9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Investigation of the evolution and interaction of e-ITB and core MHD in J-TEXT

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The internal transport barrier (ITB) is attractive for future fusion reactors due to its excellent confinement [1,2]. MHD activities are one of the mechanisms that trigger ITBs [3-5]. Recent experiments on J-TEXT have demonstrated a significant correlation between e-ITB features and core MHD activities, and observed the evolution of MHD mode interactions during ITB discharge.

In J-TEXT, e-ITB can be triggered by on-axis deposition of electron ECRH power under specific plasma parameters. During the ITB sustainment phase, the plasma core exhibits a strong 1/1 internal kink mode and small-amplitude sawteeth. This implies that the q value in the plasma core is slightly less than 1 and the q profile is relatively flat, likely contributing to the ITB's sustainment. Furthermore, the ITB performance can be adjusted by varying the ECRH power. As shown in figure 1(a), it is positively correlated with the density-normalized ECRH power with no obvious power threshold.

Off-axis ECRH deposition can also trigger e-ITB formation, accompanied by an m/n = 1/1 internal kink mode and an m/n = 2/1 neoclassical tearing mode (NTM). These two MHD modes are strongly coupled at the same frequency. The basic signal waveform is shown in figure 1(b), and figure 1(c) presents electron temperature profiles under different plasma conditions. Observations using soft X-ray array imaging and electron cyclotron emission (ECE) diagnostics reveal that the coupling phase of these two MHD modes evolves from in-phase to out-of-phase with increasing β. Figure 1(d) shows the two MHD modes in an out-of-phase coupling. Their interaction also affects the amplitude evolution of each other. Initially, the amplitude of the 2/1 NTM increases. Upon reaching a certain threshold, the core 1/1 mode begins to grow rapidly and saturate. Subsequently, the amplitude of the 2/1 mode decreases until it completely disappears. Thereafter, the plasma confinement performance further improves, evidenced by a further increase in the core electron temperature.

Notably, in both scenarios, the strength of the ITB is positively correlated with the amplitude of the core perturbation displacement caused by the 1/1 mode, and the position of the ITB is strongly associated with the location of the MHD modes. Further details will be presented at the conference.

This work is supported by the National MCF Energy R&D Program of China (No. 2019YFE03010004).

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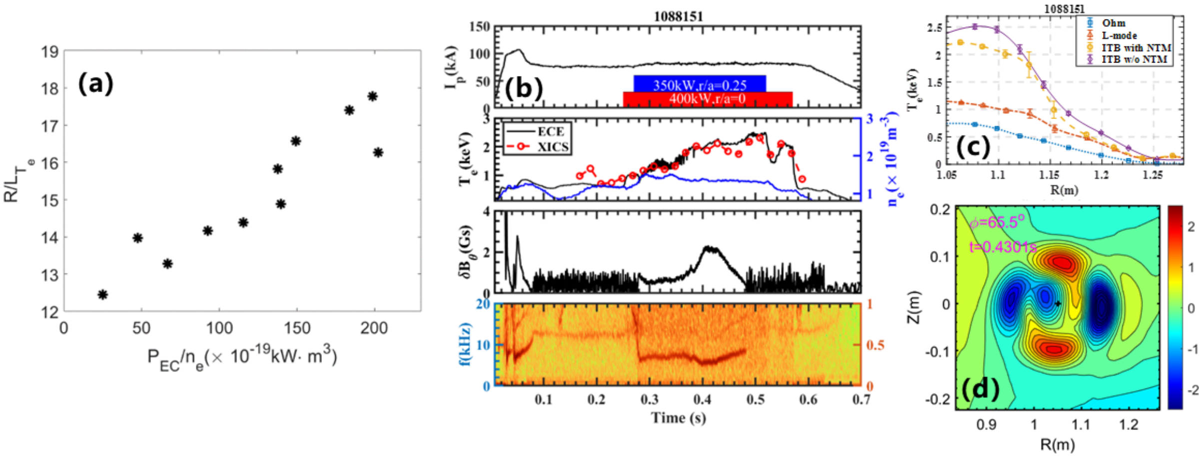

Figure 1 (a) The relationship between ITB performance and normalized power of ECH. (b) Basic waveform of ITB discharge. (c) Electron temperature profiles. (d) Distribution of reconstructed SXR perturbations.