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Moment equations for a polytropic gas reproducing adjustable transport coeffcients

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We will consider the kinetic model of continuous type describing a polyatomic gas in the non-weighted setting. Such a model introduces a single continuous variable supposed to capture all the phenomena related to the more complex structure of a polyatomic molecule. For the complete polyatomic collision operator we propose a convex combination of purely polyatomic (non-frozen) and frozen collisions. Motivated by recently proven rigorous existence and uniqueness result in the space homogeneous case, we use the cross section proposed in that analysis and establish macroscopic models. In order to see contribution of frozen collisions and moment hierarchy, we compute relaxation times and transport coefficients in a linearized setting for fourteen and seventeen moments system. Then, in the case of seventeen moments with included frozen collision show both matching with the experimental data for dependence of the shear viscosity upon temperature and agreement with the theoretical value of Prandtl number given by the Eucken formula. Finally, we conclude that higher order system together with frozen collisions gives more adjustable transport coefficients. In addition, the consistency with the monatomic case is achieved by properly rescaling the collision frequency.

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References

[1] J.-F. Bourgat, L. Desvillettes, P. Le Tallec and B. Perthame, Microreversible collisions for polyatomic gases and Boltzmann's theorem, *Eur. J. Mech. B Fluids*, 13: 237–254, 1994.

[2] L. Desvillettes, R. Monaco, F. Salvarani, A kinetic model allowing to obtain the energy law of polytropic gases in the presence of chemical reactions, *Eur. J. Mech., B/Fluids*, 24(2): 219–236, 2005.

[3] V. Djordjić, M. Pavić-Čolić, N. Spasojević, Polytropic gas modelling at kinetic and macroscopic levels, *Kinet. & Relat. Mod.*, 14: 483–522, 2021.

[4] I. M. Gamba, M. Pavić-Čolić, On the Cauchy problem for Boltzmann equation modelling a polyatomic gas, arXiv:2005.01017 , 2020.

[5] V. Djordjić, Pavić-Čolić, M. Torrilhon, *GitHub /Boltzmann-polyatomic/Supplements2021*, 2021.

[6] V. Djordjić, Pavić-Čolić, M. Torrilhon, Consistent, explicit, and accessible Boltzmann collision operator for polyatomic gases, *Phys. Rev. E*, 104(2): 025309, 2021.

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