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Polarized proton acceleration from laser plasma wakefields

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A scheme has been proposed for the generation of polarized proton beams with a kinetic energy up to several GeV via laser interaction with pre-polarized plasma. There are many mechanisms for laser-driven proton acceleration, and most of them are relevant to the interaction of laser and solid target. While, the density of pre-polarized plasma is usually under critical density for a Ti:Sapphire laser facility. Here, we find that the polarized proton beams with multi-GeV energies can be obtained in the interaction of ultra-intense laser (nearly 10^{23}W/cm^2) with near critical density plasma, which is composed of two species ions [1].

In order to study the dynamic of polarization of particle beam, a module about the precession of particle spins has been added in the particle-in-cell (PIC) code "EPOCH". The particle beam polarization is defined by the spin vector of individual particle, which has an absolute value of 1 and a direction calculated from the Thomas-Bargmann-Michel-Telegdi equation [2].

In this work [1], we have found that the protons could be accelerated by laser firstly, then be injected and continue accelerated in the bubble regime. Meanwhile, the polarization of protons could not only be modulated by the laser field directly, but also be affected by the wakefield, especially when the protons locate at the positions nearly the sheath of electron "bubble", as presented at Fig. 1. The effect of proton-ion ratio on the proton acceleration and polarization is analyzed in detail. It is found that the protons can obtain higher energy with the decreasing initial proportion of protons, while the polarization of them will decrease since the transverse defocusing force becomes more intense.

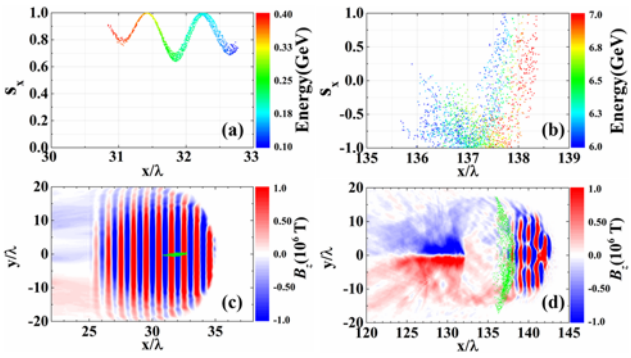

Figure 1. Distribution of s_x with x for selected protons at different times: (a) 100 fs and (b) 400 fs. Their positions are denoted by green dots in (c) and (d). The distribution of B_z at the respondence times (c) 100 fs and (d) 400 fs.

References

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