Positive Reinforcement for Lasers:

The Dichroic Atomic Vapour Laser Lock

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Why?

Lasers tend to be unstable due to internal and environmental factors

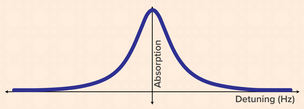
The Dichroic Atomic Vapour Laser Lock (DAVLL) stabilizes a laser's frequency to that of an atomic resonance

How does it work?

Atomic Transitions

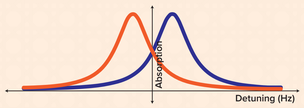
At precise frequencies known as resonances, atoms absorb light

As frequency drifts from resonance, less light is absorbed



The Zeeman Effect

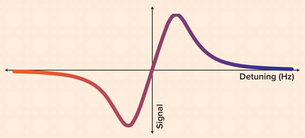
In a magnetic field, the frequency of absorption is split, based on the light's polarization [2]

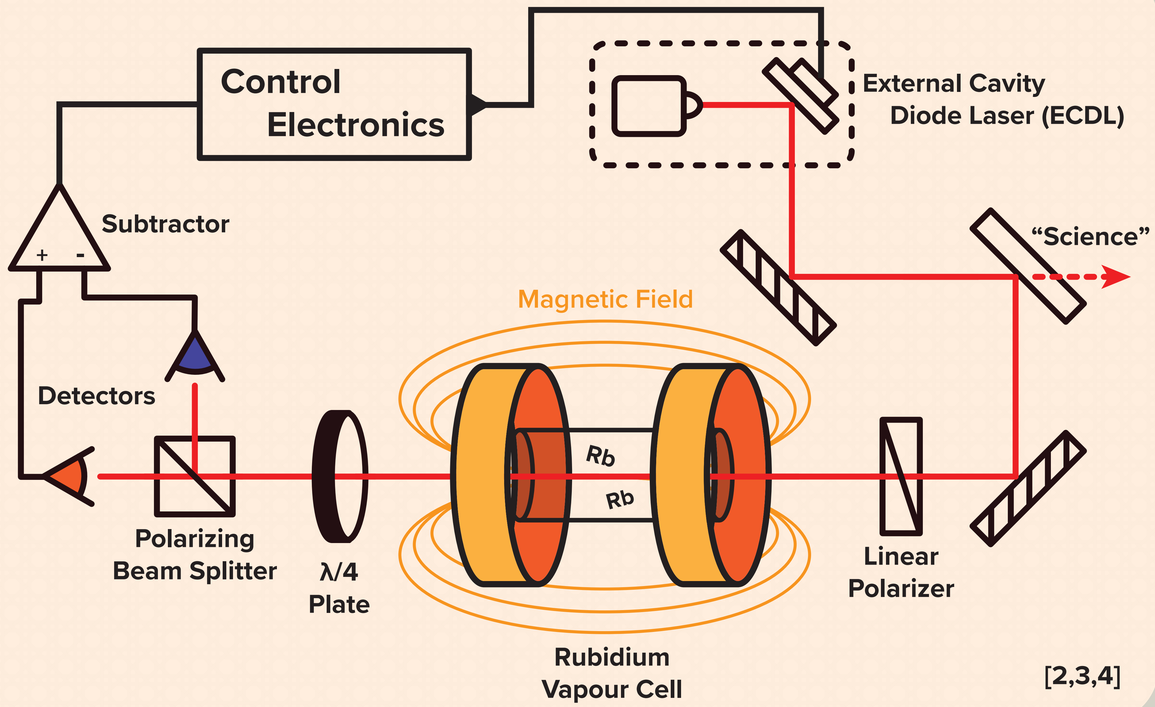


Controlling a Laser

By subtracting these peaks, we make an "error signal" centered exactly on resonance [2]

By feeding this signal back into the laser, we can control its frequency





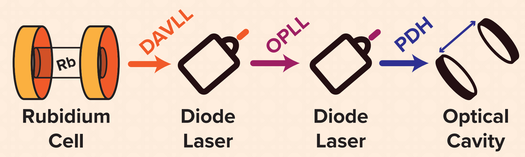
[2,3,4]

Where does this go?

We need to coordinate many seemingly disconnected systems

The DAVLL is the first step. By combining it with two other locking mechanisms, we plan to:

- Lock a laser to an atomic resonance using the **DAVLL**
- Lock another laser to the first using an Optical Phase Locked Loop (**OPLL**)
- Lock an optical cavity to the second laser with a Pound-Drever-Hall Lock (**PDH**)

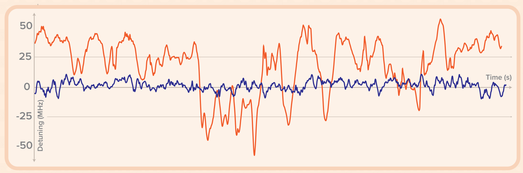


Dual DAVLL Test [2,3]

The frequency of the light from our lasers is so high that we cannot directly measure it

Instead, we measure the 'low' frequency beat note between two lasers

Comparing the stability of a locked and unlocked lasers, we can observe how well the DAVLL is working

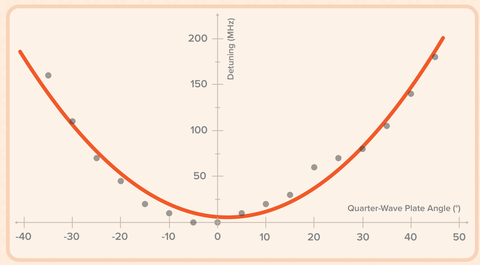


Unlocked DAVLL over 120 seconds
Locked DAVLL over 120 seconds

Locking Range [1]

Intentionally unbalancing the quarter wave plate offsets the error signal

This allows us to lock to frequencies other than resonance



Lock Point Detuning vs. Wave Plate Rotation

References

[1] S. Pustelny et al, *2016*. Dichroic atomic vapor laser lock with multi-gigahertz stabilization range. Rev. Sci. Instr., 87(6), 063107–063107.

[2] K. L. Corwin et al, *1998*. Frequency-stabilized diode laser with the Zeeman shift in an atomic vapor. App. Optics, 37(15), 3295–3298

[3] V. V. Yashchuk, et al, *2000*. Laser frequency stabilization using linear magneto-optics. Rev. Sci. Instr., 71(2), 341–346

[4] C. Lee et al, *2011*. Small-sized dichroic atomic vapor laser lock. Rev. Sci. Instr., 82(4), 043107–043107–6

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