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Scrape-Off Layer Turbulence in Tokamaks Simulated with a Continuum Gyrokinetic Code

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We present a new gyrokinetic code, Gkeyll, for use in edge plasma simulations. The code implements energy conserving discontinuous Galerkin schemes, applicable to a general class of Hamiltonian equations. Several applications of our code to various test problems are presented. We compute the parallel heat-flux on divertor plates resulting from an ELM crash in JET, for a 1D/1V SOL scenario explored previously, where the ELM is modeled as a time-dependent intense upstream source, and walls modeled with using sheath boundary conditions. We simulate bad-curvature-driven ETG turbulence, running the full-F non-local code in a periodic local limit, illustrating 3x/2v capability. We will show results from simulating turbulence in an SOL in a simplified helical open-field-line geometry with the bad curvature drive, which is useful for demonstrating the feasibility of this approach and for initial physics studies of SOL turbulence. The inclusion of magnetic fluctuations with kinetic electrons has been challenging for many gyrokinetic algorithms in the past, requiring special treatment to reduce the Ampere cancellation problem. An important feature of this work is that we have developed novel versions of DG that can handle gyrokinetic magnetic fluctuations in an efficient way while preserving the energy invariant. We developed a novel version of DG that uses Maxwellian-weighted basis functions while still preserving exact particle and energy conservation. At a fixed error, the Maxwellian-weighted DG method achieves the same error with 4 times less computational cost, or 16 times lower cost in the 2 velocity dimensions of gyrokientics (assuming memory bandwidth is the limiting factor). Finally, we have derived the adjoint of the gyrokinetic equation, we can be used for various purposes, including studying the fastest-growing instantaneous configuration due to non-normal modes (related to sub-critical nonlinearly-sustained turbulence).

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