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Particle beam-driven wakefield in carbon nanotubes: hydrodynamic model vs PIC simulations

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The interactions of charged particles with carbon nanotubes (CNTs) may excite electromagnetic modes in the electron gas that makes up the nanotube surface. This novel effect has recently been proposed as an alternative method to achieve ultra-high gradients for particle acceleration. In this contribution, the excitations produced by a localized point-like charge propagating in a single wall nanotube are described by means of the linearized hydrodynamic model. In this model, the electron gas is treated as a plasma with specific solid-state properties. The governing set of differential equations consists of the continuity and momentum equations for the electron fluid, in conjunction with Poisson's equation. Through numerical simulations, we investigate the influence of key factors, including the driving velocity, CNT radius, surface density and the friction (between the electron fluid and the ionic lattice) parameter, on the excited wakefields, comparing the results with Particle-in-Cell (PIC) simulations. A comprehensive discussion is presented to analyze similarities, differences and limitations of both methods. This research provides a valuable perspective on the potential use of CNTs to enhance particle acceleration techniques, paving the way for further advancements in high-energy physics and related fields.

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