§64. Measurement of Ion Cyclotron Emissions by Use of High-frequency Magnetic Probes in LHD

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We installed two pairs of high-frequency magnetic probes in LHD from upper ports (5.5U and 6.5U). One of purposes of these probes is measurement of ion cyclotron emissions (ICEs). ICE measurement is utilized for the detection of fusion products in large tokamaks [1]. ICEs are excited when the distribution function of ions increases with the perpendicular velocity, and the frequencies are close to multiples of the ion cyclotron frequency at the excitation point [2]. A pair of probes consists of two one-turn loops with Faraday shields. The direction of turn of loops is opposite in order to cancel the noise on transmission lines and the electro static component of signals by combining two signals.

During the injection of perpendicular neutral beam, ICEs with the frequency corresponding to the ion cyclotron frequency at the plasma edge were detected, which is the same with the result measured by using of spare ICRF heating antennas [3]. Besides it was found that the phase difference of signals measured by a pair of probes with the different turn direction was 180°, which means that the signals are originated from magnetic perturbation. By measurement of the phase difference between probes at the two ports, toroidal phase velocity was estimated and it was less than a tenth of light velocity. It means that the wave is transmitted in plasma.

Other type of ICEs was found in LHD. At the timing of TAE bursts (f≈70 kHz), ICEs with the fundamental frequency of 10 MHz were detected as shown in Fig.1, where the line averaged electron density was 1×10^{19} m^{-3} and the magnetic field strength on axis was 0.75 T. Figure 2 shows the timing of ICEs, TAE bursts measured with a Mirnov coil and the intensity of lost ion flux measured with a scintillator-based lost fast-ion probe [4], and it shows that they are synchronized. Therefore the source of this type of ICEs is thought to be the ejected particles by the TAE. The dependence of magnetic field strength on the frequency of ICEs was also investigated. The measured ICE frequency increases linearly with the magnetic field strength as shown in Fig. 3. The reason is that the ion cyclotron frequency, which is close to the fundamental ICE frequency, increases with the magnetic field strength. The power spectral density is not so peaky compared to that of ICEs excited with the injection of perpendicular neutral beam. Therefore the ion cyclotron resonance layers where the ICEs are excited are crossing plasma in wide region.

In LHD newly installed magnetic probes detected two types of ICEs. ICEs excited by fusion products are also expected to be detected with these magnetic probes.

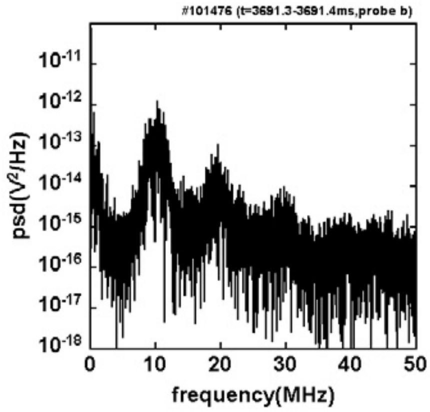

Fig. 1 Power spectral density of ICEs.

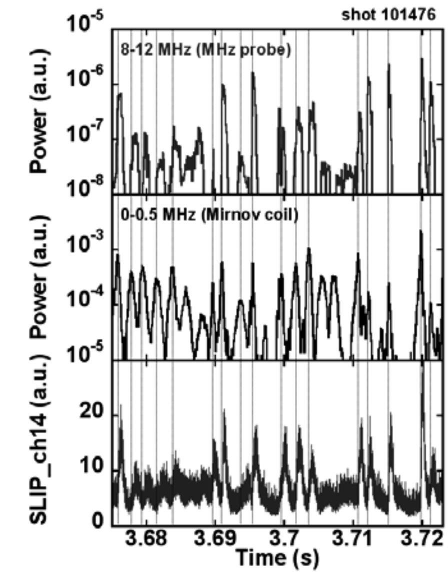

Fig. 2 Signal of ICEs synchronizing with TAE burst and lost ion flux.

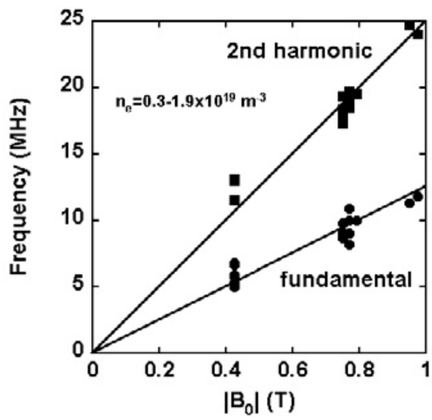

Fig. 3 Frequency of ICEs depending on the magnetic field strength.

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2) Dendy, R.O. et al.: Phys. Plasmas **1** (1994) 1918.
3) Saito, K. et al.: Fusion Eng. Des. **84** (2009) 1676.
4) Ogawa, K. et al.: J. Plasma Fusion Res. Ser. **8** (2009) 655.