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EX/2-3: ECRH Effects on Toroidal Rotation: KSTAR Experiments and Gyrokinetic Simulations of Intrinsic Torque at ITG - TEM Transitions

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Toroidal rotation is important for control of stability and transport in tokamaks. Intrinsic rotation is self-generated by ambient turbulence via the non-diffusive residual stress, which motivates the question of how macroscopic rotation profiles will evolve in response to changes in the ambient micro-turbulence. One ʻcontrol knob'for the micro-turbulence population is the heating mix of NBI and ECRH. The change in rotation to counter-direction by ECH in KSTAR is explained by the turbulence change from ITG to CTEM. We investigate the effect of ECRH heating on NBI-driven toroidal rotation profiles in L-mode and H-mode discharges in KSTAR tokamak. 1.3 MW of NBI is injected in the co-current direction and 350 kW of ECRH are applied. The ion temperature and toroidal rotation are measured with high resolution XICS and CES. NBI in the co-current direction drives peaked rotation profiles with (H-mode) and without (L-mode) a pedestal. Dramatic decreases in the core toroidal rotation values are observed when on-axis ECRH is added to H-mode. These increments delta(Vtor)/Vtor ˜ -30% indicate the presence of on ECH-induced counter-current torque acting in the discharge core. We note that, for steady state with same external torque and boundary condition, the change of the radial gradient of plasma rotation implies the change of residual stress. Interestingly, edge and pedestal rotation velocities in H-mode are nearly unchanged. We explore the viability of the ITG–TEM transition as an explanation of the observed change in the sign of the core intrinsic torque. The global gyrokinetic code gKPSP was used for the study. We performed ITG and TEM simulations at values of eta_i = 3.1 (i.e. ITG) and eta_i = 1.0 (i.e. TEM), respectively. Note that the low value of eta_i for the CTEM case is qualitatively consistent with the reduction in core grad(Ti) observed with ECRH in KSTAR. Results show that the residual stress changes sign as ITG–TEM transition occurs, indicating a change in the direction of the net wave energy density flux. Direct simulations also reveal a mean macroscopic profile reversal at ITG–TEM transition, thus confirming the overall consistency of the argument. Also we will perform nonlinear gyrokinetic simulations to calculate the strength of intrinsic torque reversal at ITG–TEM transition and compare the simulation results with experiments.

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