Simulations of spin-polarized ion beams from laser-plasma interaction

Lars Reichwein[1], Markus Büscher[2,3], Alexander Pukhov[1]

[1] *Insitut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany,*

[2] *Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, Jülich, Germany,*

[3] *Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany*

lars.reichwein@hhu.de

Spin-polarized particles are of interest for a variety of applications such as fusion, where the use of spin-polarized reactants may increase the nuclear cross section, or further investigation of the nucleon structure by means of deep inelastic scattering. In recent years, the acceleration of such polarized particles via laser-plasma interaction has gained traction in research due to the short acceleration distances needed compared to conventional accelerators [1]. While several schemes for efficient ion acceleration are generally known, many of them are not feasible for polarized beams since the target needs to be pre-polarized.

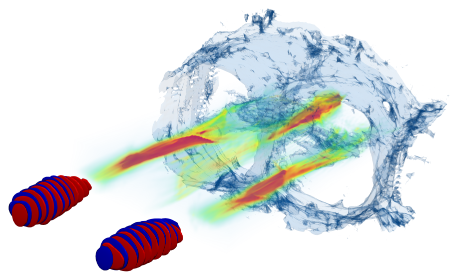

Figure 1: Schematic depiction of a dual-pulse laser scheme for highly polarized proton beams.

In our talk, we present an overview over the current state-of-the-art for spin-polarized ion beams and their study by means of particle-in-cell simulations. More specifically, we propose two possible acceleration schemes, the first being Magnetic Vortex Acceleration (MVA), where the laser creates a plasma channel of low density in whose center an ion filament is formed. This filament is ejected at the end of the target when the expanding electromagnetic fields lead to the formation of accelerating and focusing electric fields. With this mechanism, proton beams up to 53 MeV can be obtained from laser pulses with $a_0 = 25$ while maintaining a beam polarization of up to 82%. It is possible to utilize a dual-pulse scheme (cf. Fig. 1) which delivers well-polarized beams even for higher laser intensities [2].

We further present the option of obtaining high-quality beams from Collisionless Shock Acceleration (CSA). Here, a Carbon foil is placed in front of the target. When the laser pulse irradiates the foil, the ions are reflected by it without being subjected to the strong laser fields. This setup proves to be a source of highly polarized beams even in the regime of near-future laser facilities.

References

[1] M. Büscher et al., *High Power Laser Sci. Eng.* **8**, e36 (2020)

[2] L. Reichwein et al., *Phys. Rev. Accel. Beams* **25**, 081001 (2022)