§28. Development of Scattering Measurement System Using a Gyrotron as a Power Source and its Application to CHS

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Electromagnetic waves in the submillimeter wavelength range are well suited for scattering from low frequency density fluctuations in a plasma. Their wavelengths are short enough to ensure that reflection and refraction effects due to plasma are small, but not significantly shorter than those of the drift waves that are expected to be present. A well-collimated submillimeter wave beam scattering at a relatively large scattering angle has excellent spatial and wave number resolutions.

However, it is also necessary to have a suitably high S/N ratio. The S/N ratio is determined by the intensity of the scattered wave which in turn is proportional to the intensity of the incident beam. The S/N ratio can be improved by using an incident beam of higher intensity. Gyrotrons have clear advantages at these wavelengths because of their capacity to deliver high powers1).

Unlike molecular vapor lasers, gyrotrons produce hollow cone shaped beams. It is therefore necessary to convert the output of a gyrotron into a well-collimated, linearly-polarized beam for plasma scattering. We have designed and constructed a quasi-optical transmission line2) that carries out the conversion.

The size of the measured beam is in broad agreement with that of calculated result (calculation; Δx=58 mm, Δy=55 mm, measurement; Δx=42 mm, Δz=67 mm).

The beam was injected into the plasma in the O-mode. With a scattering angle set to 8.8°, the observed wave number of the density fluctuations was around 11.4 cm^{-1}. The waves scattered by plasma density fluctuations were received by horn antennas installed in the plasma vessel and are converted into low frequency signals by a homodyne detection system.

The target plasma was formed by electron cyclotron heating (ECH) using a 53.2 GHz and a 106 GHz high-power gyrotron. Then 1000 kW was delivered into the plasma by neutral beam injection (NBI). The time evolution of each plasma shot therefore consists of three phases, that is, a pure ECH heating phase (t=15 ms~25 ms), a combined ECH & NBI heating phase (t=25 ms~56 ms) and finally pure NBI phase (t=56 ms~126 ms).

Two frequency spectra of the scattered waves are shown in Fig.1. The upper spectrum Fig.1(a) is obtained at the begining of the pure NBI heating phase (t=60 ms~70 ms) and the lower spectrum Fig.1(b) is obtained at the end of the pure NBI heating phase (t=100 ms~105 ms), respectively. A peak is found around 150 kHz in the upper spectrum. In the scattering volume, the electron temperature was 210eV at the earlier time and 110eV at the later time. Over this period no significant change was seen in the electron density. On the contrary, the gradient of electron density at the earlier time was lower than that at the later time. The intensity of the peak in the scattering spectrum does not depend on the gradient of the electron density but on the electron temperature. In addition, although the frequency of the electron drift waves deduced from the plasma parameters changed from 100 kHz to 300 kHz, the observed peak frequency did not change. This suggests that the peak is not merely due to the electron drift waves.

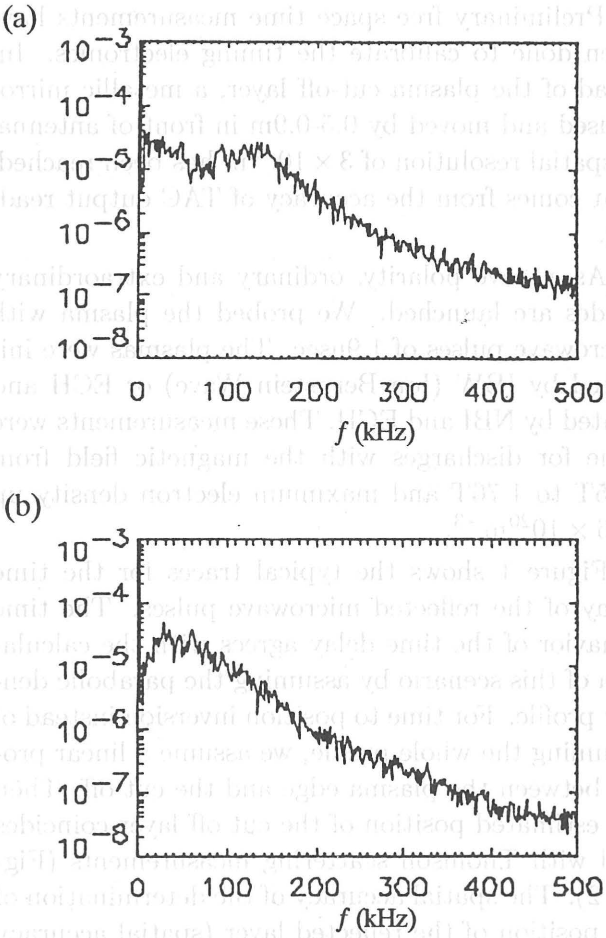

Fig.1 Density fluctuation spectra.
(a); at the beginning of the pure NBI heating phase,
(b) at the end of the pure NBI heating phase.

References
1) Idehara, T. et al.:Phys. Plasmas **2** (1995)3246.
2) Ogawa, I. et al.:Int. J. Electronics **83** (1997) 635.