Deciphering in situ Electron Dynamics of Ultrarelativistic Plasma via Polarization Pattern of Emitted Gamma-Photons

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Understanding and interpreting 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.