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

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The incoherent Thomson scattering is one of the essential diagnostics to measure electron temperature and density profiles in fusion plasma experiments. Plural lasers for a burst mode operation has been used to realize high repetitive measurement so far, and this is an established technique. On the other hand, we have newly proposed a multi pass Thomson scattering method employing phase conjugate mirror based on stimulated Brillouin scattering (SBS-PCM). [1] The multi pass method has a possibility of high repetitive measurement, and only one laser is enough for high repetitive measurement. In the multi pass method with SBS-PCMs, SBS-PCMs are installed facing each other through the plasma. A pulsed laser beam is confined between a pair of SBS-PCMs by controlling the polarization of the laser beam. Therefore the pulsed laser beam is shuttled between SBS-PCMs, scattered light is generated whenever the laser beam passes through the plasma. When the distance between SBS-PCMs is adjusted, the appropriate measurement period is obtained. A reflected beam by the SBS-PCM returns on the same path as the incident beam by means of the phase conjugation of the optically nonlinear stimulated Brillouin scattering process. Consequently alignment free operation is available except for initial setting, and this is an advantage of this method. For the SBS-PCM, a liquid fluorocarbon (trade name is 3M Fluorinert FC-75) is utilized as SBS medium.[2]

To demonstrate the multi pass Thomson scattering method, we are considering the proof-of-principle tests in LHD. The optical layout for the multi pass scattering in LHD is shown in Fig.1. A longitudinal mode of the laser is important to realize the multi pass scattering. Since a Brillouin gain coefficient is in inverse proportional to line width of the laser, single longitudinal mode is necessary to obtain the high reflectivity of the SBS-PCM. For the first stage, we are developing a high power YAG laser system with single longitudinal mode by using two existing commercial lasers. The first laser is a single longitudinal mode laser, but low output energy (0.55 J, 50 Hz). The second laser is a multi mode laser, but high output energy (2 J, 10 Hz). In this improvement, the first laser and the second laser are utilized as a master oscillator and a power amplifier, respectively. A SBS-PCM is employed to compensate the thermal optical effect of laser rod. The effective amplification is also expected by double pass amplification by the SBS-PCM. The optical layout is shown in Fig.2.

We have carried out amplification tests for improved laser system. At the 10 Hz of repetition rate, laser energy of single pass amplification is 1.52 J. In the case of double pass amplification with SBS-PCM, 1.86 J of the laser energy is achieved, and the energy is improved up to 1.22 times compared to that of single pass amplification. At the 25 Hz of repetition rate, 1.16 J of the laser energy is obtained. The repetition rate and highest laser energy is limited by capability of the power supply for the power amplifier. At the 25-Hz operation, reflectivity of the SBS-PCM and the pulse width are 96.7 % and 10 ns, respectively.

For the future plan, we are planning to carry out the double pass Thomson scattering measurement using a SBS-PCM in LHD. We will try the multi pass scattering measurement after success of the double pass scattering.

1) Hatae, T. *et al.*:Rev. Sci. Instrum **77** (2006) 10E508
2) Yoshida, H. *et al.*: Appl. Optics **36** (1997) 3739

This work is supported in part by Grant-in-Aid for Scientific Researches on Priority Area "Advanced diagnostics for burning plasma" from Ministry of Education, Culture, Sports, Science and Technology (No. 20026011).

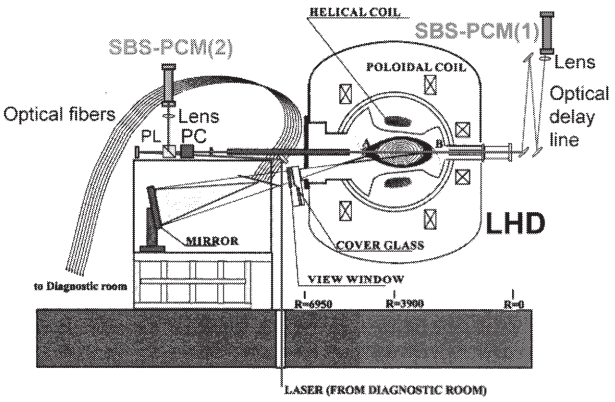

Fig. 1. Optical layout for the multi pass Thomson scattering method in LHD

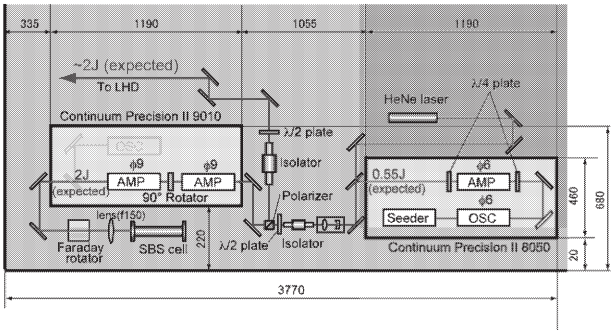

Fig. 2. Optical layout of YAG laser system for the multi pass Thomson scattering method in LHD