Surface integral formulation for light scattering from 3D objects: surface plasmon resonances in metallic nanoantennas

Rogelio Rodríguez-Oliveros, J.A.Sánchez-Gil
Instituto de Estructura de la Materia CSIC, Serrano 121 (28006), Madrid, spain
Phone: +34 91 5616800, Fax: +34 91 5645557
Rogelio@iem.cfmac.csic.es

We develop theoretically and numerically a rigorous method to investigate the EM wave scattering from 3D objects with arbitrary surfaces and dielectric function. The formulation is based on the surface integral equations for the electric and magnetic fields given by the Stratton-Chu formulas [1,2,3]. The integral equations are generalized for a 3D object with its surface in parametric coordinates (recently derived for 2D objects in Ref. [4]). The electric and magnetic fields are expressed in terms of two tangential components to the surface and a normal one, in order to get physical insight into the induced EM fields in the surface of the scatterer. In fact, it is shown that the surface integral equations are remarkably simplified if the parametric coordinates are chosen so that an orthonormal basis can be defined on the surface, and if the chosen basis is an intrinsic basis of the surface, defined in terms of two tangent vectors and the normal one. This simplification is in turn crucial in the numerical implementation of the surface integral scattering equations, converted into matrix equations for the surface EM field components by discretizing the surface through a quadrature scheme.

Finally, it should be emphasized that this formalism straightforwardly allows one to deal with an arbitrary number of scatterers and shapes, with the advantage that it scales with the scatterer surface (rather than its volume). In particular, this method will be exploited to investigate surface plasmon resonances in complex 3D metallic nanoparticles, obtaining far-field patterns Fig(1)(a,b), scattering cross sections, near-field maps and surface charge distributions Fig(1)(c,d) as done for 2D nanoparticles (nanowires) in Ref. [4]. If a point dipole source is considered instead of a plane wave, single molecule fluorescence (and/or quantum dot emission) close to metallic nanoantennas can be thoroughly explored by calculating radiative and nonradiative decay rates (and quantum yields), addressing crucial issues as the modification and enhancement (or quenching) of spontaneous emission in (bio)molecular and optoelectronic systems due to the strong impact on the local EM density of states of surface plasmon resonances in dimer nanoantennas [5].

References

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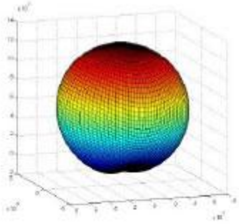
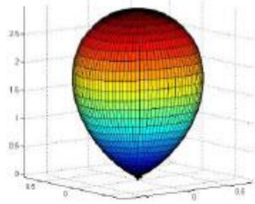
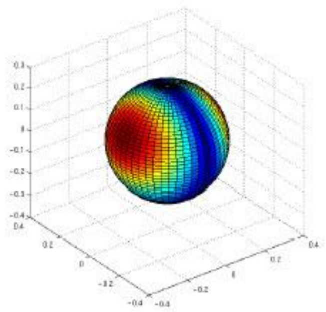
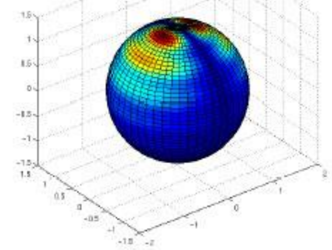
Figures

	
a) Far-field pattern of a dielectric sphere with n=1.25 and geométrical factor q=1.6.	b) Far-field pattern of a dielectric sphere n=1.25 and geométrical factor q=4.
	
c) Scattered field on the surface of a dielectric sphere with n=1.25 and geométrical factor q=1.6.	d) Scattered field on the surface of a dielectric sphere with n=1.25 and geométrical factor q=4.