Numerical and experimental investigations of ion acceleration by ultraintense laser pulses in high-density gas jets

Valeria OSPINA-BOHÓRQUEZ [1,2,3] C. Salgado [3], M. Ehret [1,4], J.A. Perez-Hernández [3], M. Huault [3], M.deMarco [3], J.I. Apiñaniz [3], F. Hannachi [5], D. deLuis [3], D. Arana [3], J. Hernández Toro [3], J.D. Pisonero [3], J.L. Sagredo [3], J. García Ajates [3], I. Hernández [3], E. García[3], O. Varela [3], C.Méndez [3], A. Debayle [2], E. d'Humières [1], T.-H. Nguyen-Bui [1], E. Olivier[1], G. Revet [1], C. Sergeant [5], Ph. Barberet [5], J. Henares [5], C. Brabetz [6], J. Caron [1], T. Ceccotti [7], R. Nuter [1], D. Raffestin [1], G. Schaumann [4], M. Roth [4], X. Vaisseau [3], G. Gatti [3], L. Volpe [3], J.J. Santos [1] and L. Gremillet [2]

1) Univ. Bordeaux, CNRS, CEA, CELIA (Centre Lasers Intenses et Applications), UMR 5107, Talence, France
2) CEA-DAM/DIF, CEA/DAM Île-de-France, Arpajon, France
3) CLPU - Universidad de Salamanca, Salamanca, Spain
4) Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany
5) CENBG, CNRS-IN2P3, Université de Bordeaux, Gradignan, France
6) Plasma Physik/PHELIX, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany
7) CEA/IRAMIS, SPAM, Gif-sur-Yvette, France
valeria.ospina-bohorquez@u-bordeaux.fr

High-energy (~10-100 MeV) ion sources driven by ultra-intense laser pulses are interesting for many applications such as ultrafast radiography, creation of warm dense matter, isotope production, intense neutron sources, etc. So far, laser-driven ion acceleration has been mainly investigated in solid targets in the so-called target normal sheath acceleration (TNSA) regime [1]. Fewer studies have addressed the case or near-critical plasmas ($n_e \sim n_c$) due to the technical difficulty of achieving such gas densities. Previous experiments have targeted solid foils [2] or CO_2 lasers with gas jet targets [3]. Near-critical plasmas are predicted to give rise to new ion acceleration regimes combining TNSA and collisionless shock acceleration (CSA) [4], as well as enhanced hot-electron production, beyond the standard ponderomotive scaling. A particle-in-cell (PIC) simulation study carried out in our group have thus revealed that efficient volumetric electron heating can take place due to phase mixing between bulk electrons and electrons trapped in laser-induced plasma waves. Electron pressure can then trigger an electrostatic shock, enhancing ion acceleration [5].

In this talk, I will first report on the results of an experiment conducted in late 2018 at the 200 TW, 20 fs VEGA II laser system (CLPU, Salamanca). Its objective was to assess the potential for ion acceleration of the state-of-the-art SourceLab gas jet [6]. Data obtained by three diagnostics including CR-39 particle tracking, radiochromic film analysis and time-of -flight signals, will be compared to large-scale 1D PIC simulations. In a second part, I will present the design of our forthcoming experimental campaign at the 1 PW VEGA III laser system, together with the extensive parametric PIC study conducted to explore the physics of the expected laser-plasma interaction.

References

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