Magneto-Optical properties of nanostructured thin films

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Electromagnetic scattering from nanometer-scale objects has long been a topic of large interest and relevance to fields from astrophysics or meteorology to biophysics, medicine and material science [1-5]. In the last few years, small particles with resonant magnetic properties are being explored as constitutive elements of new metamaterials and devices. The studies in the field often involve randomly distributed small elements or particles where the dipole approximation may be sufficient to describe the optical response. We will discuss the optical response of disordered nano-materials where the constitutive nanoparticles can have a non-negligible response to static (**Magneto-Optical active nanoparticles**) or dynamic (**Magneto-dielectric nanoparticles**) magnetic fields.

We will first analyse the peculiar scattering properties of single nanoparticles. In particular, we derive the radiative corrections to the polarizability tensor of anisotropic particles, a fundamental issue to understand the energy balance between absorption and scattering processes [1]. As we will show, Magneto optical Kerr effects in non-absorbing nanoparticles with magneto-optical activity arise as a consequence of radiative corrections to the electrostatic polarizability tensor.
We will also explore the properties of high-permittivity dielectric particles with resonant magnetic properties as constitutive elements of new metamaterials and devices [2]. Magnetic properties of low-loss dielectric nanoparticles in the visible or infrared are not expected due to intrinsic low refractive index of optical media in these regimes. Here we analyze the dipolar electric and magnetic response of lossless dielectric spheres made of moderate permittivity materials. For low material refractive index there are no sharp resonances due to strong overlapping between different multipole contributions. However, we find that Silicon particles with index of refraction ~ 3.5 and radius ~ 200nm present strong electric and magnetic dipolar resonances in telecom and near-infrared frequencies, (i.e. at wavelengths $\approx 1.2 - 2$ μm) without spectral overlap with quadrupolar and higher order resonances. The light scattered by these Si particles can then be perfectly described by dipolar electric and magnetic fields.

As we will see, the striking characteristics of the scattering diagram of small magneto-optical and magnetodielectric particles [3,4] lead to a number of non-conventional effects in the optical response of nanostructured magneto-optical structures.

References

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