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Finite Larmor Radius Effects on Low-n Magnetohydrodynamic Modes at H-Mode Pedestal with Plasma Rotation

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Finite Larmor radius effects (FLR) on the low-n MHD modes at high-mode (H-mode) pedestal are investigated in this paper with the inclusion of bootstrap current for equilibrium and rotation effects for stability. When bootstrap current is taken into account, a safety-factor reversal or plateau can be generated at the pedestal. We have shown that the modes of infernal type (or fat interchange modes) can prevail at the safety-factor reversal or plateau region and such a type of modes exhibits the typical features of the so-called edge harmonic oscillations (EHOs) at the QH-mode discharges. There is a physical ground for us to consider the FLR effects. We note that the diamagnetic frequency (ω_*) is directly proportional to pressure gradient and inversely proportional to density. This leads ω_* to become big and vary dramatically at the pedestal, where the infernal modes tend to develop. The AEGIS code is extended to include the FLR effects using the steep pressure gradient ordering. The JET H-mode discharges are reconstructed numerically using the VMEC code, with bootstrap current taken into account. Generally speaking, the FLR effects are stabilizing for infernal modes. Our results show that the FLR effects depend sensitively on the safe factor value (q_s) at the safety-factor reversal or plateau region. The FLR effects are weaker, when q_s is larger than an integer; while stronger, when q_s is smaller or less larger than an integer. We also found that the FLR effects also depend sensitively on the rotation direction. The FLR stabilization in the co-rotation case (for sheared rotation) is stronger than in the counter rotation case with respect to the ion diamagnetic drift direction. We have studied $n = 1$, 2, and 3 cases and found that with the FLR drift effects being taken into account the frequency-multiplying rule $\omega = n\Omega_s$ are still roughly held. However, we found that in the higher mode number case the wave-particle resonance effects need to be considered. We are also applying the AEGIS-K code to study the MHD modes at the plasma edge fully kinetically. Our investigation on low-n MHD modes at H-mode pedestal is relevant to ITER as well.

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