Plasmon Resonances of Flexible Shape Nanoparticles

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We present an advanced numerical formulation to calculate the optical properties of 3D nanoparticles (single or coupled) of arbitrary shape and lack of symmetry [1]. The method is based on the (formally exact) surface integral equation formulation, implemented for parametric surfaces describing particles with arbitrary shape through a unified treatment that we call flexible surfaces based on the so called Gieli's formula [2].

Flexible surfaces can be consider an extremely appealing tool in a numerical implementation of a scattering method, since selecting a few number of parameters can lead to very different surfaces, that mimic the most common shapes of nanoparticles experimentally synthesized on plasmonics, as sphere, cubes, cylinders and stars. Moreover this remarkable feature of the flexible surfaces not only saves computational time, since we only have to implement a program to achieve different shapes instead one program each, but also avoids problems in the implementation of the scattering method related to the matching and sharpness of the surfaces.

In figure [1] we show a sort of surfaces achievable by a flexible surface called *SuperShape* [3] described by the following parametric equations:

$$r(\phi) = \left(\left| \frac{1}{a} sin\left(\frac{m}{4}\phi\right) \right|^{n_2} + \left| \frac{1}{b} cos\left(\frac{m}{4}\phi\right) \right|^{n_3} \right)^{-\frac{1}{n_1}}$$

$$x(t,s) = r_1(s) r_2(t) sin(t) cos(s)$$
$$y(t,s) = r_1(s) r_2(t) sin(t) sin(s)$$
$$z(t,s) = r_2(t) cos(t)$$

In order to show the flexibility and reliability of the formulation, we plot in figure [2] the surface field at the resonance wavelength for a 5-fold star made of silver. In figure [3] we study the dependence of the scattering cross section of a insulate cube made of silver on the sharpness of the edges. The scattering cross section shows a blue shift when the sharpness of the vertex increase. Finally, figure[4] shows the electric field on the surface of a spherical dimer made of gold, it illustrates the fact this approach deals with all sorts of complex surfaces as the star in figure[1] along the less complex ones as spheres.

The implementation of flexible surfaces in the 3d scattering methods based on the green theorem makes it specially suitable for complex scattering problems in Nano-Optics and -Photonics.

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References

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[2] Gielis, J. American Journal of Botany, **90** (2003) 333
[3] Bourke, P. http://local.wasp.uwa.edu.au/~pbourke/geometry/supershape3d/.

Figures

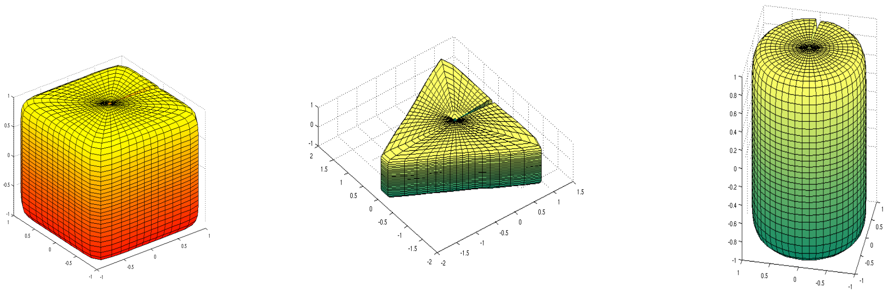

Figure1 .- *Geometrical shapes achievable to the SuperShape changing the parameters.*

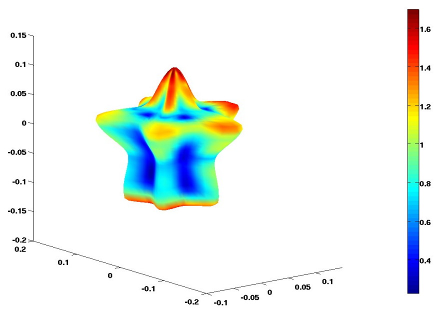

Figure2 .- *Electric field on the surface of a silver nanostar with r=50nm at λ=531nm*

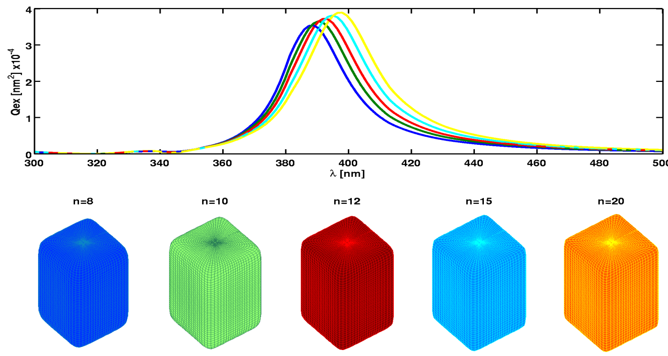

Figure3.- *Scattering cross section for silver nanocubes L=50nm with increasing sharpness*

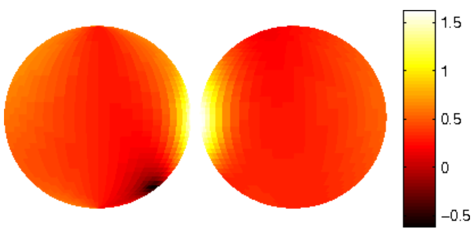

Figure4.- *Electric field on the surface for a gold dimer with r=15nm and gap=2nm at resonance wavelength λ=535nm*