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Progress in Theoretical Studies of Resistive Wall Modes for RFP plasmas and Comparison with Tokamaks

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Recent results of the theoretic studies on Resistive Wall Modes (RWM) in Reversed Field Pinch (RFP) plasmas are reported. Different features of RWM instabilities between RFP and tokamak are investigated in order to provide in-depth understanding on RWM physics. The toroidal MHD-kinetic hybrid stability code MARS-K [1] was applied to the studies, taking into account the full kinetic effects of the thermal particles and the isotropic/anisotropic Energetic Particles (EP).
A brief summary on the characteristics of RWMs in RFP configuration are presented. Especially, due to the different mechanisms of the kinetic damping, the stabilization of RWMs in RFPs requires a plasma rotation at least in the range of the ion acoustic frequency; whereas only very slow, even vanishing rotation is required for stabilizing the pressure driven RWMs in the tokamak plasmas.
The shaped cross section of the RFP plasmas leads to a lower ideal wall beta limit than that of the circular one; and does not bring an appreciable benefit in kinetic damping on RWMs. The physics mechanism leading to the conclusion is provided by the analysis. The energetic particle effects on RWMs in RFP plasmas are also investigated. Furthermore, a non-resonant fishbone-like mode (FLM) in RFP plasmas is predicted. The FLM instability is an external kink mode, which can be driven by the resonance of the precession drift of the trapped EPs under certain condition, even for a RFP with an ideal wall. The kinetic effect of thermal particles plays a stabilizing role on FLMs in RFPs,. Different features of FLM instabilities in RFP and tokamak plasmas are discussed. 3-D magnetic perturbation of RWMs can induce neoclassical toroidal viscosity (NTV) in RFP plasmas. The preliminary results will be presented and discussed.
Example of the experimental study on RWM in RFX-mod, correlated to the theory, will be presented.
In a complementary way, the possibility to exploit the internally non-resonant kink instability to build up 3-D RFP helical state is studied by means of the 3-D non-linear MHD visco-resistive codes SpeCyl and PIXIE3D [2].

[1] Y.Q. Liu et al, PoP 15, 112503 (2008)
[2] S. Cappello et al., Proc 24th IAEA FEC(2012)

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