# §24. Bench Testing of a Dispersion Interferometer Using a Ratio of Modulation Amplitudes

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

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

The dispersion interferometer utilizes the mixed beam of the fundamental and the second harmonics as a probe beam. As shown in Fig. 1(a), the second harmonics is generated with a nonlinear crystal. After passing through a plasma (here, a zinc selenide ZnSe plate for simulation of a plasma), the probe beam passes the nonlinear crystal again and another second harmonics is generated. The remaining fundamental is cut by a filter (a sapphire plate), and the interference signal between two second harmonics is detected. While phases due to the vibration are the same between two second harmonics, that due to a plasma is different because of dispersion. Therefore, the vibration term is canceled and the phase shift reflects only the dispersion of the plasma. In this way, the dispersion interferometer can measure the electron density without contamination by the vibrations.

In this bench testing, a laser is a continues-wave $CO_2$ laser with a wavelength and an output power are 10.6 μm and 8 W, respectively. The nonlinear crystal is $AgGaSe_2$, whose conversion efficiency is relatively high and the absorption coefficient is small. The interference signal of the usual dispersion interferometer is $A+B\cos\phi$. $A$ and $B$ are the DC component and the amplitude, which are determined by detected intensities. To evaluate the phase $\phi$, which is proportional to the line density, $A$ and $B$ are necessary. However, they may vary during a discharge due to the beam refraction in a plasma and instabilities of laser oscillation. In order to eliminate measurement errors due intensity variations, the phase modulation with the photoelastic modulator (PEM) and the phase extraction method using a ration of modulation amplitudes are introduced[1)].

Figure 1 (b) shows a demonstration of immunity to the mechanical vibration[2)]. One flat mirror is vibrated with a piezo-transducer with a distance of ±10 μm, larger than the wavelength. Even so, measurement results, which are converted to the line density, are not affected. Although small spiky signals (1.6 deg.) are observed, they are caused by the output instabilities. A small fraction of the back beam goes into the laser again and it makes the feedback control of the cavity length unstable. This problem can be solved by adding the second nonlinear crystal behind the ZnSe plate and changing the optical path to one way system, not the back and forth beam system. The amplitude of baseline fluctuations is about $\pm 4\times 10^{17}$ $m^{-2}$ when the time response of lock-in amplifiers, which are used to detect the fundamental and the second harmonics of the drive frequency $\omega_m$ of the PEM, is longer than 1 ms. Since this fluctuation would be enhanced by the output instabilities of the laser, above change of the optical system is expected to improve the density resolution. Evaluation of a wedge angle of the ZnSe plate from the measured phase shift shows good agreement to the designed value. This measurement suggests feasibility of the phase extraction method using a ratio of modulation amplitudes.

1) Akiyama, T. et. al.: Plasma and Fusion Research **5** (2010) S1041.
2) Akiyama, T. et. al.: accepted to Rev. Sci. Instrum. **81** (2010).

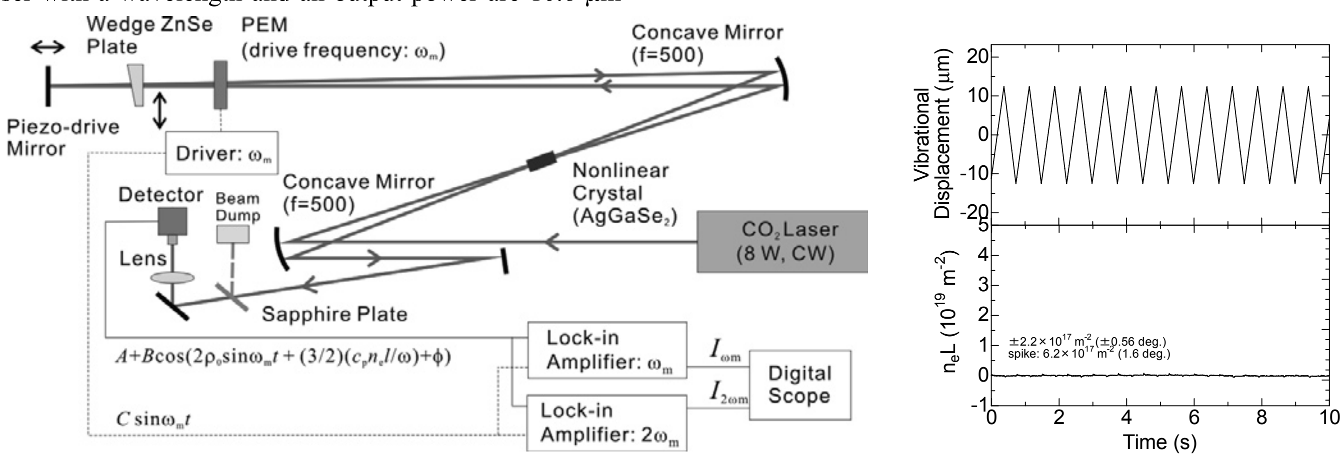


Fig. 1 : (a) Optical and electrical systems of the dispersion interferometer using a ratio of modulation amplitudes. (b) One example of measurement when a mechanical vibration is added artificially with a piezo-drive mirror.