§17. Measurements of Electron Density Fluctuations in CHS Plasmas by Using YAG Laser Imaging Method

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We have applied a novel technique of a YAG laser imaging method for obtaining information on electron density fluctuations, including the spatial distribution in CHS plasmas.[1)] In this fiscal year, i) a development of a dual beam optical system was advanced for increasing further the signal intensity, ii) a sound isolation cylinder was installed to prevent contamination of noise by acoustic wave in the air, iii) a application of the maximum entropy spectral analysis (MEM) was being tried with the aim of the improvement on the spectral resolution.

Figure 1 shows the optical system for CHS. The YAG laser (λ_i= 1.064 μm, 1.2 W) beam is transported by a SM optical fiber near the CHS plasma. A radiation beam from the SM fiber is expanded and collimated by a beam-expander and passes through the plasma. The probe beam is then transmitted through focusing and imaging lenses along with a phase mirror, and then received by a one-dimensional 16-fiber array connected to low noise detectors. In addition to the one-dimensional spatial measurements, two-dimensional spatial measurements at the detecting plane were performed by making the detector array to rotate shot by shot under the condition of fixed operation to observe 2D image equivalently. The measurable frequency range determined by the frequency response of the detector is 20 kHz to 1 MHz. The measurable wavelength determined by the beam width and number of detector channels ranges 2 mm to 47 mm. (This optical system will be improved into the dual beam optical system in the middle of next fiscal year.)

Plasma is initially produced and heated by ECH and further heated by NBI. The spectrum of the density fluctuation distributes broadly between 20 kHz - 300 kHz, and decreases as the frequency increases. Figure 2 shows an example of a distribution of propagational direction of the fluctuations as a function of the frequency by the contour lines, which is analyzed by the MEM . 0 and 90 degrees show the components which propagate in major radius and toroidal directions respectively. In this method spatial positions of the density fluctuations are required by the correspondence of observed propagational direction with direction of magnetic line of force, because the observed micro-turbulence generally propagates toward perpendicular direction to a magnetic filed. In Fig. 2, "+" means upper half region and "–" means lower half region along the probe beam path in the plasma cross section. The fluctuations are strong near +40 and -30 degrees. These angles are corresponding to normalized radius $\rho \sim 0.9$ when they are correspondent to the direction of magnetic lines of force of CHS. The improvement of the resolution can be expected from the analyzed result by the MEM, because the spectral band width narrows in comparison with the analysis by the conventional FFT.

By such original method, the data is going to be obtained on the spatial positions of the fluctuations in CHS.

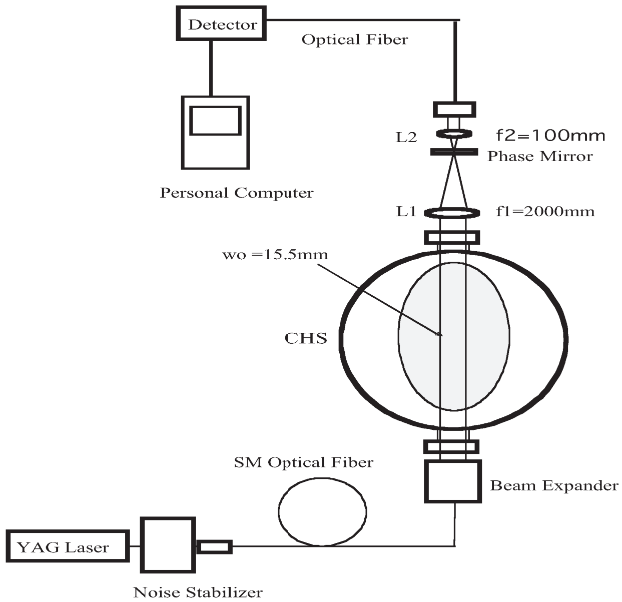

Fig. 1 Laser Imaging System for CHS.

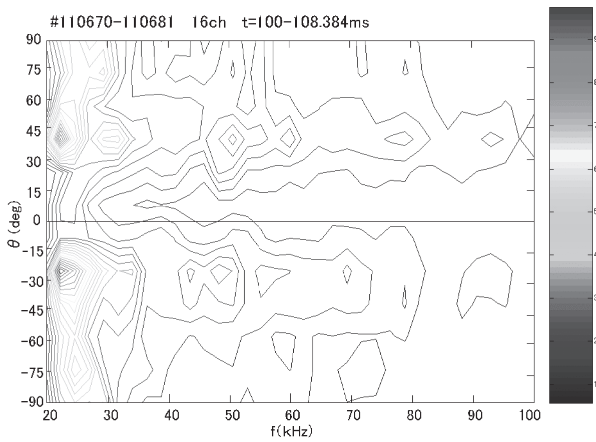

Fig. 2 An example of the distribution of the propagational direction analyzed by MEM as a function of the frequency.

1)JJAP Vol.43, No.5A, 2004, pp2721-2725 "Applicability of Laser Imaging System Using a Near Infrared Laser to Measure Density Fluctuations in High-Temperature Plasmas"