Interaction between Resonant Magnetic Perturbations and Sheared Flows

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The control of edge localized modes (ELMs) is an important problem for advanced confinement regimes in ITER. Control of these relaxations through externally induced resonant magnetic perturbations (RMPs) has first been demonstrated on DIII-D [1] and then confirmed in several other tokamak experiments [2, 3]. However, it is not clear to which extend the externally induced perturbation actually penetrates into the plasma. In particular, theoretical investigations [1] as well as magnetohydrodynamical (MHD) [4, 5], and more general fluid modeling [6] reveals an effective screening of RMPs by a rotating plasma.

In this work, we study the penetration of RMPs via numerical simulations in a reduced MHD model using the three-dimensional electromagnetic turbulence code EMEDGE3D [7]. In this model, the plasma response to RMPs can be studied in presence of flux driven micro-turbulence and a transport barrier induced by sheared plasma rotation. In a first step, we consider cases where the total heat flux and the corresponding pressure gradient are below the micro-instability limit. This condition is used to focus only on the effect of plasma rotation on RMP penetration. The screening of the external RMP clearly increases with the plasma rotation and penetration only occurs if the velocity vanishes on the corresponding resonant surface. If an external multiple harmonics perturbation is applied, only one resonant RMP harmonic penetrates. This harmonic is localized on the resonant surface where the poloidal velocity vanishes. The origin of this screening effect is due to the self generation of counter currents in Ohm's law.

When the plasma is studied in a statistically stationary turbulent state, the self consistent plasma rotation, governed by Reynolds and Maxwell stresses, leads to a self organization where RMP penetrates.

In presence of turbulence, the sheared plasma rotation studied here is known to generate a transport barrier which relaxes quasi-periodically [7]. Previous works based on electrostatic turbulence simulations, have shown that the transport barrier can relax, which is an essential characteristics of ELMs, and that relaxations can be suppressed by RMPs [8, 9]. In the next part of this work, the interaction between ELMs and RMP will be studied in an electromagnetic case.

References:

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