Long term dynamics of the forced magnetic island in tokamak plasmas with the flow

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In tokamak fusion plasma, the plasma is confined by the magnetic field with torus topology. It is well known that the magnetic reconnection and the resulting magnetic island formation, which change the initial magnetic configuration, deteriorate the confinement of the plasma particle and temperature. Hence, the suppression and control of the magnetic island formation is one of the important research issues. There are two main reasons for the origins of the magnetic island. One is the spontaneous instability, like as the tearing mode. The other one is the forced magnetic island, which is driven by the external perturbation at the tearing stable resonant surface. Usually, the forced magnetic island formed by the later process is stable and does not growth so large. In high temperature tokamak plasma, however, the initially stable forced magnetic island is driven by the bootstrap current, which is the plasma current peculiar to the torus plasma, when the magnetic island width becomes larger than some critical value. This kind of the magnetic island growth process is known as the neoclassical tearing mode (NTM) and the forced magnetic island is called the seed magnetic island for NTM. Tokamak plasmas are usually rotating in the direction of the magnetic filed, because the momentum is input externally by the neutral beam injection etc. in order to supply the energy to the core plasma. Several works have shown that, in the rotating tokamak plasma, there is a critical value, beyond which the forced magnetic island grows explosively. Until now, the dependency of such a critical value on the plasma parameters has been investigated in detail.

In this study, we have found that the second magnetic reconnection occurs by the explosive growth and the deformation of the forced magnetic island, by the nonlinear MHD (magneto hydrodynamics) simulation in the wide parameter regime. This process is important for the sudden onset of the seed magnetic island for the NTM.

In this study, we solve the reduced resistive MHD equations including the background flow in cylindrical geometry. The external magnetic perturbation, which is resonant with the initially tearing stable rational surface, is applied at the plasma surface as the time depending function. In the former theory and simulation studies, the error field is though as the external perturbation. So, it is assumed that the externally applied magnetic perturbation has the slow time scale and balances with the dissipation rate at the resonant surface. In this study, we consider the external perturbation caused by the MHD event like as the sawtooth oscillation. Such an external perturbation has the Alfven transit time scale. As the result, the balance between the external perturbation and the dissipation at the resonant surface is lost. In order to study the forced island formation process in such a condition, we did the nonlinear MHD simulations in the wide regime of the resistivity, , and the viscosity, . In this study, it was found that the localized plasma current is formed around the X-point and make the resistivity effect clear not in the high resistivity regime, but in the low resistivity regime.