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Development of Double Pockels Cells Multi-path Thomson Scattering System in Heliotron J based on Gauss Beam Analysis

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A multi-path Thomson scattering system has been constructed on the Heliotron J, which is aimed to improve the time resolution of measurement of temperature and density of electron, to increase scattered photons in low-density plasma, and to observe the anisotropy velocity distribution and temperature along and perpendicular to the local magnetic field. However, due to the limited room provided by Heliotron J to set the optical path of the multi-path Thomson scattering system, the raw scattering signals corresponding to different incident beams overlap with each other, increasing difficulty to analyze the data separately.

In this case, a double Pockels cells Thomson scattering system (DPCT) is proposed to improve the overlapping scattering light signal in Heliotron J [1, 2]. By switching on the 2nd Pockels cell, the optical path propagated by the laser beam is extended so that the overlap between two adjacent raw scattering signals can be relieved. As the laser is a Gaussian beam and the optical path of the DPCT is much longer than the previous single path Thomson scattering system's [3], two image relay systems (IRS) working as Kepler telescope are incorporated into the current optical path to maintain the laser beam profile in such a long reciprocating path of DPCT. Fig. 1 and 2 manifest the evolution of diameter and power density as the laser beam moves away from the laser machine. Fig. 1 demonstrates that without the IRS, the laser beam's diameter will keep on expanding and finally exceeding the limit diameter of entering the Pockels cell. Fig. 2 shows that a specific area of the optical path is necessary to get vacuumed to avoid spark breakdown occurring at the focal point of the IRS caused by excessive power density carried by the laser beam. Besides, the relationship between the focal length of lenses in the 1st IRS and the required length of the vacuum region is estimated, as shown in Fig. 3. The longer the focal length of the lenses in the 1st IRS, the shorter the vacuum region length when the focal length of lenses in the 2nd IRS is a constant. Meanwhile, it can be seen that setting lens 1 farther to the end mirror of IRS 1 can also shorten the length of the vacuum region when the focal length of lenses in the 1st IRS is a constant. In addition, by optimizing the position of lens and mirror in IRS, the expansion of radius of Gaussian beam can be confined within 10% at the entry of some fragile optical components, against the vibration within 5 mm deviation in the direction of laser propagation caused by plasma discharge in Heliotron J.

References

[1] Minami, T, et al. JINST. Current Status and Plan of Development of Nd:YAG Laser Thomson Scattering System in Heliotron J (2020).
[2] Qiu D, et al. Plasma Fusion Research, 2020, Volume 15, 2401044 (2020).
[3] Minami, T, et al. Review of Scientific Instruments 81.10(2010):10D532-10D532-4.

Figures

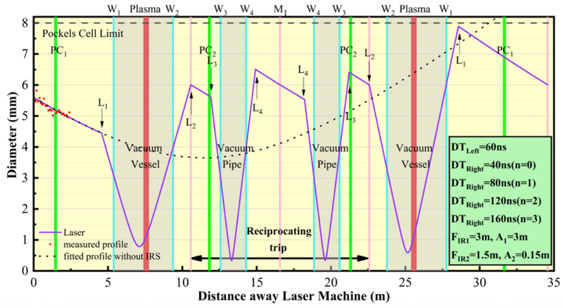

Fig. 1 the evolution of diameter as the laser beam moves away the laser machine.

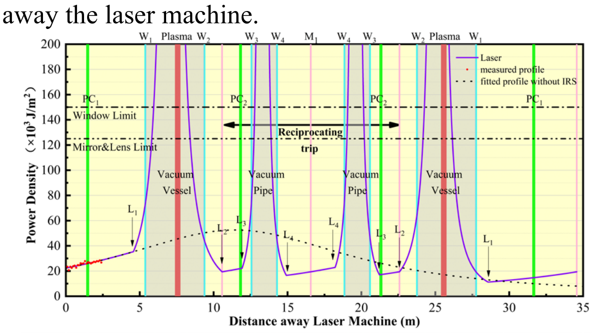

Fig. 2 the evolution of power density as the laser beam moves away the laser machine.

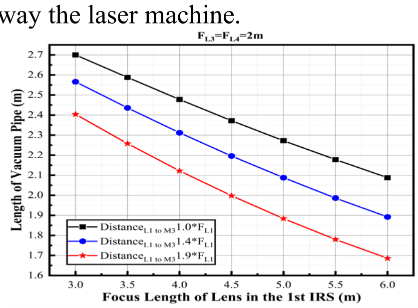

Fig. 3 The relationship between the focus length of the lenses in the 1st IRS and the length of vacuum region.