Experimental Observation of Low-frequency MHD Instabilities Driven by Energetic Electrons in LHCD Plasmas

L.M. Yu[1*], W. Chen[1], Z.B. Shi[1], X.Q. Ji[1], R.R. Ma[1], P.W. Shi[1], X.Y. Bai[1], J.X. Li[1], Y.G. Li[1], Z.C. Yang[1], X.M. Song[1], B. Lu[1], Yi Liu[1], L.W. Yan[1], X.T. Ding[1],W.L. Zhong[1] and M. Xu[1]
[1]Southwestern Institute of Physics, P.O. Box 432 Chengdu 610041, China
e-mail: yulm@swip.ac.cn

The 3.5 MeV alphas, generated by deuterium-tritium (D-T) fusion reactions in the burning plasma, will transfer their energy mostly to electrons firstly. The small resonant particle orbit width of energetic electrons (EEs) of device can be utilized to simulate and analyse the analogous effect of alphas characterized by small dimensionless orbits similar to EEs in tokamak plasmas. It is the energy but not the mass that plays an important role between reactions of macro-MHD waves and energetic particles. Therefore, investigating the interactions between EEs and plasma waves will provide important experimental experiences for burning plasmas, especially for ITER and DEMO.

Low-frequency MHD instabilities, e.g., core localized fishbone modes (FBs) and beta induced Alfvén eigenmodes (BAEs) localized in edge, driven by EEs are found in the co- and counter-driving low hybrid current drive (LHCD) plasmas on HL-2A, respectively. These modes all propagate in electron diamagnetic drift direction in poloidal, though in the different LHCD driving direction conditions. The FBs or BAEs even can co-exist at the same time.

There are 4 FBs with various frequencies of 2-5, 5-7, 10-12 and 13-15 kHz are observed on the spectrogram of the core soft X-ray (SXR) signals (inside q=1 surface, with d=2.4, 7.0 and 10.0 cm). The frequencies jump phenomena of 4 FBs and even co-existance of FBs are found, and the fluctuations from different channel SXR indicate low-(2-5, 5-7 kHz) and high-frequency (10-12, 13-15 kHz) FBs locate near r~2.4 and 10.0 cm, respectively.

While, 2 BAEs are found on the spectrogram of Mrinov coil signal when the LHCD driving current is in couter-direction with plasma current. The frequency of m/n=3/1 BAE mode are in the range of 9-11 kHz when LHCD power (P_{LHCD}) is 0.44 MW. The strong 15-17~kHz m/n=5/2 mode appears when PLHCD is 0.52 MW, and the weak 7-9 kHz 3/1 mode can coexists at the same time, as shown in Figure.1. The frequencies of the two modes are closes to continue accumulation point frequency frequency of BAE. With the increase of P_{LHCD}, the value of safety factor decreases from 3.0 to 2.5 (near r~ 29cm) in which the BAEs located. It's indicated that the variation of mode numbers are caused by the changed q values near mode position.

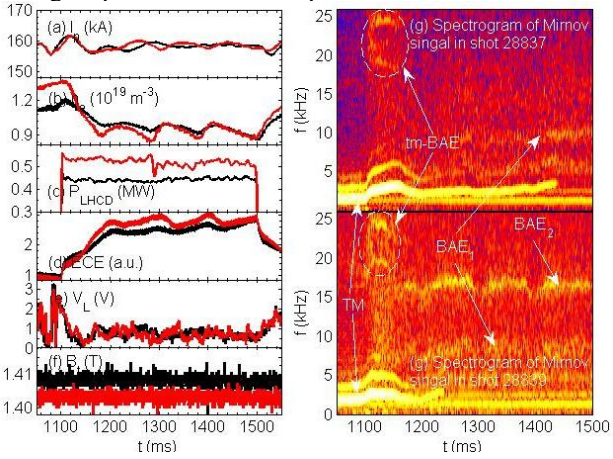

Figure.2 BAEs found in the counter-driving LHCD plamsa

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