§18. HCN Laser Scattering Measurement on CHS

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Anomalous transport plays a dominant role in the confinement in magnetic confinement fusion devices. Hence it is indispensable to understand fluctuations to improve confinement since they are supposed to cause the anomalous transport. The edge transport barrier (ETB), which can improve particle transport in the edge region, has been observed in CHS [1,2]. The relationship between transport and fluctuations can be made clear in these plasmas with transitions to H-mode. In this research we develop an HCN laser scattering measurement system to examine the correlations between electron density fluctuations and confinement. In order to reveal the relation of transport barriers to fluctuations we plan to investigate changes in features of turbulences before and after a transition to an improved mode.

An HCN laser interferometer on CHS works routinely. The HCN laser scattering measurement system utilizes optics of the interferometer with slight modification for heterodyne detection of the scattered beam. Scattered angle θ_s and frequencies of scattered beam ω_s are given as follows;

$$\theta_s = 2\sin^{-1}\{k/(2k_0)\}$$

$$\omega_s = \omega_0 \pm \omega$$

where k, k_0, ω and ω_0 are wavenumbers and frequencies of fluctuations and incident beam, respectively. Accordingly the wavenumber and spectrum of fluctuations can be evaluated from the scattered angle and spectrum of scattered beam. A collective heterodyne scattering measurement was adopted because it can distinguish the directions in which electron density fluctuations propagate.

By changing the incident beam path, we can select the measured wavenumber k component k_r or k_θ as shown in Fig. 1. The measurable range of k is limited by the aperture width of window and possible area of arrangement of optics. Since CHS has a strong magnetic shear near the plasma edge region, the scattered beam has displacement in the toroidal direction. Hence a scattered beam by density fluctuations with large wavenumber cannot come out of the vacuum vessel. Considering these effects, measurable ranges of wavenumber are;

$$1.4\ \text{cm}^{-1} < k_\theta^{\text{upper}} < 13\ \text{cm}^{-1}$$

$$1.4\ \text{cm}^{-1} < k_\theta^{\text{lower}} < 34\ \text{cm}^{-1}$$

$$1.4\ \text{cm}^{-1} < k_r < 20\ \text{cm}^{-1}.$$

The upper limit of k_θ^{upper} is smaller than that of k_θ^{lower} because the distance between the scattered position and an output window is longer and the displacement in the poloidal direction becomes larger. The lower limit of measurable wavenumber is set from the beam separation of incident and scattered beams.

Figure 2 shows initial measurement results of k_r component. The spatial resolution along the radial direction is 30 mm, which is determined by the width of the incident beam, and that along the beam axis is 360 mm. Because of integration effect along the beam axis the range of measured k_r is;

$$5.1\ \text{cm}^{-1} < k_r < 5.7\ \text{cm}^{-1}.$$

Study of dependences of spectrum on electron temperature and magnetic field strength are future works. A present problem is that signal to noise ratio is small because there are significant switching noises of thyristors from a power supply for coil discharge.

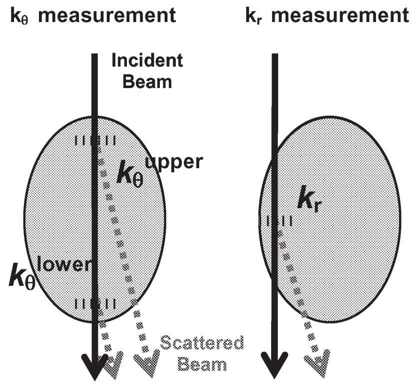

Fig. 1. Measured wavenumber components depend on the path of incident beam.

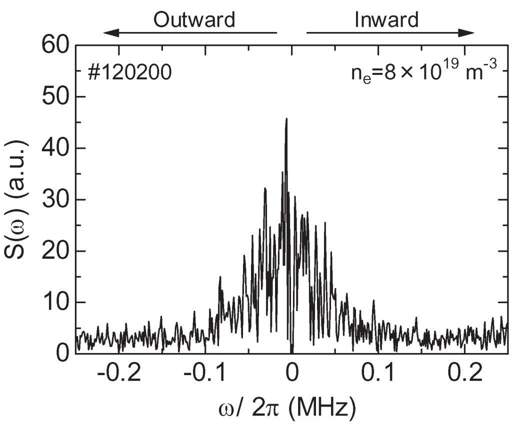

Fig. 2. Initial measurement result of frequency spectrum of density fluctuations.

References
1) S. Okamura *et. al.*, J. Plasma Fusion Res. Vol.79, No.10 (2003) 977.
2) S. Okamura *et. al.*, Plasma Phys. Control. Fusion **46** (2004) A113.