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Progress towards modeling tokamak boundary plasma turbulence and understanding its role in setting divertor heat flux widths[1]

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QCMs (quasi-coherent modes) are well characterized in the edge of Alcator C-Mod, when operating in the Enhanced D_α (EDA) H-mode, a promising alternative regime for ELM (edge localized modes) suppressed operation. To improve the understanding of the physics behind the QCMs, three typical C-Mod EDA H-Mode discharges are simulated by BOUT++ using a six-field two-fluid model (based on the Braginskii equations). The simulated characteristics of the frequency versus wave number spectra of the modes is in reasonable agreement with phase contrast imaging data. The key simulation results are: 1) Linear spectrum analysis and the nonlinear phase relationship indicate the dominance of resistive-ballooning modes and drift-Alfven wave instabilities; 2) QCMs originate inside the separatrix; (3) magnetic flutter causes the mode spreading into the SOL; 4) the boundary electric field E_r changes the turbulent characteristics of the QCMs and controls edge transport and the divertor heat flux width; 5) the magnitude of the divertor heat flux depends on the physics models, such as sources and sinks, sheath boundary conditions, and parallel heat flux limiting coefficient. The BOUT++ simulations have also been performed for inter-ELM periods of DIII-D and EAST discharges, and similar quasi-coherent modes have been found. The parallel electron heat fluxes projected onto the target from these BOUT++ simulations follow the experimental heat flux width scaling, in particular the inverse dependence of the width on the poloidal magnetic field with an outlier. Further turbulence statistics analysis shows that the blobs are generated near the pedestal peak gradient region inside the separatrix and contribute to the transport of the particle and heat in the SOL region. To understand the Goldston heuristic drift-based model, results will also be presented from self-consistent transport simulations with the electric and magnetic drifts in BOUT++ and with the sheath potential included in the SOL.

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