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Control of neo-classical tearing mode in reversed magnetic shear tokamak plasmas

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Abstract

A reduced magnetohydrodynamic (MHD) model including bootstrap current is employed to numerically study the neo-classical tearing mode (NTM) in the reversed magnetic shear (RMS) configuration. It is found that, in the large Δr_s case, an explosive burst, which was previously observed only in the intermediate Δr_s case with $f_b = 0$, can also be induced as long as the fraction of bootstrap current f_b is high enough. In the intermediate Δr_s case, such explosive bursts can be evidently brought forward. Considering the underlying risk of plasma disruptions, the control of the NTM and the NTM triggered explosive burst is urgently imperative. Thus, two effective suppressing methods are investigated in this work. One is the employment of differential plasma rotation. It is found that the differential rotation with a strong shear at the outer rational surface can effectively suppress the explosive burst. Moreover, a couple of measurable parameters (δ, κ), respectively corresponding to the triangularity and elongation of the magnetic islands, are introduced to characterize the deformation of islands. It is found that the triangularity δ is a promising parameter to precisely predict the onset of burst. The other method adopted in this work is electron cyclotron current drive (ECCD). The self-consistently evolving EC driven current is included in the reduced MHD equations. It is found that the ECCD with appropriate input power and switch-on time can effectively stabilize the neo-classical islands. During the nonlinear evolution, the intense fluctuations of the magnetic surfaces, directly related to the strong zonal magnetic field, can damage the steady deposition of the driven current. Thus, the switch-on time should be put forward to avoid the strong zonal field. By adopting this scheme, the explosive burst can also be effectively suppressed. Moreover, some suggestions are proposed for tokamak experiments.

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