Twisted THz generation via LG laser pulse in magnetized plasma

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The interaction of intense, short laser pulses with plasma plays a crucial role in a wide range of applications, including laser wakefield acceleration (LWFA) and the generation of intense radiation sources [1–4]. This study presents an analytical and computational investigation into the generation of twisted terahertz (THz) radiation via the propagation of a circularly polarized Laguerre-Gaussian (LG) laser pulse in axially magnetized plasma. Perturbation theory and the quasi-static approximation are employed to derive expressions for the longitudinal and transverse wakefields arising from laser-plasma interactions in the mildly nonlinear regime. It is observed that two orthogonally polarized THz beams are generated in mutually perpendicular planes. The superposition of these fields results in a single linearly polarized twisted THz beam with modified amplitude and polarization direction.

To validate the analytical findings, three-dimensional particle-in-cell (PIC) simulations are carried out using the FBPIC code [1]. The simulation results show strong agreement with the analytical findings for even azimuthal LG modes (e.g., $\ell = 0, 2$), while odd modes (e.g., $\ell = 1$) exhibit frequency and amplitude modulations not captured by the analytical model likely due to asymmetric energy distributions inherent in odd LG modes. Additionally, simulations confirm that twisted THz radiation fields are characterized by off-axis intensity maxima and distinct spatial profiles, with their intensity and frequency tunable through the laser strength parameter and plasma density, respectively [1]. These results highlight the potential of this approach for the development of advanced THz sources, enhanced material diagnostics, and nonlinear optical applications. A comparative graphical analysis of the resulting THz field amplitudes from both theoretical and simulation studies is also presented.

References

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