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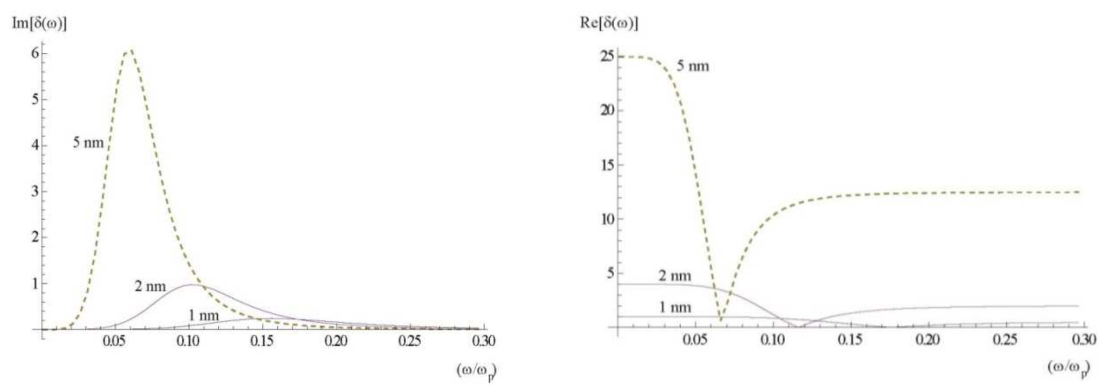
Theoretical study of nonlocal effects in nanoplasmonic structures

A.U. Asela

Department of Physics, University of Kelaniya, Sri Lanka

We study the importance of taking the nonlocal effects in optical response of metals into account for accurate determination of optical properties of nanoplasmonic structures. When considering bulk materials, to explain the optical properties, it is sufficient to take only the temporal dispersion into account. But considering nanoscale structures, it is not just enough to take temporal dispersion into account, but need to consider both temporal and spatial dispersion to explain optical properties. Here we focus on calculating the transverse static polarizability of a spherical nano particle and cylindrical nanowire by taking both temporal and spatial dispersion into account. To describe these phenomena, we have 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) $\varepsilon(k,\omega)$. The theory is applied to calculate the polarizability of dielectric and metallic nanospheres and cylindrical nanowires. The two figures show the variation of imaginary and real parts of the polarizability of a nanosphere including nonlocal effects. The figures clearly show that the absorption peaks move to the low energy region as the radii increases. Furthermore, there is a critical frequency which gives a small or zero real part for the polarizability for a nanosphere. The most significant result is that such a behavior cannot be explained using the usual local response. A simple theoretical framework for the polarizability of a nanosphere has been developed, and a nanowire that allows the inclusion of nonlocaleffects. 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 ofnanowires and nanospheres.



ushanasela@gmail.com 0710811145