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The locked mode disruption mechanism and its control by n=2 RMP in J-TEXT

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The major disruption in tokamak is commonly associated with the locking of m/n = 2/1 tearing mode (TM) and the interactions between coupled MHD modes[1-4]. Various models are developed to explain the mechanism of locked mode (LM) disruptions for efficiently mitigating or controlling the disruption. Recent research on J-TEXT has revealed the evolution of multiple coupled modes prior to disruption, and proposes a novel strategy of controlling TM and LM disruptions by n = 2 RMP.

By applying a rotating resonant magnetic perturbation (RMP) field, the TMs were locked to the rotating filed. As a result, the multiple coupled modes can be easily distinguished from the perturbated signals. The 2/1 TM is in-phase coupled with a 3/1 TM, and a 1/1 structure is also observed in the core plasma. The development of the 2/1 TM is crucial for disruption, while the amplitudes of the 3/1 TM and the 1/1 structure remains nearly unchanged approaching disruption. The growth of the 2/1 mode prior to the major disruption can be clearly divided into a phase of slow increase and a phase of rapid growth. The development of the three-dimensional structure of the thermal quench is observed by ECE and soft X-ray (SXR) arrays installed at different toroidal positions. The SXR profiles at different toroidal and poloidal positions show asymmetry structures, as shown in figure 1. The structure of the 1/1 cold bubble in the core is identified. By statistically investigating the thermal quench behavior under different locked island phases, it is found that the 1/1 cold bubble and the 2/1 magnetic island are not strictly in-phase coupled.

The n = 2 RMP has been found to suppress 2/1 TM in simulation[5]. Experiments of the 2/1 tearing mode suppression by n = 2 RMP have been carried out in J-TEXT. The newly constructed helical coils (so called external rotational transform coils for regular direction of plasma current) were used to provide the n = 2 RMP filed which mainly contains the 2/2, 3/2 and 4/2 components for reversed plasma current. In the ohmic plasma, the 2/1 TMs were locked and then suppressed after applying the n = 2 RMPs, as shown in figure 2. The suppression effect is related to the phase of the 2/1 locked island. The 2/1 TM is suppressed when the O-point of 2/1 locked island is aligned with the X-point of the 2/2 vacuum island at the low field side midplane. In the ECRH plasma, the 3/2 island is excited after applying n = 2 RMP, followed by a temperature collapse, then the 2/1 island disappears and both plasma density and temperature increase. Further details will be presented at the conference.

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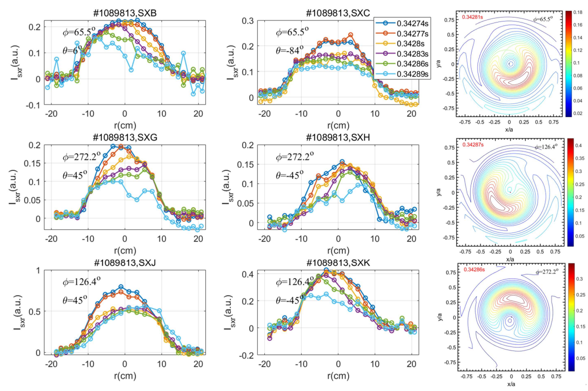

Figure 1. The evolution of SXR profile at different toroidal positions during thermal quench

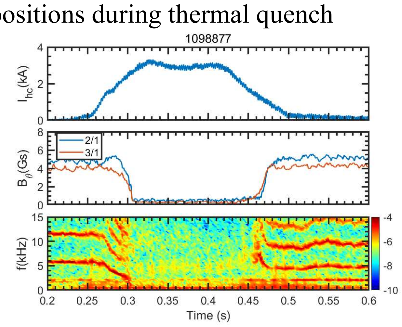

Figure 2. Suppression of a locked 2/1 island by n = 2 RMP