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Understanding the RMP-Driven Transport in Tokamak Edge Plasma from Gyrokinetic-MHD Coupled Simulation in Realistic Divertor Geometry[1]

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ITER plans to rely on RMP coils as the primary means for ELM control. However, puzzling observations on present-day experiments complicate the physics understanding: plasma density is pumped out, which can lower the fusion efficiency in ITER, while the electron heat transport is still low in the pedestal. Kinetic level understanding including most of the important physics is needed but has not been available. Gyrokinetic total-f simulation of the plasma transport driven by n=3 resonant magnetic perturbations (RMPs) in a DIII-D H-mode plasma is performed using the gyrokinetic code XGC. The RMP field is calculated in M3D-C1 and coupled into XGC in realistic divertor geometry with neutral particle recycling. The RMP field is stochastic around the pedestal foot but exhibits good KAM surfaces at pedestal top and steep-slope. The simulation qualitatively reproduces the experimental phenomena: plasma density is pumped-out due to enhanced electrostatic turbulence while electron heat transport is low. Different from earlier gyrokinetic studies, the present simulation consistently combines neoclassical and turbulent transport, a fully nonlinear Fokker-Planck collision, neutral particle recycling, and the full 3-D electric field. Density pump-out is not seen without turbulence effects. Around the pedestal foot the heat transport rate is found to be much lower than the Rechester-Rosenbluth rate. Reduction of the ExB shearing rate is identified to be responsible, mostly, for the enhanced edge turbulence, which is found to be from trapped electron modes. Comparison with experimental results will also be presented.

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