DPP20-2020-000083

Abstract for an Invited Paper
for the DPP20 Meeting of
the American Physical Society

Continuum Gyrokinetic Simulations of Edge Plasmas in Single-Null Geometries[1]

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The first continuum gyrokinetic calculations of edge plasmas in a single-null geometry are presented for the cases of 4D axisymmetric transport and 5D electrostatic ion scale turbulence. The simulations are performed with the finite-volume code COGENT, which was designed to handle the geometrical complexity of the tokamak edge. In particular, in order to facilitate simulations of highly-anisotropic microturbulence in the presence of strong magnetic shear and a magnetic X-point, a numerical algorithm utilizing a locally field-aligned multiblock coordinate system has been developed. In this approach, the toroidal direction is divided into blocks, such that within each block the cells are field-aligned and a non-matching (non-conformal) grid interface is allowed at block boundaries. The toroidal angle corresponds to the "coarse" field-aligned coordinate, whereas the poloidal cross-section, comprised of the radial and poloidal directions, is finely gridded to resolve short-scale perpendicular turbulence structures and to support accurate re-mapping (interpolation) at block boundaries. The simulation model solves the long-wavelength limit of the full-F gyrokinetic equation for ion species, coupled to the quasi-neutrality equation for electrostatic potential variations, where a fluid model is used for the electron response. The 4D transport calculations, including the effects of fully-nonlinear Fokker-Planck collisions and ad-hoc anomalous radial transport, demonstrate values of radial electric field and toroidal rotation comparable to those observed on the DIII-D facility. The 5D simulations explore cross-separatrix ion temperature gradient (ITG) turbulence in the presence of a self-consistent radial electric field and elucidate the effects of magnetic-shear stabilization in the X-point region.

[1]Work performed for USDOE, at LLNL under contract DE-AC52-07NA27344.