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Dual-angle Thomson scattering diagnostic experiment design and preliminary results

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Coherent Thomson scattering (TS) diagnostic is one of the most accurate methods to acquire information of local plasma. The detected spectrum includes two regimes, the low frequency regime (IAW) and the high frequency regime (EPW). With EPW regime, the density and temperature of electron can be achieved, while with IAW regime, one can obtain the ion flow velocity, electron temperature if average ionization state is known, ion temperature and relative drift between electrons and ions in plasma. Recently Yaoyuan, Liu[1] proposed an idea that by fitting spectrums collected at two angles simultaneously, the accuracy of *Te* and n_e can be drastically increased, with the pre-assumption that good signal-to-noise ration should be required. To verify this propose, we design and carry out a dual-angle Thomson scattering diagnostic experiment on Magnetized Laser Plasma Device (MLPD) at University of Science and Technology of China (USTC). The MLPD has a frequency-doubled heating laser (532 nm), with maximum energy output of 4J and pulse width of 7 ns (FWHM). The heating beam enters the target chamber from north, perpendicularly irradiating an aluminum foil with thickness of 100 μm to produce a blow-off plasma, and the heating beam also acts as the probe beam. The TS signal is collected at 90 ° and 135 ° relative to the heating beam via four achromatic lenses with total magnification ratio of 1. The scatter volume is designed to be located 400 μm in front of the target, and is imaged onto a multimode fiber, with NA of 0.15 and core diameter of 105 μm. The fiber transmits the scattered signal to a 750mm spectrometer (PI, SP-2750) equipped with a 1800lp reflection grating, thus in this experiment, we only measure the IAW regime of the spectrum. After the signal is dispersed, the spectrum is relayed to the ICCD with a pair of achromatic lenses, and a blackened knife-edge is placed at the image plane of the spectrometer to block unwanted green light. The gate time of ICCD is set to be 3.5 ns. The spectrum resolution of this system is 0.6 Å. The spectrums acquired in experiment show good SNR and the two peak of IAW feature can be clearly distinguished. Fitting the spectrum with the method proposed by Liu, the fitting result shows the Te is about 176 eV, Ti about 111 eV, with uncertainty of 11% and 17% respectively. Moreover, the fitting returns n_e with 6.5E18cm^{-3}, which is consistent with former interferometry result. The fitting method used above does not take density and temperature gradient into account, which may result in the inconsistence at the dip between fitted spectrum and acquired spectrum. Moreover, the scattering volumes viewing from two angles are not the same, the influence of which should be evaluated for further analysis.

References

1.Yaoyuan Liu, Yongkun Ding, and Jian Zheng, Review of Scientific Instruments 90 (8), 083501 (2019).

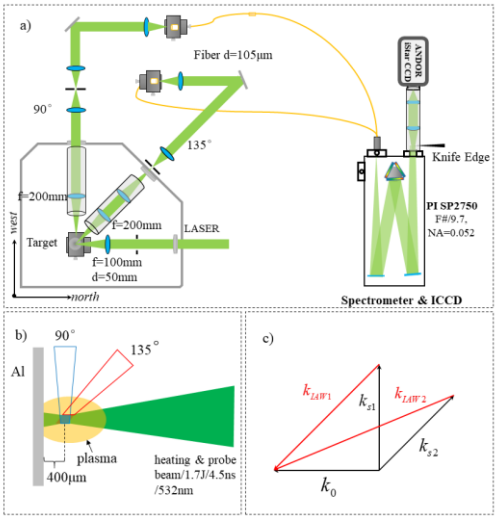

Fig. 1. a) Experiment setup; b) illustration of scattering volume; c) illustration of differential scattering vector.

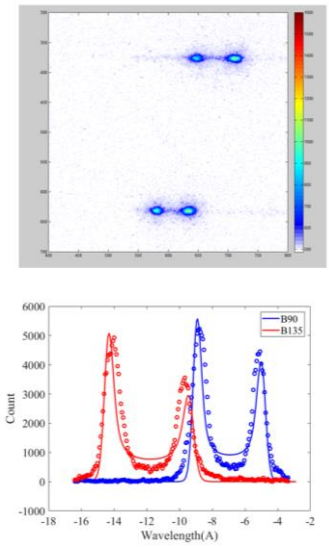

Fig. 2. up: raw data of TS spectrum from ICCD; down: fitting result of dual-angle TS spectrum.

No.	n_e	*Te*	*Ti*
Unit	Cm-3	eV	eV
Param	6.5E+18	176	111
σ	~16%	~11%	~17%

Table. 1. fitting results with uncertainty