§4. HCN Laser Scattering Measurement of Density Fluctuations in CHS

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We developed an HCN laser scattering measurement system [1, 2] to investigate electron density fluctuations in CHS. The system utilizes optics of the interferometer with slight modification for heterodyne detection of the scattered beam. By heterodyne technique, we can distinguish the propagation direction of fluctuations, which is a useful clue to identity the driving force. A super rotating grating [3] was adopted to realize high-frequency beat signal up to 1.45 MHz, which is comparable to that of the twin laser system. In this study, the beat frequency was 1 MHz with variations of less than ±0.2 kHz.

The position of the scattering volume was selected to be the plasma edge in the outer side of torus [2]. In this configuration, the dominant wavenumber component of measured fluctuations is the radial one. Figure 1 shows the time evolution of operational and plasma parameters and the frequency spectra with harmonic components. Plus and minus frequency corresponds to the inward and outward direction of propagation, respectively. The magnetic field strength at the magnetic axis position, R_{ax} = 0.921 m, was B_{ax} = 1.97 T. In the inward direction, there were turbulent fluctuations up to 200 kHz. Sharp fluctuation peaks, which had harmonic components up to the fifth, were observed in the outward direction. Although the scattering system was upgraded for three channel detections with wavenumbers k_r = 5.4 cm^{-1}, k_r = 9.8 cm^{-1} and k_r = 20.3 cm^{-1} in 2006, the harmonic peaks were detected only with k_r = 5.4 cm^{-1} which had the strongest fluctuation spectral intensity. The fluctuations propagated only in the outward direction and the amplitude of the second component was always the largest among harmonic components.

The frequency of harmonic components varied largely in this shot, and it increased rapidly with the rise in the stored energy at the beginning of the discharge. While the electron density kept increasing, the stored energy saturates after t = 0.06 s. This means that the temperature started to drop. In that phase the frequency also began to decrease and the maximum fundamental frequency was about 60 kHz in this discharge. After the application of ECH power from 98 to 103 ms, the frequency of fluctuations appeared to increase slightly. After t = 0.11 s the stored energy decreased. In this phase there were intensive turbulent fluctuations up to 50 kHz in both directions.

Figure 2 shows a result of parameter dependence analysis on the frequency of the second harmonic component.

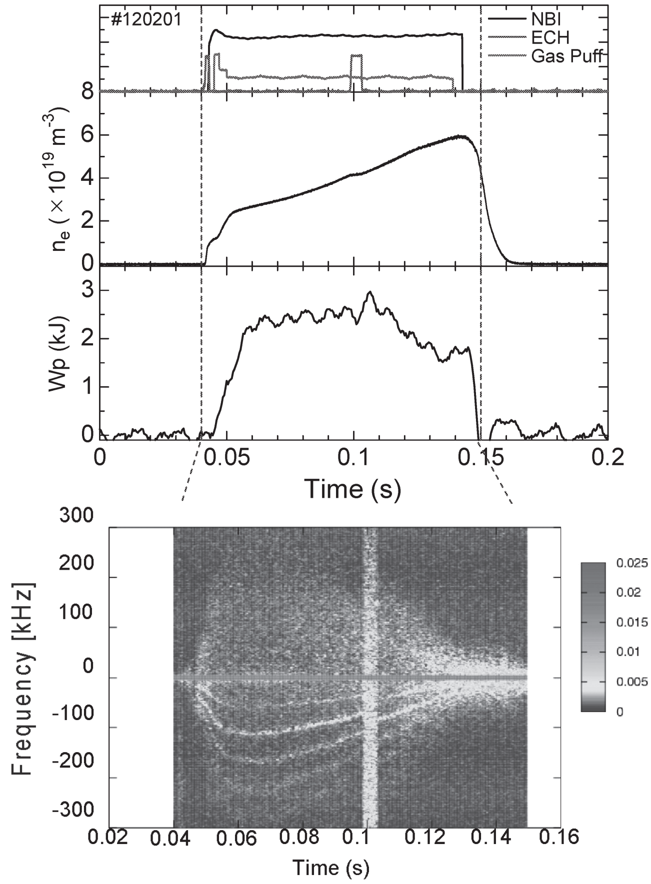

Fig. 1 Time evolution of operational and plasma parameters and frequency spectra of fluctuations with k_r = 5.4 cm^{-1}.

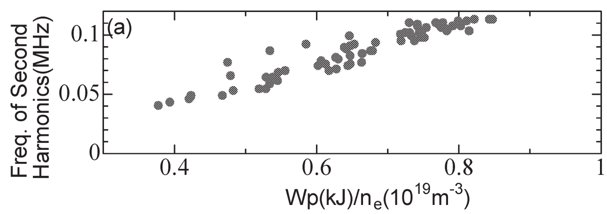

Fig. 2 Correlation of frequency of second harmonics with W_p/n_e

It was found that the frequency of harmonics correlates with the plasma stored energy divided by the line averaged density, W_p/n_e, which is equivalent to the average temperature. The frequency rises as W_p/n_e value increases. It has not been clarified what causes the fluctuations with harmonics and why they have harmonic components. Although geodesic acoustic mode (GAM), whose frequency is proportional to the square root of the ion and the electron temperature, is a plausible candidate, the identification is left for future work.

References

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2) Azuma, Y. *et. al.*, to be published in Plasma and Fusion Research.
3) Maekawa, T. *et al.*, Rev. Sci. Instrum. 62 (1991) 304.