Numerical simulation of collective Thomson scattering in laboratory astrophysics

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We have performed the laboratory experiment on collisionless shocks by using high power laser in collaboration with the Institute of Laser Engineering (ILE) at Osaka university for the past few years. To measure the local plasma quantities in the shock transition region, collective Thomson scattering (CTS) measurement is utilized. The CTS is the scattering of low frequency incident electromagnetic waves by collective oscillations of plasma electrons. The spectrum of the scattered waves enables us to infer the local plasma quantities like electron density, electron and ion temperature, valence of ions, etc, as a function of local position along the path of the incident probe laser light.

The CTS measurement has been widely used so far to measure experimental as well as space plasmas. However, details of the scattering theory are complex. In particular the theory of the CTS in a non-equilibrium plasma has not been established. In this study we build the numerical simulation system of virtual CTS applicable to the measurement system in the ILE experiment. A local non-equilibrium plasma near a shock is reproduced by using standard full particle-in-cell (PIC) simulation. The time-series data of electron density obtained from the PIC simulation is used to solve a wave equation of the scattered waves separately. Since the frequencies of the scattered waves as well as the incident probe light are much higher than the plasma frequency, the wave equation should be solved with the temporal resolution much higher than that in the PIC simulation. Furthermore, the measurement system at ILE is essentially two dimensional. We will report preliminary results of the virtual CTS simulation with realistic parameters in the ILE experiment.

Keywords: collective Thomson scattering, laboratory astrophysics, numerical simulation

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