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Gyro-Landau-Fluid Theory and Simulations of Edge-Localized-Modes[1]

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We report on the theory and simulations of edge-localized-modes (ELMs) using a gyro-Landau-fluid (GLF) extension of the BOUT++ code. Consistent with the two-fluid model (including 1st order FLR corrections), large ELMs, which are low-to-intermediate toroidal mode number (n) peeling-ballooning (P-B) modes, are suppressed by finite Larmor radius (FLR) effects as the ion temperature increases, while small ELMs (at intermediate n's) remain unstable. This result is good news for high ion temperatures in ITER due to the large stabilizing effects of FLR. Because the FLR effects are proportional to both Ti and n, the maximum growth rate is inversely proportional to Ti and the P-B mode is stabilized at high n. Nonlinear gyro-fluid simulations show results similar to those from the two-fluid model, namely that the P-B modes trigger magnetic reconnection, which drives the collapse of the pedestal pressure. Hyper-resistivity limits the radial spreading of ELMs by facilitating magnetic reconnection. The gyro-fluid ion model further limits the radial spreading of ELMs due to FLR-corrected nonlinear ExB convection of the ion gyro-center density. A gyro-fluid ETG model is being developed to self-consistently calculate the hyper-resistivity. Zonal magnetic fields arise from an ELM event and finite beta drift-wave turbulence when electron inertia effects are included. These lead to current generation and self-consistent current transport as a result of ExB convection in the generalized Ohm's law. Because edge plasmas have significant spatial inhomogeneities and complicated boundary conditions, we have developed a fast non-Fourier method for the computation of Landau-fluid closure terms based on an accurate and tunable approximation. The accuracy and the fast computational scaling of the method are demonstrated.

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