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Towards Laser Acceleration of Spin-Polarized Helium-3 Ions

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A well known means of increasing the cross section of fusion reactions and potential output energy gain is to use polarized particles [1]. For polarized fusion to occur, polarized and accelerated fuel is required. We have studied experimentally and theoretically the feasibility of laser-driven polarized ion acceleration using the PHELIX facility at GSI Darmstadt [2]. In our preparatory studies we used unpolarized ^3He and ^4He gas-jet targets with densities of $10^{19}cm^{-3}$ irradiated by high-intensity laser pulses with, I_L up to $10^{19}Wcm^{-2}$. These experiments showed that acceleration of He^{2+} and He^{1+} ions is possible with high-energy cut-offs of 4.65 MeV and 3.27 MeV, respectively, but with strong dependence on the target density, laser pulse duration and laser energy. The accelerated ions were observed mainly at 90 degrees with respect to the propagation direction of the laser pulse. These results were analyzed with the help of 2D PIC simulations [2], which also indicated that forward, TNSA-like ion acceleration from the trailing edge of the gas jet is to be expected as well as the Coulomb-explosion driven 90-deg acceleration from the channel walls, consistent with previous works [3].

A second experimental run with a polarized target is scheduled at PHELIX for November 2020. For the preparation of a pre-polarized
^3He target, an external homogeneous magnetic holding field has been designed, optimized, and constructed to hold the gas target for a sufficiently long time inside the PHELIX target chamber. For the measurement of the $^3He^{2+}$ ion polarization, a polarimeter based on the $D(^3He, p)^4He$ fusion reaction has been built within the HGF/ATHENA project. It will be commissioned during a COSY test beam time in February 2020. Based on our previous ion acceleration measurements and simulations we will discuss how to optimize conditions for the upcoming spin-polarization measurements with multi-MeV ^3He ions.

References

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