

Nonlinear interaction between toroidal Alfvén eigenmode and tearing mode on HL-2A tokamak

P. W. Shi¹ and W. Chen¹

¹ Southwestern Institute of Physics
e-mail (speaker):shipw@swip.ac.cn

Experiments related to nonlinear interaction between toroidal Alfvén eigenmodes (TAEs) and tearing mode have been carried out on HL-2A tokamak. On one hand, it is found that nonlinear mode coupling between the two modes results in the generation of other Alfvénic sidebands with toroidal mode numbers of $n = 0, \pm 1, \pm 2 \dots$. Then two deuteron modes with a same mode number but propagating in different diamagnetic directions couple together and contribute to the excitation of an axisymmetric mode with frequency in the ellipticity-induced Alfvén eigenmode (EAE) frequency region [1]. Direct evidence suggests the axisymmetric modes play an energy transfer channel role during the nonlinear procedure and cause the growth of magnetohydrodynamic instability with finite toroidal mode number via beating with tearing mode. On the other hand, Off-axis sawtooth oscillations during the presence of nonlinear coupling between TAE and tearing mode are firstly observed in the plasma without two $q = 2$ rational surfaces [2]. The low frequency oscillations always take place during the nonlinear interaction processes and the off-axis features have been confirmed by multiple diagnostics, such as soft x-ray arrays and electron cyclotron emission imaging systems. A possible physical mechanism is proposed for interpretation of those off-axis oscillations. That is, nonlinear interaction between TAEs and tearing mode causes significant losses of fast ions though the spacial overlapped global mode structures, then causes a drop in torque and leads to rotation braking or even mode locking. When magnetic fluctuation becomes large enough during braking or locking, the resulting high amplitude saturated mode leads to subsequent or immediate collapse at the $q = 2$ rational surfaces. The high frequency $n=0$ mode and off-axis collapse induced by nonlinear mode coupling between TAE and tearing mode can take place at the same time, as shown in Figure 1.

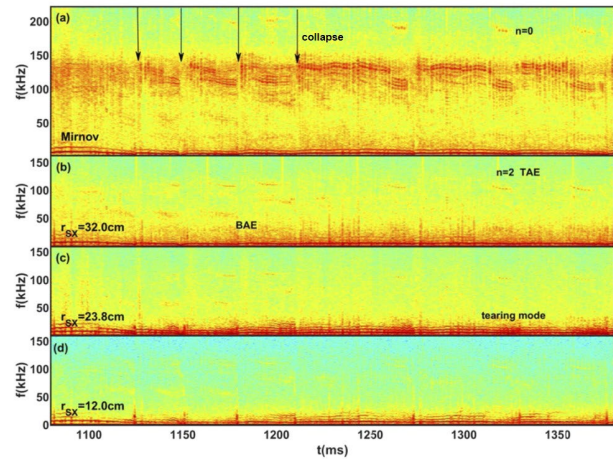


Figure 1. High frequency $n=0$ mode and off-axis collapse induced by nonlinear coupling between TAE and tearing mode. Note that, the subgraphs present the Spectrogram of (a) Mirnov coil signal and (b-d) soft x-ray signals at three different locations.

References

- (1) P. W. Shi et al., Observation of off-axis sawtooth oscillations during the presence of nonlinear mode couplings in HL-2A NBI heated plasmas. 2021 *Nucl. Fusion* 61 096025
- (2) P. W. Shi et al., Nonlinear mode coupling induced high frequency axisymmetric mode on the HL-2A tokamak. 2019 *Nucl. Fusion* 59 086001