§48. Stimulated Electron Acoustic Wave Scattering of Laser Light in a Two-Electron-Temperature Plasma

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Interaction of strong electromagnetic (EM) waves with an underdense plasma now casts challenging issues in a variety of fields of plasma science. In particular, stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS) have been intensively investigated, since these instabilities can reflect laser energy and preheat a target in inertial fusion experiments. Recently, by means of particle simulations, it was found that the strong scattering of laser light from a plasma layer of subcritical density ($n_c/4 < n/\gamma < n_c$); where γ is the relativistic factor. Intense coherent reflectivity pulsations at frequencies below the electron plasma frequency were observed in regions which were overdense for standard SRS[1]. The spectrum has been explained by a resonant three-wave parametric decay of the relativistic laser pump into the slowed Stokes light sideband and the trapped electron-acoustic wave (TEAW). In this simulation, however, small amplitude electron acoustic wave (EAW) was not observed in the initial phase of the instability and there is a large discrepancy between the frequency of the well developed electron acoustic wave observed in the simulation and that obtained by the dispersion relation. In fact, it is difficult to observe an electron acoustic wave in usual plasma, since it is strongly Landau damped. However, it was reported that it has small damping rate in a two-electron-temperature plasma[2]. With these situations in mind, we have performed 1D3V relativistic electromagnetic particle in cell (PIC) simulation of laser interaction with a two-electron-temperature plasma.

Initially, two-electron-temperature plasma with length $l=50(c/\omega_0)$ is placed in the center of the system, where c is the light speed and ω_0 is the laser frequency, respectively. The temperature of cold electron is 500 eV and the hot to the cold electron temperature ratio is 32. The density of cold electrons is $n_c=0.4n_{cr}$ and the hot electron density is $n_c=0.2n_{cr}$, where n_{cr} is the critical density for the laser propagation. Ions are initially placed as neutralized background and are kept immobile. The linearly polarized laser with electric field along y-axis propagates along x-axis from the left hand side of the plasma. The laser strength is $\beta_0=(eE_0)/(mc\omega_0)=0.4$.

In Fig. 1, the time evolution of the reflectivity observed in the left hand side of the plasma layer. We can observe strong reflection around $\omega_0 t=900$. This corresponds to the propagation of the backscattered light created by the stimulated electron acoustic scattering. In order to see the development of electrostatic wave in the plasma, time evolution of the frequency spectrum of Ex observed in the center of the plasma region is plotted in Fig. 2. A peak at $\omega/\omega_0=0.25$ is observed in the spectrum $0 < \omega_0 t < 259.05$. It is considered that this peak corresponds to the electron acoustic wave. The wave number of the electron acoustic wave observed in the center of the plasma region is about $k/k_0=1.0$. Here k_0 is the laser wave number in vacuum. We can obtain that the wave number and the frequency are $k\lambda_{Deh} = 0.4$ and $\omega/\omega_{peh} = 0.56$, respectively, by using plasma parameters of the hot electrons. This frequency is close to that obtained by linear dispersion relation for two electron temperature plasma. The peak frequency gradually increases with time and becomes $\omega/\omega_0=0.35$. It is considered that this increase is caused by electron trapping and other nonlinear effects.

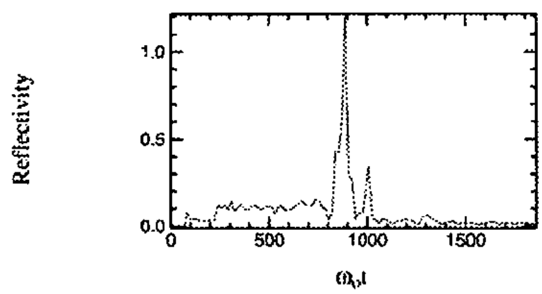

Fig. 1 Time evolution of reflectivity.

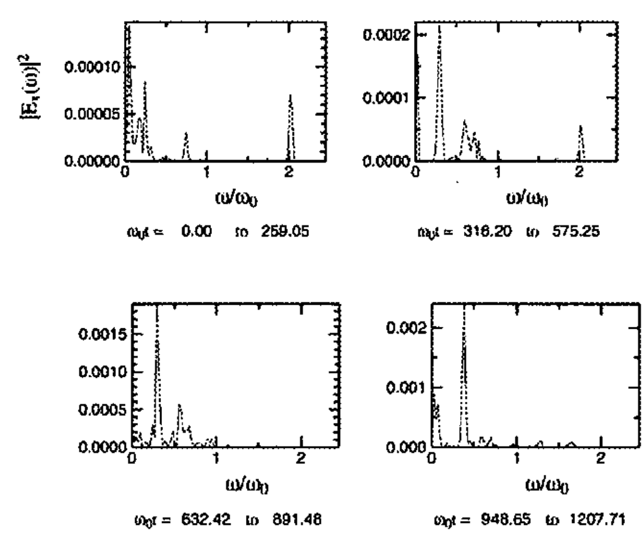

Fig. 2. Time evolution of frequency spectrum of Ex at the center of the plasma layer.

References

1) Nikolic, Lj., et al., Phys. Rev. E 66(2002) 036404.
2) Watnanbe, K. and Taniuti, T., J. Phys. Soc. Jpn. **43**, (1977)1819.