§12. Improvements of a Polarimeter with Use of Dual Silicon Photoelastic Modulators for 57/48 μm Laser

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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 and is suitable for the laser source of an interferometer in LHD. On the other hand, a ι profile can be evaluated by polarimetry. The importance of measurement of the ι 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 viewpoint of measurement resolutions, maintenance and compatibility with the present interferometer system, a measurement method with the use of dual photoelastic modulators (PEMs) is selected.

We reported an angle resolution of 0.05 (0.02) deg. with a time constant of 1 (10) ms in the annual report in 2008. In order to improve the temporal resolution, we replaced rock-in amplifier from analog to digital ones. In addition, ADCs with 12 bits also replaced to these with 16 bits and we reduced hum noises from the power supply to improve the angle resolution. As a result, we obtained the angle resolution of 0.01 (0.025) deg. with the response time of 1 (0.1) ms as shown in Fig.1 [1]. The q profile measurement on ITER requires a time resolution of 10 ms and accuracy in the profile smaller than 10%. According to the error estimation in Ref [2], the error in the polarization angle of 0.05 deg. corresponds to the RMS error of 5% in the q profile. Hence, present resolution satisfied the requirements from ITER.

Figure 2 shows a measurement for 1000 s, which is comparable to planned non-inductive operations of ITER. Slight variations in amplitudes of the second harmonics are canceled when the polarization angle is evaluated because of $\alpha = (1/2)\tan^{-1}(I_{2\omega 2}/I_{2\omega 1})$. Here, $I_{2\omega 1}$ and $I_{2\omega 2}$ are amplitudes of the second harmonics of the detected signal modulated with the PEMs (modulation frequencies of ω_1 and ω_2). This is a good demonstration that polarimetry with PEMs is insensitive to variations in the detected signal intensity. However, a drift of the base line of the polarizatioln angle is found to be typically 0.1 deg. for 1000 s, which is larger than the required angle resolution. The drift seems to be caused by the changes in the room temperature around the PEMs. When the air is warmed by 3ºC with a heater (Fig.2 (b)), the evaluated polarization angle changes by 0.4 deg. as shown in Fig.2 (c). Since the room temperature in the laser room usually varies about ±0.5 ºC for about 1 hour, the expected variation in the polarization angle is comparable to the observed one. Boxing the PEMs and active temperature control are planned.

1) Akiyama, T. et. al.: Plasma Device and Operations **17**, 117 (2009).
2) Donné, A. J. H. et. al.: Rev. Sci. Instrum. **75**, 4694 (2004).

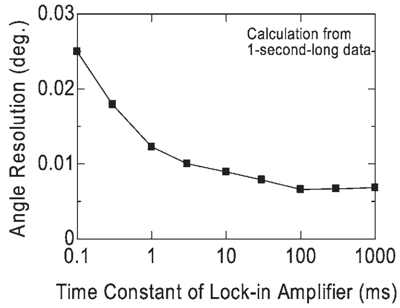

Fig.1: Relationship between an angle resolution and a time constant of lock-in amplifiers.

(a)
(b)
(c)

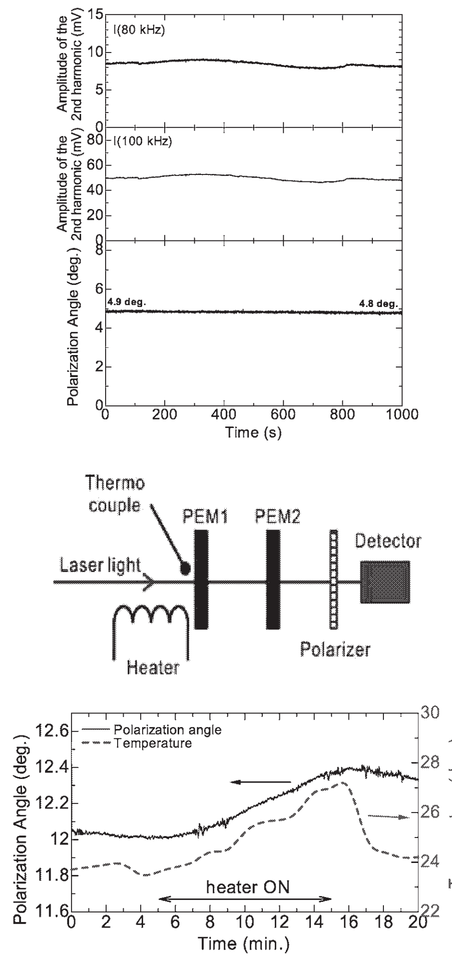

Figure 2. (a) typical measuerment for 1000 s. (b) arrangements of optics and a heater to examine effects of changes in the room temperature. (c) changes in the measured polarization angle when the room temperature changed by about 3°C.