Multiscale Field Emission Theory for Composite Surfaces with Strong Electron-Electron Interactions

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KEYWORDS: *Fowler-Nordheim theory, Gauss hypergeometric functions, Tomonaga-Luttinger liquid, Local density of states.*

ABSTRACT

In the first part of the work, we generalized the canonical Fowler-Nordheim theory (gFN) as we compute the zero temperature transmission probability for a more general case of a barrier described by a fractional power law. We derived an exact analytical formula using Gauss hypergeometric functions and analyzed the dependence of the transmission probability on the power law's exponent. In the following part, we derived a theoretical framework to investigate the emission properties of 1D correlated metals and its application in nanotube systems. The theoretical framework comprises the description of a 1D correlated metal as the Tomonaga-Luttinger liquid (TLL) model. Here we obtained expression for the TLL local density of states (LDOS). To apply the gFN, the TLL parameters are incorporated into the gFN theory as the power-law's exponents. The two obtained quantities, transmission and LDOS, are then combined to determine the tunneling current as a function of temperature for an array of nanotubes. The methodology was further developed to analyze the tunnelling spectra of two types of nanotubes: those gapless and those with mini-gaps. Finally, we merge these atomic scale results with a study of various geometrical arrangements of an array of nanotubes, a phenomenon that takes place on micrón scale. These findings contribute to the domain of nanomaterials simulation by offering a detailed understanding of electron-electron interactions in nanotube materials and highlight the significant role of multiscale modelling in predicting and analysing complex systems across various scales.

ACKNOWLEDGEMENT: Authors acknowledge financial support of EU through MSCA (Grant No. 847639).

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