Control of laser-driven compact ion sources using plasma fibers

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Compact laser plasma-based ion accelerators have experienced great progress in the past decade [1-2], which are promising to revolutionize the conventional accelerator technologies and are very attractive for a wide range of applications in science, medicine, and industry. However, the collimation and multidirectional control of the laser-driven compact ion sources with large-current and ultrashort-duration, which is unprecedentedly achieved, is a significant outstanding problem for laser plasma-based ion accelerators [3-4]. The invention of compact system [5] that can direct the laser-driven ion beams in controllable directions will tremendously innovate their applications.

In this research, we proposed a novel scheme to achieve multi-targeting well-collimated ion sources using hollow plasma fibers [6]. Our new hybrid particle-in-cell simulations, for the first time, clearly show that the light-ion (for example, proton) beams can be collimated and directed by the laser-driven self-generated radial electric field and azimuthal magnetic field in hollow plasma fibers. In addition, we identify that the reversed magnetic field induced by the localized return current below the fiber surface plays an important role in this novel scheme, which provides a new understanding on ion beam control. Eventually, our research provides a novel and compact approach for developing highly controllable micro-spot ion sources with narrow divergence angle and precise directionality, which will open up the possibility for a broad range of applications in radiography, oncology, astrophysics, medical physics, high energy density physics, and inertial fusion.

References

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