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Modelling of Unsteady Force in Compressible Multiphase Flows

MANOJ PARMAR, ANDREAS HASELBACHER, S. BALACHANDAR, University of Florida — Shock-particle interaction is a challenging problem because it is highly unsteady, inhomogeneous, nonlinear, and compressible in nature. The key to improved prediction of such flows depends on our understanding of the interaction of an individual particle in a compressible ambient flow. At present, due to lack of fundamental knowledge, no well-founded model exists for the evaluation of forces on a particle in an unsteady compressible flow. Current understanding is limited to the quasi-steady drag force. In compressible flows, unsteady contributions to the force can be very important but remain virtually unexplored. This work attempts to lay the foundation for improved understanding and prediction of compressible multiphase flows by obtaining a rigorous equation of motion for an isolated particle. Therefore, we first derive the compressible extension to the celebrated Basset-Boussinesq-Oseen equation. We then derive the compressible extension of the Maxey-Riley-Gatignol equation that accounts for the inhomogeneity of the ambient compressible flow. Through carefully constructed simulations, finite Mach- and Reynolds- number extensions for the quasi-steady and unsteady forces on the particle are developed. The improved formulation is tested for shock-particle interaction.

Manoj Parmar
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