Reverse of Tokamak Plasma Rotation under Tearing-Mode Locking by External Resonant Magnetic Perturbation

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Rotation of tokamak plasma attracts considerable attention in the fusion research because this rotation, particularly under shear of rotation velocity, affects plasma stability and confinement. The plasma rotation velocity in the vicinity of a rational magnetic surface can be influenced by the development of the tearing mode. According to experiments and numerical modelling, the tearing-mode locking by externally applied static Resonant Magnetic Perturbation (RMP) can be followed by a rotation reverse of the Resonant Plasma Layer (RPL) occupied by magnetic island structure (see [1, 2]). This reverse extends due to plasma viscosity to some area surrounding the RPL.

Results of calculations and analysis of the plasma rotation reverse subject to the tearing mode locking are presented in this paper. The main attention is paid to conditions necessary for the rotation reversals separately in toroidal and poloidal directions, as well as for the concurrent changes of both rotation directions. The dynamics of the plasma toroidal and poloidal rotation-profile variations are also presented. The TEAR code [3, 4] used for the calculations is based on the visco-resistive MHD approximation that gives coupled diffusion-type equations for the magnetic flux perturbation and for the plasma rotation velocities in toroidal and poloidal directions. In the case of sufficiently large magnetic islands [5] the mode locking occurs due to the effect of the RMP-produced electromagnetic torque applied to the RPL. The toroidal and poloidal electromagnetic torque components are balanced by corresponding components of the viscous torque depending on the RPL rotation velocities with respect to plasma velocities outside RPL. At the mode locking, the superposition of the RPL toroidal and poloidal velocity projections on the direction of the mode phase velocity (the $[\mathbf{r}\times\mathbf{B}]$ direction) is inhibited till the full stop of the mode rotation. Therefore, if the initial directions of these velocity projections coincide, one of the toroidal or poloidal velocities can change its sign. These alternative possibilities depend on the interrelation between plasma toroidal and poloidal viscosity coefficients. The concurrent reversals of the RPL toroidal and poloidal rotation velocities at the mode locking can occur under the account of the electron diamagnetic drift in the mode rotation [6, 7].

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