Modeling of robust NTM control by ECCD in AUG

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Neoclassical tearing modes (NTMs) can be controlled using Electron Cyclotron Current Drive (ECCD) as demonstrated in many tokamaks [1]. A new method, relying on sweeping ECCD deposition around the estimated position of the mode has been successfully tested on TCV[2] and applied to ASDEX-Upgrade during the 2014 MST-1 campaign. It relies on the fact that the mean effect of the sweeping will still be favorable for the mode reduction, which removes the need for modulation or precise rational surface localization. This allows the development of robust control systems.

In this work, we analyze results obtained in shot AUG #30594 using the 3D full MHD code XTOR-2F [3], which includes a current source term in the Ohm’s law modeling ECCD, as well as a additional equation to describe the equilibration of this injected current density along the field lines. XTOR-2F also features diamagnetic and neoclassical effects, the latter being implemented via the neoclassical viscous stress tensors [4].

One of the concerns arising from the sweeping procedure is that it could have deleterious effects on the equilibrium, by increasing the mode stability index when the current deposition is off the rational surface [5]. We show that this impact is however relatively small, 3D effects being therefore dominant for NTM stabilization. We then move to the framework of nonlinear simulations including neoclassical and bi-fluid effects and study the dynamics of a (3,2)-NTM in presence of an external current source. We construct an equilibrium from AUG data and find the bootstrap fraction \( j_{bs}/j \) to be around 28% on \( q = 3/2 \). We especially focus on the current intensity, and hence injected power, required to effectively control the mode. We compare it to the criterion described in [6] and to experimental results.

References