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Gyrokinetic simulation of fast L-H bifurcation dynamics in a realistic diverted tokamak edge geometry[1]

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We report the first observation of an edge transport barrier formation event in an electrostatic gyrokinetic simulation carried out in a low beta C-Mod like plasma in realistic diverted tokamak edge geometry [1]. The results show that the synergistic action between two multiscale dynamical phenomena, 1) the turbulent Reynolds-stress driven and 2) the neoclassical X-point orbit-loss driven sheared $E \times B$ flows, work together to quench turbulent transport and form a transport barrier just inside the last closed flux surface. The bifurcation occurs when the $E \times B$ shearing rate becomes greater than the strongest dissipative mode growth rate, which results from the dissipative trapped-electron mode in this plasma. The synergism helps reconcile experimental reports of the key role of turbulent stress in the bifurcation with other experimental observations that ascribe the bifurcation to X-point orbit loss/neoclassical effects. The synergism is consistent with the general experimental observation that the L-H bifurcation requires more power with the ion ∇B-drift away from the single-null X-point, in which the X-point orbit-loss effect is weaker. When the ion ∇B-drift is backward, the bifurcation occurs at the same critical $E \times B$ shearing rate, but is accompanied by persistent GAM oscillations in the bifurcation layer. The effect of isotope mass on the L-H bifurcation will also be validated against DIII-D results.

[1] C.S. Chang, S. Ku et al., Phys. Rev. Lett. 118, 175001 (2017)

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