High-efficiency compact laser-plasma electron accelerator

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Abstract
Laser-plasma accelerators (LPAs) operating in the bubble regime require driver lasers with relativistic intensities and pulse durations that are significantly shorter than the plasma wavelengths. This severely limits the laser technology that can be used to drive LPAs and with that their wide spread and the currently achievable LPA parameters, such as repetition rate. Here, we report a widely unexplored regime of laser-plasma electron acceleration that is based on the direct parametric excitation of plasma waves. This method markedly relaxes the driver laser requirements in terms of peak power and pulse duration. We show experimental data that demonstrates the generation of high-charge mildly relativistic electron bunches with laser-to-electron conversion efficiency of 12% which is unprecedented in gas-phase targets. The electron beams were generated using a gas target that can reach near the critical plasma density using a driver laser with moderate intensity. The experimental results demonstrate a novel regime that opens LPA electron acceleration for a wide range of driver laser technologies and holds the promise for a path to high-repetition rate LPAs for future compact particle accelerators and secondary sources.

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