Erratum: "Thermodynamically admissible 13-moment equations" [Phys. Fluids 34, 017105 (2022)]

Cite as: Phys. Fluids **35**, 089905 (2023); doi: 10.1063/5.0166471
Submitted: 5 July 2023 · Accepted: 27 July 2023 ·
Published Online: 8 August 2023

Henning Struchtrup[1,a)] and Hans Christian Öttinger[2]

AFFILIATIONS

[1]Department of Mechanical Engineering, University of Victoria, Victoria, British Columbia V8W 2Y2, Canada
[2]Quantum Center and Department of Materials, ETH Zürich, HCP F 47.2, CH-8093 Zürich, Switzerland

[a)]Author to whom correspondence should be addressed: struchtr@uvic.ca. URL: http://www.engr.uvic.ca/~struchtr/

https://doi.org/10.1063/5.0166471

Due to a calculation error several equations in our paper[1] must be corrected. The corrections only concern the entry $M_{44}^{\rm relax}$ in the relaxation matrix, which implies corrected factors in the relaxation term for the vector variable w_i, the entropy generation rate Σ, and the equation for heat flux q_i. These changes do not affect discussion and conclusions, which remain unchanged.

Specifically, the following equations should replace their counterparts in Ref. 1, where the corrected factors are highlighted in bold:

$$\mathcal{M}_{AB}^{\rm relax}=\frac{2m\theta}{\rho k_{\rm B}}\frac{p}{\mu}\begin{pmatrix}0&0&0&0\\0&0&0&0\\0&0&A_{\langle ij\rangle\langle kl\rangle}&\frac{1}{2}w_{\langle i}\delta_{j\rangle k}\\0&0&\frac{1}{2}\delta_{i\langle k}w_{l\rangle}&\frac{1}{4}\varphi\,\delta_{ik}+\mathbf{\frac{13}{6}}\delta_{ik}+\mathbf{\frac{7}{6}}\theta\,\Theta_{ik}^{-1}\end{pmatrix}, \tag{73}$$

$$\mathcal{M}_{AB}^{\rm relax}\frac{\partial\eta}{\partial u_B}=\begin{pmatrix}0\\0\\-\frac{p}{\mu}\left[\frac{1}{3}\theta\Theta_{rr}^{-1}+\frac{1}{30}\theta\Theta_{kr}^{-1}\Theta_{ks}^{-1}w_rw_s\right]\Theta_{\langle ij\rangle}\\-\frac{p}{\mu}\left[\frac{1}{6}\theta\Theta_{kk}^{-1}\delta_{ir}-\mathbf{\frac{1}{15}}\theta\Theta_{ir}^{-1}+\mathbf{\frac{7}{30}}\theta^2\,\Theta_{ik}^{-1}\Theta_{rk}^{-1}+\frac{1}{60}\theta\Theta_{kr}^{-1}\Theta_{ks}^{-1}w_sw_i\right]w_r\end{pmatrix}, \tag{74}$$

$$\mathcal{M}_{AB}^{\rm relax}\frac{\partial\eta}{\partial u_B}\simeq\begin{pmatrix}0\\0\\-\frac{p}{\mu}\Theta_{\langle ij\rangle}\\-\frac{2}{3}\frac{p}{\mu}\left(\delta_{ij}-\mathbf{\frac{3}{5}}\frac{1}{\theta}\Theta_{\langle ij\rangle}\right)w_j\end{pmatrix}, \tag{75}$$

$$\frac{\partial\eta}{\partial u_A}\mathcal{M}_{AB}^{\rm relax}\frac{\partial\eta}{\partial u_B}=\frac{p^2}{\mu}\frac{k_{\rm B}}{m}\left[\left(\frac{1}{3}\theta\Theta_{kk}^{-1}-1\right)\frac{1}{2}\Theta_{rr}^{-1}+\left(\mathbf{\frac{10}{17}}\theta\Theta_{rr}^{-1}-1\right)\mathbf{\frac{17}{300}}W^2+\mathbf{\frac{7}{300}}\theta\,\Theta_{ik}^{-1}W_iW_k+\frac{1}{600}\theta W^2W^2\right], \tag{76}$$

$$\frac{\partial w_i}{\partial t} + v_k \frac{\partial w_i}{\partial x_k} + w_k \frac{\partial v_i}{\partial x_k} + \left(2\frac{\partial \Theta_{ik}}{\partial x_k} + \Theta_{is}\Theta_{kl}^{-1}\frac{\partial \Theta_{kl}}{\partial x_s}\right) - \frac{1}{5}(w_i\Theta_{sl} + \Theta_{il}w_s + \Theta_{is}w_l)\frac{\partial w_n \Theta_{nl}^{-1}}{\partial x_s}$$
$$= -\frac{p}{\mu}\left[\frac{1}{6}\theta\Theta_{kk}^{-1}\delta_{ir} - \mathbf{\frac{1}{15}}\theta\Theta_{ir}^{-1} + \mathbf{\frac{7}{30}}\theta^2\Theta_{ik}^{-1}\Theta_{rk}^{-1} + \frac{1}{60}\theta\Theta_{kr}^{-1}\Theta_{ks}^{-1}w_s w_i\right]w_r\,. \tag{85}$$

$$\Sigma = \frac{p^2}{\mu}\frac{k_B}{m}\left[\frac{1}{2}\left(\frac{1}{3}\theta\Theta_{rr}^{-1} - 1\right)\Theta_{rr}^{-1} + \mathbf{\frac{17}{300}}\left(\mathbf{\frac{10}{17}}\theta\Theta_{rr}^{-1} - 1\right)\Theta_{ij}^{-1}\Theta_{ik}^{-1}w_j w_k + \mathbf{\frac{7}{300}}\theta\,\Theta_{ij}^{-1}\Theta_{jk}^{-1}\Theta_{kl}^{-1}w_i w_l + \frac{1}{600}\theta\left(\Theta_{ij}^{-1}\Theta_{ik}^{-1}w_j w_k\right)^2\right] \geq 0\,, \tag{90}$$

$$\frac{\partial q_i}{\partial t} + v_k\frac{\partial q_i}{\partial x_k} + \frac{5}{2}\rho\theta\frac{\partial \theta}{\partial x_i} + \theta\frac{\partial \sigma_{ik}}{\partial x_k} - \theta\sigma_{ik}\frac{\partial \ln\rho}{\partial x_k} + \frac{5}{2}\sigma_{ik}\frac{\partial \theta}{\partial x_k}$$
$$+\frac{7}{5}q_k\frac{\partial v_i}{\partial x_k} + \frac{7}{5}q_i\frac{\partial v_k}{\partial x_k} + \frac{2}{5}q_k\frac{\partial v_k}{\partial x_i} = -\frac{2}{3}\frac{p}{\mu}q_i + \underline{\mathbf{\frac{2}{5}}\frac{\sigma_{jk}q_k}{\mu} + \frac{4}{5}q_k\frac{\partial v_{\langle j}}{\partial x_{k\rangle}}}\,, \tag{100}$$

$$\Delta Q_i = \mathbf{\frac{2}{5}}\frac{\sigma_{jk}q_k}{\mu} + \mathbf{\frac{4}{5}}q_k\frac{\partial v_{\langle j}}{\partial x_{k\rangle}}\,, \tag{101}$$

$$\Delta Q_i \simeq \mathbf{\frac{2}{5}}\frac{\sigma_{jk}q_k}{\mu} - \mathbf{\frac{4}{5}}q_k\frac{\sigma_{ik}}{2\mu} = 0. \tag{102}$$

[1]H. Struchtrup and H. C. Öttinger, "Thermodynamically admissible 13-moment equations," Phys. Fluids **34**, 017105 (2022).