§5. CO_2 Laser Dispersion Interferometer on LHD

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The line averaged electron density along the central line of sight in the elongated cross section is convenient for data analyses and fueling control because the measurement does not affected by the Shafranov shift. LHD is equipped with the millimeter-wave interferometer and it provide the line averaged density with a high density resolution even in the case of low density plasma. On the other hand, it sometimes suffers from fringe jump errors in high density range. Although additional interferometer with a short wavelength laser, which can reduce the risk of fringe jump errors, with a horizontal line of sight is preferable, instllation of a vibration isolation system is distant. Since A dispersion interferometer is free from the mechanical vibrations [1], it was installed on LHD in 2012. However, the measured density showed disagreement with that of the FIR laser interferometer. Since the discrepancy was expected casused by distorsion of the wavefront of the phase modulated beam in LHD [2], the phase modulation is added after passing through a LHD plasma in the 17th experiment campaign.

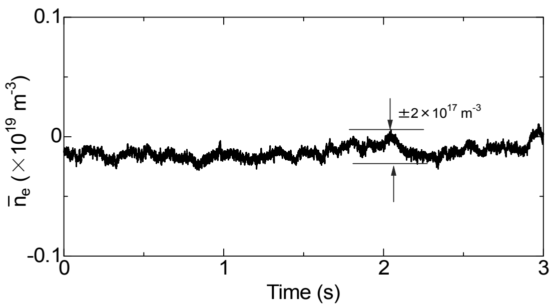
Figure 1(a) shows the baseline of the electron density. The variations determines the density resolution and is within 2×10^{17} m^{-3}. Even in the case of long time measurement for 30 min., the baseline drift is less than 5×10^{17} m^{-3}. This density resolution is realized without vibration isolation system and this indicates that the mechanical vibrations are well cancelled. The evaluated electron densities with the dispersion intefereometer is shown in Fig. 1(b). It shows good agreement with that with the existing FIR laser interferometer. It is found the the line averaged density evaluated with the dispersion interferometer is about 4% smaller thant that with the FIR laser interferometer as shown in Fig.2. One of reasons for the difference is errors in the path lengths in a plasma, which were defined the distance in the last closed magnetic surface. The other is difference in the line of sight; while the beam of the FIR laser interferometer passes thouth X points, that of dispersion does not. In addition, the small modulation of the density 2×10^{18} m^{-3} is observed. This is caused by offset in the modulation amplitude signals. When the offset C and D is included in the the modulation amplitude $I_{2\omega m}$, $I_{\omega m}$, the modulation component appears in the evaluated phase shift ϕ'.

$$I_{2\omega_m} = 2BJ_2(\rho_0)\cos(\phi) + C, \quad I_{\omega_m} = -2BJ_1(\rho_0)\sin(\phi) + D$$

$$\Rightarrow \phi' = \tan^{-1}\left(I_{\omega_m} / I_{2\omega_m}\right) = \phi + E\sin(c\phi + \alpha)$$

Here, B is the amplitude of the interference signal, J_1 and J_2 are the Bessel function of order of the first and the second, ρ_0 is the retardation and ϕ is the actual phase shift. The offsets which are about 10% of the modulation amplitudes are found. It leads to the density modulation of 1×10^{18} m^{-3},

(a)



(b)

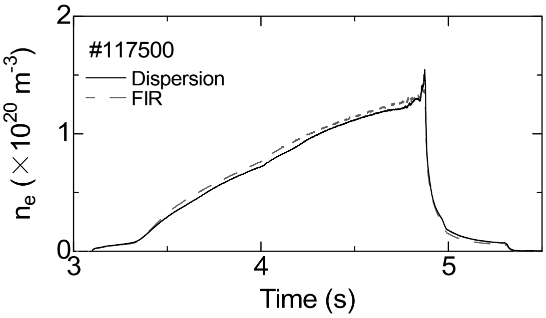


Fig. 1: (a) Baseline variations of the line averaged density (b) The evaluated line-averaged electron densities with the dispersion interferometer and the centaral chord of the FIR laser interferometer.

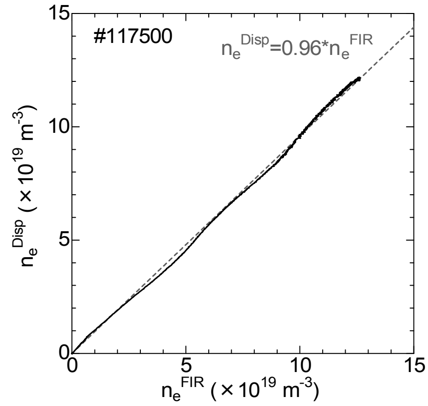


Fig. 2: Comparison between the dispersion and the FIR laser interferometer.

which is similar to the observation. The offset term might come from multi-reflection in the photoelastic modulator. If so, it will be reduced by fine adjustment of the incident angle of the probe beam to the photoelastic modulator.

1) P. A. Bagryansky *et. al.*, Rev. Sci. Instrum. **77**, 053501 (2006).
2) T. Akiyama *et. al.*, annual report 170 (2013).