Linear polarization degree of right-angle scattering for silver nanodimmers: changes induced by quadrupolar excitation.

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The spectral properties of the linear polarization degree (P_L) at a scattering angle of 90º, are analysed theoretically and numerically for a silver nanodimmer of finite size, characterized by its gap distance, *d.* We shall focus on the influence that modes of order higher than de dipolar have on parameter P_L, and on the effect of having a size distribution being the asymmetric dimmer an example.

Introduction

The excitation of localized surface plasmon resonances (LSPR) on metallic nanoparticles depends on the physical properties of the system and the surrounding medium [1]. This phenomenon is the basis of some applications in fields like Medicine, Biology or Industry [2,3].

For ideal point-like particles, only the dipolar resonance can be excited. However, for finite-size particles in the nanometric range, although the dipolar made is still very important, it is possible to efficiently excite modes of higher order and in particular quadrupolar ones.

In this work we analyze the spectral evolution of the linear polarization degree (P_L) of the scattering produced by silver nanoparticle dimmers when measured at 90º respect to the incident direction. Under this configuration the influence of higher orders modes is better shown. These results can have direct application for instance in monitoring nanorulers. [4]

Theory

The linear polarization degree is defined as [5]

$$P_L = \frac{I_\perp - I_\parallel}{I_\perp + I_\parallel} \quad (1)$$

$I_\perp$ and $I_\parallel$ being the scattered intensities when the incident polarization is perpendicular or parallel to the scattering plane, respectively.

For dipole-like particles, the parallel intensity ($I_\parallel$) is zero at $\theta_s=90º$, that is, P_L is always equal 1 at this direction. For larger particles, multipolar orders make $I_\parallel(90º)$ different from 0, and P_L different from 1.

Results

In Fig. 1 and Fig.2 we show, as an example of the kind of results produced by this study, the scattered total intensity and the linear polarization degree, both measured at 90º, as a function of the incident wavelength. This is calculated by means of T-Matrix formalism [6]. For a system of two silver particles [7], the centre aligned perpendicularly to the scattering plane, and for different gap distances between them (d). In Fig.1 the system is composed of two identical silver particles of radius $R=50nm$.(The case of an isolated particle is included for comparison).

In Fig.2, we introduce a strong asymmetry in the dimmer by considering two silver particles of different size: R_1=*50nm* and R_2=*20nm.* When a quadrupolar resonance is excited, P_L reaches a minimum (Fig.1). When the particles of the dimmer approach, the interaction between them increases, and the quadrupolar peak shows some spectral structure where P_L exhibits two minima. For large values of *d*, P_L tends to that of an isolated particle.

In Fig.2 it can be observed that the asymmetry makes the larger particle dominant, specially for large values of *d*, and the sensitivity of P_L to the value of *d* is almost last. However, there are some interesting features, like the evolution of the scattering at λ=*430nm* when d is reduced.

References:

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Figures:

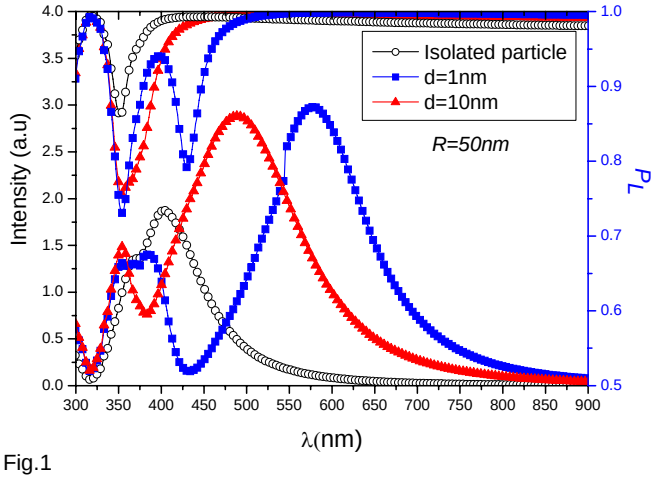

Fig.1

Figure1. Spectral dependence of the scattered total intensity and the linear polarization degree, at 90º, for a dimmer of silver spherical particles (*R=50nm*) oriented perpendicularly to the incident and observation directions, and for two distances between the particles. The isolated case is also included.

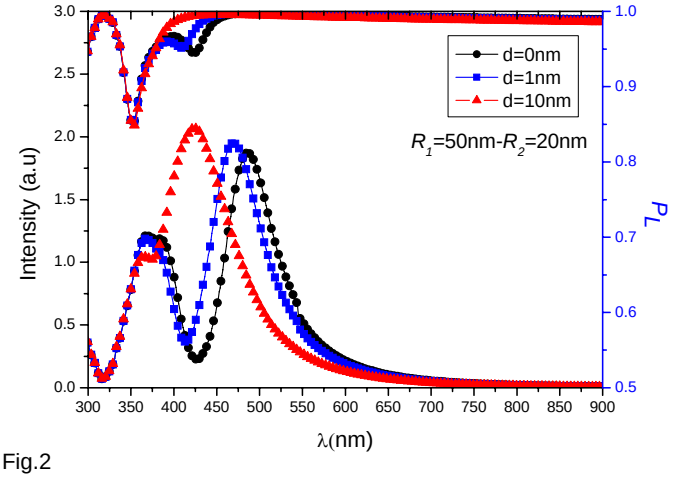

Fig.2

Figure2. Spectral dependence of the scattered total intensity and the linear polarization degree, at 90º, for a non-symmetric dimmer of silver spherical particles (R_1=*50nm*- R_2=*20nm*) aligned perpendicularly to the incident and observation directions and for there distances between the particles of the dimmer, including the contact case.