§5. Applications of Phase Conjugate Mirror to Thomson Scattering Diagnostics

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To realize the multi pass Thomson scattering method employing phase conjugate mirrors based on stimulated Brillouin scattering (SBS-PCM)[1], we have developed a high-output-energy and high-repetition-rate laser system to demonstrate this method in LHD. Since a reflected beam by the SBS-PCM returns on the same path as the incident beam by means of the phase conjugation, alignment free operation is available except for initial adjustment in this method. The Brillouin gain coefficient is inverse proportional to line width of the laser, the single longitudinal mode laser is necessary to obtain high reflectivity of the SBS-PCM. We have developed a high power YAG laser system with single longitudinal mode applying two existing commercial lasers. The first laser (Continuum 8050) is a single longitudinal mode laser, but low output energy (0.55 J, 50 Hz). The second laser (Continuum 9010) is a multi mode laser, but high output energy (2 J, 10 Hz). In this modification, the first laser and the second laser are utilized as a master oscillator and a power amplifier, respectively, as shown in Fig.1 (1). Since SBS-PCMs in Fig.1 are employed to compensate the thermo-optical effect of laser rods, the effective amplification is also expected by double pass amplification. We successfully obtained 1.15 J of output energy at the maximum pumping in the 50-Hz operation in FY2009. However, peaked beam profile damaged laser rod. In FY2010, we concentrated into improvement of beam profile for the stable laser operation as follows: (1) compensation of depolarization loss, (2) suppression of diffraction ring.

(1) Compensation of depolarization loss

In the high-output-energy and high-repetition-rate laser amplifier, thermal birefringence is induced in the laser rod. When the linear polarized beam passed the laser amplifier, the beam is depolarized at four corners, and depolarized component leads the power loss as shown in Fig.2(a). To compensate the depolarization, we removed the laser housing of the oscillator of the 9010 laser, and installed it in the 8050 laser as another amplifier, as shown in Fig.1(2). A 90° rotator was also installed between two amplifiers. The depolarization pattern was compensated from this change as shown in Fig.2(b).

(2) Suppression of diffraction ring

After the compensation of depolarization, laser damage in the laser rod still occurred, it found that a hot spot in the beam profile was formed around the 9010 amplifier position. A burn pattern triggered the rod damage is shown in Fig.2(d). We considered that the hot spot was arisen from diffraction ring as shown in Fig.2(b). To suppress the diffraction ring, a soft aperture was installed in the 8050 laser. A sandblasting AR-coated glass plate which central part is transparent was used as the soft aperture as shown in Fig.1(2). As the result, the diffraction ring was almost suppressed by the soft aperture, and beam profile is effectively improved (Fig.2(b) →(c)). The hot spot also disappeared (Fig.2(d)→(e)).

After two improvements, it became possible that high power double pass amplification without the laser damage. Burn pattern of the amplified beam is shown in Fig.2(f). Although we could not measure the output energy due to the power meter trouble, it seems that the laser energy reaches about 1.2 J from the burn pattern. For the conclusion, preparation for the laser system for the multi pass Thomson scattering measurement was complete.

1) Hatae, T. *et al.*:Rev. Sci. Instrum **77** (2006) 10E508

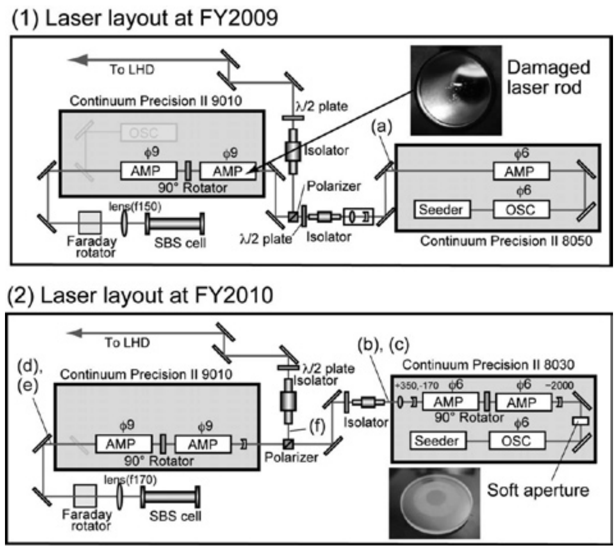

Fig. 1. Optical layout of YAG laser system

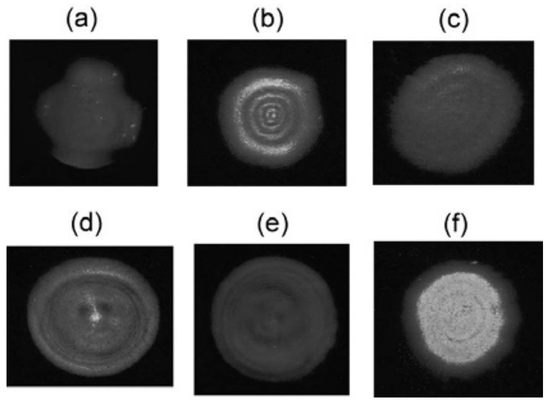

Fig.2. Burn patterns: measured places are indicated in Fig.1.