Collisional Ion and Electron Scale Gyrokinetic Simulations in the Tokamak Pedestal *

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A new gyrokinetic solver, CGYRO, has been developed for precise studies of high collisionality regimes, such as the H-mode pedestal and L-mode edge. Building on GYRO and NEO, CGYRO uses the NEO pitch angle and energy velocity-space coordinates to optimize the accuracy of the collision dynamics and allow for advanced operators beyond the standard Lorentz pitch-angle scattering model. These advanced operators include energy diffusion, multi-species collisions, and finite-FLR collisional effects. CGYRO includes kinetic electrons, multiple ion species, transverse and compressional electromagnetic perturbations, nonlinearities, ExB and parallel velocity shear, and experimental profiles input with general flux-surface geometry. The code employs a new spatial discretization and array distribution scheme that targets scalability on next-generation (exascale) HPC systems that will make use of multi-threaded and accelerator hardware. Thus, CGYRO is optimized for multiscale (coupled electron and ion turbulence scales) simulations required for accurate calculation of electron transport in the outer core and pedestal. In this work, CGYRO is used to study the complex spectrum of modes in the pedestal region, including the kinetic ballooning mode, electron and ion drift modes, and microtearing-parity modes. The onset of the linear KBM with full collisional effects is assessed to develop an improved KBM/RBM model for EPED. The analysis is extended to intermediate and high k to explore the role of electron-scale (ETG-range) physics. Progress on a recent extension to include sonic toroidal rotation (including full centrifugal effects) for comprehensive studies including heavy impurities is also reported.

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