§ 9. Precision Improvement of Interferometer and Polarimeter by CO_2 Laser Refinement

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A CO_2 laser has the advantage of small refraction as a laser source for an interferometer and polarimeter on a large fusion experimental device operated at high electron densities. We have developed a CO_2 laser polarimeter for electron density measurement and taken part in developing a CO_2 laser imaging interferometer on LHD and found that the baseline of the polarization angle and the phase difference fluctuated at frequencies of several hertz [1,2]. Since those fluctuations were a serious problem in the case of low-density discharges, we investigated the sources of the fluctuations in this study. One of the possible sources is the inhomogeneous phase or intensity across the laser beam because the cross section of lased beam was rather deformed. Another candidate is the movement of the laser beam axis. When the dominant source is identified, we may improve the baseline fluctuations through CO_2 laser refinement.

In order to examine the former source, we disturbed the wave front of the laser beam of the CO_2 laser interferometer using a Zinc Selenide plate without anti-reflection coating. Since the plate can make multi reflection lights, the interference fringes on the cross section of the laser beam that passes through it were observed. Any differences in the amplitude and frequency of the fluctuations of the baseline, however, were not observed compared with those without the Zinc Selenide plate. In addition a spatial filter which is used to remove the disturbances of the wave front could not improve the baseline fluctuations. Therefore we concluded that the effect of the former cause is not dominant.

Figure 1 (b) shows relative changes in the beam powers of right- and left-handed circularly polarized beams at a detector of typically less than $\pm 0.3\%$ [2]. Nevertheless the change in the amplitude of the beat signal measured with a lock-in amplifier is $\pm 1\%$ as shown in Fig. 1 (a). Since the beat signal amplitude depends not only on each beam power but also on the efficiency in mixing of the two beams, this result suggests that the beam axes move around and then the beam mixing efficiency varies. Indeed the baseline of the polarization angle fluctuates correlatively with the change in the beat signal amplitude as seen in Fig. 1 (a).

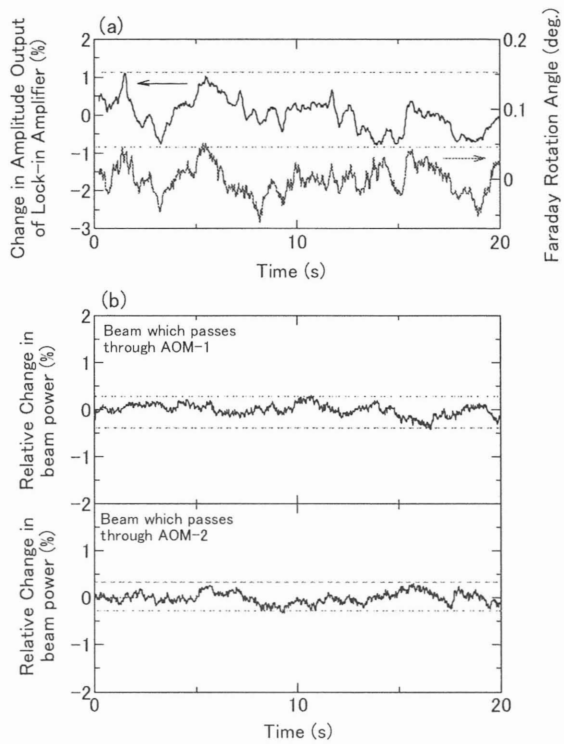

Fig. 1. Time traces of the relative amplitude of the beat signal and the Faraday rotation angle simultaneously measured with a lock-in amplifier (a) and those of relative beam powers of counter-rotating polarized beams (b).

The following four factors contribute to the movement of the beam axis; i) fluctuations in the power of RF signal that drives an acousto-optic modulator (AOM) for frequency shift, ii) the change in temperature of cooling water for the laser and AOM, iii) the laser itself, iv) mechanical vibrations. Monitoring the RF power, we found that there was no correlation between the changes in the RF power and baseline fluctuations. While the quantitative experiments on the CO_2 laser polarimeter showed that the changes in cooling water temperature could cause baseline fluctuations, the amplitude of changes in temperature that is necessary to cause the baseline fluctuations was not observed. Regarding the third and fourth factors, it was difficult to separate these two effects because the vibration isolation bench on which optical components and the laser were placed could not damp the vibrations in the frequency range of less than several hertz which are almost the same as the frequencies of baseline fluctuations.

In conclusion, although we found that the dominant source of the baseline fluctuations is the movement of the laser beam axis, we could not identify its cause.

Reference

[1] Akiyama, T., Tanaka K., Vyacheslavov, L. N. *et. al.*, Rev. Sci. Instrum **74**, 1638 (2003).

[2] Akiyama, T., Tsuji-Iio, S., Shimada, R. *et. al.*, Rev. Sci. Instrum. **74**, 2695 (2003).