar as electrons can be considered waveforms, it functions on direct analogy with optics. This is the sense in which the electron microscope is an extension of microscopy on the same logical plane. However, insofar as electrons are considered particles, the microscope image is not analogous to the continuous contrast of light absorption — rather, it is distinctly produced by the differential scattering of electrons.[131] Thus, whereas the precise function of Abbe's optical light microscope is circumscribed by a mathematical framework, the electron microscope is mathematical in its very operation. Between the two instruments lies the difference between hypology and metalogy — or, as Hacking put it in Act 1, the difference between seeing 'through' a microscope and seeing 'with' it.

Nevertheless, despite the great magnifying leap of electron microscopy, it remains inadequate for imaging at an atomic level. In 2009, a research lab announced it had been able, through an advanced electron microscope, to show images of what it considered the structure of carbon atoms. Yet these are computer-regenerated reconstructions from so-called field emission electron microscopy, based on statistical modeling in which the atom is already implicated.[132] In other words, more than a century after the first claim to proving the primary constituent of nature, nobody has ever seen an atom, or any fundamental matter constituent, in any empirical sense. In fact, as we already intimated in Act 1, by today's standards of physics, the atom merely corresponds to a certain level of extended resolution, beyond which all stable particle concepts, such as subatomic constituents, inevitably break down. As Falkenburg puts it, "the reality of subatomic particles and quantum processes is not a reality in its own right. Rather, it is relational. It only exists relative to a macroscopic environment and to our experimental devices." (XII)

In this sense, the 20th century particle claims involve a complicated series of doublings. By the mid-1920s, the light-particle is submitted to scattering, rebaptized the 'photon,' and considered empirically verified in a similar coordination of theoretical models and measurement as with the electron. In turn, this experimental confirmation of the light quantum would lend further

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[131] On this point, see Egerton, p. 20, and Bradbury, p. 318.

[132] See Castelvecchi for description of experiment and reference to physics publication.

instrumental support to the atomic models of quantum mechanics. Thus, a paradoxical doublet of discontinuous inventions reverberate in an ever spiraling twist of dynamical and statistical models.[133] The hypological particle concept is mutually constituted by, on the one hand, the quantum — the limit condition of light phenomena — and on the other hand, the atom — the limit condition of matter. Both inventions derive from the same metalogical operation, and their independent reality status is partly assured through their mutual conceptual unity. In this precise sense, the predominant physical and metaphysical problem of the 19th century — the relation between energy and matter — finds resolution in an experimental invention of particularity.

In *Matter and Memory*, Bergson had postulated as axiomatic to his intuitive method that "all division of matter into independent bodies with absolutely determined outlines is an artificial division." (259) To speak of particularity in the manner of 20th century physics would for Bergson signify a mental operation — the 'spatialization of thought' — that lacks temporal reality. After the metalogical turn, any such attempted distinction between real and artificial would become hopelessly futile. In fact, the fundamental modern philosophical differentiation of ontology and epistemology is thoroughly incapable of illuminating the development of early 20th century physics. Is the electron, or the atom, or the light quantum, ontologically real or an epistemological construct? Certainly, there is no shortage of philosophers of science debating, often in the most nuanced, scholarly language imaginable, a problem whose terms, as Bergson would put it, are insoluble, because they return us once again to the 'mysterious' correspondence of equiversal systems. Consider a typical recent encyclopedic entry on the use of symmetrical principles in quantum mechanics:

> From a philosophical point of view, the epistemic question arises whether symmetry only concerns syntactic and semantic properties of scientific theories and their models, or whether they are real structures of the world… But if they are only syntactical and semantic constructions, why do observations, measurements and predictions display these

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[133] Falkenburg, employing a very different terminological set, nonetheless comes to a convergent conclusion with mine on the discrepancy, or mismatch, between dynamical and statistical modes of reasoning: "the core of the incommensurability problem in the transition from classical to quantum physics is the mismatch between the operational, axiomatic, and referential aspects of quantum concepts. This mismatch arises as follows. The data analysis of any high energy physics experiment *forces physicists to analyze individual particle tracks and scattering events in quasi-classical terms*. But from an axiomatic point of view, *the operational basis of quantum mechanics and quantum field theory is probabilistic*. Given that only classical point mechanics deals with individual particles, and given the unresolved quantum measurement problem at the level of individual particle detections, the mismatch is unavoidable." See Falkenburg, p. 222, my emphases.

regularities? It seems to be a wonder of miracle. Hilary Putnam put it in the 'no-miracle-argument' of scientific realism: 'The positive argument for realism is that it is the only philosophy that doesn't make the success of science a miracle.'[134]

No — realism and idealism, along with the plethora of differentiated positions on the spectrum between, are but two inverse perspectives predicated on the same metaphysical assumption that modern science is oriented toward truth. What the curious cases of the electron and the light quantum clearly show is rather that the 20th century particle concept is, in Falkenburg's words, theoretically and experimentally operational.[135] The particle is the condition of possibility for physicists to act upon and into matter in such a way as to extend their research beyond the limit of optical instruments. In this sense, particles are mobilized into being. As Falkenburg describes it, "the only decisive proof of particles is apparently to *make* them and to *use* them as tools in other experiments." (91) Even as the technological means of extension fail to reveal their ontological existence, particles remain a necessary condition for physical research — all physicists act as if they exist. To question its reality status beyond what it is accorded through action — to ask, in a manner of speaking, if it's 'really real' — is precisely to revert to philosophical terms of ontological bifurcation, which configures the nature of physics as independent of rational human knowers.

In other words, the modern particle — be it in the form of the electron, atom, quark, or quantum — is neither ontological nor epistemological. It is both hypological and metalogical. It is real because we make it real, and it is real because we can use it to make more. Herein lies a direct historical and logical corollary between the constitution of physics and that of another metalogical enterprise — the corporation. As Bakan describes it:

> By the end of the 19th century, through a bizarre legal alchemy, courts had fully transformed the corporation into a 'person,' with its own identity… The corporate person had taken the place, at least in law, of the real people who owned corporations. Now

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[134] See Mainzer, 784.

[135] Falkenburg, committed to a 'moderate realism' developed from a Neo-Kantian position, works hard to elaborate an internally consistent particle concept, even for operational purposes. As a coherent phenomenon, she writes, particles can be regarded as collections of mass, energy, charge and spin — a mutually constituted dynamic structure by the theoretical framework and the defined experimental conditions under which they are circumscribed — and as independent, local events insofar as they are produced by particle detectors. See p. 221. As we saw in Act 1, there are particle concepts that defy even these general characteristics and whose status as particles can only be attributed to a generalized independence criterion — exactly the same criterion as required by metalogical reasoning in the first place.

viewed as an entity, 'not imaginary or fictitious, but real, not artificial but natural,' as it was described by one law professor in 1911, the corporation had been re-conceived as a free and independent being.[136] (16)

Just as the corporation increases its metalogical mobilization of capital through its hypological individuality, particle physics extends metalogically through the invention and incorporation of a discontinuous entity. In both cases, the autological dimension of this new creation — the causal connection to its conditions of being — is overturned. In a 'classical' hypological science, the autological is the given. In a metalogical science, the hypological is the given. And for all its continued reliance on hypological concepts and frameworks, physics in the 20th century becomes a metalogically determined science.

Yet this development passes so thoroughly unrecognized by philosophy that it is tempting to speak of metalogy as the concealed logic of modern thought. As such, its revolutionary character does not appear as an identifiable causal event but rather as an array of correlated effects — one of which is to drive a deeper wedge between the discourses of physics and philosophy. In this context, a famous encounter between Bergson and Einstein in 1922 constitutes a decisive event in the history of metaphysics. Although the debate focused on the meaning of time and relativity — as we saw in Act 2, a strictly hypological theory — and although concerns over metalogical quantum physics never surfaced, the subtext of the debate quickly became its text: physics versus philosophy on the right to determine metaphysics. Sparking a public controversy over which discipline could more legitimately claim to speak for nature, the debate would effectively polarize physicists and philosophers in the following years.[137] Bergson argued that philosophy still played a crucial role in understanding the nature of time. But Einstein inflicted a full metaphysical reversal. Whereas Bergson had claimed in *Matter and Memory* that the abstract physical conception of time failed to account for its durational, autological reality, Einstein now posited the absolute reality of

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[136] In this sense, the US Supreme Court's 2010 ruling that corporations cannot be limited in their political campaign spending, because their rights to free speech are identical to the rights of a citizen, completes the juridical circle.

[137] See Canales, p. 1169. Canales' interesting article recounts the scientific dispute between Einstein and Bergson in terms of a simultaneous political dispute between the two thinkers involving the League of Nations. The lingering bitterness between Einstein and Bergson after a series of confrontations, Canales suggests, left an indelible mark on Bergson's later years. In his final work, the *Two Sources of Morality and Religion*, Bergson's hypological harmony of earlier years has decidedly given way to an ominous view of what he in this book called "the profound war instinct which covers civilization."

physical time against the “time of philosophers,” which is “nothing more than mental constructs, logical entities.”[138] Mathematical physics, then, as the grasp on reality, and philosophy as the artificial imposition. Physics, in Einstein’s invocation, had declared its total metaphysical independence.[139]

If Bergson’s rather pragmatic call for an equiversal dualism was rebuffed, then Whitehead’s great cosmic synthesis was rather doomed from the beginning. Whitehead’s faith in reason was immense, and he advocated the hopeful view that great clashes in modern thought, like those repeatedly occurring between metaphysics and science as well as between science and religion, are “a sign that there are wider truths and finer perspectives within which reconciliation of a deeper religion and a more subtle science will be found.” (229) To this end, Whitehead lectures on the early decades of quantum theory, mostly at the level of metaphor, and sees in the discontinuity of quantum theory only an historical pendulum shift back to Newton’s particle concept, which he believes he can make “perfectly consistent” with his “cosmological outlook.” (171) Here, Whitehead distinctly parts ways with Bergson, who had critiqued the modern scientific foundation for being “a distortion of nature due to the intellectual ‘spatialization’ of things.” Says Whitehead: “I agree with Bergson in his protest: but I do not agree that such distortion is a vice necessary to the intellectual apprehension of nature.” (64) Whitehead believes he can correct this common intellectual tendency toward spatialization, what he calls the “fallacy of misplaced concreteness.” His 1929 magnum opus, *Process and Reality*, presents a metaphysical foundation for the ‘corrected’ unification of science and metaphysics. Thus, he continues unabated in the tradition of Western thought that takes intellectual knowledge of nature for its purpose. Under the philosophical sign of process, which now takes on a more foundational meaning than identity, Whitehead effectively reconstitutes the universalist logic of modern thought in new terms. And at the heart of his vision lies the principle of reason — the “deep faith in reason,” the “trust that the ultimate natures of things lie together in harmony…” (23) Yet as we have seen, what is relinquished in the metalogical rise of science is precisely the principle of reason

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[138] Ibid., p. 1171.

[139] However unfairly it arose, the widespread view in aftermath was that Einstein had ‘won’ the debate because Bergson ‘failed’ to recognize the independent reality of physical time. As Deleuze puts it, Bergson’s intervention “led to so much misunderstanding because it was thought that Bergson was seeking to refute or correct Einstein, while in fact he wanted… to give the theory of relativity the metaphysics it lacked.” (116) In this sense, the failed encounter between Bergson and Einstein marks not only the waning of Bergson’s influence in his own time, but more profoundly, the historical passing of philosophy into increasing oblivion.

upon which Whitehead predicates his metaphysics. In a metalogical world, questions of causality begin to lose their relevance, and in turn, this spells the increasing irrelevance of traditional metaphysics.

Thus, in the punctuation of a new logical order, beyond the limits of the given, physics declares metaphysical independence in a double sense: it makes discontinuity its metaphysical foundation, and it makes itself discontinuous with metaphysical tradition.

ACT V — CATA

Nature, that is, Culture:
The Constancy of Universalism

Promising to make history for itself
would never have been enough
for the modern.
At its very core,
it does not just want to make history,
but nature.

Peter Sloterdijk

Over the entrance
to the gates of science's temple
are written the words:
Ye must have faith.

Max Planck

1. Planet Earth, 2010

Finally, our story folds back on itself. And thus we now begin with the end — with the looming threat of catastrophe.

In Spring 2010, as I'm writing, the Large Hadron Collider has once again, after over a year of technical problems, managed to start up, operating at roughly a third of projected full capacity. And the world has not yet come to an end.

Then again, according to the calculations of German biochemist Otto Rössler, the microscopic black holes emerging from the collider experiment once it reaches full capacity would take at least four years — four years to grow exponentially and eventually implode Planet Earth's mass to a total diameter of 1.9 centimeters. His mathematical worst-case scenario based on one understanding of current physics formed part of the lawsuit that a coalition of European citizens filed against the Large Hadron Collider in 2008 at the European Court of Human Rights in Strasbourg.[140] In a parallel move, nuclear physicist Walter Wagner led a group of scientists in a US lawsuit against the Department of Energy, targeted for its 500 million dollar funding to CERN, to get a preliminary injunction against the experiment. For Wagner, the specific concern was not Rössler's black holes, but rather a particle dubbed a 'strangelet', whose potential production in the accelerator, Wagner claimed, could have equally disastrous implications.[141]

Predictably, the lawsuits made for sensational events reverberating through the mediasphere in the fall of 2008, creating the perfect narrative contrast to the much hyped opening of the LHC. On the one hand, a central community of scientists engaged in the biggest and costliest science experiment in the world, claiming to delve into the deepest secrets of universal creation. On the other hand, a fringe group of scientists warning that the experiment could threaten universal destruction. Thus, the Christian myth of knowledge and the fall of man redux. What is Adam to do? (Or, as this case would have it, of what is Atom made?) Reporters

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[140]My account of the public dimension of the LHC controversy is gleaned from an array of mass media sources, in particular, Boesveld, Overbye, Kolbert, Gray, Muir, and Sugden, see bibliography. For an extensive interview with Otto Rössler on his predictions and concerns, see http://www.notepad.ch/blogs/index.php/2010/03/18/interview-with-professor-otto-e-roessler.

[141] Even further to the scientific fringe, frequent speculations are currently posted concerning the possible correlation between a higher-than-normal frequency of earthquakes (and volcanic eruption) since the LHC was turned back on. Explanations range from possible gravity waves causing chain reactions through the mantle to the manifestation of God's wrath and the Rapture. For a typical sample: http://www.abovetopsecret.com/forum/thread550999/pg1

report, bloggers blog, mediators mediate — and the internal and external boundaries of science are continually reinforced, as experts are pitted against other experts, calculations proposed against counter-calculations — and all the rest of the Earth's creatures whose existence is allegedly at stake are left somewhere in the uncertain middle.

In this sense, the LHC doomsday controversy is only the latest of potential catastrophes weighing on a century of explosive technological growth in modern physics. As German philosopher Peter Sloterdijk argues in *Terror From the Air*, the invention of gas bombs in the trenches of World War I definitively marked a new order of 'increasing explication' — of rendering the air, once considered merely an environmental given, into a new battleground.[142] Under attack was no longer simply the uniformed, mobilized soldier but the conditions of life for human, 'civilian' populations. Chemical warfare, a descendant of Boltzmann and Maxwell's pioneering statistical approach to gas theory, thus constituted a new kind of weapon, what we could here call a metalogical bomb. Divorced from the principle of reason in its theoretical derivation, and separated from the causal logic of the battlefield (soldier against soldier) in its practical application, the 1915 gas bomb became the harbinger of the 1945 nuclear bomb — which in turn profoundly constrained the reordering of 20th century politics. As Sloterdijk puts it, "nuclear physics' explication of radioactive material and the latter's public demonstration via mushroom clouds over arid test sites and populated cities, simultaneously opened a new level of the explication of the atmospheric elements of concern to human beings." (56-7)

In this precise sense, the notion of a metalogical bomb, I would argue, extends from intentional warfare to the disastrous activities of human beings that threaten the conditions of their own future survival. If the 1960s and 70s were marked by the impending catastrophe of the population bomb, the following decades raised the stakes further with an increasing explication of the climate bomb.[143] Such catastrophes are logically related. The metaphysics of a nuclear

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[142] Sloterdijk's text is the English translation of a slim section from his lengthy and yet untranslated *Spheres* trilogy.

[143] Michel Serres relays Jacques Monod's poignant statement, uttered one day before his death in 1976: "I used to laugh at physicists' problems of conscience, because I was a biologist at the Pasteur Institute. By creating and proposing cures, I always worked with a clear conscience, while the physicists made contributions to arms, to violence and war. Now I see clearly that the population explosion of the third world could not have happened without our intervention. So, I ask myself as many questions as physicists ask themselves about the atomic bomb. The population bomb will perhaps prove more dangerous." (1995b: 17)

explosion is like overpopulation or climate change insofar as they all emerge as a chain reaction against constraint. A massively multiplying growth (neutrons, humans or carbon dioxides) against a containment (bomb chamber, food supply or the planet), it forces a drastic transformation, unleashing new givens and new pressures. Such is exactly the dynamic postulated by Rössler's calculations, in which a chain reaction of black holes could lead to the destruction of the planet's core. Who is to say, therefore, that the nuclear bomb of 20th century physics won't be superceded in the 21st by something even more cosmic: a black hole bomb?

Well, who is to say? Herein lies the political predicament of such metalogical catastrophes, since we effectively have no stakes in what claims us as stakes. Thus, the LHC event is but a particular expression of how we are continually situated and mobilized in the chasm between metalogical scientific production and autological living conditions. We know our climate is becoming catastrophic to biological survival, but most places, the sun is still shining. We know our economy is lunging forward to the next collapse, kept liquid by unpayable debts to future generations, but most paycheques keep arriving for now. We know nuclear warheads have spread all over the world, but most of us have never seen one explode. In this and countless other ways, we are affected by the idea of a condition that still does not affect us. This logical chasm, I believe, characterizes the current political configuration of sciences. From climate change to international finance to nuclear physics, we are continually asked to reinstitute our faith in the very institution we have ample reason to distrust — to believe in the specialization that contributed to our ever increasing array of specialized disasters.

Thus, what is at stake is most essentially the continued rising of the stakes. Against a vast cultural horizon of ever new catastrophic modes of proliferation unleashed against the uncertainty of limitations, chain reactions and multiplier effects in our imminent future, the current political configuration of the sciences is of major significance, because it fundamentally shapes the problems and projects against which scientific knowledge is mobilized. As I have tried to show in this dissertation, the universalist constitution of God and Nature is the principal metaphysical condition for the historical inventions of physics. The emergence of the nuclear bomb, for example, may be conceived as dependent on a whole host of individual and localizable factors, but it most pivotally relies on an understanding of nature that enables the invention and problematization of atoms in the first place. In the potential demystification or destruction of nature lies first and foremost a mode of action and a means of questioning determined by the metaphysical constitution of nature. Or to put it differently, the metaphysical constitution of nature has real and determinate cultural and political effects. In this sense, to speak in any meaningful way about the politics of nature first requires a critical understanding of how nature is constituted in the modern sciences. And toward this end, the final Act of this dissertation attempts to bring together the logical dimensions thus far differentiated, for a conceptual analysis of nature in the universalist discourse that lays historical claim to speak in its name.

In the case of the LHC, as soon as Rössler, Wagner and their allies succeeded in attracting public attention, two physicists working for CERN published a paper that engaged cosmological conceptions like 'white dwarfs' to the defense against any black holes produced by the LHC. CERN promptly posted the paper publicly and used it in court proceedings as evidence. However, a subsequent paper by a German astrophysicist questioned their "assumed validity of the semiclassical approximation," in effect showing how, in a multi-dimensional theory currently popular with string theorists, black holes "in the 'quantum gravity' regime might behave differently and escape white dwarfs…" (8) In a typical situation of constitutive uncertainty, the calculation of risk therefore depends on which theory of the universe is employed. Yet choosing between the proliferation of such theories is precisely the objective of the LHC experiment in the first place.

Complicated metalogical calculations are thus made all the more complex by the actual, autological situation of the physics community, which is determined by shifting alliances of mediating actors with vested interest in the experiment taking place.[144] Following Bruno Latour, such alliances or networks involve non-human as well as human actors, 'things' as well as 'beings.' Autologically, then, CERN managers are tied to multi-billion dollar constructions and theorists, who are allied to the possibility of testing by experimentalists, who act in a vast network of computers and machines — which is further implicated by international funding agencies, local sub-contractors, advanced digital grids, hydroelectric power stations, liquid argon, engineering manuals, and so on. Thus, on an autological plane of initial implication as well as on a metalogical plane of exceeding explication — that is, in the juxtaposition of acting scientists and disconnected calculations — the world appears precisely as it does to all of us in the middle: fundamentally capricious, chancy, contingent.

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[144] To assert that participating scientists and managers are invested in the experiment is neither to suggest a conspiracy nor a 'bias' that can be corrected by strict adherence to some objective ideal. Rather, it is to challenge the shared assumption of practitioners in the sciences and mass media that scientists are pure 'intermediaries' of knowledge. For elaboration on this ostensibly contentious point, see Act 1, as well as section 3 in this Act.

How do we render the world logically consistent and congruous? Through the hypological framework, which imposes retroactive order upon chaos through its connection between these two planes, by simultaneously circumscribing autological grounding and closing metalogical openness. In the case of physics, the principal hypological construction is what I have called universalism, characterized by a pervasive claim to a certain configuration of nature. In fact, if there is any consistency amongst particle physicists, CERN managers and gently speculating reporters on the doomsday scenario, it lies in the appeal to a universal nature. On the side of promises, the experiment is set to change 'our understanding of nature,' to 'rewrite the textbooks of the universe.' And on the side of perils, nature is either what is being violated — with potentially deadly consequences — or what guarantees the safety of the outcome. As CERN's risk assessment study bluntly put it: "Nature has already conducted the equivalent of about a hundred thousand LHC experimental programmes on Earth — and the planet still exists."[145] Autologically, scientists and non-scientists alike can squabble over who gets to posit the affirmative equivalence between a single experiment and the world at large, and they may bicker over which of the proliferating metalogical terms to employ, but what they all want to discover, reveal, and speak for is always and everywhere the same universal nature.

Most fundamentally, as Heidegger puts it, nature is enframed in such a way as to render itself as knowable in advance, as existing within a certain universal grasp. In his reflection on modern science's turning of the world into such an enframed picture, Heidegger calls the projected nature of physics a 'ground plan.' "This projected plan of nature finds its guarantee in the fact that physical research, in every one of its questioning steps, is bound in advance to adhere to it." (1977: 119) In turn, this ensures the ground plan of nature is ever more strictly reinforced, in a manner of self-intensification that appears to vindicate Heidegger's vision of nihilism as our historical fate.

Nevertheless, I believe the retroactive constitution implicit in all claims to destiny has to be resisted. Whereas it belongs to a hypological conception of nature to render itself as a self-evident and necessary beginning — or in Heidegger's thesis, as a final fate — my general argument is rather that things could very well be different. They could have been different in the 17th century and they could be different today. Such is both the cause and effect of the inverse metaphysical proposition I call equiversalism, which runs through the dominant fabric of

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[145] Quoted in Gray, 2008.

metaphysics like an alternate thread. In this Act, I will mobilize the shared, constructive insight of five thinkers I consider, in different ways, implicated in such an alternative configuration of nature: Michel Serres, Bruno Latour, Baruch Spinoza, Peter Sloterdijk, and Isabelle Stengers. These are thinkers, I argue, who point us toward a crucial first step in reconceiving nature and the role of the sciences in a political sense. In my reading, Spinoza and Latour most singularly join forces metaphysically, not directly for any one specific and localizable political claim or cause, nor against any one particular policy on physics. Rather, the thesis of equiversalism constitutes a conceptual opening, a preliminary ground, for thinking and engaging with the politics of nature today.

Certainly, equiversalism is neither an established idea nor an institution — in principle, it is merely one conception among others. Without hypology, after all, there is no science, no thought, no order. But that one hypology triumphs over another is a consequence of autological striving — of the relative strength and weakness of alliances or relations in the moment of its enacting. Moreover, that one axis endures while alternatives are forgotten, is a retroactive consequence of the joint constellation of logics reinforcing one another. Contrary to any prevailing liberal conception, it is never a matter of 'choosing' one conception over another, because neither are we ever neutrally or independently situated, nor is political complexity ever reducible to a singular logic. Acting, autological alliances may by means of extension be grown and mobilized metalogically; they may be divided, united or reconstituted against rivaling conceptions hypologically; they may connect themselves with everyone and everything analogically; and, ultimately, they may be decided or constrained — *catalogically*.

In its most straightforward sense, catalogy is a systematic list of relations turned into objects. The Greek prefix 'kata' carries the meaning of picking out. In a prepositional sense, cata denotes a downward tendency, in obverse relation to the upward tendency of the ana-logical. For example, in the predominant theory of metabolism — the process of living understood chemically — change is doubly constituted by the anabolic process of building and the catabolic process of breaking down. Thus, if the analogical allows us to connect one thing to another, like a movement of induction — from the LHC experiment to the cosmos; from CERN managers to computing grids — the catalogical is like the movement of deduction, coming down like a restricting closure to determine, this way rather than that. Thus, a catalog, a catalogical product, is not a list of the way things are but the way they are decided to be by the force of constraint. Never the decision of a sovereign, independent body, the catalogical is a decision comprised by a certain logical fiat, according to the multiple logics of how things are connected (ana), conceived (hypo), mediated (auto), and multiplied (meta). In this sense, the catalogical is most fundamentally the logic of constraint.

Our final Act, then, written under the sign of that sudden downturn we call catastrophe, first explores the question of how physics today is constrained — and then considers how, or in what sense, it could be constrained differently. How, in other words, a different metaphysical constitution of nature allows us to ask fundamentally political questions about the sciences in our culture — without being dismissed as relativist enemies of science. For the question throughout this historical exploration has never been science or anti-science — but rather, what kind of science? In whose interests, with which means, to what ends? As I will show, a different metaphysical constitution implies most essentially a radical turn in how we approach the problem — how we come to understand the problem of nature, as well as how we stand against the nature of the problem.

2. Nature against Universal Constancy

Thus far, I have discussed three bright stars in the contemporary metaphysical constellation under which the LHC experiment operates, universal nature. In Act 2, the 20th century invention of Big Bang Theory provided physics with a cosmological origin story, an alpha point that simultaneously conjectures an omega point, a temporal circumscription of the beginning and the end of the universe. In Act 3, the 17th century invention of the mathematical universe as such bestowed on 'natural philosophy' a spatial construction resulting from an axiomatic equivocation of God and Nature. And in Act 4, the late 19th century invention of fundamental discontinuous atoms and quanta precipitated a deep logical discrepancy within the universal spacetime these metaphysical units are thought to inhabit. Finally, then, we need to consider how this asymmetrical doubling of the universe — between a framework of General Relativity on the one hand and Quantum Mechanics on the other — is nonetheless sufficiently constrained to enable mathematical theories of unification. For in order to configure a mathematical universe that integrates cosmological singularities with microphysical wave-particle duality, the universal configuration of nature requires mathematical, operational constancy. This is what physics today calls the fundamental constants, or the Constants of Nature.

In retrospective history, this invention is squarely associated with the work of Max Planck that led to quantum theory. As discussed in Act 4, from a fixed element size in relation to wavelength Planck was able to derive a new constant for his calculations, called *h*. In the equation that would become the basis for quantum theory as it was taken up by Einstein and other physicists, $E = hv$, the minimum quantum of energy denoted by *h* is a product of energy and change over time. Strictly, it appears as a limit in calculating the very specific problem of blackbody radiation. But as Planck came to realize the implications of his metalogical reasoning, he was inclined toward claiming the general significance of *h* as a universal constant.

In the late 19th century, the chaotic metalogical growth of Western culture increasingly demanded international orders of standardization. From the metric system to world time zones, constants functioned as nodes of order, quilting points in the crumpled social fabric. Among physicists too, different unit systems were being proposed to regularize their work. Planck deeply believed, perhaps even more than Einstein, in the metaphysical independence of nature from human or cultural constructs. For him, the problem with late 19th century measures of standardization therefore lay in their sheer contingency.

> All the systems of units that have hitherto been employed… owe their origin to the coincidence of accidental circumstances, inasmuch as the choice of units lying at the base of every system has been made, not according to general points of view which would necessarily retain their importance for all place and all times, but essentially with reference to the special needs of our terrestrial civilization.[146] (24)

Here, Planck speaks as a true modern universalist, for whom the construct of the natural universe is so entrenched, rendered so unproblematic, that it turns against human efforts as 'biased' or, in a subsequent term of derision, 'anthropocentric' — that is, opposed to a universal nature written in mathematical language. What Planck specifically sought was "units of length, mass, time and temperature which are independent of special bodies or substances, which necessarily retain their significance for all times and for all environments, terrestrial and human or otherwise." (25)

Considering *h* as nature's own fundamental limit, Planck was able to derive what is today called 'base Planck units' — specific measures for length, time, mass, charge, and temperature. Further, 'derived Planck units' are extended calculations

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[146] This and subsequent Planck quotes from Barrow, 2002.

from the base units for all established dimensions of physics, from area and volume to momentum and impedance. Since these units are quantitatively miniscule, in the negative exponential range of 30 to 40, they principally concern theoretical physicists and cosmologists whose work is to constitute the limits of the universe. American cosmologist John D. Barrow explains:

> What are the limits of quantum theory and Einstein's general relativity theory? Fortunately, there is a simple answer and Planck's units tell us what it is. Suppose we take the whole mass inside the visible Universe and determine its quantum wavelength. We can ask when this quantum wavelength of the visible Universe exceeds its size. The answer is when the Universe is smaller than the Planck length in size (10^{-33} cm), less than the Planck time in age (10^{-43} sec), and hotter than the Planck temperature (10^{32} degrees). Planck's units mark the boundary of applicability of our current theories. To understand what the world is like on a scale smaller than the Planck length we have to understand fully how quantum uncertainty becomes entangled with gravity. To understand what might have gone on close to the event that we are tempted to call the beginning of the Universe or the beginning of time we have to penetrate the Planck barrier. The constants of Nature mark out the frontiers of our existing knowledge and show us where our theories start to overreach themselves. (43)

Thus, the Planck 'barrier' constitutes the logical constraint of the Universe, against which it is continually explicated. It is the parameter for how to understand the Big Bang event, black holes, white dwarfs and all other 'singularities' — the limit conditions where this calculable Universe breaks down.

Although it's only with the metalogical invention of the privileged Planck constant *h* that the base units constituting these constraints become possible, the constancy of nature is governed by an interplay of several fundamental constants. Physics today recognizes five. First, Newton's *G* for the gravitational constant. Second, *c* for Einstein's speed of light in a vacuum. And third, Planck's quantum of action, *h.* All these three constants are involved in the equations from which Planck length, mass, and time are calculated. In addition, there is the Coloumb constant, a proportionality governing electromagnetism used to formulate Planck charge. Its inverse square law makes it mathematically similar to gravitational *G,* and it retains its status as fundamental only insofar as electromagnetism and gravity are not theoretically unified — that is, its use is restricted. Finally, Boltzmann's infamous *k*, discussed in Act 4, is derived from his statistical gas analysis and used nominally to formulate Planck temperature. However, in Planck's system of units, Boltzmann's *k* is a referential constant only, typically taking the value of 1. Thus, of the five fundamental constants in Planck's system, the three most general are *G, c,* and *h* — and these are also the ones Planck recognized as salient:

> These quantities retain their natural significance as long as the law of gravitation and that of the propagation of light in a vacuum and the two principles of thermodynamics remain valid; they therefore must be found always to be the same, when measured by the most widely differing intelligences according to the most widely differing methods. (26)

Logically, we can determine how these constants differ. On the one hand, Newton's *G* was never postulated as a quantity but rather as a ratio between forces that itself was invisible. Gravity in Newton's sense is therefore hypological. As Ian Hacking relates, the implied value of Newton's constant was only retroactively calculated by scientists in the 18th century, and then expressly as a means of determining the mass of the earth — the planet's own weight. "The idea of an abstract fundamental constant — as opposed to a stable measurable property of a physical object, such as the weight of the earth — was not fully articulated until the nineteenth century." (55) As we saw in Act 2, Einstein's use of *c* as a constant for his relativity equations is exemplary of such productive abstraction, since its principal purpose is as a fulcrum of certainty through which mathematical relationships can be expressed. In this sense, Einstein's idea of *c* is logically aligned with Newton's *G* — as the hypological supposition that enables a mathematically coherent description of the universe. On the other hand, as we saw in Chapter 4, Planck's *h* emerges through metalogical calculation, or more precisely, as a quantitative expression for the limit condition of metalogical reasoning (statistics) within a hypologically constituted order (a blackbody space). Only against this metalogical limit condition do Newton's and Einstein's hypologies become reconstituted as fundamental constants in Planck's sense.

In turn, their logical difference bespeaks how physics today handles its limit conditions differently. The problem of gravity — the autological given of being situated in the world — is solved hypologically by being integrated into the framework of General Relativity. The problem of heat or energy, however, is solved metalogically through Quantum Mechanics. On one side, *G* — on the other, *h*. And the problem of light? Insofar as light is considered exclusively as uniform speed — that is, as a wave — it is understood hypologically. But insofar as light is considered as a particle, it is understood metalogically. Thus, the constant known as *c* lies in the middle between the two logical orders of physics, mediating them. As I intimated in Act 2, the autological given we know as light is precisely where the logic of General Relativity breaks down: if light is considered particulate, its photons must be without mass and therefore not subject to gravity. Light is the exception that confers stability on the system of General Relativity as a whole. At the same time, as we shall see, light is the condition for Quantum Mechanics itself bifurcating into two orders of statistical constructs — bosons and fermions, or matter and interactions. Metaphysically, then, light is the condition of asymmetrical doubling.

Considered in themselves, the constants may be constructed hypologically or metalogically. Yet in either case, they also function catalogically, because they effectively constrain theoretical and experimental possibilities. Constraint should not here be understood simply in the sense of blockage, as an actual hindrance to production. Logically, constraint is also the condition for forging new connections, for having to break open new possibilities. The logics of connecting and constraining — *ana* and *cata* — are thus always implicitly linked, in a manner of speaking, as different vibrations of the same pulsation. In 20th century history, the productive growth of physics from the oscillating movement of connection and constraint is perhaps best illustrated by how Planck's constants came to configure a complicated universe of new entities.

Following the definitive theoretical and experimental establishment of atomic physics in the first half of the 20th century, the invention of particle accelerators and colliders in the second half brought physics into an era of intensified metalogical growth. As British philosopher of science Andrew Pickering relates, the new Big Science of high-energy physics yielded a veritable "population explosion" of new particles. In the early 1930s, physicists were thinking in terms of Niels Bohr's planetary model, in which the atom was comprised simply of a positive proton, a negative electron, and a neutron. By 1951, already before the operational launch of the first major accelerator — the Cosmotron at Brookhaven — the list of experimentally produced particles counted 15. By 1964 a review article lamented, "only five years ago it was possible to draw up a tidy list of 30 sub-atomic particles… since then another 60 or 70 sub-atomic objects have been discovered." (50) Every new experiment, operating at a slightly higher energy level, would detect new particle phenomena that in almost every case would defy the tidy models of the theorists. Faced with a chaotically multiplying population, physics was in dire need of a new classifying scheme, which in turn intensified demand for specialized jargon, with which physicists themselves would struggle to remain updated. Here is Pickering's recap of only the most elementary terms used by physicists in the post-WWII era:

> Particles with half-integral spin, like the electron and the proton, became generically known as fermions; particles with integral spin, such as the pion and rho, as bosons. All of the known leptons were fermions, but fermions and bosons were equally well represented

amongst hadrons. Hadronic fermions were generically christened baryons, while hadronic bosons were named mesons. (52)

In their attempts to differentiate this kaleidoscopic array of particles mathematically, physicists would engage the concept of 'quantum number,' which restricts the momentum of each particle according to discontinuous sets of possible values — in other words, according to Planck's constant *h*. By itself, however, this discontinuity of momentum would lead to strange statistical discrepancies, since the identity — that is, the hypological constitution — of quanta could not be directly ensured. One way to understand Heisenberg's 'uncertainty principle' concerns precisely the failure of identity in quantum mechanics, over time (momentum) or space (position).[147] Thus, one of the many metalogical novelties of quantum theory is the introduction of 'spin,' angular momentum ascribed to elementary particles themselves as well as to their orbital momentum — in effect, a doubling of variables. If classical particle momentum multiplied by the quantum *h* yields statistical chaos, then a symmetrical set of statistics, based on each particle's supposed spin, could effectively reconstitute the identity of quanta. In this way, all quantized particles are demarcated by a double regime of probability, so-called Bose-Einstein statistics and Fermi-Dirac statistics — bosons and fermions. And this conceptual bifurcation in turn is upheld, or constrained, by Planck's constant, which is equally applied to momentum and spin.

Under this statistical doubling constrained by the quantum constant, the proliferating inhabitants of physics could be identified and classified as discontinuous integers of spin. Pickering's work charts this bewildering passage of constituting the new physical framework that has since become known as the Standard Model. In gist, the classifying discourse of theorists in approaching particle proliferation eventually consolidated into two rivaling research programs — in a timeframe and disciplinary scope analogous to how cosmology, as we saw in Act 2, split into Big Bang and Steady-State paradigms. In this still micro-physical discipline, one research program, called 'bootstrap,' asserted there were no truly fundamental particles; the other held all experimental particles to be built from so-called quarks. Writes Pickering:

> The rival positions were often referred to as nuclear democracy and aristocracy respectively — in the former all particles were equal, while in the latter quarks had a privileged ontological position — and together they dominated theoretical [high-energy

[147] On the identity of quanta, see also Saunders, 2009.

physics] in the 1960s. Only in the 1970s, with the rise of the new physics, did the quark program eclipse the bootstrap. (34)

In other words, the aristocratic regime won. Although the quark program still constitutes the hegemonic paradigm of particle physics, it has its challengers at the LHC. As discussed in Act 1, the so-called supersymmetry program effectively replays the metalogical pattern of doubling already described: for every detected particle phenomenon, the theory goes, there exists another symmetrical equivalent. As with the invention of bosons and fermions, it is symmetrical doubling that will yield the sufficient conditions for mathematical unity and identity. In this sense, supersymmetry must be understood in terms of yet another bifurcating unity that characterizes physics since the 1970s: the theoretical and experimental fusion with cosmology, which in effect links the quark program of fundamental particles with a Big Bang theory of nuclear creation. In this effort at reunification too, fundamental constants play the constraining role, as they stitch together the theoretical universe against the operational base units of Planck length, mass, time, energy and temperature.

In fact, the Constants of Nature have even undergone their own reunification. Much employed and discussed in theoretical cosmology today is the so-called fine structure constant — a kind of constant of constants. Dividing the square of the quantum electron charge by the multiplication of the Coloumb constant with the Planck constant and the speed of light in a vacuum, the fine-structure constant is known as a dimension-less coupling constant — dimension-less in the sense that it will by definition carry the same numerical value in all systems of units. Sometimes considered a 'pure number', the fine structure constant is thought by some to operate as a kind of meta-parameter for universes and by others as the mathematical expression of nature itself.[148]

Thus, Planck's constants are involved, or expressed, in multiple logics. Hypologically, constants are conceptions, or structures of belief. Metalogically, they are statistical constructions that enable proliferation. And catalogically, the constants limit the work of science, instituting constraints upon the autological action of physicists, as well as instituting constraints upon how the hypological universe can be conceived. Gravity is a constraint. So is light, in its variations. So is any thing, structure or body that impedes our ability to connect with the

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[148] For a current physics perspective on the possible variability of the fine structure constant, see Uzan, 2003.

multiplicity of affections in the world. In this, as Spinoza put it, the order and connection of ideas is the same as the order and connection of things. Gravity is a constraint for we who are autologically affected by it, and a constraint upon how we may conceive this affection — a limit by which the framework for understanding this affection can be constructed. For natural philosophers since Newton and for physicists since Maxwell, gravity bounds the universe of their discourse, ensuring that henceforth no science, no mathematical calculations, no experimental constructions, can fail to be shaped by it.

The common view within the history of physics, as told by physicists themselves, is that these fundamental constants are the expression of a fundamental law of the universe — the deeply hidden law of Nature itself. In Barrow's exemplary text, *The Constants of Nature*, we are treated to the metaphysical idea of constants as "the barcodes of ultimate reality, the pin numbers that will unlock the secrets of the Universe — one day." (292) After an extensive overview of the multiple means of employing and developing the idea of natural constants, Barrow concludes:

> Our uncovering of the patterns by which Nature works and the rules by which it changes led us to the mysterious numbers that define the fabric of all that is. The constants of Nature give our Universe its feel and its existence. Without them, the forces of Nature would have no strengths; the elementary particles of matter no masses; the Universe no size. The constants of Nature are the ultimate bulwark against unbridled relativism. They define the fabric of the Universe in a way that can side-step the prejudices of a human-centred view of things. (291)

The ultimate bulwark against relativism — herein lies a decisive claim to reinforcing the boundaries between a proper universalist science and its others. And the positive affirmation of universalism has powerful admirers outside the laboratory. In 2006, Barrow won the Templeton Prize worth $1.4 million for "exceptional contribution to affirming life's spiritual dimension." What does spirituality have to do with science? Here is Sir John Templeton on the reason for creating the prize:

> Until three centuries ago, spiritual information and scientific information were regarded as one unit. But then a divergence took place. Science began to advance strongly into experimental science research, and as a result, we have witnessed the most glorious race ahead… Unfortunately, this has not happened in regard to spiritual information or discoveries about spiritual realities… So we live in the most glorious, rapidly improving time in all of the world's history — except in our knowledge of divinity.[149]

[149] Templeton award brochure available at http://www.templetonprize.org/downloads.html#barrow

In other words, the problem of science today, in Templeton's understanding, is that it fails to provide enough 'information' about God. Fortunately, a universalist conception of science has ample room for the divine — of a certain configuration. As Barrow told the *New York Times,* he and his family were members of the United Reformed Church in Cambridge, which teaches "a traditional deistic picture of the universe."[150] In cosmology circles, Barrow is perhaps most known for his contributions to developing the "anthropic principle," discussed in Act 2. Despite appearances, the anthropic principle is not to be understood as a secular humanist principle avowing the centrality of humans in the cosmos, but rather the view that the constants of nature are in fact so constraining, so precise, that if they varied in the slightest, 'anthropic life' as we know it would be impossible. In this sense, the anthropic principle accomplishes two things at the same time. Hypologically, it affirms an evolutionary view of the universe that places at its apex the very human beings, or forms of anthropic life, who discover the secret of this evolution itself. And catalogically, it portrays our universe as limited by an overwhelming volatility, insofar as the subtlest change in fine-structure constancy would be catastrophic. To be sure, this mathematical construction easily affirms the ostensibly miraculous feat of creation. In other words, the anthropic principle simultaneously reinforces a scientific universality and a spiritualism configured by a Christian deity creator.

In this deep linkage of cosmology and 'spiritual realities', Barrow is certainly in good company. As Ian Hacking sums it up:

> Many cosmologists of today entertain the following picture. The universe is constituted first of all by certain deep equations, the basic laws of everything. They are composed of variables for measurable quantities, and free parameters whose values are fixed by assigning constants… Then various boundary conditions are added, conditions not determined by the equations and the fundamental constants… Such a cosmology is not far removed from Galileo's theism and his picture of God writing the Book of Nature. The Author of Nature writes down the equations, then fixes the fundamental constants, and finally chooses a series of boundary conditions. (1990: 56)

In its soundbyte form, this view was perfectly expressed by theoretical physicist Nima Arkani-Hamed to the *New York Times*, when he commented on why the so-called God Particle was not the ultimate object of affection for physicists.

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[150] See Overbye, 2006. Another high-profile theoretical physicist marrying science and God is John Polkinghorne, who has turned toward explicating the consonance between Anglicanism and current particle physics. See Polkinghorne, 2007.

"It's not that we care about the particles," he said. "We care about the laws."[151] And the laws — they are constant, natural, out there like hidden secrets to be discovered and expressed mathematically.

However, cosmological universalism has its share of critics. One of them is Pickering, a physicist turned sociologist. He argues, on the contrary to Barrow's 'uncovering' of truth, that "agency belongs to actors not phenomena: scientists make their own history, they are not the passive mouthpieces of nature." (8) His text, *Constructing Quarks*, is a history of high-energy physics conceived as a "mirror image — or reverse" of universalism. By flipping the mirror on how science history is made by scientists themselves, Pickering succeeds in pointing out the logical circularity that constitutes its belief structure:

> Scientists' account avoids any explicit reference to judgements by retrospectively adjudicating upon their validity…One can only appeal to the reality of theoretical constructs to legitimate scientific judgements when one has already decided which constructs are real. And consensus over the reality of particular constructs is the outcome of a historical process. (7)

For this reason, Pickering comes to the ultimate conclusion, that "there is no obligation upon anyone framing a view of the world to take account of what twentieth-century science has to say… World-views are cultural products; there is no need to be intimidated by them." (413-4)

Insofar as scientists' accounts are hypologically constituted, Pickering may well be right. But much hinges on what he does not elaborate in the text: in the term 'cultural products,' what is to be understood by 'cultural?' In the discourse of social constructivism generally, the idea of the social perfectly mirrors, in Pickering's metaphor, the scientific claim to nature. Sometimes called anti-realism, or instrumentalism, truth is thus considered in terms of the production of knowledge, not in terms of the actual constraints that physicists pragmatically refer to as reality, or nature. To Pickering, we do not have to be intimidated by the world-view of physics, because it is not really nature as such — it is 'only' cultural. Thus, nature already constitutes culture even when it is not explicitly claimed.

In turn, this cultural explanation always comes up short, because it fails to account for this difference, this remainder, that by logical default is thought to be nature. Whether reality is independent or not, physicsts will point out, something clearly returns from experimental procedures — something given is shown in both

[151] See Overbye, 2008.

its connection and constraint to our means of detecting it. The nuclear bomb may be a 'cultural product,' but it is no less profoundly intimidating. Thus, even if we expose scientific truth as hypological, as retroactively constituted by the invention of beginnings, something still remains that cannot easily be explained as a mirage emanating from human practice.

In this sense, Barrow and Pickering, as exemplary of scientific realism and social constructivism, teeter on exactly opposite sides of the same axis. Their ostensible opposition is the one according to which the decades-long so-called science wars are waged — universal nature versus postmodernism, or relativism, or social constructivism — fruitful only in the metalogical sense of proliferation in publication quantities.[152] It so happens that the largely contemporaneous phenomenon called the culture wars also runs along both sides of the same axis — only now the counter-claimants are explicitly aligned with conceptions of Christian faith and a politics starkly different from the sustained critical attacks on the logics of representation most prominently emerging in 1970s university cultures. In an ostensible dialectical twist, the critical and progressive arguments now associated with postmodernism have come to be employed by today's right-wing rhetoric against the scientific understanding of evolution, climate change, and many other points of conflict. In turn, louder pleas are triggered against the 'assault on reason,' reinforcing the sense of a fundamental faultline between faith and reason.[153] In this sense, the public clashes between science and scriptural faith are the surface battle ground of universalism. On both sides of the table sits a claimant for universal nature and a counter-claimant to its default opposite, be it the social or the cultural. Is the Big Bang a 'fact of Nature' or a 'cultural construct'? Are the Constants of Nature absolute or simply relative fictions? What, in other words, is Nature?

Catalogically, nature is the great constraint — that against which everything is returned and folded. As Heidegger simply puts it, "nature thus remains for the science of physics that which cannot be gotten around." (1977: 174) But everything hinges on how this impervious nature is understood, hypologically. As I demonstrated in Act 3, the nature toward which physics gestures, the nature toward which the social sciences and humanities at best can turn their backs, and the nature to whose general explication modern science is dedicated, is governed by the hypological principle of identity. In this metaphysical configuration, nature is upheld in bifurcation from God, equivocally, and this relation is the condition of its

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[152] For a useful overview of the so-called science wars, see Parsons.

[153] The exemplary book title in this regard is Al Gore's *The Assault on Reason*, NY: Penguin, 2008.

universality. Nature is thus differentiated externally, and at the same time, internally. One thing is that physics for a century has operated with a fundamental divide between micro and macro scales — to some, this may be cause for consternation, or confident predictions that such a bifurcation is but one step toward eventual unification. Another thing is the more historically entrenched bifurcation upon which universalist natural philosophy and modern physics has operated since its conception. Effectively, nature outside can be accessed only by the so-called primary, that is, objective, qualities of natural science. And nature inside, an inferior or 'merely phenomenological' nature, is privy to so-called secondary, that is, subjective, qualities.[154] Thus, the measuring of the speed of light in a vacuum stands for nature as it really is, while light as it shines upon a canvas stands for nature as it appears to us as human subjects. Modern thinkers schooled in the legends of Copernicus, Galileo and Newton now laugh at the Aristotelian idea of a fundamental divide between a celestial and terrestrial physics. But who has the last laugh?

Universalist nature is therefore axiomatic in a double sense: it simultaneously constitutes the framework within which everything is every 'thing,' that is, identifiable objects and subjects — and the axis along which further bifurcations take place. The external demarcation of God and Nature, of creator and creation, finds itself internally reconstituted as the division between human and nature. Here, the catalogical constancy of modern physics is in structural accordance with the Christian doctrine of creation, in which 'man' stands to God as son stands to father, and 'nature' stands to God as artifact to artificer.[155] As in Descartes, natural body becomes distinguished from human mind by the principle of identity. And in a string of subsequent nominal battles multiplying along the same metaphysical axis: Nature versus Society, Nature versus Nurture, Nature versus History — even Nature versus Second Nature. Nature either has to be fought or it has to be protected, exploited or stewarded, discovered or left to itself. Always everywhere the same nature, which always stems from bifurcation yet is everywhere one: the Universe.

As I have tried to demonstrate in this dissertation, the claim to resolving mysteries of nature means that physics matters today primarily as metaphysics. And what distinguishes this enterprise is its ability to explicate the configuration of

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[154] For a metaphysical argument against the modern bifurcation of nature, see Whitehead (1920). Both Latour and Stengers draw partly, if not wholesale, on Whitehead's work in explicating terms for a 'cosmopolitics.'

[155] For an elaboration of this point, see Michael B. Foster in Wybrow, 1992.

universalism. Thus, physics today matters precisely as much, and in the same sense, as God matters. Axiomatically, physics is engaged in sustaining the ostensible opposition between religion and science, believing and knowing, God and Nature — and this is in my view the only sense in which it is consistent with its own history. Metalogically, physics is of a different logical order than under both Newton and Einstein, but catalogically, what holds it together historically, logically and causally is the articulation of constraint in terms of mathematical constancy.

In this sense, Max Planck expresses most succinctly the operative mode of the universalism that connects Galilean invariance to string theory: "The increasing distance of the physical world picture from the world of the senses means nothing but a progressive approach to the real world." (28) In universalism, "a progressive approach to the real world" is predicated on the disappearance of reality. And to accomplish such a radical inversion requires, as Planck knew well, a deeply rooted belief: "Over the entrance to the gates of science's temple are written the words: Ye must have faith."[156]

Particle physics, in other words, is Christian metaphysics by other means. And at its heart lies a universalist constitution of nature that now has to be turned inwards, in order to reveal the contours of a different metaphysics.

3. Nature against the Universal Parasite

As I have tried to show in this dissertation, the identity of nature as one is never a given — it has to be conceived. And logically, this conception of the universe proceeds through an asymmetrical doubling — internally and externally. Michel Serres is among the thinkers concerned with understanding this double constitution of the sciences. As he writes in *The Natural Contract:*

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[156] Planck, 1981, p. 214. Whether individual physicists actually believe in a transcendental God the Creator or not is here irrelevant, since the universalist enterprise of physics allows the privatization of faith to be perfectly consonant with the public profession of scientific work. Except for strictly scriptural readings, there exists no real conflict between Christianity and the work of physicists. Schematically speaking, whereas most work of physicists today is governed metalogically, through statistical means of extension, the faith in God the Creator, an equivocal God, is governed hypologically, as a belief structure whose obverse dimension is universality. On the other hand, the metalogical dimension of religion occurs as proliferating varieties of this God the Creator beyond formerly centralized, hypological church structures.

> Scientific knowledge results from the passage that changes a cause into a thing and a thing into a cause, that makes a fact become a law, *de facto* become *de jure*, and vice versa. The reciprocal transformation of cause into thing and of law into fact explains the double situation of scientific knowledge, which is, on the one hand, arbitrary convention, as is all speculative theory, and, on the other hand, the faithful and exact objectivity that underlies every application. (22)

Hence, this science always shows itself as structurally similar to Henri Bergson's two systems of images, in which subject and object, mind and body, are aligned along the same axis of truth. As Serres puts it, "it is as if the verdicts of humans coincide with those of objects. That never happens, except in miracles and sciences." (ibid.) As in the case of Barrow's anthropic principle, the metaphysics of universal creation is simultaneously miraculous, insofar as we imagine the overwhelming probabilities against it, and scientific, insofar as these probabilities can be calculated.

In spirit, Serres' philosophy of science therefore shares with Bergson the rather Herculean effort of translating between and across sciences, philosophies, and arts. Yet Serres, writing in the final three decades of the 20th century, recognizes the task of philosophy as practically different from what determined Bergson's late 19th century musings.

> There was a time when any philosopher worthy of the name was a dabbler in everything. The entire encyclopedia of knowledge in their time is found in the works of Plato, Aristotle, Saint Thomas, Descartes, Leibniz, Pascal, Hegel, Auguste Comte, and even more secretly, in the works of Bergson… But today these areas are not systematic… the present order seems like a chaos, in which a kind of rationality must be sought… Indeed, one of the exciting problems of our era consists of rediscovering the chaotic nature of knowledge. (1995b: 126-7)

Thus, if Bergson saw potential for harmony between metaphysics and science, Serres appears at first too constrained by the metalogical proliferation of 20th century science to espouse any such hypological order. This decisive restriction leads Serres to a philosophical method we could deem analogical. Writing under the sign of Hermes, the Greek god of communication, Serres is on the surface a nomadic wanderer through chaos, criss-crossing multiple discourses by following a certain logical or structural pattern. In the curious text called *The Parasite*, the frequent jumps between fables, economics, and cybernetics trace the outlines of how 'universal nature' and 'human history' are held up along a double pole, a structural co-extension of being and thinking. This image would be entirely Bergsonian, were it not for the fundamental discord it reveals. "History," writes

Serres, “hides the fact that man is the universal parasite, that everything and everyone around him is a hospitable space. Plants and animals are always his hosts; man is always necessarily their guest.” (24) In this sense, ‘man’ as universal parasite means it is always working on both sides of the doubling axis — constituting both human and nature.

For Serres, the parasite is a being of mediation, whose paradoxical function is to always insert itself in the middle by hiding its mediation from itself. While the parasite may conceive of its work as striving to occupy a position in empty space, its actual success is accomplished by filling in the world, by permeating its environment. In this sense, Serres’ logic is consonant with Sloterdijk’s concept of explication: the doubly constituted “revealing-inclusion of the background givens underlying manifest operations” (2009: 9) — that is, the reintroduction of the environment into the traditional battle of adversaries. This is precisely the image that Serres presents us with in *The Natural Contract*: a painting by Goya (“Men Fighting with Sticks”*)* that shows two adversaries battling unto death whilst slowly sinking into quicksand. Modern humans, writes Serres, see in this painting first and foremost a duel, perhaps ‘human nature,’ and only secondarily ‘nature,’ that is, whatever surrounds the fighters. By the modern social contract, he argues, nature is constituted in bifurcation from culture: history is the history of human battles, of people fighting people, of debate and dialectics, always already divorced from the world in which it takes place. The essential promise of Hegelian dialectics too is the ideal reunification of nature and history. If anything characterizes this human of modern human history, then, it is blindness to its own mediation — blindness to its constitutive role in conceiving nature as one whilst making it proliferate. In other words, the parasite is the autological by another name. “He is the being of the relation, coming from it as it comes from him. His roles or incarnations are a function of the relation, the relation is a function of the parasite, in a circular causality, in feedback loops.” (2007: 63) In Serres’ conception, the autological being of relation is thus constituted as a double logic: “that of the excluded third and that of the included third.” (ibid)

What are the implications of this double constitution? Following Serres, Bruno Latour demonstrates how it constitutes a radical division within the modern self-conception of science. Graphically represented, above a horizontal line, the logic of the excluded middle turns the parasitical work into purification, that is, into hypologies that clearly distinguish things, ideas, domains — hypologies that purify Nature from the grasp of Culture. Below this line, the logic of the included middle concerns the work of translation, mediation through actual proliferation — an impure, sprawling mess of connections that continually challenge the work of purification. Effectively, the instituted division between the two modes of parasitical mediation, between the excluded and the included middle, becomes a constraint that polarizes the conditions of mediation — in effect, between hypological unification and metalogical multiplication. Thus, the more purification, the more proliferation, and vice versa.

In the case of the LHC, purification occurs in the hypological division between physicists and non-physicists, inside and outside. Threatened by the overwhelming uncertainty of unstable alliances and risky assessments, this inside has to be cleansed, bad scientists have to be distinguished from good, in order for public trust to be reinvested in the very same discipline whose actions beckon such distrust. On the one hand, purification can be a straightforward matter of simplifying a complicated science for external public relations. As Elizabeth Kolbert reports for *The New Yorker:* "CERN officials are now instructed, with respect to the LHC's world-destroying potential, 'not to say that the probability is very small but that the probability is zero.'"[157] Thus, the constitutive uncertainty of metalogical calculations is quelled by public relations management that keeps insisting everything is under control. On the other hand, such attempts typically meet with derision by scientists and journalists, who share in the elusive ideal of objectivity. In a typical news media article, journalist Dennis Overbye writes in the *New York Times*: "some experts say too much hype and not enough candor on the part of scientists about the promises and perils of what they do could boomerang into a public relations disaster for science, opening the door for charlatans and demagogues."[158] Against this perennial threat of charlatans lurking outside the door, universalist science needs, in Barrow's phrase, a 'bulwark against unbridled relativism.' Overbye quotes Francesco Calogero, a nuclear physicist at the University of Rome and co-winner of the 1995 Nobel Peace Prize, who "deplores a tendency among his colleagues to promulgate a 'leave it to the experts' attitude. 'Many, indeed most, of them,' he wrote, 'seem to me to be more concerned with the public relations impact of what they, or others, say and write, than in making sure that the facts are presented with complete scientific objectivity.'" (ibid.) In other words, either the non-scientific public is too stupid to understand the science, or scientists themselves aren't explaning it in a way they can understand. Faced with a catalogical limitation of its ongoing operation, the response is always

[157] See Kolbert, 2008.

[158] See Overbye, 2008.

polarized, like two poles of a political spectrum emerging: either police the boundaries to keep the others out, or reason with the others to make them understand why these boundaries are necessary. In both cases, a double hypological division is reinforced, externally between public and experts, and internally between proper scientists and charlatans.

Against the overwhelming chaos of interlocking subjects and objects on every possible scale, what Latour calls the modern response is also polarized: on the one hand, to identify, separate, categorize — make order in the universe — whose actual effect, on the other hand, is to create even more complicated hybrid constructions that defy the purity of the framework. The greater the constraint, the greater the polarization. In this sense, as Sloterdijk puts it, the modern "remains trapped in a phobic circle, striving to overcome anxiety through technology, which itself generates more anxiety." (2009: 79) But if the modern thinks of 'world-alienation' as the anxiety-inducing cause of its own modernizing process, that is, a widening chasm between scientific nature and human life, Latour rather proposes in *Pandora's Hope* that "the modern collective is the one in which the relations of humans and nonhumans are so intimate, the transactions so many, the mediations so convoluted, that there is no plausible sense in which artifact, corporate body, and subject can be distinguished." (197) By problematizing this universalist configuration that relegates Nature on one side and Culture or Humans or Society on the other, Latour shows how the axiomatic work of the modern is what keeps hypological purification in sanctioned view while making metalogical proliferation hidden to itself — how the modern operates like Serres' parasite.

Nevertheless, in his approach to universalism, Latour is in turn the parasite of Serres. That is, Latour becomes the mediator of Serres in both an included and excluded sense — both of which have to be considered in turn. Philosophically, Serres' influence on Latour's understanding is obvious, partly through many shared concepts. Serres' notion of the 'quasi-object', for example, elucidates the perspective of Latour's actor-network theory. Like a passing football, in relation to which players (and spectators) move, quasi-objects are actors (human or non-human) articulating the movements of shifting networks and alliances.[159] The ball passes the midfield, connecting some players running into position (whilst also connecting camera movements and spectator attention), in the very same

[159] Here, I am only concerned with the metaphysics of actor-network theory, for which Latour is only one of many contemporary articulators (or one actor in a network). For complementary articulations, definitions and methodologies, see the works of Michel Callon and John Law among others. Harman, 2009, contains an elaborate discussion of Latour's metaphysics.

movement that constrains others from acting on it (or being in view). Analogously, a concerned scientist publishes a calculation that the planet could be destroyed by an experiment, and at once his argument, be it mediated as a journalistic paragraph, a portable document file, or hearsay, becomes a quasi-object that connects an interested audience while constraining existing alliances. As a means of following 'science in action,' actor-network theory is a framework for tracing the multiple relations of acting, autological positing, according to its analogical connections and catalogical constraints.

Although this is but a fragment of a much more complicated theoretical articulation, it already gestures toward a crucial metaphysical implication. Viewed in relation to the passing ball mediating his actions, the player who now has a chance to score is not strictly the same player as the one (with the same number on his back) who was resting midfield while the ball was in defense territory. The lonesome scientist who goes to his blackboard to jot down equations is not the same scientist whose pdf of calculations circulates like a sensational torrent through linked public and science networks. In both cases, when viewed from the perspective of the networks within which they are implicated, the player and the scientist are actors defined by singular events — a chance to score, a controversial prediction. At the level of actors and networks, then, or in the dimension of autological positing through connecting and constraining mediations, there is continuous creation. A poor pass, a wet surface, a contradictory data analysis, a computer malfunction, a missed deadline: at any moment, any human and nonhuman actor in the network of translations can behave differently and thus change events as they in turn affect further connections and constraints. Thus, by Latour's principle of irreduction, his metaphysical postulate for a proliferating world, any event in the assemblage of actors and networks is strictly irreducible to any other. Events, actors, and relations are unique, singular, and different.

To conventional logic in the sense of hypologic, continuous creation is an absurdity, an affront to the principle of identity.[160] If any event is singular in relation to any other, and all things are continually created, how does anything actually remain in existence? How is constancy maintained? Is there not necessarily some deeper identity that ensures the football player is the same player on and off the field, the galaxy persists through the cosmos, and the scientist remains the same before and after his doomsday determination? Is there not some enduring sameness

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[160] In Act 2, we saw how the Steady-State Theory of the universe, which crucially relies on the doctrine of continuous creation, was attacked for being 'metaphysical' in this sense.

that constrains our world from one moment to the next? In other words, we return to the problem of substance. From Aristotle through Descartes and Spinoza, substance was the name for that which, in one sense or another, ensures consistency, constancy and coherence throughout the inexorable permutations of the world's attributes. While the notion of substance may have fallen out of intellectual fashion, the same idea, as we have seen, crops up as energy in thermodynamics, as vital spirit or life in Bergson, as Being in Heideggerian phenomenology, and so on.

For Latour, however, the problem of constancy requires a critical inversion:

> …the relation of substance to attributes does not have the genealogy that the subject-object dichotomy forced us to imagine: first a substance out there, outside history, and then phenomena observed by a mind… The word 'substance' does not designate what 'remains beneath,' impervious to history, but what gathers together a multiplicity of agents into a stable and coherent whole. A substance is more like the thread that holds the pearls of a necklace together than the rock bed that remains the same no matter what is built on it… Substance is a name that designates the stability of an assemblage. This stability, however, does not have to be permanent. (1999: 151)

Thus, Latour avers, the autological mediation of actors that is strictly irreducible from one event to another is held together or gathered in "a historical and political space in which newly emerging entities are slowly provided with all their means, all their institutions, to be slowly 'substantiated' and rendered durable and sustainable." (311)

Substance, then, is a name not for nature outside but for the cultural constructions through which stable identities are forged. Hypologically, under the principle of identity, the player who scores the goal is the same player who last year never made the team, and the scientist who wakes up from a nightmare is the same as the one who went to bed thinking about white dwarfs. Metalogically, the black hole that Stephen Hawking predicts is the same as the kind to which the doomsday calculation refers — and the hadrons in one collider experiment the same as the ones produced in the next. Both of these logical dimensions involve retroactive constitution, in much the same way as reason under the sway of identity will proceed backwards from attributes to their conceived underlying substance, from identifiable effect to identifiable cause. Thus they make history, in a double sense.

As I relate Latour's philosophy to the logics explicated in this dissertation, it becomes possible, heuristically, to schematize two divergent planes. The one upon which actor-network theory would operate, appears to trace the autological in its analogical connections and catalogical constraints — a plane of 'difference.' The other, which actor-network theory leaves open to questioning, concerns the hypological and metalogical means of reasoning — a plane of 'identity.' Before succumbing to traditional categorizations that would distinguish a materialist plane of relations from an idealist plane of conceptions, or an infrastructure from a superstructure, or ontology from epistemology, let us first consider the crucial sense in which these planes continually intersect. Once an event occurs on the plane of difference — say, the player scores a goal, or the scientist is publicly rebuked as a charlatan — it is never settled in and of itself, since it always requires the continuity of action. Here, Latour writes with reference to his exemplary case of Pasteur, whose conception of microbes is deemed by scientific history as a definitive victory over his rival Pouchet. In this matter, long since definitively settled as a fact, Latour takes issue:

> Why can't we say that Pasteur was right and Pouchet was wrong? Well, we can say it, but only on the condition that we render very clearly and precisely the institutional mechanisms that are still at work to maintain the asymmetry between the two positions. The solution to the problem is to formulate the question in the following way: In whose world are we now living, that of Pasteur or that of Pouchet? I don't know about you, but for my part, I live inside the Pasteurian network, every time I eat pasteurized yogurt, drink pasteurized milk, or swallow antibiotics. In other words, to account for even a long-lasting victory, one does not have to grant extra-historicity to a research program as if it suddenly, at some threshold or turning point, need no further upkeep. What was an event must remain a continuing event... In this sense I participate in the 'final' victory of Pasteur over Pouchet, in the same way that I participate in the 'final' victory of republican over autocratic modes of government by voting in the next presidential election instead of abstaining or refusing to register. To claim that such a victory requires no further work, no further action, would be foolish. (167-8)

In other words, the continuity of the event — the historical inheritance of a decisive goal or the consequences of a prophetic black hole calculation — may be conceived hypologically and metalogically in terms of identity, but it requires the fundamental constancy of autological enactment. As a mediation, this action is variously connected and constrained, just as the path to democratic voting, pasteurization, legendary football victory or cosmological predictions may be straightforward or filled with obstacles for any actors involved. In either case, the constitution of the world through the sciences is fundamentally a political problem. Thus, Latour's most famous claim contained in his text, *We Have Never Been Modern* — a claim to 'nonmodernity' — is principally an attempt to undermine what he considers the modern purification of science as an apolitical activity. The modern, he writes, "is a settlement that has created a politics in which most political activity justifies itself by referring to nature." (1999: 308) By imploding the universalist axis of nature and culture, the sciences stand revealed as actors in a collective, as much implicated in political questions as any other actors.

At this point, Latour's parasitism turns Serres into an excluded middle. Although Serres' tireless translation informs much of the philosophical work involved in tracing the sciences in action, he consistently shies away from entangled political questions, opting to forge new connections between past and future rather than being constrained by decisions in the present. In *Conversations on Science, Culture, and Time*, a series of five interviews Latour conducted with Serres in 1990, the elder philosopher's characteristic evasiveness is explained generationally, as a response to growing up during the devastation of World War II. Ever since, Serres has recoiled from perceived belligerence, purposely evading academic debates, and foregoing any style of critique or critical inquiry. Yet the conversations between the two thinkers, for all their friendly rapport, bring out discernible intellectual tension. Repeatedly, Latour's questions try to categorize Serres as an exemplary 'nonmodern' thinker. And repeatedly, Serres frustrates his efforts by turning away from Latour's definitions. For instance, Serres says of the intellectual questions he faced in his early career that they "were new and pressing, truly unexpected, unforeseeable: never had science so imposed itself on humanity. It was imperative to promote a modernity." Latour is bemused: "I don't understand. You wanted to be modern?" To which Serres replies, somewhat cryptically: "What I am and when I am is not really important," and quickly moves on to another connection. (46) To Serres, the question of the modern is philosophically insignificant, since the world at any moment is effectively poly-chronic, exhibiting a simultaneous co-existence of multiple historical constructions, ancient tools inhabiting modern technologies, premodern ideas co-existing with postmodern disaffections. Yet to Latour, the question of the modern is of utmost concern, since it is precisely what he proposes to dismantle. And so as Latour elaborates his criteria for definitions of the modern, Serres merely goes along in one-syllable answers, "Right…" — and then finally turns by referring to Latour as "my dear Socrates" (164) — having established Socrates as the figure who "always imposes the methodology by which he always wins." (38) Latour tries to constrain Serres, and Serres continually circumvents Latour. And so they talk back and forth past each other, like diverging tendencies from a convergent philosophy — in a sense, like the difference between the analogical and the catalogical in relation to autological mediation.

Unplaceable in specific words or definitions, the difference between Serres and Latour therefore principally occurs in the repetition of a structural pattern. Serres continually works with dualities. In *The Natural Contract*, law and science are both doubly constituted. In *The Parasite*, atoms and letters explicitly form double chains of symmetrical relations. In *The Birth of Physics*, statics is defined by declining and inclining, according to the fluctuations of a third element, the clinamen. In *Conversations* as well as in *The Troubador of Knowledge*, Serres explicitly argues for this 'third' position. The parasite is a third element in any relation; the environment is the hidden third of the dialectical battle of adversaries; and Serres' approach to knowledge constitutes a "third curriculum" from which double symmetries can be traced in their mutual constitution.[161] By contrast, Latour operates like a symmetry breaker. The double constitution of the modern, like the double constitution of science, is a means of explication that reveals a radically flattened political order, a 'nonmodern' world in which the both of the double is really the neither of two constructions. For Latour, there has never been any other doubling than what has been retroactively created.

Thus, Serres can state as the premise for his 'natural contract' that nature and culture have today come to reach other, supposing its double axis. "Global history enters nature; global nature enters history: this is something utterly new in philosophy." (4) For Latour, however, the same overreaching of nature and culture in its traditional sense means effectively that there is neither nature nor culture: "the very notion of culture is an artifact by bracketing Nature off. Cultures — different or universal — do not exist, any more than Nature does." (1993: 104) In *The Politics of Nature*, he confidently pronounces "the End of Nature," by which he means nature as universalist conception. On the one hand, then, nature and culture co-constituting a third point of view from which an extended natural contract becomes possible. On the other hand, Nature and Culture canceling each other out: there never was a Nature or Culture in any modern, that is, bifurcated sense at all. The new Natural Contract, or Death of Nature.

In turn, Serres' and Latour's convergent premise of an autological reality now shows its diverging tendencies under the opposite sign. For Latour, the erasure of the Nature-Culture distinction is precisely a means of connecting anew, of positing new and unexpected alliances between human and nonhuman actors across previously exisiting divides. Yet for Serres, the doubling of Nature and Culture appears to constrain these actors from being conceived in any other terms than the

[161] See in particular p. 185 in *Conversations*.

human. The same modern pole between Nature and Culture that Latour attempts to undo is what Serres flips upside-down — and this difference has significant implications.

Consider Serres' perspective on how nature first came to be divided from human affairs. "From our beginnings," he says to Latour, "we had regulated our actions on this distinction between things that depended on us and those that in no way depended on us… The distant future, the Earth, the universe, humanity, matter, life, all the global categories that philosophers theorize about, always eluded our influence." And now? "Suddenly, toward the middle of the century, at the end of World War II, we have the rise in power of all the mixed scientific disciplines — physics, biology, medicine, pharmacology — plus the whole set of technologies brought about by them… All of this has pushed back the limits and almost eliminated what does not depend on us." (169)

For Serres, this dramatic shift in dependency on human affairs reveals the ethical urgency of realigning nature with the actions of humanity: "Here is the name of our new ethos: *Natura sive homines* — Nature, meaning human culture; human morality, meaning the objective laws of Nature." (176) The natural contract posits that, on the one hand, humans have become the masters of the Earth, but on the other hand, that "our very mastery seems to escape our mastery. We have all things in hand, but we do not control our actions." (171) Out of our control and out of our mastery, the sciences today emerge in a deeply parasitical role — charged with creating the conditions of our collective world, with remaking our autological givens. Thus, Serres says, we now live "in the modalities of a knowledge that, further, bears the only future project of our societies. We are following the blind fate of sciences whose technology invents possibilities that immediately become necessities. So it no longer depends on us that everything depends on us." (172) During the last half-century, the necessity that formerly belonged to the laws of nature has therefore come to inhabit human freedom, to inflect all the actions of our ways of knowing the world. Thus, Serres argues, "necessity abandons nature and joins society." (173)

In the end, then, it may be that Serres' task is different from Bergson's, and it may be that his method differs, as does his outlook on the contemporary condition — but in his attempt to realign the bifurcation of the cosmos, Serres' natural contract shows deep structural kinship with his predecessor. Against the troubles of the current metaphysical order, Serres contributes, much in the way of Bergson, a slender hope for the harmonious — or perhaps more accurately, less disharmonious — co-existence of humans and nature under a new set of terms.

In this sense too, just as Bergson could be charged with neglecting the political implications of his philosophical operation, Serres fails to grapple with the looming political question that preoccupies Latour: who are 'we' in the natural contract? What is this ambiguous collective upon which everything now apparently depends? How is it constituted? For all the limitations it places upon the actors of the modern social contract, the natural contract in effect extends the human to global potency — a mutually assured doubling. In principle, then, Serres may turn the bifurcated axis of modern universalism around — but far from revealing a new freedom, or a new political configuration, it risks reinforcing contemporary political conditions as fundamentally necessary. Along with a new ethical means of connecting to the conditions of our existence, we therefore also get something resembling a governmentality of Planet Earth:

> For what reasons must I behave in one way and not another? So that the Earth can continue, so that the air remains breathable, so that the sea remains the sea. What are the reasons for some other necessity? So that time continues to flow, so that life continues to propagate itself, with comparable chances of multiplicity. (175)

For Serres, this image of the new necessity is offered as a romantic, faintly hopeful gesture. But it entails more troubling stakes, namely the moral identification of a striving individual human with a global order of nature — an identification of a living being with life as it is mobilized around the world. In other words, the renunciation not merely of modern politics, but of the political as such. If we once could say that, hypologically, it is so because we make it so, the natural contract implies the rather disturbing obversion: we make it so because it is so. What is has to be. Thus, it would seem, the double scientific constitution of fact and law now rules the planet by mutual contractual obligation — necessarily *de facto* and necessarily *de jure*.

It was against the overwhelming force and totality of this kind of enframing that Heidegger came to conceive the inexorable growth of the quantitative sciences as emblematic of a deeper fate of culture itself. In a 1954 lecture on science, he asked the question:

> Is science, then, nothing but a fabrication of man that has been elevated to this dominance in such a way as to allow us to assume that one day it can also be demolished again by the will of man through the resolution of commissions? Or does a greater destiny

rule here? Is there, ruling in science, still something other than a mere wanting to know on the part of man? (1977: 156)

For Heidegger, the answer was squarely in the affirmative. This destiny ruling in the relentless rise of the scientific enframing of nature was what he elsewhere called nihilism, a deeper cultural drive toward the radical overturning of all values and foundations. In this sense, Serres' natural contract appears as yet another stage in the fundamental overturning of nature that constitutes the human will to power and its more than two millennia-long history of nihilistic transformation.

Then again, not only is Heidegger's conception of metaphysics as the stage of historical nihilism predicated on an ontological constitution that 20th century physics has already relegated to oblivion. More problematically, Heidegger's plea against the totalitarian dominance of the modern sciences is itself predicated on an explicit appeal to nature. Certainly, Heidegger's nature is one that "presences" in ways that the sciences themselves can never capture, and least of all the mathematical nature of physics. Nevertheless, this nature is for Heidegger, much like the Being that is ontologically different from beings, contingent on an axiomatic relation to the human — even if this relation remains the great mystery of the unthought. After all, to speak of destiny always implies an external relation to the real, underlying causes of things, which like an impervious law, is bound to reach its telos. In Heidegger's conception of destiny, if nature is not what lies outside, the irreversible fate of history certainly is. Everywhere we look in Heidegger's post-war writings, 'man,' or the human, encounters either nature or Being, and in this enframing, 'man' is bound to his fate of enacting nihilism.

Thus, while it is the relation with nature that Heidegger sees threatened by the scientific means of knowing and transforming the world, it is at the same time the consequences of scientific enframing that today forces us to rethink this relation. With and against Heidegger's ambiguous charge that we are enacting our own historical fate, then, we turn to the metaphysical stakes of an alternative configuration of nature, and thus a reordering of the sciences involved in explicating it. What we require is to reconstitute the relation between Being and 'man' as such — to reconfigure the conventional divide between Nature and Culture.

4. Culture against Mobilization

In the articulation of *Natura sive homines* under the sign of necessity, Serres directly invokes Spinoza as our contemporary. Certainly, for the thinker who radically equates God and Nature, the principle of sufficient reason also turns into an axiom of necessary reason — it is, so to speak, logically required by univocity itself. But does this mean that the metaphysics of Spinoza commits us to a natural contract of human necessity?

In Act 4, we alluded to Spinoza's infamous response to those who claim a free will — a claim that "consists only in this, that they are conscious of their actions and ignorant of the causes by which they are determined. This, then, is their idea of freedom — that they do not know any cause of their actions." (IIP35S) The austere image of Spinoza's metaphysical system as iron-clad determinism is, as I have already argued, typically confused with either predeterminism, implying that another being has determined our actions for us, or the hypological identification of causes and effects, which implies that beings determined by the causes of their actions are like billiard balls bouncing about upon impact. However, in Spinoza's statement, 'cause of their actions' appears ambiguous: it can equally refer to causes for action and causes of, or from, action — that is, causes insofar as they precede our own, and causes insofar as they follow from our action. In other words, the necessity and determination of our action is not caused by something outside us but belongs to our action itself. This ambiguity is constitutive of Spinoza's metaphysics. In fact, as I will demonstrate, the perception of ambiguity in his statement merely reflects a modern, universalist conception of nature.

For a moment, let us consider such modern conceptions. Where in Spinoza do we find culture? Or humans? Or society? None of these terms appear in the *Ethica*. Certainly, in his supplementary notes throughout, Spinoza refers to 'man' — but then as a deductive consequence of metaphysical principles, as though applied to that special category by which his contemporaries recognize themselves. Yes, Spinoza philosophizes about Mind — but not in any way recognizable to discourses that assume mind as belonging to individual human beings. No wonder Spinoza's work is difficult to penetrate to a modern reader, since it lacks so many key terms of what Latour calls the modern settlement — the bifurcation of Nature and Culture. Because nature is never outside, Spinoza offers the moderns neither phenomenology, existentialism, nor critical theory. And since nature never stands under the principle of identity, nature is never universal — rather, nature is univocal, that is, internally differentiated.

In this internal differentiation of nature, there is no divide between nature and humans or Being and beings — not between any hypologically constituted entity and another. Rather, autologically, the difference emerges between acting and acted on, active and passive — *Natura naturans* and *Natura naturata*. As we saw in Act 3, this distinction in the *Ethica* constitutes the difference between necessity and contingency. For what is necessary is what is required by the principle of reason, which in its apotheosis is simply causality as such. It is so because it is so. And it — substance, God, or Nature — is so because it acts. This is how we must understand Spinoza's claim to explicating the laws of Nature: "Nature is always the same, and its virtue and power of acting are everywhere one and the same, that is, the laws and rules of Nature, according to which all things happen, and change from one form to another, are always and everywhere the same." (IIIPre) These laws and rules that give Nature its constancy cannot be embodied in number, for they essentially express autological positing that is everywhere the same only by the same logical principle. Nature is autological because Nature is essentially the striving of the world, before any hypological distinctions retroactively separates humans from creatures, things, or technologies. Thus, we are all 'naturing' insofar as we act, and we are all 'natured' insofar as we're acted on. We are not fundamentally 'free' in any liberalist sense, because we are always affecting and always being affected — meaning that we are at any one time connected and constrained.

In this sense, I propose that the relations between autology, analogy and catalogy can be understood through Spinoza's geometrical theory of the affects. As noted in Act 3, the autological "striving by which each thing strives to persevere in its being is nothing but the actual essence of the thing." (IIIP7) Spinoza defines this striving as 'desire,' an inclusion of both the 'appetite' and the 'consciousness of this appetite' — in other words, body and mind. Through autological desire, Spinoza differentiates two affects that he calls passions — passions in the sense of passive, that is, being acted into being. "The idea of any thing that increases or diminishes, aids or restrains, our body's power of acting, increases or diminishes, aids or restrains, our mind's power of thinking." (IIIP11) As a movement of inclination, the passage from a lesser to a greater power of acting is what Spinoza calls joy. As a movement of declination, the passage from a greater to a lesser power he calls sadness. Power of acting is in this sense a purely relational expression of autology, as differentiated by the fluctuating affections within the field of its movement.

For Spinoza, relating this geometrical construction of affects to human experience, there is an essential asymmetry at work. The mind, he says, always strives to imagine what increases the body's power of acting — strives to increase its reality by increasing its connection — and always strives to avoid imagining what diminishes or constrains its power. Nevertheless, we are continually acting on condition of affections beyond our control. As Spinoza puts it in a rare use of metaphor, "we are driven about in many ways by external causes, and… like the waves on the sea, driven by contrary winds, we toss about, not knowing our outcome and fate." (IIIP59S) Yet the inclining and declining affects in turn work to differentiate our action, our desire, our autological striving. They lead us, as the text of the *Ethica* does, toward intuition and toward Spinoza's conception of freedom as the mind's active alignment with the autological principle by which it is determined.

From the essence of desire and its fluctuations of joyful and sad passions, Spinoza is able to delineate and define a wide range of affects, from wonder and tenacity to anger and despondency. Spinoza's final catalogue totaling 48 affects is, he readily admits, incomplete. But this is no mere quantitative deficiency: no catalogue of affects would ever be complete, because "there are as many species of joy, sadness, and desire, and consequently of each affect composed of these or derived from them, as there are species of objects by which we are affected." (IIIP56) In this sense, the affects are principally determined by difference, or as Latour would put it, by a principle of irreduction. Spinoza elaborates on the case of 'man': "…as each man is affected by external causes with this or that species of joy, sadness, love, hate, and so on, that is, as his nature is constituted in one way or the other, so his desires vary and the nature of one desire must differ from the nature of the other as much as the affects from which each arises differ from one another." (IIIP56D)[162] The essential incomparability of any identified affect, such as hope and fear, is a consequence of the autological nature of desire, which ensures that both joy and sadness are passages or tendencies, not states amenable to hypological capture.

For instance, love is for Spinoza the affect of joy accompanied by the thought of an object; conversely, hate is the affect of sadness accompanied by the thought of an object. Hence, the autologically mediated affects give rise to hypological constructions: ebbs and flows of feeling turned toward an identifiable object of affection, according to which the movement of our striving may be determined. Love for a goal-scoring player; hatred for a meddling scientist — a relation turns under the principle of identity, constituting it as subject and object. In turn, identity

[162] This differential dimension of the affects lies at the heart of Gilles Deleuze's reading of Spinoza, as the point of connection between a rationalist system and an empiricist orientation. See Deleuze, 1988.

enables our reorganizing and transforming of our affective relations — the glorious goal that will forever be constituted in cultural memory; the cantankerous claimant that comes to stand for charlatanism. Insofar as things are explained without relations to our affects, they are easily turned into causes, as though their affecting us can in turn be attributed to something intrinsic to things in themselves. Like the sciences that turn a cause into a thing and a thing into a cause, doubly constituting fact and law, people who claim free will are, in Spinoza's view, ignorant of the causes of their action, because the hypological constitution of objects ignores the affective conditions of its own articulation. Like a parasite, the included middle becomes excluded, purified.

Moving the other way, Spinoza also shows how the possible dissonance between hypological object and affective condition all too easily turns against the affects themselves, which are thus rendered suspect. By the universalist bifurcating axis, affects become merely subjective feelings, which have to be separated from the independence of the thing or the being before us. This curious inversion, Spinoza says, follows from all the philosophers (Descartes is named) who conceive

> ...man in Nature as a dominion within a dominion. For they believe that man disturbs, rather than follows, the order of Nature, that he has absolute power over his actions, and that he is determined only by himself. And they attribute the cause of human impotence and inconstancy, not to the common power of Nature, but to I know not what vice of human nature, which they therefore bewail, or laugh at, or disdain, or (as usually happens) curse. And he who knows how to censure more eloquently and cunningly the weakness of the human mind is held to be godly.[163] (IIIPre)

Thus, the double turning: Nature against itself and humans against themselves. Humans become essentially different from nature, which means their modes of collective organization are different from nature, which means their history is different from nature, which means their learning 'in' the world is different from how they 'really' are in and of themselves, and so on. Against this hypological framework of the modern settlement that constitutes Nature as separated into two realms of knowledge, Spinoza claims that Nature is always and everywhere the same — univocally — which means always and everywhere different in itself.

Already it should be clear that Serres' invocation of *Natura Sive Homines* is not an expression of Spinozism. The principle of necessity does not readily

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[163] Incidentally, in this last remark, we see the central motif of Nietzsche's theory of ressentiment and the priestly channeling of desire in *The Genealogy of Morals*.

distinguish humans or some ambiguous notion of 'us' from our 'dependency' any more than nature can be limited to or by human practice. But what about Latour's thesis that there has never been nature outside culture — that is, *Natura sive Cultura*?

At first glance, nothing could be further from a 17th century theory of human affects than a late 20th century theory of nonhuman network relations as applied to the work of science. But despite their widely differing objects of inquiry, Spinoza shows himself as Latour's metaphysical kin. In actor-network theory as in univocal metaphysics, action is not limited to human beings but afforded to all things — like *Natura naturans*. With Spinoza, we could say about the difference between Culture and Nature that Nature is Culture — in the sense of *naturata* — insofar as it is affected, and inversely, that Culture is Nature — in the sense of *naturans* — insofar as it affects. For Spinoza as for Latour, all things are actors, or have the capacity to act, because in order to become hypologically constituted as things, they must be engaged in multiple relations with others — that is, they must affect one another through shifting alliances. Furthermore, the power of an alliance is determined by its increasing and decreasing powers of acting — that is, according to the fluctuating logic of connecting and constraining. Just as 'man' relies on affective mediations to increase his joy — relations to friends, to things, to drink, to work — the scientist too relies on mediating actors — interested colleagues, functioning computer software, scandal-seeking reporters — to strengthen the alliance against a risky experiment. And just as human affect at any one time and place is different from another, so networks of actors are strictly singular, in continuous creation.

Thus, to delineate one theory as dealing with emotion and another as dealing with material objects is to miss their shared insight: relationally, both theories operate according to autology, mediated analogically and catalogically. For Spinoza as for Latour, the world fundamentally consists of a world of acting human and non-human affective constructions. Never outside like nature in physics, the autological is continually created — constituted through its relation with hypological constructions, acting within a now connecting, now constraining field, shaping the dialectical appearance of hypology and autology as ideas and reality, mind and body, human and nature, nature and history — Nature and God — Culture and Nature. In this sense, actor-network theory can be considered a means of translating through affecting and affected things the actual work of science in action, continually conditioned by the fluctuating inclines and declines of its mediation.[164] Beyond textual and historical differences, then, Latour directly participates in Spinoza's univocal metaphysics, in the positing of a logical structure that differentiates his thought from the axis of universalism.

Nevertheless, a gaping logical chasm still separates Spinoza's affects from Latour's science studies. On the one hand, as we have seen in previous Acts, Spinoza's God is constituted by a principle of reason raised to infinite potency, which is therefore the condition for ultimate alignment, or harmony, between mind and nature. Once we discover the principle by which we are univocally connected, we have 'found' God as much as we have 'discovered' nature through our own expression. On the other hand, the means of translation across the sciences today is conditioned by the chaos of proliferation — in a word, by metalogy. As I demonstrated in Act 4, the key characteristic of the metalogical is its abandonment of the principle of reason, and thus causality, for the work of multiplication and correlation. As the hypological bifurcation of nature constitutes a turning away from autology — in a sense, a forgetting or ignoring of its mediating or causal conditions — so it in turn, through retroactive constitution, gives rise to an exponential logic divorced from causality altogether: an irreversible chain reaction of constructions that effectively repudiates the regime of reason. Thus, if God in Spinoza's sense still expresses itself through action, if our enacting of relations constitutes nature, we lack the appeal to a law of nature, or principle of reason, to make sense of our actions.

Thus, what separates Spinoza from Latour is the same logical condition that temporally separates our contemporary moment from what we consider our history. For that matter, this is the same logical condition that spatially separates a dissertation writer in urban North America from the affective constraints of metalogical problems like overpopulation, resource depletion, and weapons proliferation. We are stuck in the muddle of the middle. Despite the political problems with Serres' proposition, then, *Natura sive homines* is symptomatic of a cultural transformation in which, as Sloterdijk describes it, the givens become increasingly explicated. From the perspective of a nature in increasing constraint, it becomes increasingly necessary to reconstitute the chasm between autological mediation on the one hand and metalogical proliferation on the other. Serres' ethical problem can thus be reformulated in logical terms: what are the conditions for any 'I' to participate in a 'we,' when the affective link between 'my' mediated actions is severed from the cultural constructions to which these actions contribute? In what sense can the disconnected 'I' identify with a Nature or Humanity or Culture that constitutes metalogical disaster on ever increasing scales?

On the one hand, as we have seen, the reconstitution of this link occurs hypologically. The striving 'I' in the vortex identifies with the belief structure that best allows for the conditions to stabilize. In the same sense as, autologically, there is no point at which nature begins and humans or cultures end, there is no limit where knowledge is clearly separated from belief. Since for Spinoza, we believe insofar as we are affected, believing is not the other of knowing — that from which we must be separated at all costs — but rather its condition. Contrary to Descartes, there is no primary divide between the true and the false — and contrary to some popular strands of social constructionism or relativism, it's not that there is no truth. Apart from the hypological constructions we retroactively impose upon our affects, everything is true. As a turning from the given, belief structures can increase autological power of acting. Thus, in direct analogy to how subject-object relations make sense of affective relations, universalism allows physicists to reconstitute order from chaos. And in the same sense, the conception of a transcendental deity can confer meaning upon incomprehensible events, just as a metaphysical idea can cut through volumes of indecipherable jargon. In this sense, all hypologies as belief structures — religious, scientific or otherwise— are in principle identical, insofar as they serve the same logical function.

On the other hand, all hypologies differ, in their means of connecting and constraining existing mediations. That is, the essence of the belief structure is the believing itself: universalism as belief is only as effective as how it is continually enacted into being, repeated, recalled, as a ritualistic remembering of what is most intimate.[165] That something occurs to us as true is a consequence of it being put into action — and at the same time, in order for it to be enacted, it has to occur to us as true. In this circularity, in this double constitution, lies the parasitical condition of knowledge, in which the logic of the included middle is simultaneously excluded by itself.

Nevertheless, beyond the identity and difference of hypological configurations, how can we account for their remarkable stability — for, in Latour's sense, their political substance? If, as both Latour and Spinoza posit, the world of actors in networks is constituted by continuous creation, how do some configurations rather than others maintain their consistency? We do not need ultimate recourse to constructions like 'modernity,' 'capitalism,' or 'liberalism' to inquire how some orders, despite some obvious structural deficiencies, persist politically through their constant reinvention. This historical stability throughout tumultuous changes is precisely the underlying reason for Heidegger's prophecy of our nihilistic destiny. For despite the wills of individual actors and networks, the greater thrust of the system appears to move irreversibly, through creative destruction, toward ever greater catastrophe.

Why do continually created, unique, different actors in singular networks merely reinforce the universal, the general, the particular — the same? This cannot simply be a methodological matter of the difference between tracing localized actors and global effects, since this only leads us back to the metalogical chasm with which we began: our contingent place in the middle. And if this is a catalogical matter of singular actors always operating according to constrained conditions — the CERN manager who has to pay his mortgage; the scientist who cannot think outside the structural bounds of his discourse — we need to consider not just how actors and networks are determined by causes of which they remain ignorant, but more specifically, how they are mobilized in the service of hegemonic structures.

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[165] In a rare musing on the relations between religion and science, Latour tries to articulate this essential intimacy of religious practice, which he argues does not principally rely on believing its textual means (scriptures) in any literal way, but rather allows for a ritualistic repetition. In this sense, the adjectives typically used to describe the opposition between religion could be almost exactly reversed: "it is of science that one should say that it reaches the invisible world of beyond, that she is spiritual, miraculous, soul-fulfilling, uplifting. And it is religion that should be qualified as being local, objective, visible, mundane, unmiraculous, repetitive, obstinate, sturdy." (2005: 36) In this sense, Latour is not so much describing the difference between science and religion — after all, there is more to religion than rituals, just as there is more to science than world-pictures — as the difference between the hypological and the autological dimensions that co-exist in the practices of both science and religion.

In critical theory discourse, we appear to border on the persistent problem conceived in terms of ideology. Without renouncing the potential usefulness of such explanatory schema, I want to suggest a significant reorientation of this defining Marxist problem, by thinking it in physical or kinetic terms of mobility. For the parasite in Serres' and Latour's conception does not simply operate between two logics, at once purifying and proliferating. Additionally, it finds itself already in momentum, engaged in a runaway feedback loop: the greater the metalogical chasm between our actions and the conditions that affect them, the greater the need for hypological belief structures that will reconstitute order, and the greater the proliferation that exacerbates the metalogical chasm. Mobility begets mobility.

Herein lies in fact a critical blindspot of Latour's scheme, since the runaway momentum of the feedback loop runs exactly along the axis by which his modern is bifurcated — along the dividing line between purification and proliferation. If we think this line as the vector of metalogical growth, we arrive at what Sloterdijk might refer to as the axis of mobilization. In his 1989 text *Eurotaoismus*, decades before Latour would publicly claim Sloterdijk's so-called *Spheres* trilogy as an open ally against universalism, Sloterdijk offers a different perspective on the condition of the modern through kinetics, the physics of movement.[166] And his perspective intimates the limit condition of both Spinoza and Latour: how a metaphysics of action, grounded in the causes and effects of actively mediating existence, is always already haunted by its mobilization.

For Latour, the term mobilization refers to the scientific operation of turning the world of nonhuman actors into discourse. As he writes in *Pandora's Hope*, "it is a matter of moving toward the world, making it mobile, bringing it to the site of controversy, keeping it engaged, and making it available for arguments." (100) In this sense, mobilization takes on a character similar to Heidegger's concept of the framework, as we saw in Act 2, in which the world is progressively rendered into 'standing reserve' for technological operation. For both Heidegger and Latour, then, mobilization is primarily hypological — it is constituted by a movement of turning. Sloterdijk, on the other hand, trenchantly considers mobilization in metalogical terms, as a kind of self-intensifying momentum. When analyzed kinetically, he

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[166] Latour has recently pronounced that he "was born a Sloterdijkian" and that his network theory is complementary to Sloterdijk's conception of spheres for "reinterpreting globalization." After being publicly lauded by Sloterdijk, he received the Siegfried Unseld Preis in 2008. See Latour, 2009. The two thinkers have also collaborated on two arts exhibitions in Karlsruhe.

argues, "modernizations always have the character of mobilizations."[167] (40) In this sense, the 'modern' is to be understood in terms of its usual claim to 'progress' — but only insofar as this progression is understood metalogically:

> Progress is initiated by this step toward the step that at first introduces itself, by itself, in order to run over itself. Therefore, the term 'progress' does not mean a simple change of position where an agent advances from A to B. In its essence, the only 'step' that is progressive is the one that leads to an increase in the 'ability to step'. Thus, the formula of modernizing processes is as follows: Progress is movement toward movement, movement toward increased movement, movement toward an increased mobility. (38)

Latour can claim that 'we have never been modern' because he principally defines the modern in terms of a kind of hypological purification that reduces change to a moving agent trajectory between points A and B — an ideal construction that falls short of actual proliferation. For Sloterdijk, however, what is modern or 'modernizing' is precisely constituted within this division of purification and proliferation. The modern is neither hypological individuals nor autological mediation, but rather an exponential metalogical curve. And from such a perspective, Latour's claim to non-modernity appears somewhat dubious. Like a snake shedding its skin, for the 'modern' to truly reinvent itself, would it not precisely need to claim that we have never in fact been modern at all — that culture and nature are simply constructions? As Sloterdijk puts it, "promising to make history for itself would never have been enough for the modern. At its very core, it does not just want to make history, but nature." (1989: 23) If Latour supplies a reading of Serres with skeptical questions, Sloterdijk does much the same for Latour.

In the end, whether we have ever been modern or are in fact becoming more modern with every increase of mobilization — that is, whether the modern is to be defined hypologically or metalogically — is a perspectival problem that will not be settled by explicating the logics of contemporary science. Just as 'truth' is a constraint polarizing philosophical discourses in terms of universalism — bifurcating into either natural realism or social constructivism — the 'modern' is a discursive constraint whose effect is to polarize history according to increasingly bifurcating terms — modern versus premodern, antimodern, postmodern, or

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[167] My engagement with Sloterdijk's attempt at thinking 'political kinetics' is here limited to his concept of mobilization. In his work, Sloterdijk posits a model physics that does not easily cohere with my own construction, both in its explicit assumptions of particularity and subjectivity as well as in its conception of the modern, postmodern, and premodern. But insofar as Sloterdijk grapples with the 'momentum-effect' beyond linear logic, his work is nonetheless useful for thinking in terms of metalogy.

nonmodern. In both cases, the actual stakes of the conflict are too easily obscured: the continue rising of the stakes along with the intensifying mobilization of the 21st century.

To a German raised in a post-war culture, the concept of mobilization, prevalent in the Third Reich, strikes deeply discordant notes — but this, Sloterdijk argues, would be precisely the point. "This concept keeps the memory of the violent core of scientific, military, and industrial leading-edge processes alive — especially in a time when these enter a smart phase where violence becomes informational, cool, procedural, and analgesic." (41) If there still is a credible historical claim to nihilism in Heidegger's sense, it is perhaps not to be understood hypologically, as the turning of all givens into the void of modern scientific enframing. Rather, it is more aptly comprehended metalogically, as an explosive cultural proliferation with its concomitant mobilization. Striking biopolitical overtones, Sloterdijk calls mobilization "a 'civilizational' mechanism that uses all the modern advances in ability and knowledge, mobility, precision, and effectiveness for the strengthening and destructive processes, for armament, expansion, self-empowerment, and mutilation of cohesion." (41)

Mutilation of cohesion — yet at the same time, we need to add, forging of new conditions for cohesion. Metalogical mobilization increases the need for hypological structures that in turn enable mobilized actors to continue their proliferating work. Mobilization is therefore deeply characteristic of not only a 'modernizing' process that opens itself toward what it parastically considers an open environment beyond itself — but perhaps more relevantly today, of a process facing ever greater constraints on its momentum, in turn requiring new means of invention and connection to maintain its self-intensifying pulsation. Many of these forms of reinvention, if we are to believe Sloterdijk's assessment, are merely waiting to rear their heads on new catastrophic scales:

> The end of the Cold War may have brought with it a temporary lull in nuclear intimidation; but with respect to the integration of still undeveloped latent climatic, radio-physical, and neuro-physiological dimensions into the explicit-making military projects of world power, the 1990s rather marks the threshold of a new beginning. (2009: 63-4)

Unlike Europe in the 1930s, in which mobilization could operate according to a constrained set of hypologies — nationalisms, racisms, totalitarianisms — the mobilization of the 21st century is defined by increasingly proliferating terms, by a vast multitude of belief structures along with a viral spread of diverse weaponry. Certainly, the appearance of such a hypological heterogeneity may in effect mask more persistent, homogenous structures and processes — such as the universalism this dissertation has attempted to unravel — but it nonetheless ensures that familiar terms like war, politics, science, or metaphysics are drastically transformed. If the gas and nuclear warfare of 1915-1945 made for a revolution in classical battlefield tactics, much like quantum physics in the same period made for a revolution in physical understanding, these historical developments today appear more like semi-classical approximations in relation to a much more dramatic overturning that has since taken place. In this sense, the world wars of the 21st century will not look anything like the world wars of the 20th century in any other sense than their mobilizing, metalogical character. And by implication, the same goes for politics, science, and metaphysics.

As I argued in Act 4, the metalogical constitutes the great unthought in the modern sciences and philosophy — the vector of escalation and the impetus to growth at all costs that profoundly determines our political situation. Because the classical conceptions of modern logic produce for us a world fundamentally conceived in terms of either the universal and the particular, object and subject, nature and human, Being and 'man,' a gaping conceptual chasm between the autological striving of individual existence and the hypological totalities of the world is filled with multiplying forces beyond conventional comprehension. Just as the metalogical bombs of nuclear war heads, climate change and overpopulation become overpowering when faced with their critical constraints, the thinking of these metalogical conditions encounters its own threshold. How does one today make autological sense of the actual presence of seven billion people in the world? Or the implications of a global average temperature increase of three degrees? Or a fundamental physical object size of 10^{-35}? Against the catalogical barrier of such challenges, what is the tendency of thought, if not to return to the most entrenched, axiomatic hypological conceptions that offer themselves innocuously as givens? What is the tendency of politics, if not to seek recourse to familiar and safe measures of conservativism? How are we to make sense of the surging chaos if not by the same means of order as before — with the same axiomatic distinctions and concepts?

As the mobilization of the planet reaches a critical constraint — what in parasitical fashion is dubbed an 'environmental crisis' — it is almost everywhere forced to reinvent itself in order to maintain momentum. Such is the metaphysical formula of our catastrophic times: greater proliferation against greater constraints equals greater claims to universalist political projects to save us from the exacerbating consequences of our planetary parasitism. Who will claim to speak for nature, for humanity and for truth, and to what end? This is the metaphysical situation within which we can expect a continued rise in political claims to speak for, to know, to manage and to contain what is called nature.

In its current manifestation, physics is perhaps the most purified expression of universalism in the sciences today. In this sense, I believe the particular and limited case of the Large Hadron Collider has general implications for how contemporary knowledge production is structured. To paraphrase Latour, universalism is not the bedrock that unites all the sciences as much as the thread that runs through many sciences today — from evolutionary psychology to neurobiology to the political science of cosmopolitanism — with varying degrees of influence. Perhaps most pervasively, universalism occurs in defense of a certain configuration of science to the exclusion of other means of knowing that can claim no legitimate recourse to ahistorical, acultural, or apolitical positions. This is the intellectual situation against which we urgently require a better conceptual framework for understanding our politics of nature — to distinguish hypological conceptions and origin stories from the actual involvement of actors on the one hand, and the exponentially rising pressures to keep their momentum on the other.

Thus, having articulated an immanent logical position against universalism, we may appear to have gone beyond the hypological deadlock of the Cave with which this dissertation began, and beyond the hypological ultimatum of the modern settlement. But now we face yet another gaping double structure — a dilemma of the metalogical order. Either we continue to constitute nature in the manner of today's sciences at ever greater scales of intensity — or we are forced to imagine and enact a different kind of constitution that allows for different politics and different mobilization of our sciences.

Against the overwhelming odds of making any meaningful contribution to such a change, I offer this dissertation as a step toward thinking nature and the stakes of rising global political conflict differently. Having mobilized disparate thinkers in my construction, I have attempted to differentiate and explicate a fivefold logic that turns universalism around and sets it in its proper place, as one configuration amongst many. In this sense, my philosophical offering is a kind of Spinozism under the sign of catastrophe. That is, through the exposition of the ana-hypo-auto-meta-cata-logical, I offer an image of thought grounded in Spinoza's univocal equiversality, though affected by the metalogical proliferation of our world, for which Spinoza could not account.

Following this metaphysical orientation, the sign of catastrophe is not, as I put it in the beginning of this chapter, looming. Under the regime of universalism, it does not actually appear somewhere on our future horizon as an event yet to come, as much as it is a shadow of our own activity. The endgame, in short, lies not ahead in some future yet to affect us, but in our means of acting it out today. The catastrophe against which we find ourselves situated — the catalogy against which we are most urgently thinking — is, most essentially, universal nature itself.

5. Toward a Metaphysics of Equiversalism

Catalogy also marks the limit condition of this dissertation, because it inevitably brings its own proposed framework into questioning. Against our recovery of a metaphysical undercurrent through the history of thought, which connects Spinoza's thought with Bergson, Deleuze, Latour and Stengers, we are constrained by a radical abyss of questioning. In our equiversal construction, we appear perenially haunted by Heidegger's idea of cultural nihilism as our destiny and Sloterdijk's vision of 21st century planetary mobilization. Together, they problematize the relation between our entangled actions and our freedom to change them. Does equiversalism imply the possibility for reconfiguring ourselves as a collective of humans and nonhumans? Or does its fundamental thesis, *Natura sive Cultura,* express ignorance of the causes by which we are determined, blindness to the means by which we are mobilized?

In turn, the thesis of equiversalism reflects a deeper catalogical condition, a structural inconsistency in its own logical framework. For if, as Latour suggests, the proposition of univocity between Culture and Nature implies the Death of Nature — that is, Nature in the universalist sense, of being outside — then it also means the end of claims to a reality beyond the actual matter of affairs. It means the end of claims to some orderly substance beneath the chaotic modes of being — the end of claims to Being as different from beings. The end of ontological difference as the pivotal principle of philosophical research.

In other words, Death of Nature also, and in the same sense, means Death of General Ontological Difference. And Death of General Ontological Difference, as the pivotal condition for differentiating hypology from itself, for prying open the very concept of logic and revealing its multiple dimensions, implies the death of the principle upon which my logical argument rests. Thus, the metaphysical construction offered in this dissertation is itself born into a logical catastrophe.

General Ontological Difference is dead, and we can only point to its shadows.

In the end, what we are left with is a logical five-fold, explicated through a history of physics and metaphysics, that stands open to a weighty political charge. For much like the string theory with which our inversions began, my five-dimensional equiversalism may purport to account for a complete logical picture, but it is itself nothing. In this view, equiversalism is nothing of substance — which is to say, following Latour, it is nothing of political import. Even worse, if equiversalism is nothing, is it not then simply another expression of nihilism in an ever intensifying sense — the logic of a physical nothingness inverted into a metaphysical void that does not even have the singular force of a black hole? What is equiversalism, then, but a mere conception amongst others, yet another hypology in the cornucopia of hypologies? A little kaleidoscopic prism through which we may delineate problems differently, but not actually address them or affect them in any significant way? Neither a research program, nor a critical genealogy, nor a comprehensive methodology — what is this but an empty intellectual exercise?

In truth, equiversalism is most essentially a cosmological stance, derived only from the shadowy operations of universalism. In structural outline, it expresses little more than a different metaphysical configuration, in which the fundamental axis rather aligns Nature and Culture. But as a thread that ties us back into the world, it does deeply affect our mode of questioning. And in the final analysis, equiversalism cannot be mere empty abstraction, because its motive force is precisely to involve us as questioners in what is being questioned.

In Isabelle Stengers' argument, the implication of an idea in its affective conditions of expression — the very negation of hypological certainty in universalist science — is at the same time its condition of complexity. Borrowing a distinction from Latour, complexity is here not to be understood in the usual contrast to simplicity — thus not in the sense that academic debates deferentially appeal to whichever idea is 'more complex' — but rather distinguished from complication. In this sense, Latour explains, complication "deals with series of simple steps (a computer working with 0 and 1 is an example); the other, complexity, deals with the simultaneous irruption of many variables… Contemporary societies may be more complicated but less complex than older ones." (1999: 305) As Stengers understands the distinction, it relates directly to the practice of scientific work and the problematic question of self-implication.

> It is scientists who ask the questions, and complexity arises when they have to accept that the categories of understanding that guided their explorations are in question, when the manner in which they pose their questions has itself become problematic. (1997: 13)

Against this criterion, physicists are capable of dealing with problems to an almost infinite degree of complication. From 11-dimensional string theories to redoubling statistical orders of bosons and fermions to black holes and white dwarfs in relativistic spacetime, complication is what defines the work of contemporary physicists. But insofar as they continue to understand the universe hypologically, as a naked nature divorced from history, culture, and politics, they are emphatically not dealing with problems of complexity. This may be because universalism, as I have defined it in this dissertation, today constitutes the pivotal constraint upon the actions of physicists — in effect, it is what provides their theoretico-experimental work with logical bearings. Practically, if physicists were to reconsider the axiomatic configuration that determines the structure of their ideas, they would undoubtedly become lost in the chaotic proliferation of their own constructions — folded into the wormhole of questioning the purpose of the very actions that make up their current enterprise. In this sense, the distinction of complication and complexity bespeaks the dramatic polarization between the ideas that affect our understanding and the physical reality that affects our senses — a polarization that is emblematic of physics today.

More fundamentally, without this freedom from entertaining questions of complexity, the particular complications of today's physics would not be thinkable in their present form. For the physics of the nuclear bomb as well as the physics of gigantic particle accelerators, universalist metaphysics shapes not only the mathematical bounds of the problem but its very essence. Without the invention of particularity or universal constancy, there would be no atomic physics and no means to conceive the atom in terms of weapons technology or research machines. Without the invention of singularity or universality, there would be no cosmological origin story to ground the science and politics of universal 'anthropic life.' What would happen in its stead, how the scope of physics would develop under a different regime of complexity, now belongs to the order of an unthinkable history — a history beyond the retroactive constitution of events as being necessary simply because they unfolded the way they did.

For Stengers, the formulation of complexity in distinction from complication allows for "the uncoupling of two dimensions that are often inextricably associated in discourses for or against the sciences." On the one hand, the hypological constitution of scientific inquiry posits "the power of the analytical approach and the peremptory judgments that it appears to authorize." On the other hand, the metalogical reconstitution of the sciences mobilizes an overarching identity, "a 'scientific rationality'" and the general "production of 'scientific views of the world.'" (1997: 5-6) In the entanglement of scientific discourse, then, the general power and success of an analytical approach to any phenomenon appears to justify something like a 'scientific rationality' and in turn, such a scientific rationality is precisely what warrants the 'analytical approach' that appeared to make it so successful. By dissociating these two dimensions, Stengers shows how the notion of complexity rather involves an autological dimension, a mediation of scientists in scientific problems. And in this precise sense, the proposition of truth that underpins scientific discourse in its hypological and metalogical dimensions, is turned into a different kind of criterion: *relevance*.

Against the universalist conception of the Constants of Nature, for example, it must be said that fundamental constants are not significant because they are universally true, or because they are 'unbiased' by human activity, but because their ostensible endurance as mathematical constraints makes them relevant to scientific practice. Gravity and light are relevant in precisely the same sense, because they give bounds to physical and metaphysical problems. Autologically, then, the problem is not to find, locate or constitute truth, since logically speaking, everything is true, but rather to determine what matters and what does not — what affects us more or less. Writes Stengers:

> What is noteworthy about 'relevance' is that it designates a relational problem. One speaks of a relevant question when it stops thought from turning in circles and concentrates the attention on the singularity of an object or situation. Although relevance is central to the effective practices of the experimental sciences, in their public version it often boils down to objective truth or arbitrary decision: to objective truth when the question is justified by the object in itself, and to arbitrary decision when it refers to the use of an instrument of experimental apparatus whose choice is not otherwise commented on. In the first case, the response appears to be 'dictated' by reality. In the second, it appears to be imposed by the all-powerful categories of which the investigative instrument is bearer. Relevance designates, on the contrary, a subject that is neither absent nor all-powerful. (1997: 6)

Neither absent nor all-powerful — Stenger's turn of phrase is instructive for trying to comprehend an experimental construction like the Large Hadron Collider outside the framework of universalism. For on the one hand, the experiment clearly produces something that makes relative sense to the actors involved. To dismiss the entire operation and its claims as a sham, an arbitrary construction, an emperor with no clothes, is to think in terms of absence. In this view, physicists may talk about strings, branes, and bosons — but these are nothing but empty abstractions. On the other hand, as sweeping as the mobilization of the LHC is in its stated scope, as much as it claims to reach into the truth of nature, it is clearly not all-powerful. To engage with the doomsday scenario of the LHC is, in this perspective, to give a scientific operation far too much credit and unwittingly reinforce universalism anew. Thus, the opposite sides of this spectrum — absent or omnipresent; nothing or everything; discovery or doom — are themselves a polarized function of the universalist constraint.

In this sense, the LHC is a creature of universalism that lives or dies with its continued strength. Both the theoretical framework and the experimental machine are relevant primarily to the internal constitution of particle physics itself. Beyond this discourse, the relevance of physics is decidedly opaque, even when an experiment claims universal effects.[168] Thus, the collider keeps spinning, and will likely produce predictable and unpredictable phenomena that in turn will increase demand for further theories and experiments that can sustain the momentum of inquiry. Just as likely, the escalating demand for growth will reach a definitive constraint in the lack of capital for future operation. In the network of alliances mobilizing physicists and non-physicists in political support for building yet another experimental machine, the only constant is the appeal to universalism — be it framed as the mystery of nature or as the pinnacle of human reason. As Elizabeth Kolbert notes, when physicists are asked to explain how their work contributes to the public good, they typically offer a response that confers on the human search for knowledge a transcendental value. An oft-quoted American physicist, Robert Wilson, explained in his 1969 testimony to the Congressional Joint Committee on

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[168] This was poignantly expressed by the lawsuits filed by Rössler, Wagner and others seeking an injunction against the LHC, both of which were eventually rejected by the courts. As legal scholar Eric E. Johnson remarks, the legal dismissal was not due to lack of scientific merit in the plaintiffs' calculations, but rather because the LHC operates in such uncharted legal territory that no court could plausibly consider it to have broken any specific laws. In this sense, he notes, the legal problems posed by alleged black holes mirror the problems they create for physics: they are, as Johnson calls it, "a jurisprudential singularity." See Johnson, 2009. His study further remarks: "If litigation over the LHC does not put a judge in the position of saving the world, another case soon might. In a technological age of human-induced climate change, genetic engineering, nanotechnology, artificially intelligent machines, and other potential threats, the odds of the courts confronting a real doomsday scenario in the near future are decidedly non-trivial." (822)

Atomic Energy that a nuclear collider has nothing to do with 'the security of the country': "It only has to do with the respect with which we regard one another, the dignity of men, our love of culture… It has nothing to do directly with defending our country except to make it worth defending."[169] In 1993, when the US Congress cancelled funding for the extraordinarily named 'Superconducting Super Collider' (SSC) in Texas, one nay-voting congressman from Ohio explained the political problem matter-of-factly: "If we find more basic building blocks of the universe, it's not going to change the way people live." As Kolbert sardonically observes, "it is probably no coincidence that funding for the supercollider was cancelled almost immediately after the fall of the Soviet Union. The 'dignity of men' defense of particle physics worked best at the height of the Cold War, when no one, except maybe the scientists involved, entirely believed it." (ibid.)

Thus, the survival of particle physics as a mega-experimental discipline is not only contingent on belief in a hypological idea of universalism. Autologically speaking, the belief in universalism will survive as long as it is politically expedient and viable — that is, as long as it can be employed in the mobilization of actors and networks according to a certain political and scientific configuration. Against capital constraints, for physics to continue its work through billion-dollar machines, in other words, it is currently forced to reinvent itself. And as already intimated, one current path of reinvention lies in physical cosmology, whose work relies on the same framework for considerably less capital. The universe, in this view, may equal 'the poor man's accelerator,' but it opens the cosmos as perhaps the final frontier of metaphysics, with the tacit promise of parasitical proliferation beyond Planet Earth.

The future of particle physics is therefore faced with the same metaphysical formula as all of the politics of nature today: greater proliferation against greater constraint, with ever greater need for reinvented forms of mobilization. And in turn, as I posit, a greater need for critical means of exploring and interrogating their continued claims of legitimation. As Stengers observes, the question of relevance always figures in the mediation of scientific interests, because it directly concerns the strictly political problem of determining which question is the right to ask, which terms best suit the experimental conditions. But in this sense, relevance is also the problematic criterion for the collective that, following Latour, necessarily involves scientists and non-scientists in the same sense as humans and non-humans. This is one key sense in which equiversalism opens up to political questioning of the sciences. Not in the sense of questioning this or that scientific

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[169] See Kolbert, 2008.

report, or this or that conclusion, an equiversal stance more fundamentally questions the conditions under which problems are undertaken and defined as problems in the first place.

Along with Stengers, I argue for a 'cosmopolitics' based on metaphysical equiversalism, which means turning the question of Truth in our sciences into a question of Relevance. Equiversalism means making the relation of Nature and Culture, and thus the metaphysical and political questions of who 'we' are and what we are doing, into a problem of complexity rather than complication. Contrary to any sense in which rendering Culture and Nature equivalent might eradicate the 'mystery of nature,' I argue by logical principle that it is rather the implication of Culture in Nature that makes Nature complex — and thus as infinitely mysterious as the Culture that attempts to understand it. As an initial step, as the given of our discourses, equiversalism expresses most fundamentally the complexity of the world, within which any claim to ultimate unification of our knowledges is by principle precluded. In turn, the claim to complexity leans metaphysically away from political mobilizations associated with any definitive form of control, capture or mastery — with the constitutive conditions, in other words, of the modern social contract.

Nature, that is, Culture, then: neither the universalization of Nature nor the universalization of Culture. No more natural unification or cultural relativism; no more mononaturalism or multiculturalism. Rather, an equiversal understanding of Culture reflects directly a univocity of Nature: that is, a world of mutual implication. As an equiversal proposition, *Natura sive Cultura* is admittedly Janus-faced. On the one hand, it corresponds to a radical flattening of the hegemonic politics of the historical moment in which we find ourselves situated. On the other hand, it runs the risk of furthering metalogical intensification — of increasing claims to political mobilizations that depend on greater biopolitical controls and strictures.

Against this risk speaks only the urgency of our contemporary catastrophes, which threaten to intensify in relative proportion to our decreasing ability to even conceive of the nature of the problem. And in the end, the only proper way to decide between these faces of Janus, to settle the future of our politics of nature, is precisely in the manner that is at once both scientific and political: by putting the claim to the test. What is needed today is to imagine, conceive, mediate and proliferate new terms for our politics, our culture, our history, and yes, our nature — over and against the overwhelming historical constancy of our metaphysical constitution. For ultimately, the future of equiversalism pivots on our ability to mediate it into existence — to make it into its own metaphysics experiment.

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