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Laser plasma physics from particle motion to macroscopic transport

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High intensity lasers can generate high energy density (HED) plasmas, with driving strong flows of plasma particles by the strong light pressure above gigabar. Understanding the physics of HED plasma formation, and characteristics of energetic particles and radiations emitted from the plasma are important for astrophysics, material sciences, and various applications such as ion and neutron sources for radiography, and inertial fusion energy.

In recent years, relativistic intensity lasers with kJ energies become available, which enables us to study the HED plasma evolution under a continuous laser energy input on a picosecond time scale. This time scale is same as that of the ion fluid motion, and hence, the multiscale physics including both electron and ion collective behaviors becomes important [1]. In the kJ laser experiments, efficient particle acceleration and dense plasma heating have been observed [2]. Here, as a talk in Professor K. Mima Memorial Session, I will present a series of studies on the kJ relativistic laser-plasma interactions, initiated with collaborative works with Prof. Mima, and the prospects including applications such as laser fusion energy.

In laser-produced HED plasmas, microscopic motions of nonthermal electrons largely affect the macroscopic plasma flow and energy transport, and therefore, kinetic modeling is necessary to describe the interaction. The laser field accelerates electrons to relativistic energies on a time scale much shorter than that of the thermal equilibration of the electrons. The motion of the laser-accelerated electrons is highly nonlinear, and is also nonlocal to the background field and pressure distributions [3], which makes rich plasma structures in phase space [4]. The efficient particle accelerations and plasma heating by the kJ lasers are accompanied by changes of the laser-plasma interface structure [5], which determines the energy coupling from laser to plasma. The talk will address these laser plasma physics including recent experiments using large laser facilities.

References

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