# §23. Evaluations of Measurement Errors Due to Mechanical Vibrations and Temperature Variations of a PEM Polarimeter

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As the electron density in LHD is getting higher, a reliable electron density measurement is indispensable. A $CH_3OD$ laser (57 and 48 μm) has been developed because a beam bending effect ($\propto \lambda^2$) in a plasma, which causes fringe jump errors, is small due to the short wavelength. It is suitable for the laser source of an interferometer in LHD. On the other hand, a $\iota$ profile can be evaluated by polarimetry. The importance of measurement of the $\iota$ profile is increasing since a position of a rational surface seems to be correlated with confinement improvement mode. Therefore we are designing and testing the $CH_3OD$ laser interferometer combined with the polarimeter now. This system can also be adapted to the poloidal polarimeter in ITER. From the viewpoints of measurement resolutions, maintenance and compatibility with the present interferometer system, a measurement method with the use of dual photoelastic modulators (PEMs) is selected for polarimetry.

An actual environment on a fusion device is severe for laser diagnostics: mechanical vibrations, the beam displacement due to refraction in a plasma, changes in the temperature, and so on. In order to estimate how much above effects cause measurement errors, we carried out the bench testing. Figure 1(a) shows evaluated polarization angle when a parallel vibration with an amplitude of 100 μm is added. No effect on the polarization angle is observed[1]. The beam refraction in a plasma cause the change of the incident angle to the PEM and a detector. As shown in Fig.1(b), the change in an incident angle $\Delta\theta$ of 1 deg. leads to an error of the polarization angle $\Delta\alpha$ of about 1 deg. The maximum refraction angle due to the density gradient ($1\times10^{20}$ ($1-\rho^8$) $m^{-3}$) is about 0.01 deg even in the ITER. Hence, error from the beam refraction is smaller than the target resolution 0.05 deg.

As reported in the previous annual report, the room temperature affects to the baseline of the polarization angle. In order to suppress the temperature variations, some optics including the PEMs are put in a heat insulating box. As a result, the temperature variation in the box can be reduced smaller than 0.1°C. Consequently, the drift of the baseline can be improved, 0.024 deg. for 1000 s, smaller than the target resolution. Eliminating the effect of the temperature change, other error cause was found. When the laser cavity (both $CO_2$ and FIR lasers) is slightly changed, the evaluated polarization angle also changes. Although both laser cavities are free running at present, they will be actively stabilized soon. Then the baseline drift is expected to be improved.

1) Kawahata, K.,: accepted to Rev. Sci. Instrum. **81** (2010).

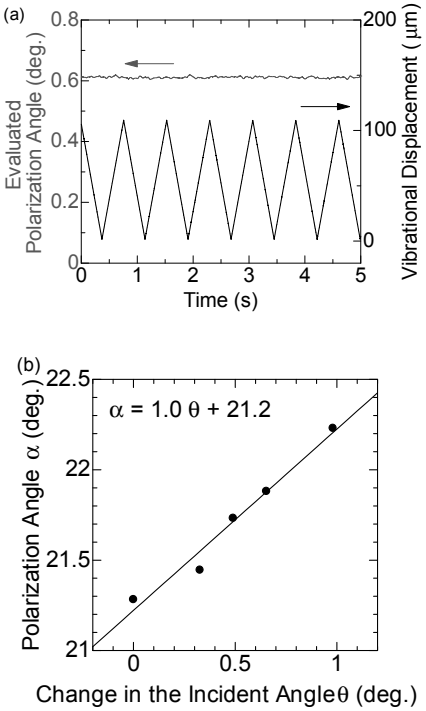


Fig. 1: The evaluated polarization angles (a) when the vibrations parallel to the beam path are added and (b) when the incident beam angle to the PEMs is changed.

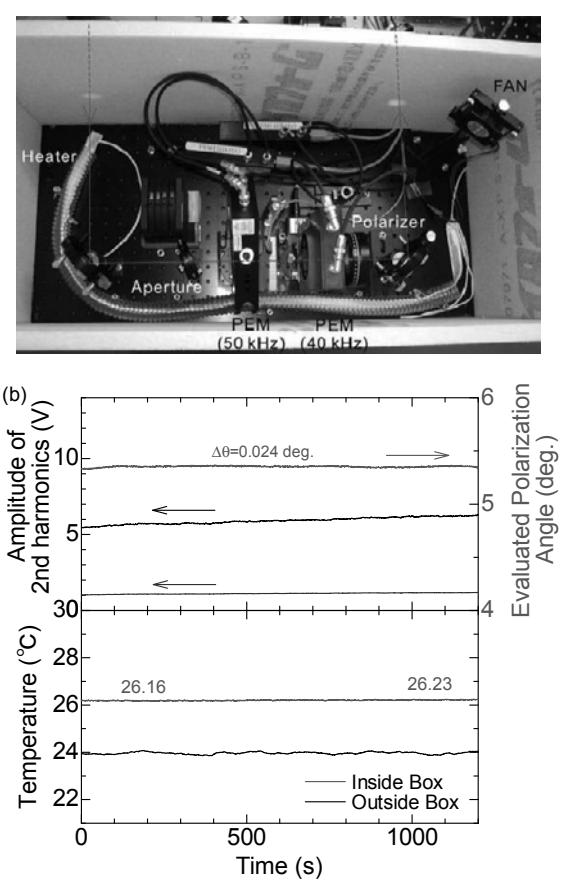


Fig.2 (a) PEMs covered by heat insulating material. (b) The line drift when the temperature variation is suppressed smaller than 0.1°C.