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The Investigation of Multi Tearing Modes Coupling and Controlling Multi Modes Coupling via Resonant Magnetic Perturbation on J-TEXT

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The coupling between tearing modes (TMs), especially m/n = 3/1 and 2/1 modes (m and n are poloidal and toroidal mode numbers, respectively), usually causes two large saturated TMs. When the amplitudes of TMs are significantly large, the initial mode locking occurs followed by major disruption. Recently, a systematic study on the multi TMs coupling and controlling the multi modes coupling by resonant magnetic perturbation (RMP) has been carried out in the J-TEXT tokamak.

During the multi modes coupling, the instantaneous rotating frequency of 3/1 TM is oscillated by the 2/1 TM, which is reflected as two peaks in the spectrum. It is found that the TM instantaneous frequency could also be oscillated by the rotating RMP. Due to the similarity between the dynamic process of those two cases, the locking of a TM to a rotating RMP has been investigated both analytically and experimentally. When the amplitude of the TM instantaneous frequency oscillation (δf) is larger than the average frequency difference between TM and RMP (Δf), the TM starts to be locked on the rotating RMP. The amplitude of δf is linear with the amplitude of RMP and increases nonlinearly with the decreases of Δf, which suggests the multi TMs coupling could be prevented by suppressing one of TMs or increasing the frequency difference between TMs.

The RMP is an effective method of the high frequency TMs control and the TM prevention. The moderate 2/1 RMP can suppress the rotating small 2/1 mode, while leaves the small 3/1 mode rotating at around 12 kHz and the multi modes coupling is prevented. The 3/1 RMP can excite a large 3/1 locked island at q = 3 in the plasma boundary, while the frequency difference between two TMs is around 8 kHz and is too high for the multi modes coupling. Both of two cases can avoid the growth of these two modes and prevent the disruption, which present a set of RMP strategies for the TM control and the disruption prevention in the large devices. For the coupled TMs, a faster rotating RMP was used to accelerated the TMs and avoid the disruption [1]. A more effective method to accelerate the TMs, the moderated RMP [2], also was presented in experiments.

References
[1] D. Li et al 2020 Nucl. Fusion 60 056022
[2] Q. Hu and Q. Yu 2016 Nucl. Fusion 56 034001

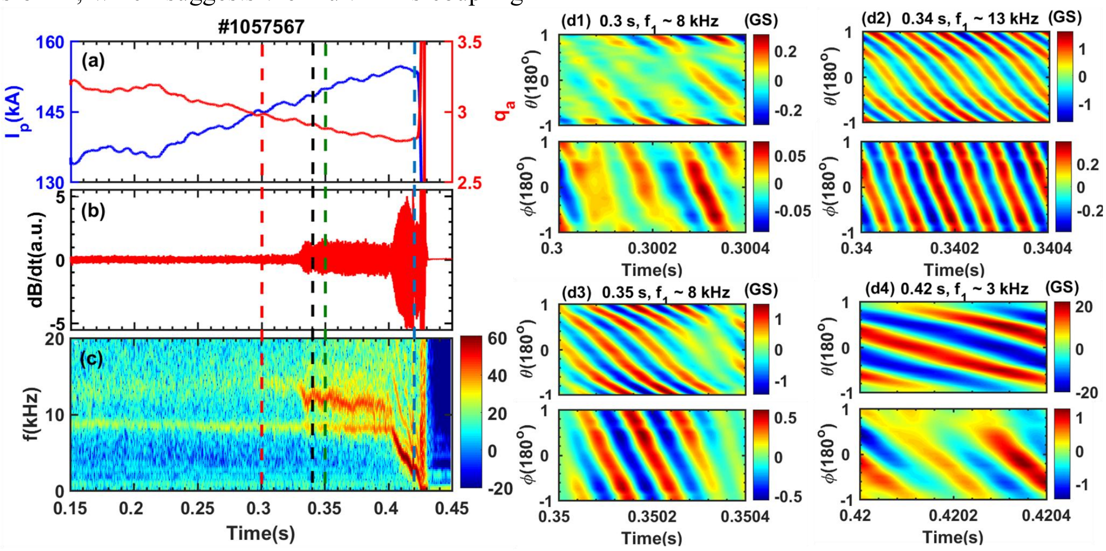

Figure 1. Temporal evolution of (a) the plasma current I_p (blue) and edge safety factor q_a (red), (b) the Mirnov coil signal dB_θ/dt, (c) power spectrum of the Mirnov signal to show the mode frequency and strength, (d1), (d2), (d3) and (d4) corresponding to the time evolution of the δB_θ poloidal and toroidal distribution measured by the poloidal and toroidal magnetic probe arrays in (c) respectively. This displays one typical example of the coupling process of multiple MHD modes during discharge #1057567.