Title:

Multi-temperature hydrodynamic equations for gas mixtures

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Abstract:

Multi-temperature models are widely used to model and investigate both inert and reactive gas mixtures. They are of particular interest in several problems of aerothermodynamics and plasma physics at high temperature, especially for gas mixtures having very disparate masses (e.g., positive ions and electrons).

Such mixtures, sometimes called ε-mixtures, are characterized by energy exchanges between light and heavy components proceeding at a different scale with respect to the ones within each constituent or between components with comparable masses [1].

At fluid-dynamic level, this two-scale process is taken into account by considering equations that involve the main distinctive macroscopic fields of each component. Thus, the resulting models are of multi-velocity and multi-temperature type.

These models can be deduced by methods of Extended Thermodynamics [2], as well as from kinetic equations by classical Chapman-Enskog asymptotic procedure [3], or by using specific closures, like Grad approximation [4].\\

The starting point of this talk is a hybrid kinetic model combining the positive features of Boltzmann and BGK formulations [5]. In particular, the detailed description given by Boltzmann terms is confined only to the part of the collision phenomenon that dominates the gas evolution; the remaining processes are modeled by BGK terms that are more manageable from a numerical point of view.

In the regime dominated by intraspecies collisions, the hydrodynamic equations are derived both at Euler and Navier-Stokes level of accuracy. The resulting equations constitute a system of balance laws for species fields, and they are coupled by proper source terms taking account of interspecies interactions. As regards the Navier-Stokes limit, Newton and Fourier laws are recovered, and the viscosity and heat conductivity coefficients are explicitly computed in terms of the microscopic parameters.

This work is performed in the frame of activities sponsored by INdAM-GNFM, Italy, and by the University of Parma, Italy, and supported by the Italian ministry MIUR with the project *Multiscale phenomena in Continuum Mechanics: singular limits, off-equilibrium and transitions* (Prin 2017YBKNCE). G. Martalò is also grateful to University of Parma for the financial support of the research project *Hybrid Boltzmann-BGK models for rarefied gas mixtures*.

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