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Comparison of direct laser acceleration performance using radially polarized near infrared and long-wave infrared lasers

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Direct laser acceleration with radially polarized lasers is an intriguing variant of laser-based particle acceleration that potentially offers GeV/cm-level gradients while avoiding the instabilities and complex beam dynamics associated with plasma-based accelerators. Currently, the performance of this method is primarily limited by the difficulty of generating high-power radially polarized beams. We propose the use of CO2-based long-wave infrared (LWIR) lasers as a driver for direct laser acceleration, as the polarization insensitivity of the gain medium allows for higher peak powers, since amplification can occur after polarization conversion. Additionally, the larger waist sizes and pulse lengths associated with a longer wavelength can improve electron beam injection efficiency. By comparing acceleration simulations using a near-infrared laser and an LWIR laser, we show that the injection efficiency is indeed improved by up to an order of magnitude using the LWIR laser. Furthermore, we show that even sub-TW LWIR lasers can provide MeV-level energy gains. Thus, radially polarized LWIR lasers show significant promise as a driver of a direct laser-driven demonstration accelerator.

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