§11. Structure Formation in Flowing Plasmas

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Magnetic island formation is important for the transport and the MHD phenomena in magnetic confinement plasmas. However, the onset condition of the magnetic island formation is still not clear. In order to investigate this onset condition, we focused on the effects of the plasma flow and the outer magnetic perturbations, such as an error field and another MHD activity, on the magnetic island formation.

i) Quasi-stationary states under an externally given error fields The stationary state of the rotating plasma for a static edge magnetic perturbation is investigated numerically in a cylindrical geometry[1]. At the fast plasma rotation velocity regime, the current sheets are generated at the Alfvén resonances which are well separated, and the resistivity becomes ineffective at the rational surface. Non-rotating islands are generated as stationary states, however, the penetrated magnetic flux is significantly reduced by the Alfvén resonances. The reduction by the rotation is more effective for smaller resistivity. The electromagnetic torque increases linearly in the rotation velocity shown in Fig. 1, which agrees with the previous theoretical prediction. This linear scaling, on the other hand, seems to be easily changed if the resonant surface is located near the plasma edge.

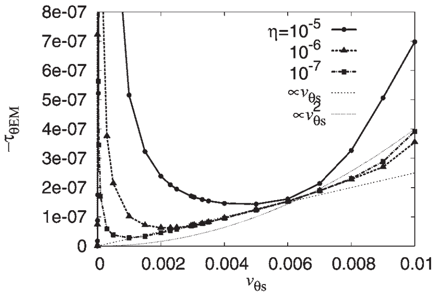

Fig. 1: Volume-integrated electromagnetic torque is plotted against plasma rotation velocity at the mode-resonant surface.

ii) Linear and quasi-linear interaction between the double tearing mode and the zonal flow The effect of zonal flow shear on double tearing mode is investigated by solving a linearized set of reduced two-fluid equations for the equilibrium including zonal flow. The zonal flow caused by micro-turbulence is obtained from nonlinear simulation results presented by references in Ref. [2] . Figure 2 shows the linear growth rate of double tearing mode obtained by solving the linearized equations for the equilibrium including zonal flow at each time $t = t_0$. The dotted line indicates the linear growth rate of the double tearing mode for the initial equilibrium that does not have any zonal flow. Linear growth rate is sometimes smaller than the dotted line and sometimes larger than the dotted line. Thus, there is no clear evidence which could indicate whether the double tearing mode is stabilized or destabilized by the zonal flow[2] .

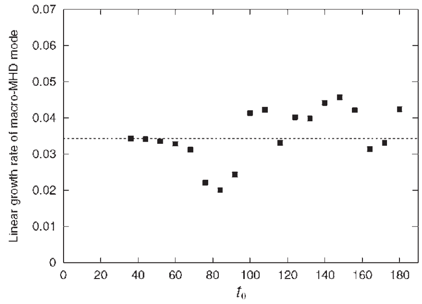

Fig. 2: Linear growth rate of double tearing mode for the equilibrium including zonal flow at each time $t = t_0$ in a nonlinear simulation.

iii) Background rotation effects on the nonlinear evolution of DTM Plasma rotation effects on the trigger and evolution of MHD activities in reversed shear profiles are studied by nonlinear MHD simulations. It is found that, in rotating plasma, magnetic islands formed around inner and outer magnetic resonant surfaces, which are stable for the tearing mode, by an external perturbation, evolve with different growth rate during an initial growth phase. After an initial growth phase, an outer magnetic island grows rapidly prior to the inner one and triggers a rapid growth of an inner magnetic island. This process can explain time delay of a plasma edge oscillation to trigger an internal MHD events and disruption.

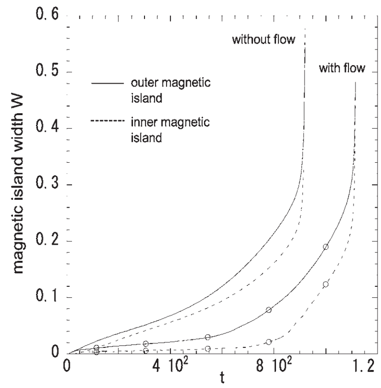

Fig. 3: Time evolution of externally driven magnetic islands in rotating and non-rotating plasmas. In case of rotating plasma, the initial growth rate is suppressed compared with that in non-rotating plasma. Moreover, there is time delay for the rapid growth of the inner magnetic island compared with the outer one.

1) M. Furukawa and L. -J. Zheng, Nucl. Fusion **49**, 075018 (2009).

2) A.Ishizawa and N.Nakajima, Phys. Plasmas **15**, 084504 (2008).