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Infernal modes at tokamak H-mode pedestal

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Abstract

This paper investigates the infernal modes at tokamak H-mode pedestal and their possible correlation with the so-called outer modes (OMs) observed at JET or edge harmonic oscillations (EHOs) observed at DIII-D and other tokamaks. It is also proposed to mitigate edge localized modes (ELMs) by externally exciting infernal modes at the extremal points of safety factor at H-mode pedestal. In the H-mode pedestal region, safety factor can be non-monotonic. The bootstrap current induces a q_{max} at pedestal top and q_{min} closer to the edge. Since magnetic shear vanishes at q_{max} or q_{min}, total field line reconnection (i.e., islands) is minimized. On the other hand, the minimum shear stabilization pertinent at the extremal points of safety factor, tends to favor the excitation of infernal modes. In this study, the excitation of infernal modes is investigated by our AEGIS code numerical computations. Our study is intended to support our conjecture that OMs observed at JET or EHOs observed at DIII-D and other tokamaks are actually the infernal modes at the extremal points of safety factor at pedestal. Infernal modes at the extremal points of safety factor at H-mode pedestal are predominant internal modes and are decoupled from the scrape-off-layer (SOL) MHD activities. Therefore, they have less chance to develop into ELMs through the positive feedback process due to the excitation of SOL current. Infernal modes, therefore, can allow release transport barrier energy in a nonirritating manner. These characters show that the infernal modes can be an interesting candidate to explain the OMs/EHOs observed experimentally. In addition, we propose another type of ELM mitigation method based on externally applying resonance magnetic perturbation (RMP) with magnetic pitch coinciding with the safety factor at the extremal points of safety factor at pedestal in H-mode discharges. It is referred to as magnetic-surface-preserving RMPs (MSP-RMPs). Conventional RMP experiments target on generating a stochastic field line structure at plasma edge to release plasma energy in order to mitigate ELMs. But magnetic islands and stochastic field line structures can, considerably, affect H-mode confinement. Instead, MSP-RMPs may be much less damaging to the magnetic surface structure, thereby allowing ELM mitigation without seriously downgrading H-mode confinement. This is just like externally exciting infernal modes (or OMs/EHOs in our explanation) to mitigate ELMs. This research was supported by the Office of Fusion Energy Sciences of the U.S. Department of Energy under Grant DE-FG02-04ER54742.