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§17. Observation of Large Electrostatic Potential Fluctuation Associated with the Energetic-particle Driven Geodesic Acoustic Mode in the LHD Plasmas

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Energetic-particle drive geodesic acoustic mode(EGAM)[1] have been observed in LHD[2]. The time constant of a growth of an EGAM burst is a few ms, and the frequency rapidly increases from the GAM frequency to the orbital frequency of fast ions from NBI. The change in the energy spectra of fast ions is also observed during the excitation of the EGAM by neutral particle analyzer (NPA), and it indicates the excitation of the GAM by the fast ions through the inverse Landau damping[3], as shown by a simulation[4]. In addition to that, the behaviors of energy spectra measured by NPA indicate that the bulk ions gain energy during the burst of the EGAM. One of the candidate mechanisms is the GAM channeling [5], in which the energy of the GAM is directly absorbed by ions through the Landau damping. In order to clarify the mechanism quantitatively, the radial electric field associated with the GAM has been measured by HIBP in this study.

In the previous experiments, the amplitude of the electrostatic potential fluctuation associated with the EGAM is so large that it exceeded the measurable electrostatic potential by HIBP (~ 7 kV) when the change in the energy of the bulk ions was detected by NPA. Because the upper limit of the measurable electrostatic potential by HIBP is proportional to the probe beam energy, higher beam energy is required to increase the upper limit of the potential measurement. The probe beam energy is determined so that the Larmor radius of the probe beam is comparable to the size of the vacuum vessel. Thus, lighter probe ions are required for increasing the beam energy. In this campaign, we used Cu^- instead of Au^- as the probe beam. Therefore, the upper limit of the electrostatic potential measurement increased up to 23 kV.

The experiments were performed under the condition that the magnetic field strength is 1.375 T, the major radius and the averaged minor radius of the plasma are 3.75 m and about 0.6 m, respectively. The plasmas were produced and sustained by tangential NBI with the beam energy of 175 keV, and the absorbed NBI power is about 85 kW. The line averaged electron density is about 0.1 x 10^{19} (m^{-3}), and the central electron temperature is 2 keV, and it increases to 7 keV during the superposition of ECH with the power of 760 kW. Figure 1 shows the temporal evolution of the magnetic field fluctuation measured by a Mirnov coil and the electrostatic potential fluctuation measured by HIBP. The significant electrostatic potential fluctuation associated with EGAM is detected, successfully.

Figure 2 shows the relation between the magnetic field fluctuation measured by a Mirnov coil and the electrostatic potential fluctuation measured by HIBP. The linear relation agrees with a theoretical prediction [6]. The quantitative assessment of the interaction between EGAM and ions based on the results is in progress.

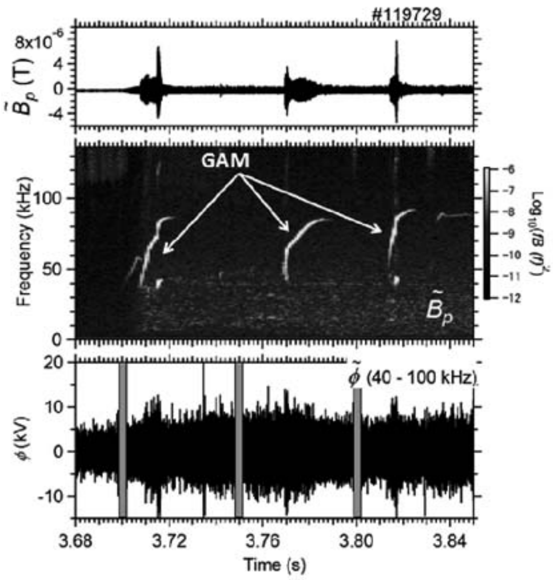

Fig.1 Temporal evolution of the magnetic field fluctuation measured by a Mirnov signal, its spectrogram, and the electrostatic potential fluctuation measured by the HIBP. The measurement position of the HIBP is swept with the frequency of 10 Hz, and the gray-colored terms indicate the beam is blocked by the vacuum vessel of LHD.

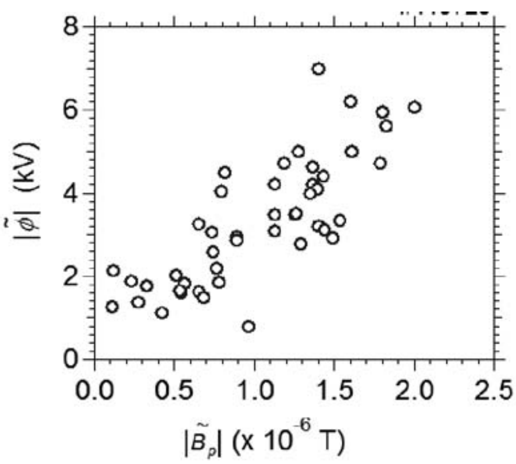

Fig. 2 Relation between the magnetic field fluctuation measured by a Mirnov coil and the electrostatic potential fluctuation measured by HIBP

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