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Radially compressed full-f ITG turbulence dynamics across the pre-transition L-mode edge pedestal in magnetic separatrix geometry[1]

CHOONG-SEOCK CHANG, New York University and KAIST

We find from the full-f XGC1 gyrokinetic edge code that there is ITG turbulence excited in a real-geometry, pre-transition L-mode edge pedestal that includes a separatrix and X-point. The neoclassical and turbulence dynamics are simulated together in numerical g-eqdsk magnetic equilibrium with material wall. It has been a conventional assumption in the L-H transition scenarios that the ITG mode itself is stable in the L-mode edge since η_i in the pedestal stays below the conventional critical η_{ic} for the linear ITG instability onset due to broader T_i profile than the density profile. Since the broader T_i profile yields high $\eta_i > \eta_{ic}$ at the density pedestal top (and radially inward), the ITG turbulence activity has been assumed to be limited to the core side in from the pedestal. The strong ExB shearing in the pre-transition pedestal was supposed to prevent the turbulence spreading. Surprisingly, we find that the turbulence grows simultaneously from the pedestal top to the bottom. Unlike in a core plasma, the growth of the radial streamers is accompanied with zonal flow growth from the beginning, indicating that the ITG mode growth is quasilinear in the edge. This observation suggests a new possibility for the understanding of L-H transition mechanism. The ion thermal conductivity χ_i is found to be in the range of experimental observations. Turbulence is severely compressed in the pedestal toward the separatrix, implying a global interaction of the turbulence with the many spatially coupled nonlocal edge-specific kinetic mechanisms, including the strong neoclassical ExB and the Reynolds stress mean field in the high-q separatrix region (with X-point), strong plasma gradient, finite ion orbit dynamics with transitional collisionality, and the nonlocal GAM energy exchange with turbulence.

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