Study of the mechanism of neutral beam injection parameters on the fishbone cycle frequency on the EAST tokamak

Xiang Zhu[1], Long Zeng[2], Zhiyong Qiu[3], Wei Shen[4], Tian Tang[4], Chenxi Luo[4], Haiqing Liu[4], Liqing Xu[4], Yifei Jin[4], Qing Zang[4], Xiaodong Lin[1], Xiang Gao[4]

[1] Advanced Energy Research Center, Shenzhen University, Shenzhen 518060, China

[2] Department of Engineering Physics, Tsinghua University, Beijing 100084, China

[3] Key Laboratory of Frontier Physics in Controlled Nuclear Fusion and Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China

[4] Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China

Energetic particle (EP) physics is one of the key issues in magnetic confinement fusion research, and fishbone instability, as an important branch of EP physics, plays an important role in H-mode plasma confinement and transport. Fishbone cycle frequency (f_{fc}) refers to the reciprocal of the time interval between neighboring fishbones, and the larger the cycle frequency, the denser the fishbones. It is generally closely related to the plasma heating power. Two opposite types of dependencies between the fishbone cycle frequency and the NBI injection power have been observed on the EAST tokamak with similar experimental parameters [1], as shown in figure 1.

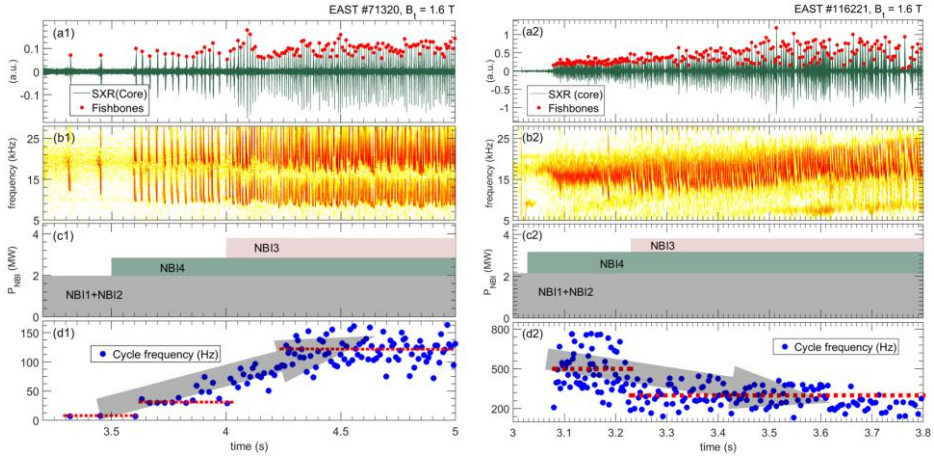

Fig. 1 Two opposite dependencies between the fishbone cycle frequency and NBI heating power observed on the EAST tokamak: a positive correlation (#71320) and a negative correlation (#116221). (a) Filtered soft X-ray signals, where each red circle corresponds to a fishbone mode, (b) Spectra of soft X-ray, (c) NBI injection power; (d) Fishbone cycle frequency.

This study will utilize simulation codes such as TRANSP, NUBEAM, ORBIT, and M3D-K to conduct in-depth analysis of the experimental phenomena mentioned above. The goal is to identify key factors influencing the dependency between fishbone cycle frequency and NBI injection parameters, as well as plasma parameters. The study aims to clearly elucidate the physical mechanisms underlying these observations. Additionally, it will analyze variations in fishbone characteristics (frequency, growth rate, amplitude, etc.) under both situations. Furthermore, the study will assess the EP loss caused by fishbones and their impact on H-mode plasma confinement performance. These results may provide insights for actively controlling fishbones on future fusion reactors to mitigate EP losses.

[1] X. Zhu, L. Zeng, Z.Y. Qiu, *et al.*, Dependence of fishbone cycle on energetic particle intensity in EAST low-magnetic-shear plasmas [J]. *J. Plasma Phys.*, 2020, **86** 905860610.

* If time permits, we plan to submit the research results to the Nuclear Fusion journal.