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QH-modeとELMy H-modeにおけるMHD安定性に対する プラズマ回転・イオン反磁性ドリフト効果の影響の比較

Comparison of MHD stability property between QH-mode and ELMy H-mode plasmas by considering plasma rotation and ion diamagnetic drift effects

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In H-mode regime in tokamaks, edge localized modes (ELMs) often appear and induce large heat load to divertors. Quiescent H-mode (QH-mode) is one of the promising candidates realizing ELM suppression and high confinement performance with reactor-relevant plasma parameters [1]. The QH-mode plasma in DIII-D can be obtained easily when plama current I_p, ion temperature T_i and sheared rotation counter to the I_p direction are large in edge pedestal region under low pedestal collisionality condittion. Linear MHD stability in QH-mode plasmas has been analyzed by considering plasma rotation and ion diamagnetic drift (ω_{*i}) effects with MINERVA-DI code, and it was clarified that the coupled rotation and ω_{*i} effects stabilize current-driven kink/peeling modes (K/PM) although rotation destabilizes the modes when neglecting the ω_{*i} effect [2]. On the other hand, the analysis with MINERVA-DI also identified that a peeling-ballooning mode (PBM) in JT-60U and JET-ILW can be destabilized by rotation even when including the ω_{*i} effect [3]. As discussed in [2,3], rotation direction dependence of stability is one of the candidates of the physics reason responsible for the difference, but a difference in driving source of MHD modes and/or that in the ω_{*i} effect are also candidates of the reasons.

In this study, we analyze the MHD stability at edge pedestal in ELMy H- and QH-mode plasmas in DIII-D by considering the rotation and ω_{*i} effects. As shown in the stability diagrams of #163477/1.8sec. (QH-mode) and #163477/4.44sec. (ELMy H-mode) plasmas in Fig. 1, the operational point is near K/PM boundary in QH-mode although that is near PBM one in ELMy H-mode. In addition, the plasma rotation stabilizes the K/PM in QH-mode, but has little impact on the PBM stability in ELMy H-mode. Physics reasons responsible for the difference in MHD stability property will be discussed; in particular, we will pay attention to the effects of plasma rotation and ω_{*i}. Work supported by US DOE under DE-FC02-04ER54698.

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[2] N. Aiba et al, Nucl. Fusion 60, 092005 (2020).
[3] N. Aiba et al., Nucl. Fusion 57, 022011 (2017), N. Aiba et al., Nucl. Fusion 57, 126001 (2017).

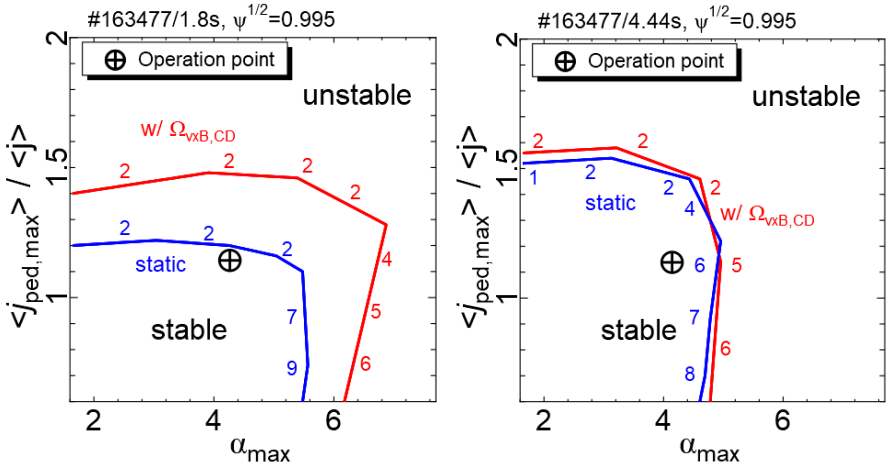

Fig.1: Stability diagrams of QH-mode (#163477/1.8sec., top) and ELMy H-mode (#163477/4.44sec., bottom) plasmas. Red (blue) line shows MHD stability boundary analyzed with (without) rotation effect.