§14. Simulation on Laser-Plasma Interaction and Fluid Dynamics in Inertial Confinement Fusion

Mima, K., Miyamoto, S. (Institute of Laser Engineering, Osaka University)
Takamaru, H., Sato, T.

One of the important issues in the fast ignitor concept[1] is the propagation of an intense short pulse laser in laser coronal plasma. So far, many theory and simulation works have been carried out on this subject[2-4]. By those previous works, found are the hole boring, electron heating up to a few MeV, ion acceleration, self-generated magnetic field, and so on. However very few works have been done on the effects of laser polarization on the relativistic laser plasma interaction and electron/ion acceleration.

We used a two dimensional electro-magnetic particle (PIC) code to analyze the ion acceleration mechanism. We have done simulations for three types of laser polarization; p-polarized (electric field lie in the incident x-y plane), s-polarized (electric field is perpendicular to the incident x-y plane), and circularly polarized. Simulation parameters are as follows; initial plasma density $n_0 = 7n_{cr}$ (n_{cr} is critical density of laser light), initial electron (ion) temperature T_e (T_i) = 20 keV, and laser intensity $I_L = 10^{20}$ W/cm^2.

By the laser photon pressure, a shock wave is formed in the plasma. As the result of simulations, it was observed that the plasma density became high at the laser-plasma interface because of the shock compression. The distinction between circularly polarized and linear polarized cases (s and p) was that in the circularly polarized case, density jump was much higher than those in the s and p polarized case. The maximum electron density (normalized by initial density) after $\omega_p t$ = 83 was 2.97, 2.05, and 2.10, for circularly polarized, p-polarized, and s-polarized cases respectively. It is explained by the oscillation of ponderomotive force with 2ω (see Ref. 2) where ω is the laser frequency. This oscillation of the ponderomotive force appears only in the linear polarization. Therefore, in the linear polarization, the electron density onthe plasma-laser interface oscillates with the oscillation of the ponderomotive force. These oscillation will propagate into the overdense plasma as electron plasma waves to generate hot electrons. Therefore, the density is decreased compared with the circularly polarized case.

In figure 1, ion phase space plots (p_x - p_y) for circularly polarized (a) and p-polarized (b) are shown. Ion was accelerated to higher energy in the circularly polarized case than p-polarized case. This may correspond to the higher density compression by the ponderomotive force of the circularly polarized laser. From our previous works, it has been found that high energy ions were accelerated at the shock front by the potential jump in the shock. Since the difference of shock potential is proportional to the density, therefore, ions get higher energy in the case of circular polarized than p or s-polarized.

Finally we refer to the energy conversion efficiency of the particle kinetic energy in plasma to the laser. From our previous work of one dimensional particle simulation, it has been found that the energy conversion efficiency was the order of 10% over the wide laser intensity range of 10^{19} - 10^{21} W/cm^2 . From two dimensional simulation, energy conversion efficiency was 26.7%, 40.1%, and 19.9% for circularly polarized, p-polarized, and s-polarized respectively. These high efficiency result from the energy absorption around the periphery of the hole drilled by the laser.

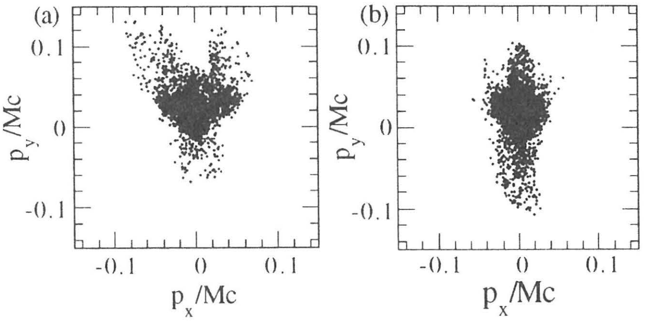

Fig. 1. Phase space plots of ion for circularly polarized (a) and p-polarized (b).

References

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