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Securing high beta_N JT-60SA operational space by MHD stability and active control modelling

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A careful numerical evaluation of MHD stability and of active control strategies is of paramount importance to reach one of the main goals of JT-60SA (Super Advanced) device, namely the development and qualification of high beta_N, steady-state regimes for future reactors like DEMO. Thanks to its powerful and flexible additional systems for heating and current drive, to its shaping capabilities and to several actuators for different kinds of real-time plasma control, JT-60SA aims at studying plasmas exceeding both the threshold for neoclassical tearing mode (NTM) destabilization and the so called Troyon no-wall beta limit for external kink instabilities. This work reports on the latest results on key issues in MHD stability and control of JT-60SA advanced tokamak plasmas, with particular reference to Neoclassical Tearing modes (NTM) and Resistive Wall Mode (RWM) physics.

The amplitude evolution of NTM instabilities in the reference high beta_N scenarios is investigated by numerical tools developed in the framework of the European Integrated Tokamak Modelling effort. By solving the Generalized Rutherford Equation the role of different effects (such as bootstrap, curvature and polarization) is evaluated, including mode frequency evolution. Active NTM stabilization techniques are explored by modeling the action of the dual frequency (110 GHz and 138 GHz) electron cyclotron system.

JT-60SA steady state scenarios present also new challenges for RWM stability studies given their targets in terms of beta_N (˜4) and bootstrap current fraction (˜70%). A further issue is given by the presence of a population of fast particles generated by high-power, high energy (10 MW at 500 keV) negative neutral beam injection system. The 2D stability code MARS-F/K is used to study plasma flow and drift kinetics stabilizing effects. Wall stabilization effects are estimated by the CarMa code that couples the 2D plasma stability to a 3D description of the passive boundaries surrounding the plasma. Feedback control of RWMs as provided by a set of 18 active coils is studied by the self-consistent inclusion in the model of a representation of the control system producing an overall dynamic model cast in the state variable space.

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