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# Towards a Laser-driven polarized $^3$He Ion Beam Source

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Polarized $^3$He is of particular importance for fundamental research since the spins of the two protons are oriented anti-parallel so that the nuclear spin is basically carried by the unpaired neutron. That is why polarized $^3$He [1] can be used, for example, as an effective polarized neutron target for studying the neutron structure by scattering with polarized electrons [2]. For many experiments in nuclear and particle physics, like experiments with stored particle beams, the use of polarized $^3$He ion beams would be advantageous. $^3$He gas can be polarized for long time durations at standard conditions. However, building a spin-polarized $^3$He ion source for nuclear and particle physics experiments with high degrees of polarization is extremely challenging. Until now, only a few approaches could be accomplished - but not with the desired particle currents or an adequate beam polarization [3]. At Brookhaven National Lab's Relativistic Heavy Ion Collider (Rhic) attempts are now being made to develop a polarized $^3$He ion beam source [4]. An unsolved question in the context of laser-driven ion acceleration is the in
uence of the strong laser and plasma fields on the spin polarization of the particle beams. Two scenarios are possible here: either the magnetic fields of the incoming laser beam or the induced plasma change the spin direction of the accelerated particles, or the spins are too inert so that the short laser pulse has no effct on the spin alignment of a pre-polarized target, and the polarization is conserved. In the latter case, the polarization could be conserved during laser-acceleration processes, and also laser-induced polarized nuclear fusion with increased energy gains seems to be feasible: due to the use of polarized fuel, the cross-sections for nuclear fusion reactions may be enhanced which leads to higher energy yields compared to the case of unpolarized fuel. While the above mentioned first scenario (polarization creation by laser-particle interaction) has already been investigated with conventional foil targets by spin-dependent hadronic proton scattering off silicon nuclei 5, for the second one (polarization conservation during laser-plasma interaction) pre-polarized $^3$He gas can be used as production target. The relaxation rate of the polarization degree of $^3$He is depending on several conditions, e.g. gas pressure or magnetic field gradients. Also the absence of one electron in the atomic shell leads to a rapid decrease of the polarization degree: the interaction time $\tau_{HF}$ for the coupling of the nuclear spins with the spin of the remaining electron is about 0.2 ns (GHz energy level). Thus, a full ionization of the pre-polarized $^3$He has to be accomplished within a few picoseconds. This can be easily achieved with currently available laser intensities.

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