6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Helicity Transfer in Strong Laser Fields via the Electron Anomalous Magnetic Moment

Yan-Fei Li[1], Yue-Yue Chen[2], Karen Z. Hatsagortsyan[3], Christoph H. Keitel[3]
[1] Department of Nuclear Science and Technology, Xi'an Jiaotong University,
[2] Department of Physics, Shanghai Normal University,
[3] Max-Planck-Institut für Kernphysik (MPIK)
e-mail (speaker): liyanfei@xjtu.edu.cn

The development of modern ultraintense laser facilities brings about new possibilities for testing predictions of strong-field quantum electrodynamics (QED) theory and explore new applications accordingly. In strong background fields electrons can be polarized due to the spin-flip during photon emissions, which was first discovered for synchrotron radiation and termed as radiative polarization. Recently, the possibility has been proven of efficient radiative polarization using ultrastrong laser fields, applied to produce polarized leptons or photons [1-4]. However, ultrastrong laser fields initially unpolarized electrons are mostly polarized transversely after the interaction. Nevertheless, high-precision high-energy physics at accelerators demands longitudinal beam polarization mainly.

There were a series of attempts to employ helicity transfer effect during Compton scattering process for production of longitudinal polarized electrons. While the transfer of helicity of the laser photons to the scattered electrons is not efficient in the linear regime and suppressed in the nonlinear regime. Recently, it has been demonstrated that QED radiative corrections, i.e., the interaction of the electron with its own radiation field, can also affect the electron spin dynamics in intense background fields scattered one.

We investigate the role of the electrons' anomalous magnetic moment on the helicity transfer from a circularly polarized (CP) laser pulse to an ultrarelativistic electron beam for the nonlinear Compton scattering process in the radiation reaction dominated regime. The electron three-dimensional polarization properties are analyzed using numerical Monte Carlo simulations based on the spin-resolved radiation probabilities in the local constant field approximation (LCFA). While previous studies neglecting the QED radiative corrections came to a conclusion that the helicity transfer from laser photons to electrons is forbidden in the nonlinear Compton scattering process, we obtain a sizable longitudinal polarization of electrons when the one-loop QED vertex correction to the anomalous contribution to the magnetic moment is accounted for. A longitudinal polarization degree close to 3% is shown, which could be further improved up to 10% with postselection techniques. his signature is robust with respect to the laser and electron parameters and measurable with currently available experimental technology. It could serve for testing QED predictions on radiative corrections.

References

[1] Y.-F. Li *et al.*, Phys. Rev. Lett. 122, 154801(2019).
[2] Y.-Y. Chen *et al.*, Phys. Rev. Lett.123 174801 (2019).
[3] Y.-F. Li *et al.*, Phys. Rev. Lett. 124, 014801 (2020).
[4] Y.-F. Li *et al.*, Phys. Rev. Lett. 125, 044802 (2020).
[5] Y.-F. Li *et al.*, Phys. Rev. Lett. 128, 174801 (2022).

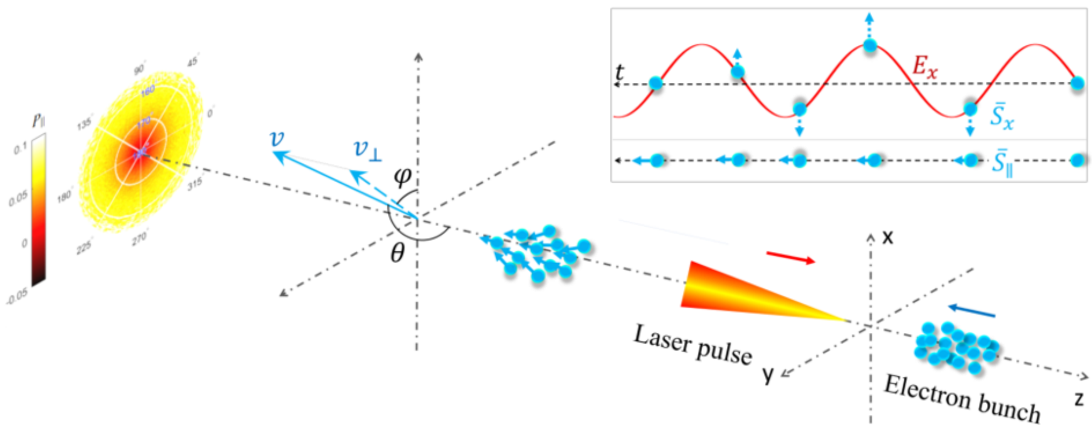

FIG. 1. The schemes of producing longitudinally polarized electrons via helicity transfer during nonlinear Compton scattering of a circularly polarized strong laser and unpolarized electron beam. The insert shows the phase matching dynamics between electric field $\boldsymbol{E}$ and transverse polarization $\boldsymbol{S}_\perp$ along x-axis, as well as the dynamics of longitudinal polarization $S_\parallel$. θ and φ indicate the polar and azimuthal angles of electron velocity $\boldsymbol{v}$, respectively.