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Production of highly polarized positron beams via interaction of ultra-intense laser pulses with longitudinally spin-polarized electron beams

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Spin-polarized positrons work as powerful probe in fundamental physical studies and applications, such as in characterization of the surface and bulk magnetism of materials, in measurement of the two photon effects, and so on. In particular, polarized ultra-relativistic positrons make essential roles in the famous International Linear Collider (ILC), which is designed for discovering physics beyond the Standard Model. However, requirements on the beam quality, such as high intensity and polarization, low angle divergence and beam size, are far beyond the current experimental capability. Novel methods are needed urgently to be proposed to meet the requirements.

We have investigated the feasibility of production of a longitudinally polarized ultra-relativistic positron beam via the interaction of a circularly polarized (CP) ultra-intense laser pulse with a longitudinally spin polarized (LSP) counter-propagating ultra-relativistic electron beam in the quantum radiation-dominated regime theoretically, as shown in Fig. 1. The inset shows the two main successive physical processes: nonlinear Compton scattering and nonlinear Breit-Wheeler pair production. The helicity of the seed electron transfers to electron-positron pair via the high-energy photon.

Figure 2 shows the simulated result of distributions of positron density and polarization. It can be seen that the polarization transfer efficiency can approach 100% for the energetic positrons moving at smaller deflection angles. In a feasible scheme, a high-quality positron beam can be generated with polarization degree 40%, angle range 5 mrad, density 10^6/bunch and average energy 1.4 GeV.

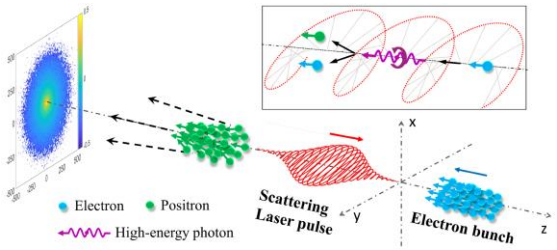

FIG. 1. Scenarios of generation of a LSP ultra-relativistic positron beam via an ultra-intense laser pulse head-on colliding with a counter-propagating LSP electron beam.

The yield and angular divergence of the positron beam is increased and decreased, respectively, by orders with respected to the current available ones. This longitudinally polarized positron source is desirable for applications in high-energy physics, such as ILC, and other applications such as material science.

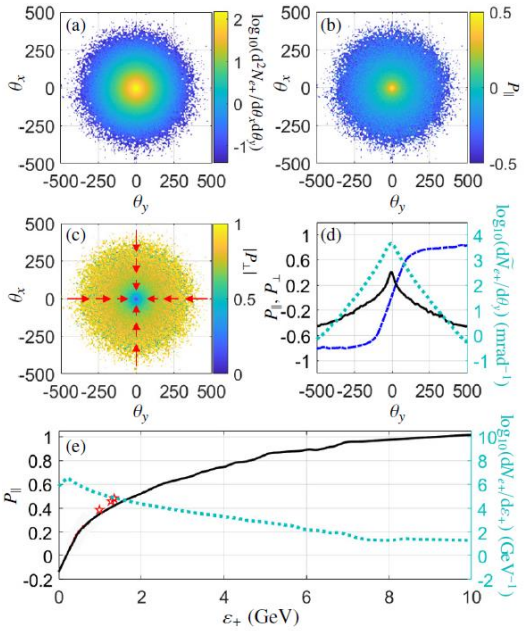

FIG. 2. Two-dimensional distribution of positron number density (a), longitudinal polarization (b), and transverse polarization degree (c). (d): Density and polarization of positrons with θ_x into [-20, 20] vs θ_y. (e): Density and polarization vs positron-energy.

References

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