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TH/P3-24: Intrinsic Plasma Rotation Determined by Neoclassical Toroidal Plasma Viscosity in Tokamaks

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Intrinsic steady state plasma rotation is important for plasma confinement in ITER, since the momentum input is expected to be small. It is well known that the intrinsic plasma rotation in stellarators is determined by non-ambipolar diffusion due to helical ripple. The non-ambipolar diffusion due to small 3D magnetic perturbation described by the Neoclassical Toroidal plasma Viscosity (NTV) theory may be important in determining the intrinsic plasma rotation in tokamaks, because the Non-Axisymmetric Magnetic Perturbations (NAMP) always exist. The NTV theory in different collisionality regimes has been well developed in the last few years, and it has been summarized in [Shaing etal., Nucl. Fusion 50, 025022 (2010)]. The numerical results showed a good agreement with the analytic solutions in different asymptotic limits [Y. Sun et al., Phys. Rev. Lett. 105, 145002 (2010)]. The intrinsic toroidal plasma rotation determined by the NTV effect in tokamaks is investigated in this paper. It is found by searching the root of the ambipolarity constraint $\sum_{j=i,e} e_j \Gamma_j(\Omega_\phi) = 0$, where Ω_ϕ is the toroidal rotation, and e_j and Γ_j are the electric charge and the particle flux of the j ($i \equiv$ ions, and $e \equiv$ electrons) species. It is found that the result strongly depends on the plasma collisionality. In high collisionality case, the ion flux is dominant and the intrinsic steady state flow is in counter-current direction. It corresponds to the 'ion root' named in stellarators. In low collisionality case, there are three roots. One corresponds to the 'ion root' in counter-current direction. The second stable one corresponds to the 'electron root' in co-current direction, near which the electron flux is dominant. The third one is an unstable root. The NTV torque drives the plasma rotation towards one of the stable roots. This means that the intrinsic toroidal rotation in low collisionality case can also be possible in co-current direction. Both of these two roots scale like the diamagnetic frequency. The prediction of intrinsic rotation due to NTV on ITER will also be discussed.

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