Hole-boring radiation pressure acceleration of ion beams for fast ignition

A. Mukherjee[1,2], D. Seipt[1,2] and M. Zepf[1,2,3]

[1] Helmholtz Institute Jena, Germany, [2] GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany, [3] Institute of Optics and Quantum Electronics, Friedrich-Schiller-Universität, Jena, Germany

e-mail (speaker): arghyamukherjee2000@gmail.com

The progress in ultrashort, ultra-intense laser science and technology has led to the generation of relativistic ion or electron beams in a tabletop set-up with various advantageous features [1]. Specifically relativistic ion beams generated from the interaction of lasers with solid foil targets are widely used for a number of applications such as cancer therapy, proton imaging, and ion based fast ignition (FI) schemes of inertial confinement fusion (ICF) studies. The latter primarily relies on hole boring (HB) ion acceleration [2].

In HB, a circularly polarized laser is focused on a semi-infinite target and a charge separation layer is developed by the radiation pressure of the laser. Ions are accelerated by the longitudinal electric field developed in the charge separation regime. In this acceleration process the energy and the quality of the beam essentially depend on the target and the laser parameters [3]. For FI, a high-quality beam with a high fluence is required to efficiently heat the pre-compressed fuel which still remains one of the key challenges [4].

Here, by conducting particle-in-cell (PIC) simulations using the code SMILEI [5], we demonstrate that HB-driven stable proton beams can be produced, with properties close to those required for proton based FI. We have studied in particular composite targets in order to improve the beam quality. The characteristics of the ion beams and the laser-to-ion conversion efficiency will also be discussed in detail.

References:

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