Active Coated Nano-Particle Driven by an Electric Hertzian Dipole

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Recent research in optical metamaterials (MTMs) has demonstrated that including lossless plasmonic materials to achieve a negative permittivity in the spherical shell of a coated nano-particle (CNP) can lead to novel optical properties such as resonant scattering and transparency, see e.g., (J. A. Gordon, and R. W. Ziolkowski, Opt. Exp., 15, 1252-12582, 2007) and the works referenced therein. In practice, however, plasmonic materials have high losses at optical frequencies. It has been demonstrated that with the introduction of active materials, the intrinsic absorption in the plasmonic shell can be overcome and new optical properties, such as, e.g., a "super resonance", can be observed in the scattering and absorption cross-sections of these CNPs (J. A. Gordon, and R. W. Ziolkowski, Opt. Exp., 15, 1252-12582, 2007), (J. A. Gordon, and R. W. Ziolkowski, Opt. Exp., 15, 2622-2653, 2007). Moreover, scattering from active small particles was considered in (N. G. Alexopoulos, and N. K. Uzunoglu, Appl. Opt., 17, 235-239, 1978), (M. Kerker, Appl. Opt., 17, 3337-3339, 1978), and (M. Kerker, Appl. Opt., 18, 1180-1189, 1979) with the purpose of achieving a version of optical cloaking. The electromagnetic responses of fluorescent (optically stimulated) molecules in the presence of electrically small particles were considered previously in (D.-S. Wang, M. Kerker, and H. W. Chew, Appl. Opt., 19, 2315-2328, 1980) and (H. W. Chew, P. J. McNulty, and M. Kerker, Phys. Rev. A, 13, 396-404, 1976). The overall objective of these studies was to achieve sensors that could provide measurements of the electromagnetic properties of the molecules or the particles. The stimulated molecules were treated as electric dipoles, a representation of the two-level system describing the excited and ground state of the molecules.

While the excitation of coated spherical passive particles with an electric Hertzian dipole (EHD) was considered in (S. Arslanagic, R. W. Ziolkowski, and O. Breinbjerg, Radio Sci., 42, doi:10.1029/2007RS003663,2007), this work reports the extension of these studies to the case of an EHD exciting an active CNP. In particular, the enhanced scattering and radiation properties of several spherical CNPs that consist of a silver nano-shell surrounding an active silica nano-core and that are excited by the EHD are being investigated. The previously reported localized active CNP-based sensor efforts have led us to consider their possible fluorescence applications. Some initial results on this problem have been obtained; they will be discussed in our presentation.