Three Dimensional Visualization of Electromagnetic Fields from One Dimensional Nanostructures

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One-dimensional (1D) nanostructures have been regarded as the most promising building blocks for nanoelectronics and nanocomposite material systems as well as for alternative energy applications. Magnetic nanowires with circular cross-section, are of utmost importance from theoretical and technological aspects. 1D carbon-based nanostructures such as carbon nanotubes are amongst the best candidates for field emission displays and new high-brightness electron sources. The confinement effects in 1D nanostructures can alter their properties and subsequently their behavior significantly. Hence it is necessary to understand the strong effect of their size on their three-dimensional (3D) properties such as the magnetic and electric fields associated with nanowires and nanotubes completely before they can be used in applications. There are currently very few methods, which have the capability to visualize the complete 3D fields associated with nanowires. In this work, we show that using a combination of symmetry arguments and electron-optical phase shift data obtained using TEM, it is possible to recover the entire 3D magnetic or electric field in and around nanowires and nanotubes from a single image.