§8. Density Fluctuation Measurements by Using a Phase Contrast Interferometer on LHD

Tanaka, K.,
Vyacheslavov, L. (Budker Institute of Nuclear Physics),
Akiyama, T. (Tokyo Institute for Technology),
Kawahata, K.

The study of the microturbulence is one of the key topics to understand anomalous transport of the magnetically confined plasmas. A phase contrast interferometer (PCI) is a powerful diagnostics to measure electron density fluctuations. On LHD, PCI systems are installed in order to measure edge density fluctuations. PCI measures small phase variation of the probing beam due to the electron density fluctuations as a small intensity variation. This becomes possible by using a homodyne scheme giving $\pi/2$ initial phase difference between scattered and non-scattered components. Since no phase counter and any digital phase analysis technique are necessary, the fine phase resolution is possible, which cannot be achieved by using a conventional heterodyne interferometer. Also, PCI is capable for wide range of wavenumber measurements. The present setup can detect the wave number from $0.07mm^{-1}$ up to $0.6mm^{-1}$. The $250x50mm^2$ slab beam for PCI covers the edge region (typically ρ (normalize average radius) >0.7) of the LHD plasma and the 32 channels liquid nitrogen cooled HgCdTe detector array is used for the detection of the fluctuation image. The optical system is designed minimizing the effect of the aberration of the lenses in order to measure fluctuation image without deformation. The present phase resolution is around 0.5 mrad, which is determined by the noise of detectors and amplifiers. Since the present probe beam passes the edge region, the dominant wavenumber components are radial components.

Figures.1 and 2 show density trace, PCI signals and S(k, f) spectrum at Bt=1T and 2.64T of the NBI heated discharges, respectively. At the 1T magnetic filed operation, most of the components are lower than 50kHz, and peak wavenumbers are around $0.15mm^{-1}$. At the 2.64T magnetic filed operation under almost the same density and the same heating power, fluctuation amplitude reduces by a factor of 9 in the same frequency domain and, peak wavenumbers are around $0.3mm^{-1}$. The energy confinement time at 2.64T operation is four times longer than 1 T operation. Clear differences of the fluctuation characteristics are observed between different confinement discharges. These results suggest fluctuation characteristics are correlated to confinements characteristics.

Since the present measurements are line-integrated along beam axis, several schemes (cross beam correlation technique, magnetic shear technique, filed depth technique) are under development

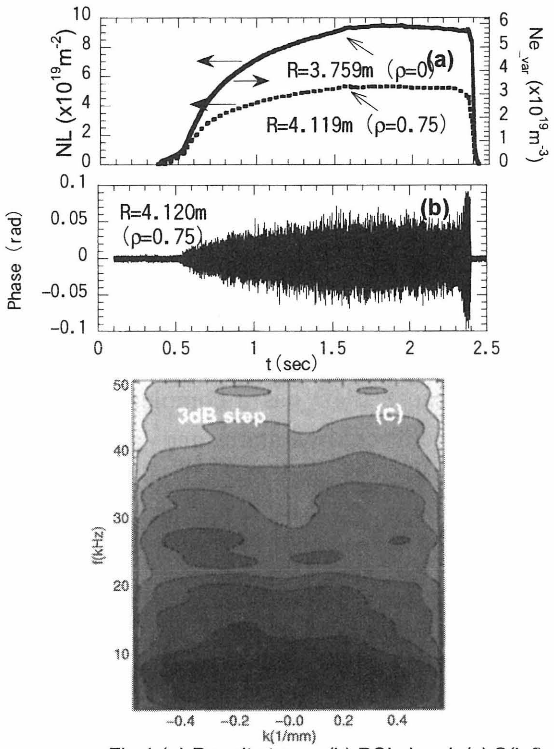

Fig.1 (a) Density trace, (b) PCI signal, (c) S(k,f) spectrum, Rax=3.75m, Bt=1T, NBI heated, τ_e=36msec.

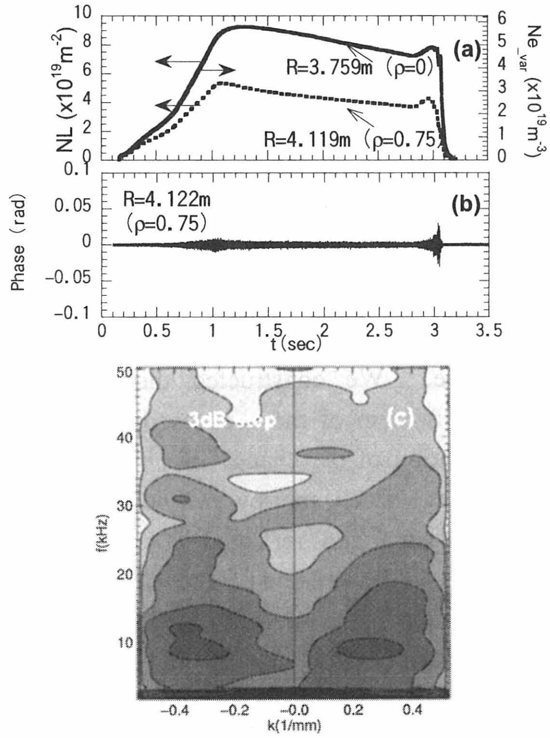

Fig.2 (a) Density trace, (b) PCI signal, (c) S(k,f) spectrum, Rax=3.75m, Bt=2.64T, NBI heated, τ_e=157msec.