

## Excitation of Alfvén Eigenmodes and Formation of ITB during off-axis Sawteeth in EAST

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The internal transport barrier (ITB), Alfvén Eigenmodes (AEs) and double tearing modes (DTM) have been observed during the off-axis sawteeth oscillation in EAST.

The ITB of electron temperature  $T_e$  is modulated by the sawteeth oscillation, and the formation of ITB can be divided into three stages: (1) the transport produced by sawteeth final crash is suppressed at the first stage with steep gradient of  $T_e$ ; (2) the micro-instability is developed at the second stage for the further increasing of the gradient of  $T_e$ ; (3) the ITB is formed eventually after the transition from BAEs to RSAEs, where the BAEs-RSAEs pair enables the tracking of  $q_{min} \leq 1$  from the experiment directly.

Furthermore, a new BAAE-like instability is also observed that coexists with BAEs pair, while the frequency of the former is far below than the latter. The BAAE-like locates outward than the BAEs pair as Ref [1]. Interestingly, the triangle shape of the two modes are similar that travel in ion diamagnetic drift direction, and the phases of outer regions is lag behind than the center as Ref [1-4]. The radial position of BAAE-like shifts inward after the excitation of RSAEs, and the frequencies of BAAE-like and RSAEs are sweeping upward.

The off-axis sawteeth final crash is triggered by DTM: (1) the DTM can be excited by the redistributed of the profile of thermal particles, where the downward transport of energetic ions is detected indirectly by the SXR arrays for the first time; (2) the DTM can be excited by the transformed from kink instability.

[1] Cheng, J., W. Zhang, et al. "Nonlinear co-existence of beta-induced Alfvén eigenmodes and beta-induced Alfvén-acoustic eigenmodes." *Physics of Plasmas* 24(9): 092516(2017)

[2] Zhang, H. S., Z. Lin, et al. "Gyrokinetic particle simulation of Beta-induced Alfvén Eigenmode." *Physics of Plasmas* 17(11): 112505 (2010)

[3] Zhang, H. S., Z. Lin, et al. "Nonlinear dynamics of beta-induced Alfvén eigenmode in tokamak." *Physics of Plasmas* 20(1): 012510(2013)

[4] Zhang, H. S., Y. Q. Liu, et al. "Gyrokinetic particle simulation of beta-induced Alfvén-acoustic eigenmode." *Physics of Plasmas* 23(4): 042510(2016)

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