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High-power terahertz emission from laser wakefield acceleration

Multi-mJ terahertz (THz) radiation was generated in the process of laser wakefield acceleration (LWFA) when a gas jet was irradiated by 100-TW-class laser pulses [1]. The emitted THz radiation is radially polarized and broadband with an energy conversion efficiency of 0.15%. The amount of energy is orders of magnitude larger than expected from the coherent transition radiation (CTR) model, in which a relativistic electron bunch produced in LWFA emits coherent THz radiation when it exits the plasma-vacuum boundary. The correlation between the electron beam properties (energy and charge) and THz output energy shows that high-energy (>150 MeV) electrons do not necessarily yield high-power terahertz radiation. Instead, low-energy (<MeV) but high-charge electrons can produce much stronger terahertz radiation. To explain such results, a coherent radiation (CR) model is proposed—the electrons accelerated by the laser ponderomotive force and subsequent plasma wakefields radiate broadband emission continuously along the laser propagation direction, resulting in phase-matched conical THz radiation in the far field [1]. A particle-in-cell (PIC) simulation also shows that the wakefields are highly nonlinear and the spatiotemporal structure decays on the time scale of picosecond, generating coherent THz radiation throughout the propagation [2]. Recently, a multi-petawatt laser was used to produce high-energy (tens of mJ) THz radiation, together with multi-GeV electron beams.
[1] T. Park et al., "Multi-millijoule terahertz emission from laser-wakefield-accelerated electrons," Light Sci. Appl. 12 37 (2023).
[2] M. Rezaei-Pandari et al., " Investigation of terahertz radiation generation from laser-wakefield acceleration," AIP Advances 14, 025347 (2024).

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