

A hydrodynamic model for particle beam-driven plasmon wakefield in carbon nanotubes

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Abstract

Charged particles moving through a carbon nanotube may be used to excite electromagnetic modes in the electron gas produced by π and σ orbitals in the cylindrical graphene shell that makes up a nanotube wall [1]. This effect has recently been proposed as a potential novel method of short-wavelength-high-gradient particle acceleration [2, 3]. In this contribution, first we review the existing theory based on a linearised hydrodynamic model for a non-relativistic, localised point-charge propagating in a single wall nanotube (SWNT) [4]. Then we extend it to the relativistic case. In this hydrodynamic 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: beam charges, electrons and ions of the lattice. These equations are then coupled by Maxwell's equations. The ions are assumed to be quasi-static and provide a neutralising background. To solve the differential equation system a modified Fourier-Bessel transform has been applied. Furthermore, a spectral analysis has been realised to determine the plasma modes able to excite a longitudinal electrical wakefield component in the SWNT to accelerate test charges. Eventually, we discuss the suitability and possible limitations of the method proposed in this study for particle acceleration.

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[3] J. Resta-Lopez, et al., *Study of Ultra-High Gradient Acceleration in Carbon Nanotube Arrays*, Proc. of IPAC'18, paper TUXGBE2, Vancouver, Canada, Apr.-May 2018.

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