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Multi-Scale Interaction between Ballooning Mode and Electron-Scale Turbulence and the Mesoscale Structure Formation in the Edge Pedestal

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Recent MHD simulations [1-2] have demonstrated that one of the important ingredients giving rise to the ELM [3] crash is the hyper-resistivity in the Ohms law. In this paper, we address three key issues: i) the source for the hyper dissipations (e.g. hyper resistivity and hyper viscosity); ii) high-k ballooning mode (BM) driven by hyper-dissipation near marginally stable BM boundary; iii) the possible nonlinear saturation mechanism of the high- BM. We present a simple self-consistent theoretical model for hyper-resistivity ballooning modes (HRBM) accounting for the multi-scale interaction between the long scale BM and the short scale ETG mode above a BM threshold. Here, the coupling between the BM and the ETG turbulence has been identified as a primary mechanism for the generation of the long scale hyper-resistivity ( ) [4] and hyper-viscosity ( ) in BM dynamics. Based on the linear theory, the physics of HRBM mode has been elucidated, as well as the parameter space where it is important. It is shown that the growth rate of HRBM increases with the increasing poloidal wave vector ( ) whereas standard BM growth decreases with . Another long standing problem is how KBM (here particularly HRBM) saturation occurs so rapidly. The possibility of long scale zonal fields [e.g. mesoscale poloidal magnetic fields (zonal current) and radial magnetic fields (streamers)] are examined in this study. Further their potential impact on thermal transport and an ELM crash are also considered.

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