Gyrokinetic edge transport bifurcation through turbulence and neoclassical interaction in XGC1[a,b,c]

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We report the first gyrokinetic simulation of edge turbulence and transport bifurcation in the usual L-H or L-I bifurcation layer just inside the magnetic separatrix surface. Electrostatic turbulence, neoclassical physics including X-loss, and neutral particle recycling is simulated together in the total-f edge gyrokinetic code XGC1 with fully nonlinear Fokker-Planck collision operation. The simulation started with an L-mode like plasma in the C-Mod geometry with the Grad-B drift direction away from the magnetic X-point. Two simulations are performed: one with an induced GAM activity and the other without. In the induced GAM case, the plasma equilibrium is instantaneously perturbed mimicking a sawtooth crash event. A nonlocal GAM activity with a large ExB shearing rate grew up. The GAM showed a local compressed limit-cycle type interaction with turbulence intensity. In the second GAM oscillation period, the oscillatory ExB shearing from GAM is transferred and locked to the less-oscillatory mean ExB shearing. The mean ExB flow also increases in magnitude. During this period, the turbulence shows a first order transition behavior, with its intensity decreasing fast in time to a small level. The essential bifurcation period takes less than 0.1ms. In the case without an artificial agitation of a large GAM, it appears that the transition is more gradual, with the natural GAM/limit cycle oscillation growing while the turbulence intensity is reduced and the plasma ExB flow increases. Energy transfer from turbulence to the GAM/limit cycle oscillation and the mean ExB flow will be studied and presented. More direct comparisons with experiments are being pursued.

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