SURFACE PLASMON RESONANCES OF METAL NANOPARTICLE DIMERS THROUGH THE HYBRIDIZATION MODEL AND GENERALIZATION TO NANOPARTICLE CHAINS

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The study of plasmon resonances in metallic structures at the nanoscale has recently attracted huge efforts from the Nano-Science community for the obvious impact that such resonances may have on a variety of applications in Nano-Photonics and (Bio)-Sensing. Generally speaking, numerical methods have been developed in order to describe this kind of resonances in metallic nanostructures, commonly based upon Maxwell equations, such as extended Mie, discrete dipole approximation, multiple-multipole methods, surface and volume integral equation formulations, etc. On the other hand, approximate methods have also proven successful in given configurations.

In particular, the hybridization method, developed by Nordlander at al. [1], introduces a microscopic model based upon the description of nanoparticle resonances as a set of vibrational modes in the sea of electrons on the surface of the nanoparticles. In this method, the hybridization concept, used in molecular physics since long ago, is applied to the calculation of nanoparticle resonances in complex configurations consisting of a combination of simpler nanostructures with known plasmon resonances. The resulting plasmon modes take the role of molecules in the orbital theory; namely, the initial (known) plasmon modes interact with each other in order to yield the plasmon modes of the entire nanostructure, much in the same way that electrons interact one to each other leading to the molecular energy levels. This method has been successfully applied to different configurations, as for instance: spheres, nano-shells and dimers. In order to calculate the plasmon resonances of a nanoparticle dimer, we have to build the lagrangian of the system; the kinetic part contains the single modes of the isolated nanoparticle, whereas the potential part describes the Coulomb interaction that strongly depends on the interparticle distance.

In this comunication we have used the dimer model appearing in Ref. [1] in two different experiments. Firstly, we describe the design and tuning with interparticle distance of the plasmon resonances of dimers composed by two silver nanospheres with radii around 25nm; specific amines take the role of nanoparticle linkers. Our results confirm the red-shift of the longitudinal plasmon resonance with closing distance in the ~2 nm range [2], in agreement with the experimental UV-visible absorption spectra. At resonance, in turn, these nanoparticle dimers provide a huge increase of the EM field in between the nanoparticles, leading to larger surface-enhanced Raman scattering (SERS), as revealed by SERS signals of complex molecules allocated therein by the molecular linker.

Secondly, we try to explain the trend of the red-shift of plasmon resonances appearing in aggregates of silver nanoparticles, as the temperature is varied [3]. We emulate this variation in the model by choosing the main interparticle distance properly in connection with temperature.

Finally, we propose a generalization of this model increasing the number of solid spheres in the system, and we use it in order to study the plasmon resonances in a chain of silver nanoparticles [4].

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