§26. Study of Anomalous Transport of Fast Ions Induced by Alfven Eigenmodes and Development of External Control Method in Heliotron J

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Recently, stabilization of Alfven eigenmode (AEs) has been demonstrated with application of electron cyclotron current drive (ECCD) in Heliotron J [1], in which the iota shear is considered to play an important role to stabilize the AEs. The stabilizing effects of electron cyclotron resonance heating (ECH) on AEs have been also observed in DIII-D tokamak [2], TJ-II stellarator [3] and LHD [4]. The classical mechanisms of AE stabilization such as collisional damping, electron Landau damping cannot explain the experiments of AE stabilization with ECH, which is an open question to be solved. In order to investigate the damping mechanism of AEs, the experimental evaluation of AE drive with direct measurement of interactions between fast ions and AEs by directional probe method have been carried out.

Figure 1 shows a schematic of head structure of the hybrid direction Langmuir probe (HDLP). Five electrodes mounted around the main body of the probe head with the interval of 60 degrees constituting directional probe. The probe can be rotated around the axis, therefore the area of each electrodes are easily calibrated. The electrodes and the body of plasma head are made by molybdenum in order to survive in heavy heat flux circumstance. The magnetic probe is also mounted in the head of HDLP. A slit perpendicular to the magnetic field was made to penetrate the magnetic perturbations inside the HDLP head.

Figure 2 shows a typical example of fast ion measurement using the HDLP in the neutral beam heated plasma in Heliotron J. The cross-coherence between ion saturation currents and magnetic fluctuations measured by the HDLP was calculated. Strong coherence between co-directed ion flux and magnetic fluctuation was observed in two frequency regimes; high frequency (f_{high}~150 kHz) and low frequency (f_{low}~90 kHz), while the coherence in high frequency regime disappeared in the cross-coherence of the counter-directed ion flux. This observation suggests that the co-directed fast ions respond to the high frequency AE at the probe position. Systematic experiments and the analysis of the phase may reveal the interactions of fast ions with the high frequency AE.

In order to investigate the ECH effects on AEs, the AE responses to the ECH modulation will be investigated in the next campaign of Heliotron J. The new diagnostics tool (wave-particle interaction analyzer) which can observe phase space structure of fast ions interacting with AEs will be prepared for the research of fast ion physics.

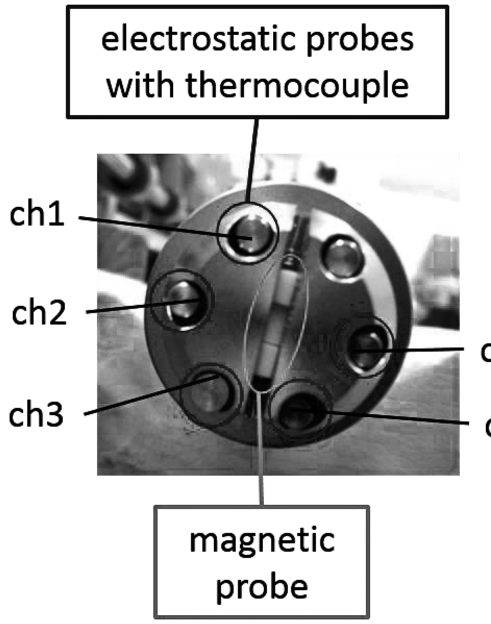

Fig. 1. Schematic of probe head structure of HDLP.

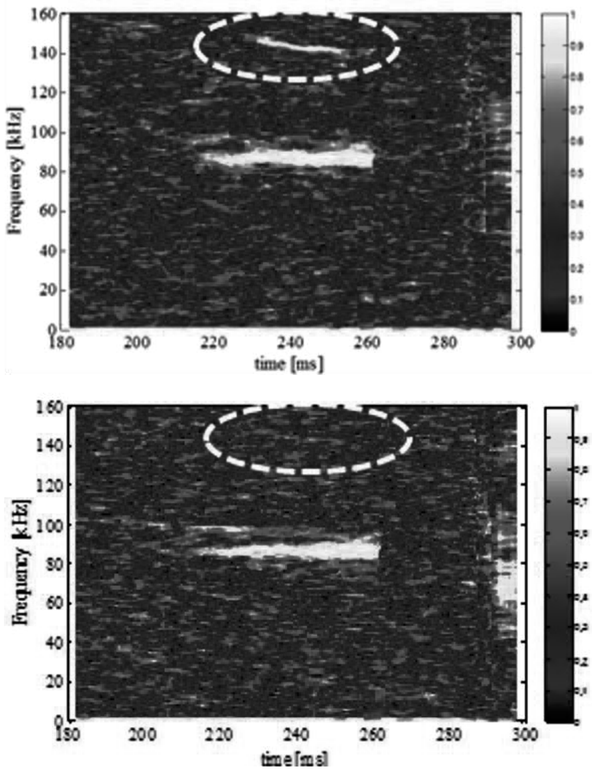

Fig. 2. (Upper) Cross-coherence of co-directed ion flux and magnetic fluctuation measured by the directional probe and (bottom) cross-coherence of counter-directed ion flux and the magnetic fluctuation.

[1] S. Yamamoto, et al., IAEA-FEC 2014, EX/P4-27.
[2] M. Van Zeeland, et al, Nucl. Fusion 49 (2009) 065003.
[3] K. Nagaoka, et al., Nucl. Fusion, 53 (2013) 072004.
[4] K. Nagaoka, et al., 4th APTWG, 2014, invited talk.