Density effect on the electron acceleration by Bessel-Gauss laser beam from a laser wakefield accelerator

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Laser Wakefield Acceleration (LWFA) is an alternative approach to get high-energy particles which are needed for various applications, including generation of secondary radiation, material science, ultrafast X-ray imaging, or radiotherapy. Interaction of spatially and temporally shaped laser pulse with tailored gas jet target is the key for injection and acceleration of electron bunch. We employed hybrid laser ablation processing techniques in fused silica to manufacture specifically designed gas nozzles. The technology provides us flexibility in optimising laser beam shaping and gas target tailoring to generate high-energy electrons with a narrow spectrum using TW-class lasers with limited pulse energy below 100 mJ. Two-stage supersonic gas nozzles combining ionisation injection and acceleration stages were used in the numerical study of the LWFA of electrons. We present Fourier–Bessel particle-in-cell (FBPIC) simulation results from a laser wakefield electron accelerator driven by Gaussian (G) and Bessel-Gauss (BG) laser beams in hydrogen and a mixture of hydrogen–nitrogen gases with different nitrogen concentrations. A TW-class ultrashort 10 fs laser beam is used to study the impact of different nitrogen gas concentrations on the electron beam quality up to an acceleration distance of 1 mm. FBPIC simulations were done in the presence of a two-stage designed gas nozzle. It was found that the highest electron energy is obtained when the nitrogen concentration is 1%, and the electron energy reaches around 150 MeV. Additionally, it is observed that the electron energy decreases with increasing nitrogen concentrations (>1%), and the majority of the accelerated charge exhibits a low-energy Maxwellian spectrum. Experimental validation is ongoing using SYLOS3 lasers at ELI ALPS to verify the simulation results.

References

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