Methodology of controlling HED plasma by the interaction between a high-intensity laser and structured targets

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Abstract

Due to the development of a high-intensity laser technology, the peak intensity of the laser has reached $10^{20\text{-}22}$ W/cm^2 [1]. By the irradiation of such a high-intensity laser to the matter, a high energy density (HED) plasma with a pressure of several Gbar and an electron velocity of close to the light speed, is generated. For example, a high-energy ion source (~100 MeV/u) for cancer therapy is a typical application using laser-produced HED plasma. However, the range of application is also limited due to the limitation of laser (spatiotemporal region) and target (structure or purity).

Here, we propose a new scheme [2] to produce high-quality protons contributing to medical applications using a micron-size hydrogen cluster, referred to as a structured target. According to a series of three-dimensional particle-in-cell simulations, high-purity protons with highly directional and quasi-monoenergetic ($\delta E/E$~10%) with energies reaching 300 MeV have been obtained due to multiple processes including converging shock utilizing the internal and external degrees of freedom of spherical cluster. In addition, we have successfully obtained sub-GeV protons through the bifurcation process of nonlinear waves by utilizing solid hydrogen and designed lasers. In the presentation, we discuss the method of deriving the self-organization function inherent in HED plasma by improving target structures and interaction processes.

References

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