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

Deciphering in situ electron dynamics of ultrarelativistic plasma via polarization pattern of emitted gamma-photons

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Understanding and interpretation of the dynamics of ultrarelativistic plasma is a challenge, which calls for the development of methods for in situ probing the plasma dynamical characteristics. We put forward a new method, harnessing polarization properties of gamma-photons emitted from a non-pre-polarized plasma irradiated by a circularly polarized pulse. We show that the angular pattern of gamma-photon linear polarization is explicitly correlated with the dynamics of the radiating electrons, which provides information on the laser-plasma interaction regime. Furthermore, with the gamma-photon circular polarization originating from the electron radiative spin-flips, the plasma susceptibility to quantum electrodynamical processes is gauged. Our study demonstrates that the polarization signal of emitted gamma-photons can be a versatile information source, which would be beneficial for the research fields of laser-driven plasma, accelerator science, and laboratory astrophysics.

References
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[2] Z. Gong, K. Z. Hatsagortsyan, and C. H. Keitel, Physical Review Research 4 (2), L022024 (2022).

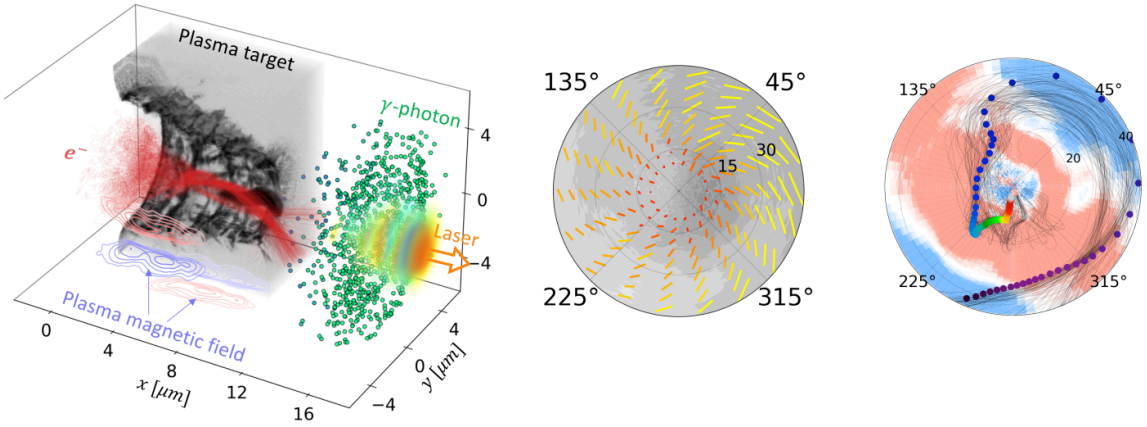

Figure 1. Left panel: 3D PIC simulation results of a plasma slab target irradiated by a strong laser pulse. Middle panel: the angular distribution of gamma photon linear polarization. Right panel: the correlation between the electron acceleration dynamics and the angular distribution of spiral tendency of the gamma photon linear polarization.