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A DSMC-based variance reduction formulation for low-signal flows[1] HUSAIN AL-MOHSSEN, NICOLAS HADJICONSTANTINOU, MIT — Particle methods for simulating the Boltzmann equation become prohibitively expensive in low-signal (e.g. low-speed) flows due to the large statistical uncertainty associated with the sampling of hydrodynamic quantities. We present a variance reduction technique for use in such flows (typically encountered in small-scale applications) that does not require modification of the DSMC procedure. The proposed method is based on the observation that low-signal flows are characterized by small deviations from well-defined equilibrium states and thus lend themselves naturally to variance reduction approaches. The present formulation uses an "auxiliary" simulation to describe a judiciously chosen equilibrium state using the same particle data samples as the non-equilibrium simulation. Subtracting the equilibrium hydrodynamic fields from the ones obtained by the non-equilibrium simulation significantly reduces the statistical uncertainty of the latter because the two calculations are correlated. We find that, similarly to previous variance reduction approaches, the present method exhibits statistical uncertainty that scales with the deviation from equilibrium, making the simulation of arbitrarily small deviations from equilibrium possible.

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