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Recent study on the locked mode physics in J-TEXT

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The formation of Locked Mode (LM) in an axisymmetric tokamak plasma due to the penetration of resonant magnetic perturbation (RMP) is of great importance in the control of various MHD activities. It could be either harmful for a core mode (m/n = 2/1 mode) or beneficial for a boundary mode in the pedestal region for ELM control. Recently, a systematic study on the locked mode physics has been carried out on J-TEXT by using the flexible RMP coils, which can produce a RMP field with dominant 2/1, 3/1 or 2/2 component, respectively.

The excitation threshold of 2/1 LM has been observed to first increase [1] and then decrease [2] with the increase of core line averaged density towards $4.5*10^{19}$ m^{-3}. The roll-over of density scaling contradicts to the previous empirical density scaling law, which is usually monotonic. By taking the dependence of plasma rotation into account, it is found that the LM threshold depends only weakly on the density but linearly on the plasma rotation. This result is not only important for the prediction of error field tolerance in fusion devices, but also opens a question on the role of density in the forced magnetic reconnection process in magnetized plasmas.

The formation of locked mode in other rational surfaces, such as q = 1 or 3, is not so dangerous as the 2/1 LM, while they may be even helpful for the control of plasma. By applying an n = 2 RMP field, the 2/2 LM is excited due to the penetration of 2/2 RMP field, and then triggers the bifurcation of sawtooth behavior [3], characterized by the abrupt decrease of sawtooth period and magnitude. This might provide a new tool for understanding the sawtooth physics. The RMP coil connection recipe has been modified in the middle of 2019, and hence allows the differential phase ($\Delta\varphi$) scan among the three rows of coils. The 3/1 RMP component with $\Delta\varphi$ = -90 degree is much larger than the previous odd parity case ($\Delta\varphi$ =180 degree), and hence successful formation of 3/1 locked island was achieved in the edge plasma at a much higher electron density (n_e = $2.5\sim3.5*10^{19}m^{-3}$) compared to the previous results [4]. Especially, it is found that the 3/1 island width is reduced periodically corresponding to each sawtooth crashes, which is enhanced by depositing ECRH power just inside the q = 1 surface. This type of interaction between core MHD activities and the boundary locked island might be also important for maintaining the ELM suppression by using RMP, where a LM is supposed to be induced at the top of pedestal.

References

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