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Polarizability of a metallic nano-cylinder: Local random-phase approximation (LRPA)

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We develop a method to calculate the polarizability of a nano-cylinder by taking temporal and spatial dispersion in to account where dispersion due to the Landau damping. To describe these phenomena, we developed analytical theory based on local random-phase approximation. Our theory is very general in the sense that it can be applied to any material which can be characterized by a bulk dielectric function of the form $\varepsilon(k,\omega)$. The theory is applied to calculate the polarizabilities of dielectric and metallic nano-cylinders. Here we focus on calculating the transverse static polarizability of a cylindrical nanowire by taking the temporal and spatial dispersion into account. To describe these phenomena, we developed an analytical theory by solving the well-known Lindhard formula which gives one of the closed solutions in the theory of Fermi systems that explicitly gives the nonlocal dielectric response function (longitudinal) $\varepsilon(k,\omega)$. We developed a simple theoretical framework for the polarizability of a nanowire that allows the inclusion of nonlocal effects. Our results are significant for thin wires and small particles, where the nonlocal effects are much more relevant. We hope that our work will be useful in studying the optical properties of nano particles in particular nanowires.

Keywords: Cylindrical nanowire, Lindhard formula, Nonlocal effects, Polarizability