Flasmon Spectroscopy of Metallic Nanoparticles Close to Dielectric Substrates. Analysis of Particle-substrate Interaction Effects

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Plasmon spectroscopy of metallic nanoparticles has been a very active field of research during the last decade [1]. The excitation of lacalized plasmons, or plasmon resonances, in small metallic particles generates strong local electric fields very close to the particle surface. This enhancement of the electric field finds many applications that have generated new technologies in the nanoscopic world [1].

It is well known that the spectrum of plasmon resonances depends on the size and shape of the individual particles and also on the particle-particle interaction when the particle density is high and multiple scattering is important. This interaction modifies the spectrum in such a way that dipolar resonances shift (normally th the red) and other multipolar resonances appear [2, 3]. Usually, in experimental works with nanoparticles, these are grown inside a dielectric high-refractive-index matrix ($GaAs$, TiO_2, a-Si, *etc.*) in order to shift the resonance to the visible part of the spectrum [4, 5]. This matrix is ,in turn, located on a flat substrate, which normally is dielectric. In these works, particle shape and size, and particle-particle interaction are considered in order to account for the structure of the resonance (either, peak position or shape). Because of the presence of the substrate, particle-substrate interaction is another source of modification of the spectrum of the plasmon resonance, which can contribute to the shift of the dipolar component and also to the appearance of new resonances of higher orders, but it has not been considered so far.

In this research, we present a systematic numerical study of the scattering crosssection of a small metallic particle (Ag) immersed in a dielectric medium of refractive index n and located at a given distance above flat, dielectric substrate of refractive index n' ($> n$, $< n$). The geometry is restricted to the 1D case, which has been shown to be successful in dealing with this kind of electromagnetic problem [2]. The study is made as a function of both the distance to the substrate and the angle of incidence, the latter case to analyze the effect of the component of the incident electric field when it is parallel/perpendicular to the substrate. The numerical work has been performed by using exact numerical techniques based on the application of the Extinction Theorem of the Physical Optics [6], where the authors have previously studied scattering for both far and near field approximations [7, 8].

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