§ 7. Microturbulence Study by Imaging CO_2 Interferometer on LHD

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The flexible arrangement of optics of CO_2 laser interferometer allows operation in both heterodyne interferometer (HI) mode for the density profile measurements and in phase contrast interferometer (PCI) mode for observation of fluctuations. Since standard PCI record information integrated along the beam axis, several approached was tried to get the longitudinal resolution. One of them employs strong magnetic shear on LHD to obtain modest spatial resolution [1]. The parallel to the magnetic field component of the wave vector of fluctuations is expected to be much smaller than perpendicular one and smaller than cut off wavenumber of PCI technique. Therefore if detector array is oriented normally to the magnetic field lines at the plasma top signals form bottom fluctuations can not be detected. The imaging optics was designed to record fluctuations with 2.5 mm sampling by one dimensional 32 channel linear detector array. Measured longitudinal resolution for this layout is about the minor radius of LHD. In series of plasma shots during last experimental campaign the probe laser beam was tilted and detector axis was set transversely to the magnetic field line near the plasma

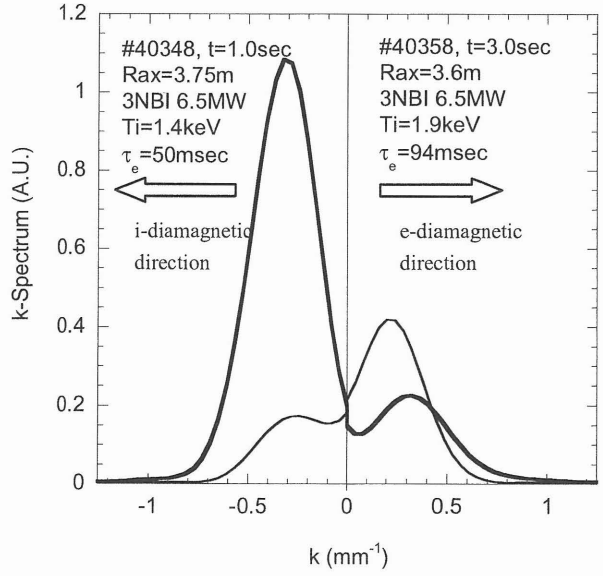

Fig. 1. Wave number spectrum measured by PCI

top. Fig. 1 shows an example of obtained spatial spectra of fluctuations. Two discharges with different magnetic configurations (magnetic axis positions R_{ax}= 3.6 m with better characteristics of neoclassical confinement and 3.75 m which is optimized for interchange instability) and with the same plasma density are presented. If poloidal propagation of the fluctuation is dominated by the plasma rotation, different propagation directions of fluctuations agree with theoretical predictions for parameters of this experiment [2].

New imaging scheme for the localized fluctuation study was proposed. Simultaneous record of phase and amplitude variations of radiation passed trough the plasma fluctuations makes possible axial localization of fluctuations from the ratio of two signals. The bench-top experiment was performed to determine the best spatial resolution, which can be achieved. This test experiment was done using two separate detectors to measure the phase and amplitude signals in the layout close to the real

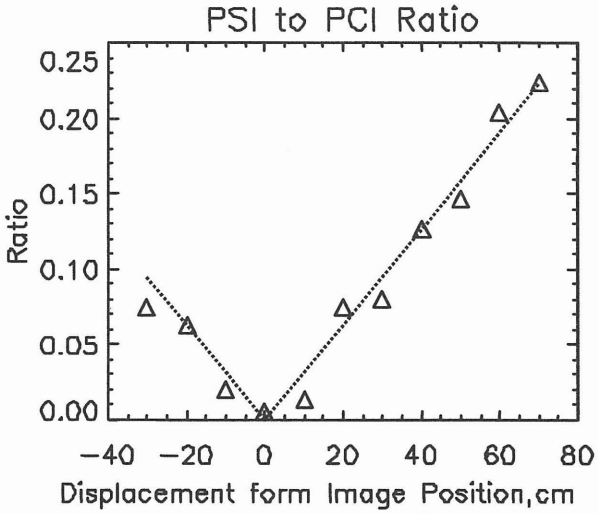

Fig. 2. Ratio of amplitude (PSI) and phase (PCI) signals for bench-top experiment.

experiment geometry. Ultrasonic wave (US) in air with wavelength 1 cm and total phase shift of about $3 \cdot 10^{-4}$ radians was used as test object. The optical gain up to 5 was used during this test experiment. At Fig.2 the ratio of amplitude to phase signals versus the displacement of US from imaging plane along the CO_2 laser beam direction is plotted. Axial spatial resolution is calculated from spread of data points form theoretical dependence (dashed line) and is better than 10 cm for fluctuations with 1 cm wavelength. First experiments for observation of fluctuations with two detector scheme was performed on LHD [3]. Due to small amount of obtained data these results can be regarded as preliminary.

References

1) Kado, S., et al, Jpn. J. Appl. Phys., Part 1 **34** (1995) 6492.
2) Yokoyama, M., et al, Nucl.Fusion, **42**, (2002) 143.
3) Sanin, A., at al, 30th EPS Conference on Plasma Physics and Controlled Fusion, St.Perersburg, 17-21 July 2003, P-1.73.