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Multiple-scattering-angle scheme of collective Thomson scattering and its application on the investigation of electron thermal force

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Thomson scattering is a powerful diagnostics for high-temperature plasmas. The so-called multiple-scattering-angle scheme of collective Thomson scattering is proposed to meet the requirement of high measurement precisions of laser-produced plasmas in relevant to high-energy-density physics [1]. With the aid of Monte Carlo simulations and statistical analysis, we find that the fitting uncertainties of plasma parameters like electron density and electron and ion temperatures can reach an unprecedented level by just fitting the ion-acoustic features of Thomson scattering from two scattering angles simultaneously. For example, the fitting uncertainty of electron temperature can be smaller than 1% and that of electron density can be just several percent when the plasma is homogeneous.

A series of experiments are thus performed in the Joule-level laser device at University of Science and Technology of China [2]. By fitting the ion-acoustic-wave feature spectra collected from two angles simultaneously, the electron density inferred from Thomson scattering is in good agreement with that from digital holography diagnosis. Detailed analyses indicate that dual-angle Thomson scattering diagnosis can provide a good estimation of the electron density in the case that the scattering parameter is less than 2.

Since the plasmas are inhomogeneous, transport processes become significant and are of importance. We find that the asymmetry of the ion-acoustic features of Thomson scattering depends on the so-called thermal force, i.e., the momentum exchange rate between electrons and ions driven by electron temperature gradient [3]. Our experimental results show that the inferred thermal force coefficients are much larger than the classical Braginskii results. Fokker-Planck simulations are performed, and show that transport processes become non-local in our experiments.

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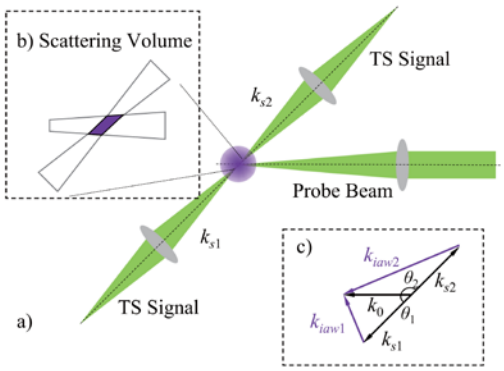

Figure 1 (a) The schematic of dual-angle Thomson scattering. (b) Scattering volume. (c) The *k*-vector diagram of ion-acoustic waves.