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STSM at RWTH Aachen University

at RWTH Aachen University (16 October to 17 December 2020)

Background information. The proposed STSM aimed at initiating a collaboration between the grantee and Prof. Dr. Manuel Torrilhon from RWTH Aachen University, both members of the Working Group 2.

The focus of the STSM was to establish the kinetic model describing a polyatomic gas with the relevant physical interpretation, which at the mesoscopic level amounts to study the Boltzmann equation and at the macroscopic level yields moment equations, with the aim to extend concepts developed for the case of a monatomic gas in [1].

Goals of the Short Term Scientific Mission. The main goal of STSM was to built moment equations for polyatomic gases starting from the Boltzmann equation for the cross-section introduced in papers [2, 3] by adapting and extending procedures for the case of monatomic gases given in [1]. The idea was to establish moment equations hierarchy using Laguerre polynomials as test functions that include internal energy variable. The closure would be provided by extending the Grad closure to the polyatomic case. The final goal was to lower the error of the Prandtl number obtained within the fourteen moments model from [3].

Results of the Short Term Scientific Mission. We have implemented computations of the quadratic collision operator moments describing a polyatomic gas, leading to explicit production terms at the macroscopic level. This implementation is available publicly [4]. Computations are carried out for all three models of the cross-section proposed in [2]. One of the conclusions is that in order to lower the error of the Prandtl number appearing in [3] for the fourteen moments model, it is necessary to increase the number of moments to seventeen, and to study monatomic behavior of a polyatomic gas. With these ingredients, we proposed a consistent, explicit and accessible Boltzmann collision operator describing a polyatomic gas with constant heat capacity. These results obtained during STSM are summarized in a preprint [5], submitted for publication. There is a joint interest to continue to discuss and work on the topic, and so we can say that the STSM also initiated long-term collaboration between the grantee and the host.

References

[1] M. Torrilhon, Modeling nonequilibrium gas flow based on moment equations, Ann. Rev. Fluid Mech., 48: 429-458, 2016.

[2] I. M. Gamba and M. Pavić-Čolić, On the Cauchy problem for Boltzmann equation modelling a polyatomic gas, preprint, ArXiv:2005.01017.

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

[4] V. Djordjić and M. Pavić-Čolić and M. Torrilhon,
Explicit evaluation of the polyatomic Boltzmann collision operator, GitHub, `/Boltzmann-polyatomic/Supplements2021`, https://github.com/Boltzmann-polyatomic/Supplements2021, 2021.

[5] V. Djordjić and M. Pavić-Čolić and M. Torrilhon, A consistent, explicit and accessible Boltzmann collision operator for polyatomic gases, preprint, 2021.