§25. Faraday Rotation Densitometry for LHD

Tsuji-Iio, S., Akiyama, T. (Res. Lab. for Nucl. Reactors, Tokyo Tech.),
Okajima, S., Nakayama, K. (Chubu Univ.),
Kawahata, K.

The tangential 3-channel CO_2 laser polarimeter was tested to complement the interferometer system on LHD. We adopted the polarization rotation method using the frequency-shift heterodyne technique and the digital complex demodulation combined with digital band-pass filtering to measure the angle with high resolution. Hence we achieved the Faraday rotation angle resolution defined as the standard deviation of 2-s long phase difference signals of 0.01 degrees, which corresponds to a line-averaged density of 5.0×10^{17} m^{-3} at B = 3 T, with a response time of 3 ms[1]. The baseline of the rotation angle, however, sometimes fluctuates with amplitudes up to 0.05 deg. in several seconds and this determines the accuracy of the polarimeter.

After the fourth experimental campaign, bench testing of the CO_2 laser polarimeter was conducted in the Plasma Diagnostics Laboratories. We found that the stability of the baseline deteriorates when the axes of the two counter-rotating beams were not well aligned as shown in Fig. 1. The fluctuations of the baseline increased by more than a factor of three even with slight beam misalignment that dropped the amplitude of the beat signal only by 5%. Figure 2 shows the shift of the apparent Faraday rotation angle with the deviation of laser beam with respect to the detector. The shift becomes larger when the collinearity of two beams was not optimized. We speculate that the movement of the beam axes changes the phases of the wave fronts which incident on the detectors and causes the resulting phase shifts of the beat signals. The non-sinusoidal behavior of the baseline trace suggests that the origin of beam axis fluctuations may be the laser itself rather than mechanical vibrations of some optical components.

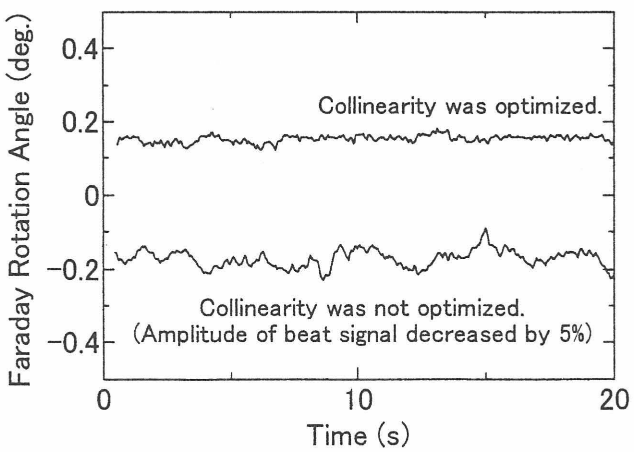

Fig. 1 Comparison of baseline fluctuations of the Faraday rotation angle.

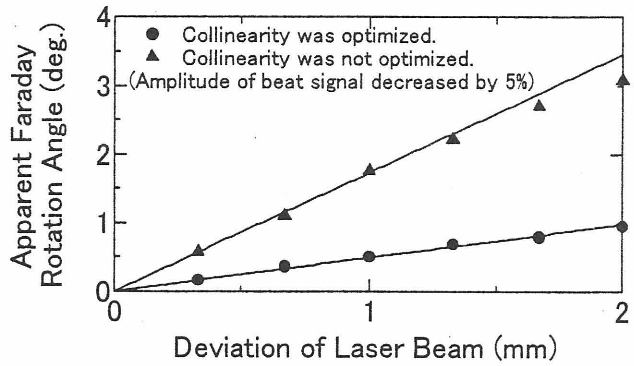

Fig. 2 The apparent Faraday rotation angle shifts with laser beam deviation.

Figure 3 shows the electron density profile after pellet injection estimated from the 3-ch polarimeter data. We assumed functional dependence of the profile as,

$$n_e(\rho) = a\left\{1-(\rho/\rho_{BC})^b\right\}$$

where a and b are fitting parameters, ρ is the normalized magnetic flux radius and ρ_{BC} is the plasma boundary radius. Open and closed circles are results of the Abel inversion of the inner and outer channel data of FIR interferometer, respectively. The profile from the polarimeter is consistent with those from the FIR interferometer. This is the first demonstration of the electron density profile obtained from polarimetry in the world.

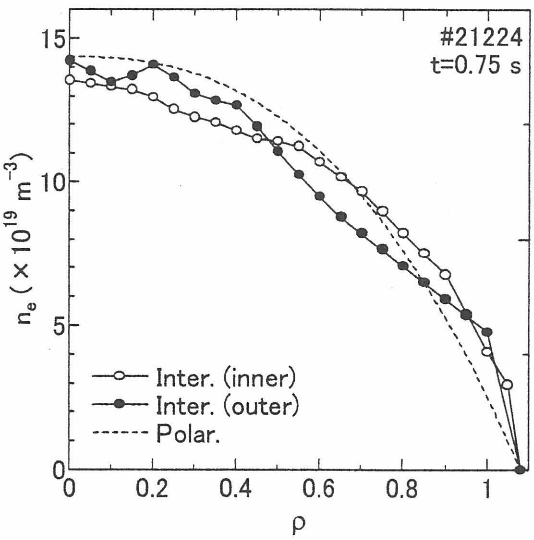

Fig. 3 Comparison of the electron density profile estimated from the 3-ch polarimeter with those from the 13-ch interferometer.

Reference

1) Akiyama, T. *et al.*, 28th EPS Conf. on Contr. Fusion and Plasma Phys., Vol. 25A (2001) 1289.