§13. Observation of the Energetic-particle Induced Geodesic Acoustic Mode Using a Heavy Ion Beam Probe

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In LHD, the rotational transform can be controlled by use of electron cyclotron current drive (ECCD) [1], and weak or negative magnetic shear profiles are obtained using ECCD in Co-direction which increases the rotational transform in core region. In such weak magnetic shear plasmas heated by tangential NBI, several Alfven eigen modes are observed in the magnetic and electrostatic fluctuations. Especially, one of the modes has a similar frequency to the geodesic acoustic mode (GAM). In order to investigate characteristics of the mode, the fluctuations were observed locally and directly using a heavy ion beam probe(HIBP)[2].

The plasma is produced and sustained by balanced tangential NBI, and ECCD is superposed for 0.6 s. The line averaged electron density is 0.1×10^{19} m^{-3} and constant. Figure 1 shows spectrograms of the magnetic fluctuation observed by a magnetic probe and the electrostatic potential fluctuation observed by the HIBP. Note that Fig. 1 (c) reflects the spatial distribution as well as the temporal evolution because the measurement position of the HIBP is reciprocated at the frequency of 10 Hz as shown in Fig.1 (b). Several magnetic and electrostatic potential fluctuations are observed in the frequency range of 40 kHz and more, and their frequencies change gradually with the time constant of a few hundred milliseconds. The frequency change seems to reflect the temporal evolution of the rotational transform. Similar fluctuations are observed in plasmas with weak or reversed magnetic shear produced by neutral beam current drive (NBCD)[3], and the fluctuations are the Reversed-Shear-induced Alfvén Eigenmodes (RSAEs).

In the spectrogram of the potential fluctuation (Fig.1 (c)), a coherent mode with a constant frequency of about 35 kHz during ECCD and 20 kHz just after ECCD is observed. The frequency depends on the electron temperature(Fig.2), and its absolute value almost agrees with the geodesic acoustic mode(GAM) frequency. The mode is not observed in plasmas without the tangential NBI. Thus, the mode with the constant frequency will be the energetic-particle induced GAM.

The spatial distribution can be also obtained from the Fig.1(c) because the measurement position is reciprocated as mentioned above. The spatial distribution of the GAM and RSAE is shown in Fig.3. The lower frequency mode exists in inner region, and the mode with the GAM frequency is excited in the most inner region.

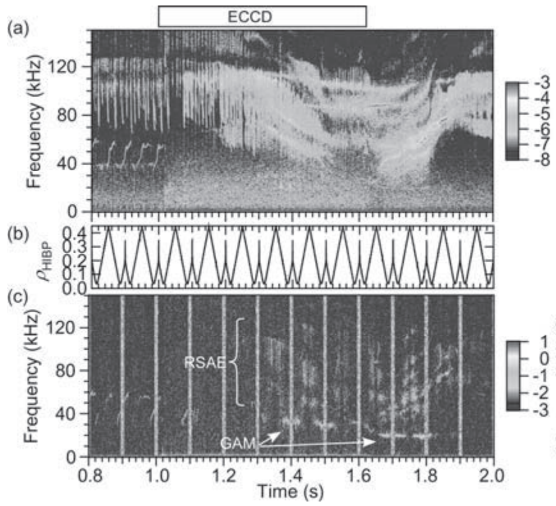

Fig. 1. (a) Spectrogram of the magnetic fluctuation. (b) Measurement position of the HIBP. (c)Spectrogram of the electrostatic potential fluctuation.

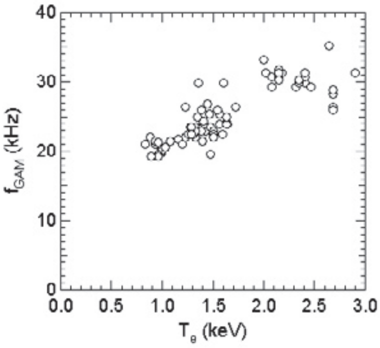

Fig. 2. Temperature dependence of observed GAM frequency.

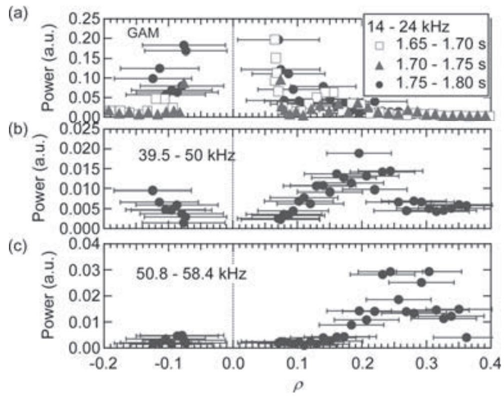

Fig. 3. Spatial distribution of coherent potential fluctuations in each frequency range. The data from 1.75 to 1.80 s are analyzed in Fig.1.

1) Kubo, S., et al.: *22nd IAEA Fusion Energy Conference, Geneve, 2008* (http://www-pub.iaea.org/MTCD/Meetings/FEC2008/ex_p6-14.pdf)
2) Ido, T., et al.: Rev. Sci. Instrum. **79**(2008)10F318
3) Toi, K., et al.: 22nd IAEA Fusion Energy Conference, Geneve, 2008 (http://www-pub.iaea.org/MTCD/Meetings/FEC2008/ex_p8-4.pdf)