A fully implicit kinetic code for parallel electron transport in the Scrape-Off Layer

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Modeling of transport in the edge region of tokamaks has relied traditionally on either a hydrodynamic two-fluid approach backed up by transport coefficients calculated by Braginskii [1], or kinetic approaches based on PIC (particle-in-cell) or Monte Carlo methods. These approaches suffer from the inability to easily capture non-local effects (due to varying collisionality in the plasma edge), as well as noise inherent to particle methods. A third approach is to solve kinetic equations using a finite difference method and to obtain particle distribution functions. While codes employing the finite difference method have been used and reported in the Scrape-Off Layer transport literature [2], their use up to now appears to be limited.

Kinetic codes capable of capturing non-local effects have been used in simulations of laser-plasma interactions [3,4]. Those codes employ a spherical harmonic decomposition of the electron distribution function (EDF), which allows for efficient treatment of transport and the effects of anisotropy. On the other hand, the same decomposition of the EDF has been used in electron swarm models [5], where electron-neutral interactions are dominant. For simulations involving detached plasmas as well as steep temperature and density gradients (such as those during ELM bursts), a novel combination of these two approaches appears to be natural. This has been the motivation for developing a new fully implicit kinetic 1D3V code using the combination of the above approaches to model plasma of highly varying collisionality.

Here we present our new fully implicit 1D3V code for the treatment of parallel electron transport in hydrogen plasmas of varying collisionality and with any level of distribution function anisotropy. The code includes models for both Coulomb collisions of charged species, as well as models for several electron-neutral collision processes. Self-consistent fields are calculated using a combination of Ohm's law and Maxwell's equations. Presented are tests of various aspects of the model used for benchmarking the code, from individual collisional terms to 1D transport.

References

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