

Reduction of sawtooth amplitude by $m/n = 2/2$ resonant magnetic perturbation in J-TEXT

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Researches of resonant magnetic perturbations (RMPs) and MHD activities have been carried out in J-TEXT for several years [1], such as MHD control by external RMPs. In early stage, it was found that 2/1 RMP would trigger 2/1 locked island so that sawtooth oscillations would transform into oscillations of a small amplitude [2]. To study effects of RMP on sawteeth, 1/1 RMP was first utilized in several campaigns of J-TEXT experiments, but no obvious effects have been not found in J-TEXT yet though sawteeth have been mitigated in DIII-D and RFX plasmas with lower edge safety factor [3]. Afterwards, 2/2 RMP is considered as a likely reliable way to affect sawteeth due to the same resonance layer near $q = 1$ surface and then large amount of experiments applying 2/2 RMP have been conducted for this target in recent years in J-TEXT.

The J-TEXT is a limiter tokamak with major radius $R = 105$ cm and minor radius $a = 25 - 29$ cm, equipped with 24 in-vessel RMP coils [3] to produce RMPs of dominating 2/1, 1/1 or 2/2 component. In this work, the RMP system employs the 2/2 configuration and generates $n = 2$ RMPs with a dominant resonant 2/2 component of an amplitude of 7.5 Gauss/kA at plasma edge ($r = a$) and the amplitudes of $m/n = 3/2, 4/2$ and $5/2$ sidebands are 1.6, 1.0 and 0.8 Gauss/kA, respectively. In addition, a small 2/1 component (0.5 Gauss/kA) is produced and not enough to trigger 2/1 locked mode yet.

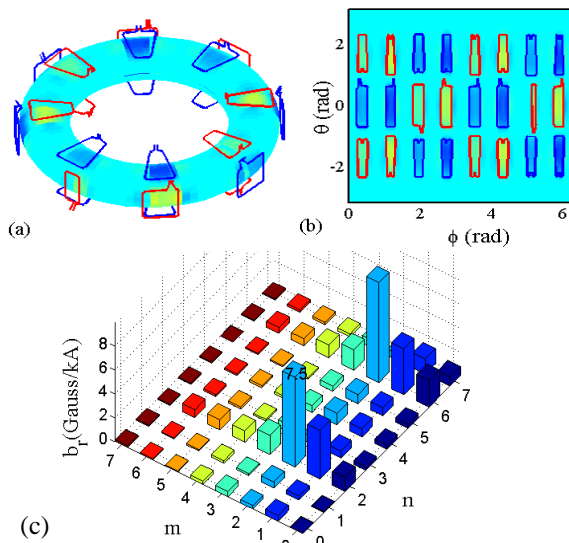


Fig. 1. (a) 24 RMP coils, (b) magnetic perturbations on plasma edge in (θ, ϕ) plane, and (c) the amplitude of each component

When applying 2/2 RMP, the sawteeth are reduced by a half in amplitude and the core plasma rotation velocity is driven towards the co-current direction [4], which is shown in Fig. 2. The profiles of electron density and temperature are pulled down inside $q = 1$ surface, and 2/2 unlocked island is observed in ECE measurements after RMP is off, revealing that the 2/2 island should be triggered by 2/2 RMP. Sawteeth recover the foremost period and amplitude when the 2/2 island starts rotating, inferring reducing sawteeth should be highly related to 2/2 locked island triggered by RMP penetration.

In J-TEXT, the RMP system has the maximal current of 4 kA at present and based on the capacity, the sawtooth mitigation is observed with lower q_a and n_e values ($q_a < 2.8$ and $n_e < 2 \times 10^{19} \text{ m}^{-3}$). Further experiments and numerical modelling are still essential to clarify the effects of 2/2 RMP on sawteeth with the higher q_a and n_e .

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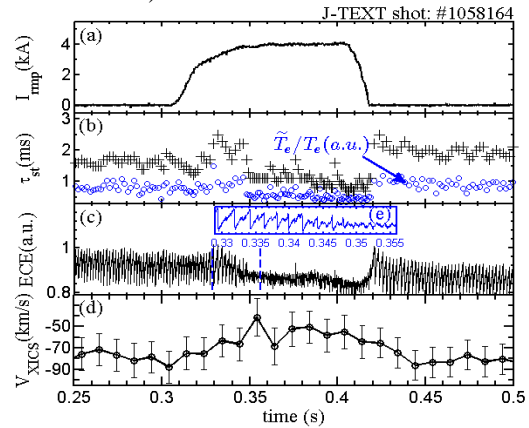


Fig. 2. Sawtooth is reduced by 2/2 RMP: (a) the RMP coil current I_{rmp} , (b) sawtooth period and magnitude, (c) the ECE signal at 8.2 cm, (d) toroidal rotation velocity in plasma core.

References

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