LASER ion ACCELERATION AND RADIOACTIVE SOURCES BASED ON IT

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Laser-plasma methods of charged particle acceleration attract increased attention due to the large number of potential applications for astrophysics, inertial confinement fusion, nuclear physics, security systems, biology and medicine. Recently, there has been noticeable progress on the problem of laser ion acceleration due to the improvement in the quality and energy of short laser pulses and the use of innovative targets, which made it possible to increase the maximum ion energy and improve the quality of the generated ion beam.

When laser radiation interacts with matter in the range of relativistic and ultrarelativistic light intensities, target electrons can be accelerated to ultrarelativistic energies, generating strong charge separation fields capable of accelerating ions to multi-MeV energies on the scale of several micrometers. In the context of presented recent world achievements, the report discusses new ideas and their rationale based on multidimensional numerical modeling, which lead to the creation of practically interesting ion sources for nuclear applications.

Three-dimensional PIC modeling demonstrates the effective ion acceleration during interaction of short high-power laser pulses (with energies from a few millijoules to tens of joules) with ultrathin films or low-density targets. On the basis of theoretical estimates and calculations carried out, the existence of optimal target thicknesses which maximize the energies of accelerated ions is demonstrated. A new scaling law of the growth of the energy of protons accelerated from thin plastic films with the energy of a laser pulse was found. A new efficient scheme of synchronized laser acceleration of ions by slow light of relativistic intensity has been proposed. The laser light acting on a target with a density of the order of critical density, slows down at the leading edge and then increases its group velocity as it propagates inside target. A comparison of ion acceleration by circular and linearly polarized laser pulses was made, and conditions were found under which a circularly polarized laser pulse is more advantageous for ion acceleration. Promising schemes for the ion volume heating in microstructured targets are discussed and their optimization is carried out.

An analysis of a number of laser-plasma interaction schemes for the use of laser-accelerated ions (protons, deuterons) is given in order to initiate nuclear reactions to obtain short-lived isotopes necessary for nuclear medicine, as well as to create a neutron source.

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