The impact of locked mode on the disruption process and the generation of runaway current

Ruihai Tong[1], Zhongyong Chen[2], Z.F. Lin[2], Z.H. Jiang[2], J. Huang[2], L.Z. Liu[2], W. Li[2], Y.N. Wei[2], W. Yan[2], D. Li[2], X.M. Pan[2], P. Shi[2], N.C. Wang[2] , C.S. Shen[2], Z.J. Yang[2] and J-TEXT Team
[1] Southwestern Institute of Physics, [2] Huazhong University of Science and Technology
e-mail (speaker): tongruihai@swip.ac.cn

Major disruption is one of the most serious concerns for the reliable operation of future large-scale tokamaks such as ITER. The generation of a large post-disruption runaway electron (RE) current poses a serious threat for high current tokamaks [1, 2]. Localized loss of a RE beam with energy up to tens of MeV and a current up to about ten MA can lead to severe melting and damage of plasma facing components and underlying structures in ITER. To minimalize potential disruption damage, a reliable runaway current suppression scenario and a well understand of physics during disruption process are required.

For the inevitable disruption in ITER, the locked uncontrolled modes are likely to appear before the application of disruption mitigation system (DMS). So, the interaction between injected impurities and plasma with 3D effect in plasmas with large pre-existing locked modes must be well understood to ensure the effective disruption mitigation and RE suppression in ITER.

A series experimental works has been carried out to study the impact of the pre-existing locked mode on disruption process during the DMS shutdown [3]. The *m/n* = 2/1 locked mode is induced by resonant magnetic perturbation (RMP) penetration and then massive gas injection (MGI) system is triggered to shutdown the plasma. It is found that both the phase and width of the 2/1 locked mode have an important effect on MGI shutdown dynamics. When the mode is larger than a critical width (W_T ≈ 4 to 5 cm in J-TEXT), the penetration depth and the assimilation of impurities can be enhanced during the pre-TQ phase. This results in a faster quenching process when the relative phase between the O-point of the 2/1 island and the MGI valve is around +90°.

The RMP system is alternative for runaway suppression by the advantage of generating the stochastic magnetic field lines [4, 5]. It is found that with a large amplitude RMP, the generation of the RE current can be enhanced [6]. The full runaway suppression has been achieved in some case. The NIMROD simulations shows that the relative phase between the MGI and 2/1 islands induced by RMP is important for RE suppression [7]. All these results suggest that the 3D effect between the injected impurities and the 2/1 locked mode is important during the disruption and RE suppression process.

References

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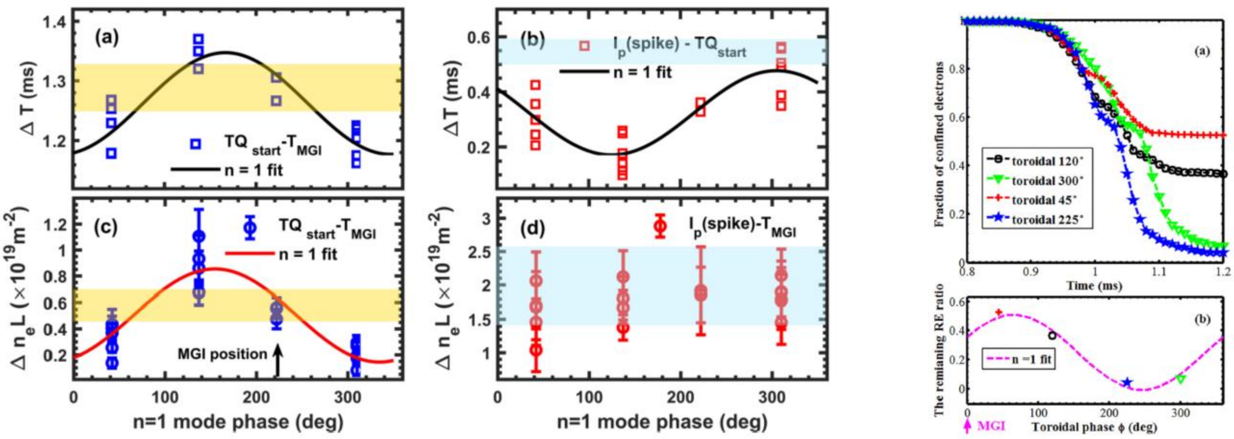

Figure 1. The impact of the n = 1 locked mode phase to MGI shutdown dynamics. Left (a) The time interval between TQ-start and T-MGI, (b) the time interval between the Ip-spike and TQ-start. The average value of neL from r = −18 to +18 cm, (c) at the TQ-start and (d) at the Ip-spike are shown as a function of the n = 1 mode phase. Right the effect of different phases of pre-existing 2/1 islands on RE loss. (a) Fraction of confined REs vs time. (b) The relationship between the remaining ratio of REs and the toroidal phase