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Mechanisms of impurity radiation effects on tearing mode growth in a tokamak

P. Zhu[1,2], S.-Y. Zeng[3], V.A. Izzo[4], H.-L. Li[5], Z.-H. Jiang[1], R.-J. Zhou[6], M. Xu[6], D. Escande[7]

[1] Huazhong University of Science and Technology

[2] University of Wisconsin-Madison

[3] University of Science and Technology of China

[4] Fiat Lux

[5] Shenzhen University

[6] Institute of Plasma Physics, CAS

[7] Aix-Marseille University

e-mail (speaker): zhup@hust.edu.cn

The impurity radiation induced tearing mode growth is believed to play a central role in the processes of massive gas injection (MGI), as well as the disruption near density limit. Based on the equilibriums from J-TEXT and EAST experiments, recent MHD simulations using the NIMROD code including the KPRAD model are able to demonstrate the effects of impurity radiation on the tearing mode onset and island growth, and reproduce many key features of plasma evolution towards disruption following the impurity penetration that are commonly observed in experiments [1,2]. These include the cold-bubble formation from the 2/1 tearing mode growth before thermal quench during an MGI process, and the successive emergence of 4/1, 3/1 and 2/1 islands followed by the rotation damping and mode locking during the low-Z impurity penetration on EAST. The impurity driven tearing mode growth is found to be mainly attributable to a novel mechanism involving a resistive interchange reversal where the classical Glasser, Greene and Johnson ("GGJ") mechanism turns out destabilizing. This mechanism is directly brought out by the impurity penetration and radiation, which continue to drive the island growth toward saturation as well [3]. Correspondingly, a modified Rutherford equation is constructed, which can fit well the island growth obtained from these NIMROD simulations (Figure 1a). The observed impurity level threshold for the tearing mode growth (Figure 1b), and its dependence on the parallel thermal conductivity are consistent with the resistive interchange reversal mechanism.

References

[1] S.-Y. Zeng, P. Zhu, V.A. Izzo, H.-L. Li, Z.-H. Jiang, MHD simulations of cold bubble formation from 2/1 tearing mode during massive gas injection in a tokamak, Nucl. Fusion 62, 026015 (2022)

[2] S.-Y. Zeng, P. Zhu, R.-J. Zhou, and M. Xu, Simulation study on impurity penetration and the induced radiation-driven tearing mode growth in EAST (in preparation)

[3] S.-Y. Zeng, P. Zhu, R.-J. Zhou, and D. Escande, The triggering of tearing instability by impurity radiation through resistive interchange reversal in a tokamak (in preparation)

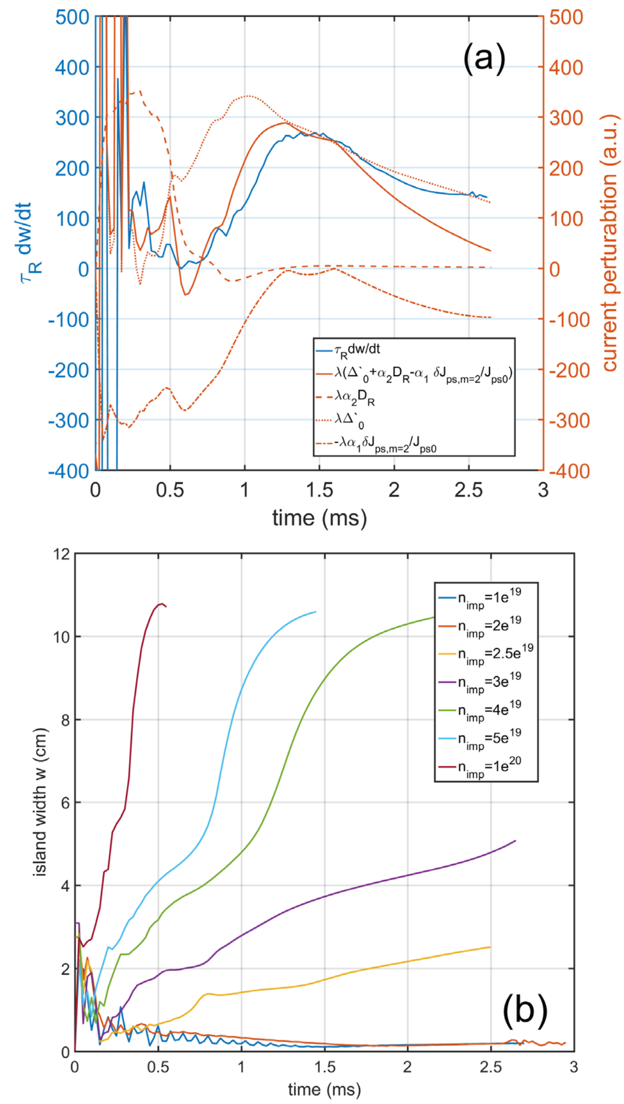

Figure 1. (a) The 2/1 island growth rates from NIMROD simulation (blue) and a fitted modified Rutherford equation (orange), and (b) the island width growth with various impurity injection levels from NIMROD simulations as functions of time.