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I-mode experiment and simulation results on EAST tokamak

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I-mode is a promising operation mode of fusion in the future, featured high temperature confinement and low-density confinement, but the reason for the decoupling of temperature and density is always an important event in exploration. Sixty-five discharges have been confirmed as I-mode discharges after searching the EAST database from 2016 to 2018[1], and some additional I-mode discharges were obtained in 2019. One typical I-mode shot has been shown in Fig. 1. The I-mode regime has been obtained over a small parameter space (B_T = 2.2 ~2.7 T, Ip = 0.4~0.6 MA, q_{95} = 4~6) using a configuration with Bx▽B drift away from the active X-point. Most of the discharges in EAST are dominated by lower hybrid wave (LHW) heating. In addition, some are heated with both LHW and neutral beam injection (NBI) heating, and a few discharges are heated by NBI and electron cyclotron resonance heating (ECRH). Turbulence suppression in density perturbation has been defined as signaling the onset of the L-I transition. The power threshold of the I-mode is slightly larger than that of the 2008 ITPA scaling law of H-mode. The minimum L-I power threshold varies only weakly with BT, and the power range for the I-mode increases with increasing BT. The I-mode is superior to the L-mode in terms of energy confinement but is still slightly inferior to the H-mode under similar conditions, although the energy confinement time decreases more slowly with increasing heating power than it does in the typical H-mode case [2].

The experimental results from EAST showed that the weakly coherent mode (WCM) is directly related to sustaining I-mode, and the peak amplitude of WCM is proportional to the temperature in pedestal. Simulate the experimental data from EAST by the six-field model of BOUT++, we find a density perturbation close to the frequency of WCM observed in experiment. By testing all the physical terms in this model, we find that the density perturbation and particle transport are directly related to the drift Alfven wave (DAW) mode as show in Fig.2 , which is partly consistant with the previous results from C-Mod [3]. We also use the SimPIC program [4] to simulate the same experimental data, and get the density dominant mode close to that of BOUT++. Therefore, the WCM of I-mode can be considered as driven by the DAW, and it helps to improve the transport of particle thus maintaining the low-density gradient in pedestal.

References

[1] X. Feng, A.D. Liu, C. Zhou, Z. X. Liu et al., Nuclear Fusion, 59, 096025, 2019

[2] Y.J. Liu, Z.X. Liu, et.al., Nuclear Fusion, 2020, 60, 082003;

[3] Z. X. Liu, et.al., Physics of Plasmas, 2016, 13, 056103;

[4] J. Xiao et. al., Plasma Science and Technology 20, 110501, 2018.

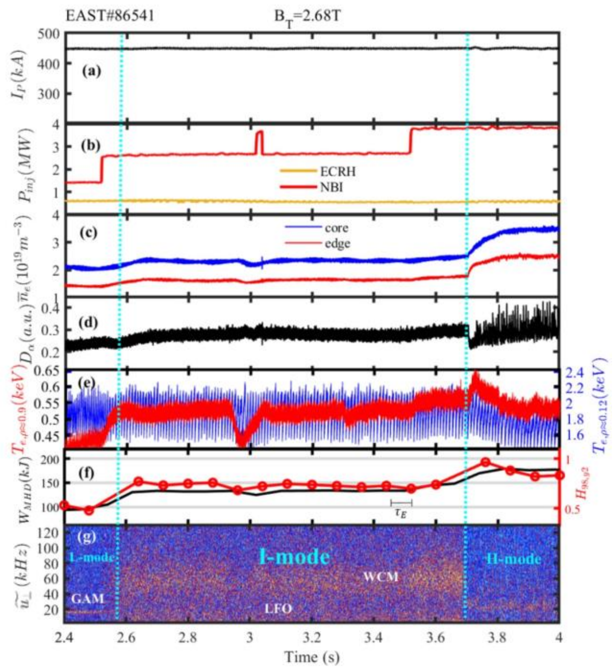

Figure 1 Typical I-mode in EAST under NBI and ECRH, with a USN configuration. The dashed lines represent the three phases: the L-mode, I-mode and H-mode.

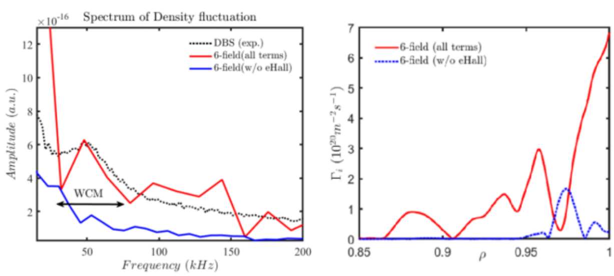

Figure 2 Left is the power spectrum of density fluctuation with three conditions: experimental data from DBS signal, all terms open in six-field progress and that without eHall term. Right is Profiles of the particle flux with all terms open and all term but without eHall that calculated from the BOUT++ simulation result.