§17. Dispersion Interferometer with a Low-power Nd: YAG Laser

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For fueling control, the line averaged electron density is indispensable and its measurement has to be reliable. While an interferometer is widely used for the fueling control, it needs mechanical vibration compensation. In addition, there is risk of fringe jump error, which leads to uncontrollability of the electron density. The reason why the fringe jump happen is multipul fringe shifts. Since the phase has 2π ambiguity, the total fringe shift is lost when the phase signal is temporaly interrupted by some reasons during phase change.

The dispersion interferometer is insensitive to the vibaraion and needs no vibration isolation. Hence there is few limitation for installation locations. The CO_2 laser (a wavelength of 10.6 μm) dispersion interferometer was installed on LHD and demonstrated the feasibility of the density measurement [1] and the robustness against the vibrations. The another advantage is the possibility of fringe-jump-less interferometer. If the phase shift is always smaller than one fringe, the electron density can be determined without ambiguity. Although the phase shift by a plasma can be made smaller than one fringe by using a short wavelength laser for comventional interferometers, the phase shift by the vibrations becomes larger. Hence, the the fringe-jump-less interferometer has not been realistic so far. However, a short-wavelength dispersion interferometer can be the fringe-jump-less interferometer because it is insensitive to the vibrations. Even if the phase shift by a plasma is small, it will be measurable since the phase shift by the vibrations is quite small, which are main noise source for a conventional interferometer.

Figure 1 shows the arrangement of the short-wavelength dispersion interferometer. The laser source is a Nd:YAG laser whose wavelength is 1.064 μm. For most fusion plasmas at present including LHD and JT-60SA, the phase shift by a plasma is smaller than one fringe. The proof of principle experiment of the Nd:YAG laser dispersion interferometer had been conducted [2]. Another advantage is compactness of the optical system. For the 10.6 μm dispersion interferometer, the high power output is necessary because the efficiency of the second harmonic generation is usally small for the wavelength. Since the high power laser is relatively large and it needs a chillar with high cooling capacity, the optical system tends to be large. On the other hand, there is high efficiency nonlinear crystalT for 1 μm such as PPMgSL and even a small laser power around the 1 W can generate a second harmonic power more than 10 mW, which is surficient for detection, as shown in Fig. 2. Therefore, the optical system can be compact like around 50 × 50 cm (Fig. 1). The second harmonic generation with 1 W output and the dispersion interferometer measurement was conducted as shown in Fig. 3. For long-time measurements, the phase resolution is determined by the offset drift. A variations of ±3 deg., which corresponds to a line density of $\pm 1.2 \times 10^{19}$ m^{-2} is obtained for 200 s. Since the offset drift seems to be caused by the temperature variations of air, reduction of the path length or reduction of the air pressure will effective to improved the density resolution.

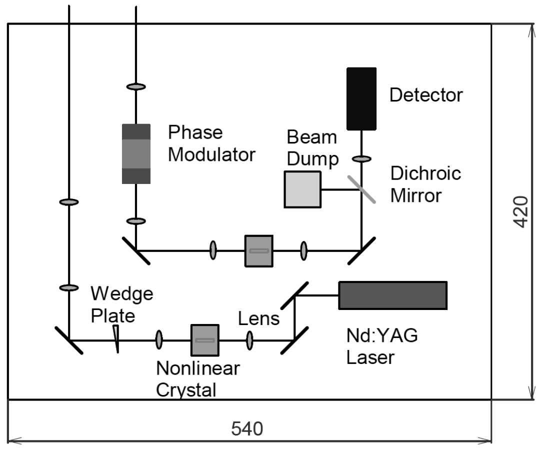

Fig. 1: Layout of a low-power 1 μm dispersion interferometer

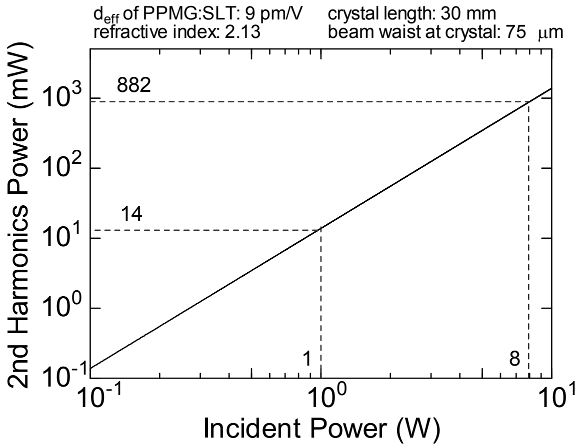

Fig. 2: Second harmonic generation with a high efficiency nonlinear crystal PPMgSLT.

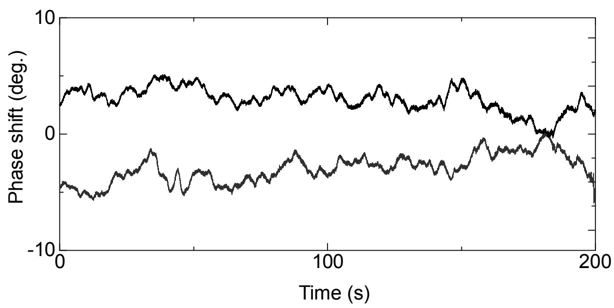

Fig. 3: Measuerd offset drifts of the low-power 1 μm dispersion interferometer. Two data were acquired in different times.

1) T. Akiyama *et. al.*, Rev Sci Instrum. **85**, 11D301 (2014).
2) T. Akiyama *et. al.*, Nucl. Fusion **55**, 093032 (2015).