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Hydrodynamic Model for Particle Beam-Driven Wakefield in Carbon Nanotubes

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Charged particles moving through a carbon nanotube may be used to excite electromagnetic modes in the electron gas produced in the cylindrical graphene shell that makes up a nanotube wall. This effect has recently been proposed as a potential novel method of short-wavelength-high-gradient particle acceleration. In this contribution, the existing theory based on a linearised hydrodynamic model for a localised point-charge propagating in a single wall nanotube (SWNT) is reviewed. In this model, the electron gas is treated as a plasma with additional contributions to the fluid momentum equation from specific solid-state properties of the gas. The governing set of differential equations is formed by the continuity and momentum equations for the involved species. These equations are then coupled by Maxwell's equations. The differential equation system is solved applying a modified Fourier-Bessel transform. An analysis has been realised to determine the plasma modes able to excite a longitudinal electrical wakefield component in the SWNT to accelerate test charges. Numerical results are obtained showing the influence of the damping factor, the velocity of the driver, the nanotube radius, and the particle position on the excited wakefields. A discussion is presented on the suitability and possible limitations of using this method for modelling CNT-based particle acceleration.

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Footnotes

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