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Laser wakefield acceleration in a carbon nanotube-based plasma

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Laser wakefield acceleration (LWFA) has been evidenced by a capability of reaching acceleration gradients ranging from tens to hundreds of GV/m, thereby reducing the footprint and cost of accelerators. Carbon nanotubes (CNTs), featuring high plasma density (>10^{19} cm^{-3}) and the ability to tailor plasma density effectively, have emerged as a novel solid-state plasma source. Recent numerical studies suggest that using CNT-based structures can enhance the acceleration gradient to the TV/m regime, offering unique advantages for compact medical accelerators. In this work, we modelled the structure of a hollow solid-state plasma which is composed of carbon nanotube bundles. An intense laser pulse is injected into this channel, where self-injected electrons achieve TeV/m-scale acceleration, as simulated using a particle-in-cell (PIC) code. Energy gain and beam quality of the electron bunches, such as charge absorbed, energy spread, and emittance, are optimised by tuning the plasma density, geometric properties of the carbon nanotubes, and laser parameters.

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