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A quadrature-based kinetic equation solver for arbitrary Knudsen numbers RODNEY O. FOX, Iowa State University, PRAKASH VEDULA, University of Oklahoma — The Boltzmann kinetic equation can be applied to a wide range of flow phenomena including rarefied gas dynamics, gaseous flows in micro devices, and dilute gas-solids flows. While each application differs in the details, a fundamental problem is the treatment of cases far from equilibrium. Such flows are usually treated by (1) direct simulation Monte Carlo (DSMC) or (2) direct solvers for the velocity distribution function $f(\mathbf{r}, \mathbf{c}, \mathbf{t})$. While each method has its advantages and disadvantages, both are computationally expensive relative to moment methods (e.g., hydrodynamic equations.) However, current implementations of moment methods fail when free molecular flow creates non-equilibrium velocity distributions (i.e. finite Knudsen numbers.) Here we propose a quadrature-based moment method for solving the kinetic equation for all Kn. The method solves the transport equations for velocity moments by kinetic methods based on a finite set of velocities found by inverting the moments using quadrature. A particle mixing layer (equivalent at infinite Stokes to a Riemann shock tube) is used to illustrate the method for selected Mach and Stokes numbers, and for $0 \leq \mathrm{Kn} \leq \infty$. The results compare very favorably to published results using (1) and/or (2), but are computed at a fraction of the cost. Limitations of the approach and extensions to other flows (e.g. particle-laden channel flow) will also be discussed.

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