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# Electron acceleration by Laguerre-Gaussian beams from a high-density dual-staged plasma nozzle

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Laser wakefield acceleration (LWFA) of electrons is predominantly achieved using gas targets. In recent years, the development of high-repetition-rate, high-intensity lasers has driven research into employing high-density gas targets to generate very high-energy electrons (VHEE) beams, which hold potential for medical applications. Laguerre-Gaussian (LG) laser beams differ from Gaussian beams by their azimuthal phase structure, imparting orbital angular momentum (OAM), and a donut-shaped intensity profile with a central minimum. These features, combined with advanced gas nozzle setups, enable new possibilities for optimising electron acceleration. This research explores the LWFA of electrons driven by LG beams in a dual-stage gas nozzle setup. The method offers precise control over the plasma density profile, facilitating improved electron injection and acceleration. To assess the effectiveness of this configuration, Fourier–Bessel Particle-In-Cell (FBPIC) simulations are performed using hydrogen and hydrogen-nitrogen ($H_2$ + 1% $N_2$) gas mixtures within the bubble regime over a 1 mm acceleration distance. Simulation results indicate that combining vortex beams, such as LG beams, with optimised dual-stage gas nozzles is an effective technique for producing VHEE beams and controlling energy spread.

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