Magnetically controlled optical nanoantennas

[1]**A. García-Martín**, [2]N. de Sousa and [3]L.S. Froufe-Pérez

[1]IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), Isaac Newton 8, PTM, E-28760 Tres Cantos, Madrid, Spain.
[2] Departamento de Física de la Materia Condensada,Universidad Autónoma de Madrid, 28049 Madrid, Spain.
[3]Soft Matter and Photonics Group, University of Fribourg, Switzerland.
a.garcia.martin@csic.es

The study of light emission through optical nanoantennas has been a matter of intense research during the last decade. They allow to control and manipulate optical radiation at subwavelength, with applications in photodetection [1, 2], sensing [3], heat transfer [4, 5] or spectroscopy [6], among others. A fluorescent molecule, as a first approximation, can be regarded as a dipole nanoantenna. The emission properties of these molecules, essentially lifetime and angular radiation pattern, depend not only on the intrinsic properties but also on the environment where they are embedded. This phenomenon, initially described by Purcell [7], has been observed in emitters placed close to photonic crystals [8] and more recently in plasmonic [9, 10] and magnetoplasmonic structures [11]. The possibility of creating and manipulate nanostructured materials encouraged the exploration of new strategies to control the electromagnetic properties with an external agent. A possible approach is combining magnetic and plasmonic materials, where it is feasible control the optical properties with magnetic fields [12-14].

In this work we present a fundamental study of the properties of an emitter in two different situations: in the presence of a single magneto-plasmonic nanoparticle and inside a cavity formed by two magneto-plasmonic nanoparticles.
We analyze the effect of the magneto-optical activity both in the decay rate (inverse lifetime) and in the radiated far field patterns.

We will show that the decay rate of an emitter experiments a weak dependence on the magneto-optical effect, both in the presence of a single particle and within a cavity. This weak modification is in contrast to the large modification of the far field pattern for a given range of distances between the emitter and the scatterers. This implies that the radiated field pattern can be dramatically distorted while causing a small modification on the dynamics of the emitter. In the particular case of absorptionless particles, the situation is radically different and there is a region in which also the decay rate is largely affected by the magneto-optical effect.

References

[1] L. Tang, et al., Nature Phot. **2**, 226 (2008)
[2] L. Cao, et al., Nano Lett. **10**, 1229 (2010)
[3] J.N. Anker, , et al., Nature Mat. **7**, 442 (2008)
[4] Y. De Wilde, et al., Nature **444**, 740 (2006)
[5] J.A. Schuller, et al., Nature Phot. **3**, 658 (2009).
[6] L. Novotny, et al., Annu. Rev. Phys. Chem. **57**, 303 (2006)
[7] E.M. Purcell, Phys. Rev. **69,** 681 (1946)
[8] P. Lodahl, et al., Nature **430**, 654 (2004)
[9] R. Carminati, et al., Optics Comm. **261**, 368 (2006)
[10] E. Castanié, et al., Opt. Lett. **37**, 3006 (2012)
[11] D. Nikolova, and A. J. Fisher, Phys. Rev. B **88**,125136 (2013)
[12] G. Armelles, et al., Adv. Opt. Mat. **1**, 10 (2013)
[13] G. Armelles, et al., Opt. Express **21**, 27356 (2013)
[14] N. de Sousa, et al., submitted.