Understanding the Dynamics of H-mode Pedestal and ELMs in KSTAR Through Extended Plasma Edge Modeling*

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Using the ECE imaging diagnostic, several distinctive patterns of the MHD activity have been recently discovered in KSTAR. In particular in a large number of discharges with type I ELMs, a quick stage of the pedestal recovery is followed by the formation of quasi-stationary structures that are characterized by n=7-9 toroidal mode numbers. During the later stage of the H-mode pedestal development, similar quasi-stationary structures, but with lower toroidal mode numbers in the range from 5 to 6, are observed. It is not clear if the observed MHD structures lead to the enhanced particle and thermal transport in the plasma edge region and limit the pedestal growth. It is also not clear if these structures are related to the triggering of ELM crashes. Progress in the development of a comprehensive model for the KSTAR plasma edge, that can be used in the interpretation of experimental results and resolving the ambiguities related to the quasi-stationary MHD structures, is presented. The equilibrium TEQ and TOQ solvers are used to generate a KSTAR equilibrium cloud. The ideal stability codes are used to analyze the H-mode pedestal stability. The kinetic neoclassical XGC0 code is used to investigate the neoclassical aspects of the H-mode pedestal dynamics. This includes the computation of the radial electric field structures and the bootstrap current profiles. The extended MHD NIMROD and BOUT++ codes are used to study the pedestal stability and the dynamics of ELM crashes. A hierarchy of MHD models in NIMROD is considered in order to isolate the role of separate effects on the H-mode pedestal dynamics. The models include the resistive, gyro-viscous, two-fluid and two-fluid two-temperature models. Using the combination of ideal MHD, extended MHD, and neoclassical codes, it is found that the Sauter formula for the bootstrap current is likely to under-predict the parallel current density by at least 15%. The BOUT++ and NIMROD codes yield comparable growth rates but different spectrum of unstable modes. The gyro-viscosity and parallel viscosity effects are found to stabilize these modes. The two-fluid effects destabilize them and bring the growth rates close to the resistive growth rates. The extended MHD analysis shows that two-fluid two-temperature MHD effects can either stabilize or destabilize the MHD modes in the plasma edge region. Preliminary nonlinear results are also presented.

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