Hybrid kinetic-MHD multi-n simulations of ELMs in the ASDEX Upgrade tokamak with MEGA

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Edge localized modes (ELMs) driven by sharp pressure gradients and current densities at the plasma boundary will likely lead to transient and intolerable energy and particle losses in future fusion devices, like ITER [1]. Although the ELM nature is well understood, their behavior and their consequences in a burning plasma with a significant population of energetic-ions is still missing. Recent experimental observations show the ejection and acceleration of energetic ions during ELM crashes [2, 3], indicating a strong interaction between the energetic particle population at the plasma edge and the electromagnetic perturbation developed during an ELM crash. A thorough understanding of the interplay between energetic ions and ELMs is, thus, mandatory to develop sound ELM control techniques for burning plasmas, as well as to be able to predict their impact on the plasma, including fast-ion confinement.

The nonlinear hybrid kinetic-MHD MEGA code [4] has been used to study the interaction between energetic particles and ELMs in an ASDEX Upgrade H-mode plasma [5]. Previous simulations showed (for the first time) that, although the ELM is driven by the edge pressure gradients, energetic ions kinetic effects determine the spatio-temporal structure of ELMs. These simulations reproduced some outstanding ELM observations in low collisionality plasmas with large fast-ion contents that feature abrupt and large type I ELM crashes [6]. In this contribution, we extend our previous work to multi-n simulations of ELMs (with $n = 0, \cdots, 10$) in the presence of energetic-ion kinetic effects. These new simulations show that fast-ions modify the most dominant mode number due to the poloidal rotation induced by fast-ion kinetic effects. While $n = 10$ is the most unstable mode in the standard MHD simulations, $n = 8$ becomes more unstable in the presence of energetic-ion kinetic effects. A resonant power exchange between fast-ions and each mode is observed, which strongly affects the spatio-temporal structure of all modes.

References

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