Polarization Properties of the Scattered Radiation by Silicon Nanoparticles in the Infrared

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Abstract

The main properties of the light scattered by isolated particles or particle systems contain much information about the scatterer: size, shape and optical properties. Although most of research analyzes scattered intensity properties (spectrum, scattering patterns, etc), polarization parameters can be also very interesting to obtain this information [1]. In particular, in a previous research [2], we showed that the spectral evolution of the linear polarization degree measured at a scattering angle of 90º [$P_L(90º)$] is sensitive to deviations from a pure dipolar behavior (size, anisotropy, multiple scattering). Concerning isolated and isotropic particles, this means that if the size parameter, $x=2\pi R/\lambda$, is much smaller than 1 and multipolar effects are absent, P_L(90º) remains equal to 1. If particle size grows and/or multipolar contributions become important, significant changes are detected in P_L(90º). In a similar way, we stated that this parameter can also identify magnetic response in light scattering by dipole-like particles [3]. Thus, P_L(90º) get negative values when the magnetic character of the particle dominates, while it remains positive if the dominate behavior is electric.

Recently, it has been shown that nanoparticles (*R~200nm*), made of silicon or germanium, present both electric- and magnetic-like resonant behaviors in the near-infrared range [4, 5]. Taking this into account, the objective of this contribution is to analyze the polarimetric properties of scattered radiation by silicon nanoparticles in the infrared (1-2 μm). Applying our knowledge developed in [3], we will analyze the electric and magnetic response of this kind of nanoparticles and the influence of their size by means of the spectral evolution of the linear polarization degree at right-angle scattering configuration (RASC). This analysis will allow us to relate polarimetric and energetic properties of light scattering of this realistic system.

In Figure 1 we show the spectral evolution of the considered polarimetric parameter [$P_L(90º)$] for a silicon nanoparticle with *R=230 nm* in the interval (1-2μm). Size effects become non-negligible in the considered range. For this reason, we have considered multipolar contributions. In particular, the first four Mie terms (electric and magnetic, dipolar and quadrupolar ones) are plotted. As in [3], when the electric dipolar character (a_1) dominates, P_L is clearly positive and tends to the ideal value of 1. As the magnetic dipolar conduct (b_1) becomes more important, P_L tends to decrease and it is negative when the magnetic dipolar resonance is excited. For shorter wavelengths, the size/wavelength ration induces that quadrupolar terms are comparable to the dipolar ones and even a magnetic quadrupolar mode (b_2) is excited. This produces a complex behavior of $P_L(90º)$ that will be explained.

In summary, in this research we have analyzed the spectral evolution of the linear polarization degree at right angle scattering configuration, P_L(90º), of silicon particles (R~200nm) in the IR. We can conclude that its measurement can be a complementary tool to the conventional analysis of either the scattering or extinction spectra. P_L(90º) can reveal and distinguish electric and magnetic responses of the scattering system. In addition, in this research we have considered multipolar contributions, in other to study how they contribute to the polarimetric parameter.

Acknowledgments

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Figures

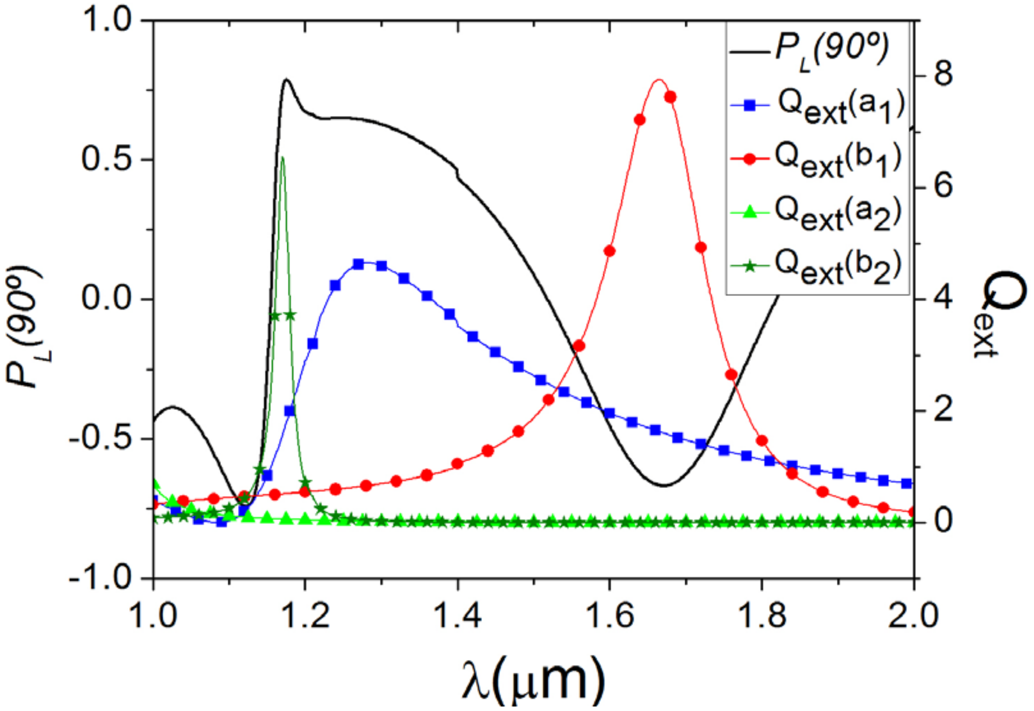

Figure 1. Spectral evolution of $P_L(90º)$ of a silicon particle (R = 230nm). The first four contributions of the Mie expansion to the extinction efficiency are also shown.