Local discrete velocity grids for multi-species rarefied flow simulations

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The objective of this work consists in developping a new deterministic method for multi-species kinetic equations, which is adaptative with respect to the kinetic velocity variable, as proposed for monospecies gas in [1]. In classical numerical methods, a set of discrete velocities is chosen identically for every space discretization point. This set is chosen according to the inital conditions and is kept fixed in time. However, in rarefied gas flows, such as the airflow around the walls of a shuttle, important gradients of velocity and temperature can appear.
The idea of this work is to define dynamic sets of discrete velocities independantly for each species and each space discretization point. The BGK operator derived in [2] is used to model multi-component interactions. To adapt dynamically to the gradients of macroscopic quantities, partial moments are computed by the use of conservation laws obtained by taking the moments of the discrete kinetic equations. This formulation allows for an implicit treatment of the relaxation operator, which gives an Asymptotic-Preserving scheme for Euler.
In this presentation, the model used for gas mixtures will firstly be presented, then the different components of the method will be shown in details. Finally, some numerical results will be presented in order to show efficiency when compared to the classical method.

Références

[1] Brull, S. and Mieussens, L., *Local discrete velocity grids for deterministic rarefied flow simulations*, Journal of Computational Physics, 2014.

[2] Andries, P. and Aoki, K. and Perthame, B., *A consistent BGK-type model for gas mixtures*, Journal of Statistical Physics, 2002.

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