§2. Developments of Two Color YAG/CO_2 Laser Imaging Interferometer on LHD

Tanaka, K., Sanin, A.L. (JSPS fellow),
Vyacheslavov, L.N. (Budker Institute of Nuclear Physics.), Kawahata, K.

A multichannel imaging heterodyne interferometer is installed on LHD. Two branches of the interferometer, one with a CO_2 laser (wavelength λ_i=10.6 μm) and other with a diode pumped YAG laser (wavelength λ_i =1.06 μm) are used for electron density measurements and vibration compensation. In figure 1, the sight lines of the newly installed CO_2 and existing FIR interferometer are compared. Three wide viewing ports are used. Two slab beams (at port 1 and 3) and one circular beam (at port 2) are injected. At port 1 and port 3, imaging interferometers are designed. The phase distributions of the injected probe beam are detected by a 1D multi-channel detector with telescopic optics. A line-integrated image of plasma can be detected. The chordal resolution of CO_2 interferometers is from 15 to 22.5 mm, and the phase resolution is 10^{-3} of a CO_2 fringe, which is determined by the electrical noise of phase counter. A YAG laser interferometer is installed to compensate mechanical vibration on the same axis of CO_2 laser interferometer. Presently five channels with 30~40mm spacing are used. About $5\cdot10^{-3}$ ~ 10^{-2} of CO_2 fringe uncompensated signal remains after vibration compensation.

Figure 2 shows the time histories of line density during multiple pellet injection in high density experiments. As shown in fig. 2 (a), the FIR interferometer suffers from fringe jump when pellets are injected. Five of 13 channels jumped in this discharge. On the other hand, CO_2 interferometer channels have no fringe jumps as shown in figs 2 (b)~(c). In this discharge, 9 channels of port 1, 1 channel of port 2 and 8 channels of port 3 were operational. The CO_2 interferometer is tolerant to refraction effects. As shown in fig. 2 (c), 10 pellets are injected. Figure 2 (d) shows expanded view of the last pellet injection. The pellet ablates between t = 0.8496 sec and t = 0.852. There are differences in the ablation process between channels. Stronger increases are observed in the upper traces in figure 2 (d). Upper traces correspond to viewing lines, which traverse the core region (port 2 and port 3), while the viewing lines associated with lower traces intersect only the edge region (port 1). The strong increase of the upper traces indicates that the last pellet penetrated into the plasma core. Figure 3 shows the change of the reconstructed density profile before and after the last pellet injection. For this reconstruction, 4 channels of the FIR interferometer which are free from fringe jumps, and 18 channels of the CO_2 interferometer are used. Since the cross sections of the CO_2 and FIR interferometers are not identical as shown in fig.1, the path lengths are different for the same major radius. Therefore, in order to combine both interferometer data, the path differences were taken into account. Radial profiles are obtained by discrete numerical density reconstruction. Error analyses are done taking into account un-compensated vibration components. The density profile is observed to change from hollow to peaked after last pellet injection.

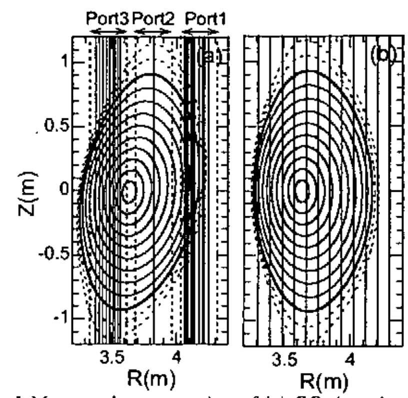

Fig.1 Measured cross section of (a) CO_2 imaging interferometer and (b) multichannel FIR interferometer. The dotted lines in fig.1 (a) indicate viewing regions of the ports. The vertical solid lines indicate viewing lines of the detectors.

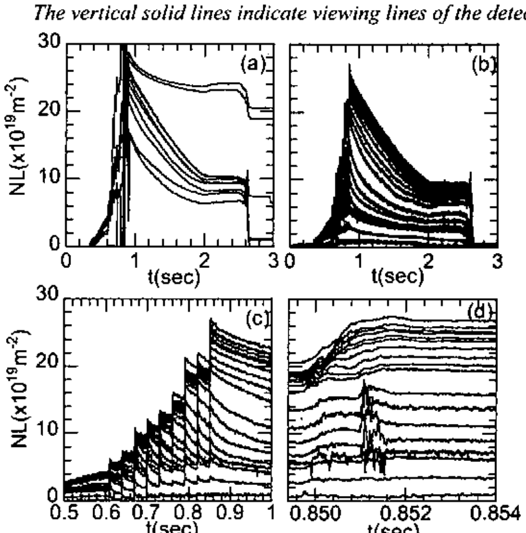

Fig.2 Time trace of line density for multiple pellets injection (a) FIR and (b) CO_2 interferometer (c) expanded view during pellets injection (d) expanded view of the last pellet injection. (b), (c) and (d) are signals from CO_2 interferometer.

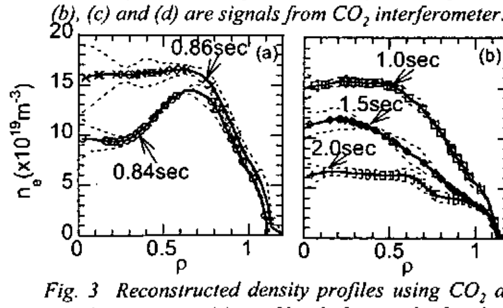

Fig. 3 Reconstructed density profiles using CO_2 and FIR interferometer. (a) profiles before and after last pellet injection, (b) profiles after last pellet injection. Each symbols corresponds to chord position. Dotted lines indicates upper and lower error bars.