The optical design of a vertical Thomson scattering system on SUNIST-2

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Thomson scattering (TS) is a key method to measure electron temperature (T_e) and density (n_e) profiles in fusion plasmas. A vertical Thomson scattering system with 900 mm field of view using a 5J/100 Hz laser as the light source is being developed for the upgraded Sino-UNIted Spherical Tokamak (SUNIST-2) to measure T_e and n_e in the ranges of 100 ~ 3000 eV and 5×10^{18}~10×10^{19} m^{-3}, respectively. The optical design, simulation and test results of the TS system mainly including the laser beam path, a special beam dump, a scattered light collection optics and fiber bundles will be presented.

Figure 1 shows the optimized optical design of the collection optics with ZEMAX software. The axis of the lens is tilted up by 16 degrees in order to cover the 900 mm field of view. The near-axis magnification and NA in the image plane are about -0.28 and 0.34, respectively. Solid angles of the view fields are in the range from 9.3 msr to 27 msr. The RMS radius of the whole field of view is from 89 μm to 270 μm. The Brewster windows, tube baffles, the beam dump and wire grid polarizers are designed to suppress the stray laser light [1]. The self-developed high performance 5-ch polychromator [2] will be employed to detect the scattered light, which has a trans-impedance gain of 22k Ohms and the noise level is below 5 mV. Considering the solid angles, scattering angles, scattering lengths, laser pulse width, detector quantum efficiency, laser pulse energy, and the transmissivity of the entire optical system, the estimated errors of T_e in the core and edge regions are about 10% and 20%, respectively.

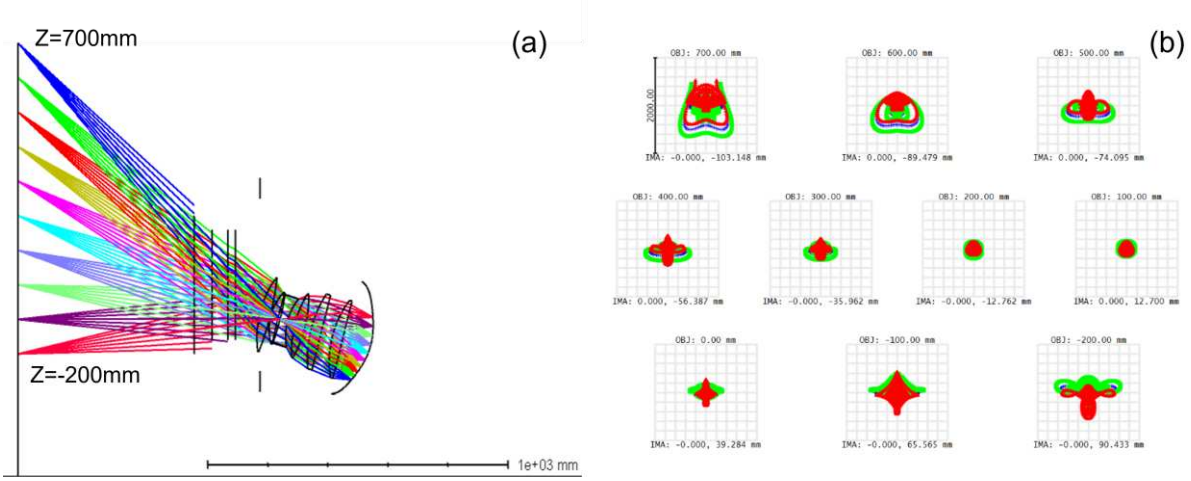

Figure 1. Optical design results of the collection optics. (a) Ray traces from the fields of view to the image plane, and (b) Spot diagrams in the image plane with wavelengths of 850 nm, 950 nm and 1050 nm indicated by colors.

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[2] Gong S B, *et al.,* Plasma Science and Technology **25** (2023) 075601.

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