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Asymptotic-preserving multilevel Monte Carlo for Kinetic Equations in Plasma Edge Simulations

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When designing tokamak fusion reactors, two sets of particles need to be modeled. The electromagnetically constrained plasma, which harbors the reaction, is generally modeled as a fluid. This fluid model is coupled with a kinetic equation modeling neutral particles. When the collision rate of neutrals with the background is high, a well-defined limiting equation exists. High-dimensionality of the position-velocity phase-space means that particle-based Monte Carlo becomes a go-to approach in many cases. These methods become very expensive, however, when approaching the high-collisional limit as small time steps are required to resolve the collision dynamics.
The multilevel Monte Carlo method is a method that combines simulations with coarse time steps and simulations with fine time steps in order to perform simulations with the accuracy of the fine time steps at a reduced computational cost. In this poster we show how asymptotic-preserving schemes and the multilevel Monte Carlo method can be combined to drastically reduce the computational cost of the considered simulations of neutral particle models. We will also demonstrate the achieved speed-up through numerical results.

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