§4. Electron Density Measurement with a CO_2 Laser Dispersion Interferometer on LHD

Akiyama, T., Yasuhara, R.,
Okajima, S., Nakayama, K. (Chubu Univ.)

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 not realistic. Hence, we installed a CO_2 laser dispersion interferometer in 2012. A good density resolution of 4×10^{17} m^{-3} has been obtained [1].

As for temporal resolution, we evaluated it with a atmospheric pressure plasmas. When the voltage is applied to the plasma source, it had already proven that a plasma is produced with a time constant of several μs. On the other hand, it is found that there is a response delay of 80 μs and the response time constant is about 100 μs as shown in Fig. 1. These temporal responses are expected to be determined by lock-in amplifiers, which are used for detection of amplitudes of modulation components. Althogh these responses are acceptable on present LHD, imporovement is preferable. Digital data processing without the lock-in amplifiers are one of ideas.

As shown in Fig. 2, there is no fringe jump error in the dispersion interferometer when data sampling time is enough shorter than time scale of a density rise of 2π. A sampling frequency of 100 kHz seems to be enough for LHD. In this way, it is confirmed that the dispersion interferometer is reliable in the high density region, where a FIR laser interferometer suffers from the fringe jump errors.

Even so, fringe jump errors are observed at impurity pellets injected discharges as shown in Fig. 3. As for the speed of density change, that due to impurity pellet is smaller by 1/10 than ice pellets. Hence, fringe jump errors at the impurity pellet is not caused by slow response time of the dispersion interferometer. The impurity pellet injector locats at the same equatorial port and the minimum distance between the line of sight of the dispersion interferometer and a trajectory of impurity pellet is about 10 cm. Hence, it is possible that the high density ablation cloud perturbates the wavefront of the dispersion interferometer. The the dispersion interferomter should be located far from a pellet injector, or use of short wavelength which can reduce the phase shift smaller than 1 fringe to be free from the fringe jump errors.

1) T. Akiyama *et. al.*, Rev Sci Instrum. 85, 11D301 (2014).

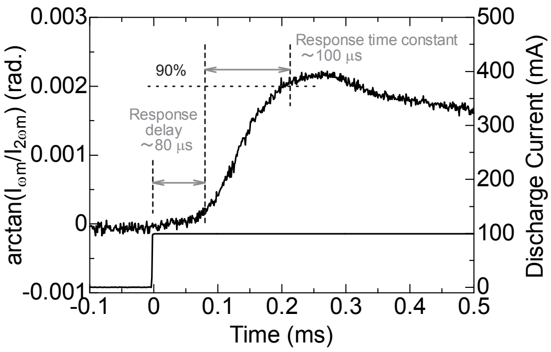

Fig. 1: A Temporal behaviour of the CO_2 laser dispersion interferometer.

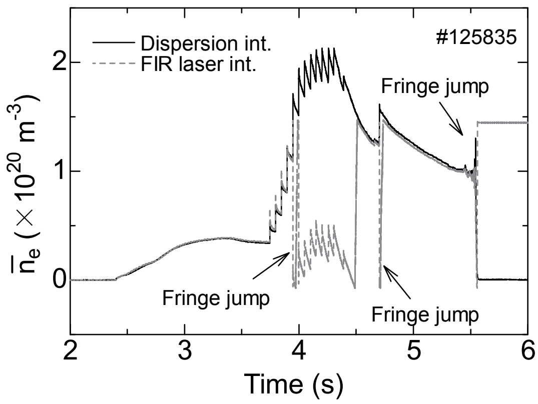

Fig. 2: Measurement results of the FIRlaser interferometer and the dispersion interferometer of a pellet injected discharge.

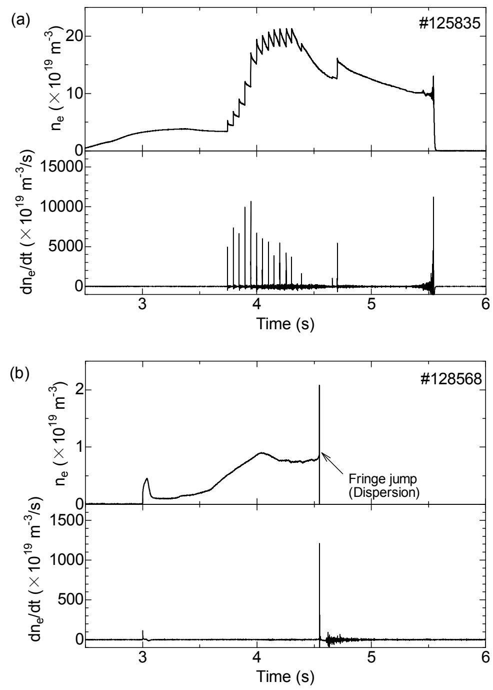

Fig. 3: Measurement results of (a) ice pellets and (b) impurity pellets injected plasmas.