§16. Bench-testing of a Polarimeter with Use of Silicon Photoelastic Modulators for 57/48 μm Laser

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

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 [1, 2] 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 an interferometer combined with a polarimeter with the use of the CH_3OD laser 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 photoelastic modulators (PEMs) is selected. We upgraded a single PEM polarimeter, which was tested last fiscal year, to a dual one as shown in Fig. 1 in order to improve resolutions. The detector output I and then the polarization angle α are evaluated as follows.

$$I = \frac{I_0}{2}\left((DC) - \frac{1}{\sqrt{2}}\{2J_2(\rho_0)\cos\alpha\cos(2\omega_1 t) - 2J_2(\rho_0)\sin\alpha\cos(2\omega_2 t) + \cdots\}\right)$$

$$\therefore\ \alpha = -\frac{1}{2}\tan^{-1}\left\{\frac{I(2\omega_1)}{I(2\omega_2)}\right\}$$

J_k : *Bessel function*, ρ_0 : *Maximum of retardation*,
ω_m : *Drive frequency*, α : *Polarization angle*

Figure 2 shows a relationship between an evaluated and an actual polarization angles. The polarization was rotated with a half-wave plate on a rotation stage. Good linearity is obtained after fine adjustment of the transmission axis of a polarizer in front of a detector. Figure 3 shows an angular resolution as a function of a time constant of lock-in amplifiers. An angular resolution of 0.05 (0.02) deg. with a time constant of 1 (10) ms is obtained while the maximum of the Faraday rotation in LHD and ITER are 5 and 14 deg., respectively, in the case of 1×10^{20} m^{-3}. Since the minimum time constant, 1 ms, is determined by the specification of the analog lock-in amplifiers we use now, we have plan to replace them to digital ones whose minimum time constant is 10 μs. Though present time constant is expected to be enough for equilibrium analyses, much faster system is attractive in the view point of study of magnetic fluctuations. Application of digital lock-in technique is also our future plan to improve the temporal resolution. As for long time stability, the drift of the baseline is typically 0.1 deg. during 1000 s. This is caused by change in the refractive index of photoelastic element (or AR-coating) due to variations of the room temperature, which is confirmed by experiments with heaters. Control of temperature around PEM is necessary to suppress the baseline drifts.

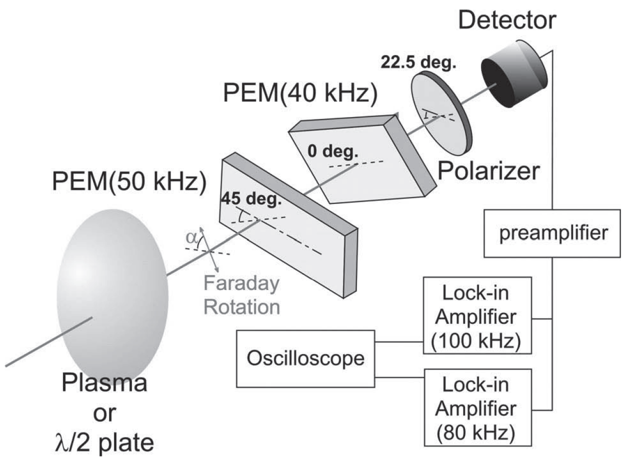

Fig. 1: Illustration of the optical setup of the dual PEM polarimeter

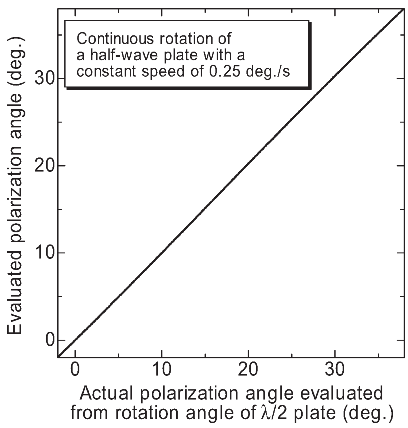

Fig.2: Relationship between an actual and an evaluated polarization angles. The polarization angle is rotated with a half-wave plate whose optical axis can be rotated.

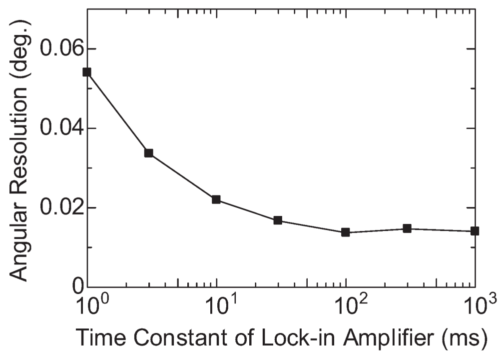

Fig.3: Relationship between an angular resolution and a time constant of Lock-in amplifier.