Multi mode Hybrid Kinetic-MHD Simulations of Edge Localized Modes and Alfvén Waves in the Presence of Energetic Particles in the ASDEX Upgrade Tokamak

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Extensive experimental [1, 2] and theoretical [3] works have recently demonstrated a strong interaction between energetic particles and Edge Localized Modes (ELMs).

Hybrid kinetic-MHD simulations conducted with the MEGA code [4] revealed the key role that energetic particles kinetic effects have on the spatio-temporal structure of type-I ELMs in NBI heated discharges in the ASDEX Upgrade tokamak. A resonant interaction between the fast-ions and the ELM perturbation lead to a wave-particle energy and momentum exchange that modifies the ELM amplitude, crash timing and spatial structure.

In the presence of Alfvénic fluctuations, during the linear phase, a strong interaction between both the Alfvénic and the ballooning mode prior to the ELM crash is observed. The edge pressure and fluid velocity perturbations tend to oscillate at the Alfvénic mode frequency with a static ballooning structure. Within the radial overlapping layer of both perturbations, they rotate, out of phase, at the Alfvénic frequency (~150 kHz). In the presence of the ELM, the growth rate of the Alfvénic fluctuation is ~2 larger and a redistribution of the fast-ion radial profile in the region of positive gradient is observed right after the ELM starts building up (i.e. before the Alfvén wave emerges). Redistributed particles are observed to overlap with the ELM region along their outer banana leg and the Alfvén instability along the inner banana leg. Wave-particle power exchange analysis is applied to study the role of this redistribution in the drive or damping of the Alfvénic waves.

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