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Analysis of non-equilibrium multi-species mixing based on Boltzmann kinetic theory PRAKASH VEDULA, University of Oklahoma, RODNEY O. FOX, Iowa State University — In many applications of non-equilibrium flows relevant to design of micro-fluidic devices and spacecraft propulsion systems, where standard continuum field descriptions of multi-species mixing break down (when Knudsen number is not negligible), descriptions based on fundamental kinetic theory can be insightful. We use Boltzmann kinetic theory to obtain a statistical description of macroscopic system properties of multi-species mixing, using particle distribution functions for each species, which are governed by a system of coupled, nonlinear, integro-differential Boltzmann equations involving full collision operators. Formidable challenges involved in the computational treatment of full collision operators, consisting of multi-dimensional integrals, are addressed through an efficient quadrature-based moment method which not only preserves collision invariants but is also capable of describing general far-from equilibrium behavior. In this method, discrete representations of the particle distribution functions for each species are sought by accounting for generalized moment contributions due to full collision operators, which can be evaluated analytically via multinomial expansions. Fundamental behavior relevant to exchange of momentum, energy and generalized stresses among inert multiple species undergoing mixing, with and without the presence of spatial inhomogeneities, will be analyzed using this method.

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