§5. Development of an Advanced Data Analysis Technique for Density Fluctuation Measurements by the Laser Phase Contrast Method

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We developed a laser phase contrast (LPC) method with a folded beam to obtain information concerning the spatial distribution of electron density fluctuations in magnetically-confined plasmas. The LPC produces real images of the fluctuations, so it is possible to use standard signal analysis tools. However, the characteristics have blocked researchers from exploiting the full potential of the LPC with the standard analytical methods alone. The authors have carried out investigations of a 2-dimensional maximum entropy method (MEM) with polar coordinates as a means of analyzing data that is appropriate for the LPC. The MEM in particular is anticipated to provide a high spectral resolution in spite of the low amount of data. Therefore, we have developed an analytical technique that can reduce the deterioration of the resolution, especially in a low wavenumber range, by formulating the MEM using polar coordinates.[1)] In this fiscal year, we advanced the analysis of the spatial distribution of the average phase velocity as the development of the analytical technique and studied a single shot measurement without a two-dimensional array detector to develop the measurement method.

Figure 1 shows the LPC optical system for the CHS. The measurable frequency range is 20 kHz to 1 MHz. The measurable wavelength ranges are from 2 mm to 47 mm. Figure 2 shows an example of the distribution of the average phase velocity of measured fluctuations before and after the formation of the ETB (Edge Transport Barrier). We derived the phase velocity from a dispersion relation analysis obtained by the MEM. It was found that fluctuations propagating in the diamagnetic direction of the ions moved toward the periphery before ETB production. The transition took place when the component reached the edge. It was found that it propagated in the electron diamagnetic direction inside the edge and propagated in the ion diamagnetic direction outside the edge after the transition. It is possible that the phase velocity rose in response to the Doppler shift due to the influence of the radial electric field, as it has been pointed out in previous studies, and it also affected the propagation direction of the fluctuation. We are currently processing its verification.

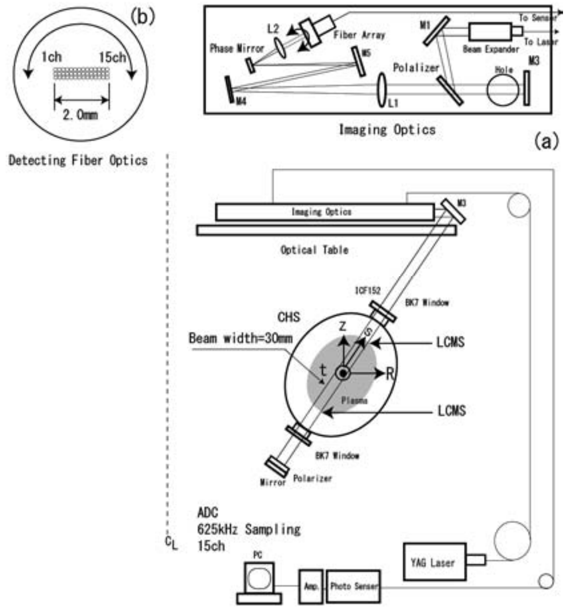

Fig.1 LPC optical system The light from the YAG laser was guided by an optical fiber, expanded in a beam expander, injected into the plasma via a port in the upper part of the CHS, reflected by a mirror, injected again into the plasma from a port in the lower part of the CHS, and then introduced into the optical detection system.

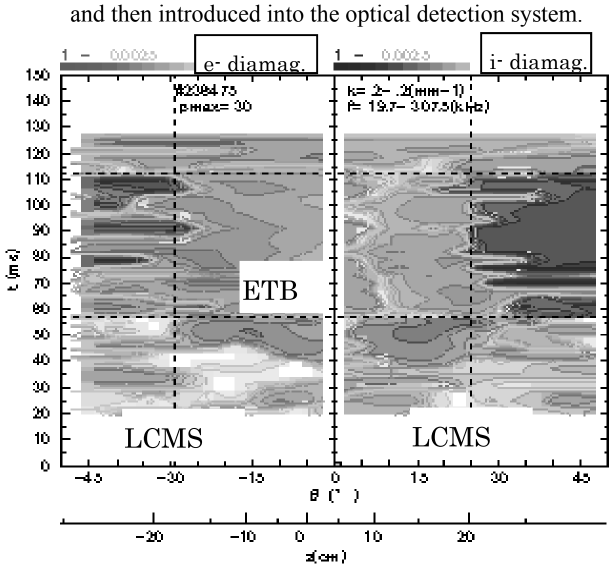

Fig.2 The spatial distribution of the average phase velocity of the measured density fluctuations before and after transition as a function of time. The ETB transition happened at t=57ms. Maximum phase velocity is 4.6×10^{5}cm/s.

The addition of a high-speed rotating dove prism to the detection part of this system will promote the development of a time- space distribution measurement system can be measured in a single shot.

1) K. Matsuo, H. Iguchi, S. Okamura, K. Matsuoka, Rev. Sci. Instrum. (2012)**83**(013501) 1-9.