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The limits of Navier-Stokes theory and kinetic extensions for describing small-scale gaseous hydrodynamics[1] NICOLAS HADJICONSTANTINOU, Mechanical Engineering Department, MIT — Small-scale gaseous flows have received significant attention in connection to micro- and nanoscale engineering. Of particular interest to us are the scientific challenges arising from the breakdown of the Navier-Stokes description as characteristic lengthscales become of the order of, or smaller than the molecular mean free path. Gaseous hydrodynamics beyond Navier-Stokes can be described by the Boltzmann equation. In this talk we will review some basic results from asymptotic analysis of the Boltzmann equation, and show that these results can be used to resolve, sometimes in unexpected ways, a number of "open questions." Examples include the limit of applicability of the Navier-Stokes constitutive laws, the concept of second-order slip and the appropriate form of such a model, and how to reconcile experimental measurements of slipping flows with theory. We will also review a number of recent theoretical results on canonical nanoscale flows which cannot be described by Navier-Stokes transport. Finally, we will discuss recent developments in molecular simulation and numerical solution of the Boltzmann equation, with particular emphasis on variance reduction ideas which address the poor performance of particle-based methods in low-speed flows.

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