PLASMA ION AND ELECTRON ACCELERATION BY RELATIVISTICALLY STRONG LASER RADIATION

S.V. Bulanov

Prokhorov Institute of General Physics, Russian Academy of Sciences, Moscow, Russia  
Kansai Photon Science Institute, Japan Atomic Energy Agency, Kizugawa, Kyoto, Japan

We review the results of the studies of the charged particle acceleration during interaction of high power laser radiation with various targets.

The acceleration mechanism of electrons is based on the use of strong electric fields in the wake plasma wave excited in the underdense plasmas by an ultrashort laser driver pulse. The central problem is the electron injection to the wake field acceleration phase providing high quality of ultrarelativistic electron beams. The mechanisms of the electron injection into the acceleration phase are based either on a spontaneous wake wave breaking, or on an additional ionization in the region of the laser plasma interaction, or on the optical injection using colliding lasers pulses, or on the controllable wake wave breaking in the plasma with inhomogeneous density. The energy of the laser wake field accelerated electrons is limited by the processes of the electron dephasing and by the laser energy depletion. These constraints are mitigated within the framework of the multi-stage laser wake field accelerator. In the case of the equal stage LWFA accelerator, the final electron energy is proportional to the number of stages. A significant part of the laser wake field accelerators uses the capillary discharges to form the laser wake guide providing the laser radiation transport over the distance substantially larger than the defocusing length. The studies of the LWFA electron acceleration are motivated by numerous applications including the compact electron-positron collider and the XFEL.

As far it concerns the laser accelerator ion beams, their applications include the controlled nuclear fusion within the framework of the fast ignition concept, the proton radiography, the hadron therapy, and nuclear physics. Here we discuss basic mechanisms of the ion acceleration during the laser interaction with solid and gas targets. Substantial attention is paid to the radiation pressure acceleration mechanism having high efficiency of the laser energy transformation to the energy of fast ions. Tailored targets, e.g. the double layer thin foil target, allow obtaining the high quality ion beams with narrow energy spectrum.

We present a brief review of the results obtained by the world leading groups on the high-energy electron and ion acceleration during high power laser-plasma interaction.