§50. Polarity of Alfven Eigenmode and Anomalous Transport of Fast Ions on LHD

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Anomalous transport of energetic particles induced by energetic-particle-driven Alfven eigenmode is one of the most important issues in burning plasma experiments such as ITER and is intensively studied in tokamak and helical devices. In order to understand the characteristics of energetic-particle-driven Alfven eigenmode, a set of Mirnov coils which can measure three-dimensional components of magnetic fluctuation was newly mounted on hybrid directional Langmuir probe (HDLP) in 13th LHD experiment campaign. The HDLP is a directional probe for measurement of co-directed fast ions at the outboard side of almost vertically elongated cross section in LHD [1]. The Mirnov coils were tilted along the magnetic field line at the probe position, and have sensitivities to parallel component (mainly toroidal component:$B^*_{\rm tor}$) and two perpendicular component; one parallel to the last closed magnetic surface (LCFS)(mainly poloidal component:$B^*_{\rm pol}$) and the other perpendicular to the LCFS(mainly radial component:$B^*_{\rm r}$).

The experiment using new HDLP have been performed in the high-energy particle theme group, and the scintillator-type lost ion probes (LIP, SLIP), neutral particle analyzers(NPAs) and reflectometry were operated in the collaboration on energetic particle study in LHD. Many bursting MHD activities driven by energetic particles were observed in the low density plasmas heated by neutral beam injections with low magnetic field strength conditions. Figure 1 show a typical bursting mode observed in the low density plasma (line-averaged density $\overline{n_{\rm e}} \sim 1.2 \times 10^{19}{\rm m}^{-3}$) with the magnetic configuration of $R_{\rm ax} = 3.60$ m and the magnetic strength of $B_{\rm t} = -0.60$ T. This bursting activity consists of several branches and two sequentially destabilized branches were observed in lower frequency range than 100 kHz. The former one shows wide range of frequency shift down from 100kHz to 40kHz and relatively small amplitude. On the other hand, the latter shows small range of frequency shift down and relatively large amplitude. The duration time of the latter mode is longer than the former. The co-directed fast ions measured by the HDLP responded to the two modes. The large peak of the fast ion flux was observed just after the time when the latter low frequency mode reaches the peak amplitude. Thus the larger fast ion flux was lost by the latter mode. The phases between two components of magnetic fluctuation were investigated, which is also shown in Fig. 1. The phases of $B^*_{\rm tor}$ and $B^*_{\rm r}$ in the former mode are different about 90 degrees from $B^*_{\rm pol}$, thus the Lissajous orbits in $B^*_{\rm tol}$-$B^*_{\rm pol}$ and $B^*_{\rm r}$- $B^*_{\rm pol}$ spaces are almost circular shape. The phase relation in the latter is different from that in the former. While the higher harmonic component modifies the Lissajous orbit, roughly speaking, the $B^*_{\rm tor}$ component is out of phase with $B^*_{\rm pol}$ component, and $B^*_{\rm r}$ is in phase with $B^*_{\rm pol}$. It is noted that the different polarity of magnetic fluctuation were observed between sequentially destabilized two modes which have different characteristics in frequency chirping, duration time, fast ion transport and so on. The analysis of shear Alfven continuum and the mode identification are not completed yet.

The new HDLP may be useful for identification of compressional Alfven eigenmodes, weak mode and so on, which are next step of this study.

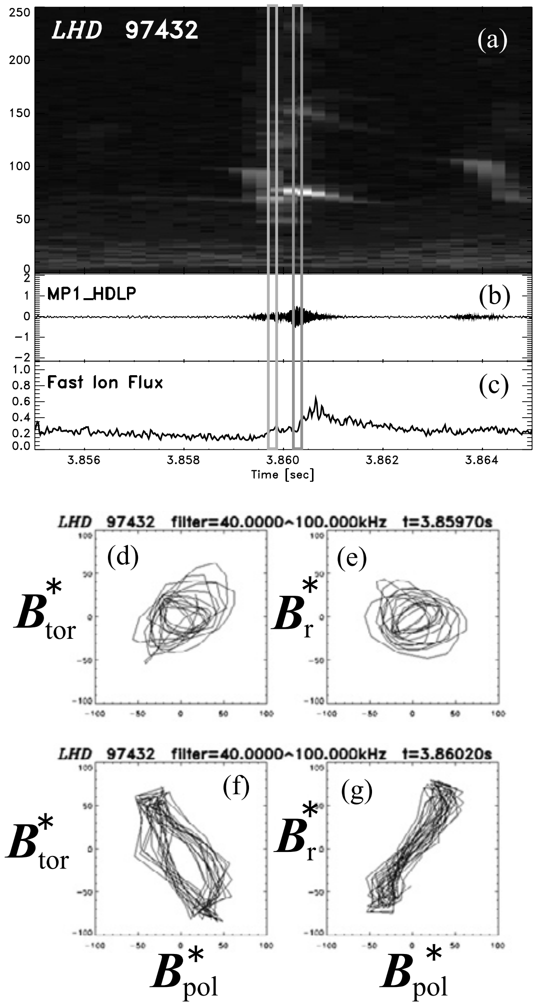

Fig. 1: The upper three graphs show (a) the power spectrum of magnetic fluctuation, (b) Mirnov signal and (c) co-directed fast ion flux meaured by HDLP. The lower four graphs (d)-(g) show the Lissajous orbits of magnetic fluctuation component; the upper two (d)-(e) are for the former mode and the lower two (f)-(g) are the latter.

1) K. Nagaoka, K.Y. Watanabe, M. Osakabe, et al., Rev. Sci. Instrum. **79**, (2008) 10E523.