Advances in Eulerian Gyrokinetic Modeling of Tokamak Edge Plasmas

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ABSTRACT

Understanding the edge plasma region of a tokamak fusion reactor is important to maintaining the confinement of the burning plasma in the core. However, simulation of the edge region is computationally challenging for several reasons: a wide range of spatial and temporal scales; large anisotropies in plasma behavior relative to a complex magnetic field structure; equilibrium to highly non-equilibrium behavior across the edge; etc. Because of highly non-equilibrium behavior, a kinetic plasma description is required over a significant fraction of the edge region.

We will discuss algorithmic challenges and advances for continuum, Eulerian kinetic simulation. Our approach is based on conservative, limited, fourth-order finite volume methods suitable for mapped grids and adaptive mesh refinement [1]. In the gyrokinetic edge plasma setting, we will discuss the development of the Eulerian code COGENT. To handle the complicated magnetic field coordinate systems required in the edge, we rely on a mapped multiblock generalization, where each block possesses its own mapping and grid lines across block boundaries are continuous but not smooth. We will discuss our discretizations and multiblock algorithms and the challenges of solving the gyrokinetic Poisson problem robustly for the high-order, mapped multiblock discretizations. In addition, we will describe our approach for satisfying the discrete divergence-free velocity property to machine roundoff. We will also describe the implementation of high-order, conservative implicit-explicit time integrators to handle efficiently the large variation in the collisional time scale across the tokamak edge region.

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REFERENCES

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