Development of a Coupled Kinetic Plasma - Neutral Transport Code

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Abstract

Monte Carlo neutral transport codes have been run in conjunction with fluid plasma transport codes for more than a decade. The logical next step is to couple a Monte Carlo neutral transport package to a kinetic plasma transport code. The XGC neoclassical particle transport [1] does just this with a built-in, rudimentary Monte Carlo neutral transport routine. A primary objective of the Center for Plasma Edge Science project is the replacement of this routine with a more general routine based on the DEGAS 2 Monte Carlo neutral transport code. As was done by XGC's neutral routine, the DEGAS 2 neutrals collide off of a fluid plasma background with its moments computed from the kinetic XGC ions. The resulting neutral density, flow velocity and temperature profiles are passed back to XGC. XGC's ions and electrons collide off of this background using the same ionization and charge exchange rates employed in the neutral transport calculation.

Efforts to obtain self-consistent solutions of Monte Carlo neutral and fluid plasma transport codes were complicated by subtle numerical and physical problems beyond those associated with finite Monte Carlo statistical noise [2,3]. Those convergence problems are less of a concern here since XGC uses a particle-based approach to solving its underlying equations. Nonetheless, we need to ensure overall conservation of particles, momentum, and energy in the exchanges between plasma and neutral populations. Not doing so could lead to spurious sources that could accumulate throughout the simulation, compromising the accuracy of the final result. We will describe an approach to the coupling designed to avoid this problem.

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