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Algebraic decomposition as a seamless multiscale coupling strategy NICOLAS HADJICONSTANTINOU, MIT — We discuss a new class of approaches for efficiently simulating multiscale kinetic problems, with particular emphasis on applications related to small-scale transport. These approaches, referred to as deviational, are based on a decomposition of the kinetic description into an equilibrium part, that is described deterministically (analytically or numerically), and the remainder, which is described using a particle simulation method. We show that it is possible to derive evolution equations for the two parts from the governing kinetic equation, leading to a decomposition that is dynamically and automatically adaptive, and a multiscale method that seamlessly bridges the two descriptions *without introducing any approximation.* Our discussion pays particular attention to stochastic simulation methods that are typically used to simulate kinetic phenomena; in this context, these decomposition approaches can be thought of as control-variate variance reduction formulations, with the nearby equilibrium serving as the control. Such formulations can provide substantial computational benefits in a broad spectrum of applications because a number of transport processes and phenomena of practical interest correspond to perturbations from nearby equilibrium distributions which can be exploited to drastically reduce the number of particles required in the simulation. In many cases the computational cost reduction is sufficiently large to enable otherwise impossible simulations.

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