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Toroidal Rotation Profile Structure in L- and H-Mode KSTAR Plasmas

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We report the results of L- and H-mode toroidal rotation experiments in KSTAR. Both NBI and ECH with varying resonance conditions were used for the heating mix and turbulence population control. The experimental results show that ECH causes a counter-current rotation increment both in L- and H-mode plasmas. In the H-mode case, the rotation profiles are flattened by on-axis ECH with a clear pivot point inside the pedestal and on-axis ECH can produce larger counter-current rotation than the off-axis ECH. There is no pivot point observed in rotation profiles for ECH in L-mode plasma. These KSTAR results suggest that toroidal rotation profiles are determined by an interplay of i) a co-current NBI torque, ii) a pedestal intrinsic torque, which is notable in H-mode plasma and insignificant in L-mode plasma, iii) a core intrinsic torque, which can become counter-current with ECH. We hypothesize here that the change of the core intrinsic torque with ECH is due to a transition from a state of ITG turbulence to CTEM turbulence, and thus a change in the sign of the turbulence-driven residual stress. For H-mode plasma, linear gyrokinetic analyses suggest that the steepening of ∇Te and density peaking are two important mechanism for ITG$\longrightarrow$TEM transition. For L-mode plasmas, gyrokinetic analyses indicate that off-axis ECH causes the excitation of TEM at r/a=0.5, while on-axis ECH can excite TEM at core region only (r/a=0.25). TEM at r/a=0.5 is stronger than TEM at r/a=0.25 within the framework of linear growth rate. This stronger TEM excitation in the off-axis ECH can be understood as a consequence of increased trapped particle population as the ECH resonance location moves to radially outward direction. The momentum transport coefficients i.e. diffusivity and convection velocity were investigated with modulation ECH experiments in KSTAR. An inward pinch was found with the perturbation method. More detailed gyrokinetic analysis of micro-instabilities will be presented for varying ECH deposition locations and target plasmas. Also, we will perform nonlinear gyrokinetic simulations to calculate Te fluctuation spectra and compare them with ECEI fluctuation measurements. Combining transport analysis and the nonlinear simulations, we will identify the role of the non-diffusive stress component in the formation of global rotation profile.

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