Feeding Nanoantennas with Nanowaveguides

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It is well known from the Mie scattering theory that a nanosphere with electrically small radius made of noble metal (such as gold or silver) exhibits high scattering in free space at the frequency for which its relative permittivity is around -2. If instead of a solid sphere, a concentric set of spheres is used with a core and a shell made of double-positive (DPS) and epsilon-negative (ENG) materials, respectively, the resonant frequency can be tuned by choosing the core/shell ratio of radii. Such nanoparticles can indeed behave as nanoantennas (e.g., A. K. Sarychev, D. A. Genov, A. Wei, and V. M. Shalaev, "Periodical arrays of optical nanoantennas," *Proceedings of SPIE, Complex Mediums IV: Beyond Linear Isotropic Dielectrics*, August 4-5, 2003, pp. 81-92; N. Engheta, J. Li, and A. Salandrino, "Pattern Synthesis in Optical Nano-Antennas Using Collections of Metallic Nanoparticles," *the Frontiers in Optics 2005 the 89th Annual Meeting of the Optical Society of America, Tucson, Arizona*, October 16-20, 2005.) However, an interesting issue is the feeding mechanism for such nanoantennas.

Here in the present work, we study, using analytical techniques and numerical simulations, the use of planar waveguide in feeding plasmonic nanoantennas in its vicinity. In our work a two-dimensional (2-D) version of this problem is studied for the sake of mathematic simplicity. The Mie scattering theory is first applied to nano-sized concentric cylindrical structures (nanowires) with either core or shell made of plasmonic materials. When such nanowires are placed near a planar waveguide, the surface wave guided by the waveguide can interact with these nanoantennas, resulting in far-field scattering with specific patterns. In this scenario, the nanowires take the role of conventional antennas, that are being fed by the waveguides, but at optical frequencies. In our approach, a rigorous treatment of the problem is developed. The Green function of a 2-D dipole line placed near a planar waveguide is first considered. The induced dipole line on the nanowire near the waveguide is then related to the incident electric field via the polarizability of the nanowire and the Green function of the system. The radiation pattern and the *S* parameters are evaluated when the induced dipole line are obtained. Expressions for multiple nanowires arranged in proximity of the feeding nanowaveguide are also derived. Finite element method is used to numerically simulate the problem.

In this talk, we will present our theoretical and numerical results of this problem, and we will discuss physical insights into these findings.