§6. CO_2 Laser Dispersion Interferometer on LHD

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A vibration isolation system and a massive flame are equipped with conventional interferometers for electron density measurement to reduce the phase errors. However, complete suppression of the vibration will be difficult on future large fusion devices. One of the advantages of a dispersion interferometer [1] is insensitive to mechanical vibrations. The wavelength of the light source is determined to have a larger phase shift than that due to the vibrations for the conventional interferometers. In the case of the dispersion interferometer, such a restriction is not necessary because of the immunity to the vibrations. Hence a short wavelength whose phase shift is smaller than 2π can be used. Then, the phase is determined without ambiguity. This means that the dispersion interferometer can be free from fringe jump errors. From these advantages, the dispersion interferometer is suitable for future large and high density fusion devices such as high density operations of LHD and ITER.

Figure 1 (a) shows the optical flame of the CO_2 laser dispersion interferometer installed on LHD. The flame is placed without a vibration isolation system. The optical plate is divided into two parts: upper plate for phase modulation with a photoelastic modulator (PEM) before beam injection to LHD, lower for signal detection. The laser beam is injected from the outboard (10-O port) to the inboard (10-I) side and reflected by a retroreflector. The width of variations of the signal baseline of the electron density, which determines the density resolution, is 1×10^{18} m^{-3}. As shown in Fig. 1 (b), an evaluated line averaged density was found to be about a half of the actual density measured with the FIR laser interferometer. The calibration experiment with a ZnSe plate on LHD also showed a smaller phase shift than actual one, although the appropriate one was measured on the bench test [2].

One of the reasons is a distortion of a wavefront of the probe beam by a vacuum window and the retroreflector. The power of the second harmonics generated before injection to LHD, whose phase is modulated with the PEM, is very small about 50 μW. Since it was speculated that the modulated signal was easy to be disturbed due to the small signal, the position of the PEM was changed to the lower optical plate from the upper to modulate the returned beam. Figure 2 (a) shows the calibration test on LHD after modification of the optical arrangement. On previous bench test, the total phase shift was 169 deg. when the wedged ZnSe plate was moved for 23 mm (Fig. 2 (b)). The evaluated total phase shift is 167 deg. after the modification and is comparable to that of the previous bench test. The stepwise phase shift on LHD is due to manual move of the ZnSe plate. Plasma measurement will be performed with this modified optical arrangement in the 17th experiment campaign.

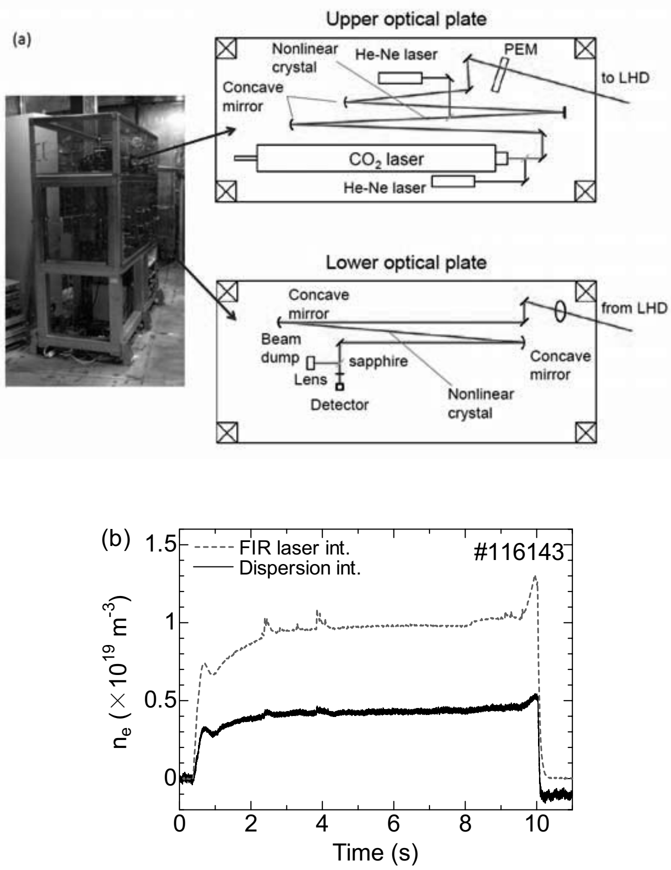

Fig. 1: (a) A photo of the optical flame of the CO_2 laser dispersion interferometer on LHD and optical arrangement. (b) The evaluated line-averaged electron density with the dispersion interferometer and comparison with that with the FIR laser interferometer.

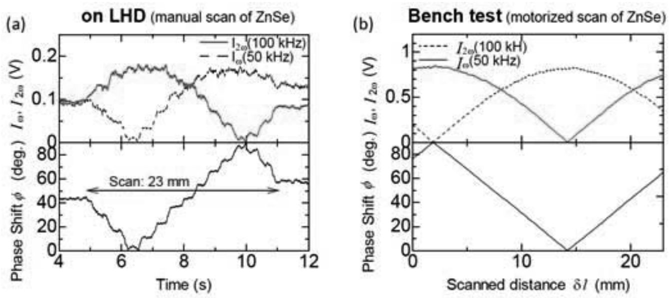

Fig. 2: Calibration test with a wedged ZnSe plate on LHD (a) and on bench test (b).

1) P. A. Bagryansky *et. al.*, Rev. Sci. Instrum. **77**, 053501 (2006).
2) T. Akiyama *et. al.*, Plasma ad Fusion Res. **5**, 047 (2010).