Laser Contrast Study of Laser-Accelerated Multi-MeV Protons from a Continuous Hydrogen Cluster-Jet Target

Esin Aktan[1], Jens Ehlert[1], Thomas Burg[1], Mirela Cerchez[1], Marcus J. Westhues[1], Toma Toncian[2], Christian Mannweiler[3], Alfons Khoukaz[3], Oswald Willi[1]

[1] *Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany*
[2] *Institute for Radiation Physics, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany*
[3] *Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Münster, Germany*

esin.aktan@hhu.de

Cluster targets are of high interest as a radiation particle source. They deliver µm-sized mass-limited targets with a gaseous background in a continuous beam. Their unique combination of different states of matter make them quite attractive i.a. for proton acceleration [1].
The dynamics of the acceleration process in clusters/nanoplasmas still needs to be understood and a purely hydrogen-based target is favourable to study the mechanisms. In this talk, we will present the preliminary results of the effect of the laser pulse contrast on the interaction between a hydrogen cluster-jet target and a high-intensity laser pulse. The experiments were carried out at the 200 TW Arcturus laser facility in Düsseldorf. The system is based on a double CPA Ti:Sa laser system with a pulse duration of 30 fs at a repetition rate of 5 Hz with energies up to 7 J before compression. As a target, a cryogenic cooled hydrogen cluster-jet was provided by the Westfälische Wilhelms-Universität Münster.
The experiments give insight into the heating process during the interaction and lead to an improved characterisation of the acceleration process. Previous studies including a cluster-jet target and a high intensity laser pulse identified Coulomb explosion as the main acceleration mechanism of the protons [2]. For the first time, the effect of the laser contrast on Coulomb explosion is investigated. With the intrinsic laser contrast, energies in the range of a few 100 keV were observed. Enhancing the laser contrast by means of a plasma mirror, proton energies up to several MeV could be obtained. The relative laser contrast is improved by the plasma mirror from approximately 10^{-9} to 10^{-12}.
Further, the interaction is visualised by imaging the second harmonic emission from the interaction. The images reveal the intensity profile within the cluster jet target.

References

[1] S. Grieser, B. Aurand, E. Aktan et al., Rev Sci Instrum **90**, 043301 (2019)
[2] B. Aurand, K. Schwind, T. Toncian, E. Aktan et al., New Journal of Physics **22**, 033025 (2020)