Exploring the electric and magnetic light emission with plasmonic cavities

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Keywords: nanophotonics, electric and magnetic dipole transitions, optical cavities, local density of states.

The constant advances of the field of nanophotonics have recently led to the development of optical structures allowing to manipulate the emission of fluorescent emitters at the nanoscale [1]. However, these underlying interactions between light and matter have been so far considered to be mediated only by the optical electric field, discarding the magnetic side of the light. In fact, most of the past studies involving single emitters have been studying the modification of the excitation or emission properties of electric dipole transitions solely [2]. Nevertheless, it was recently demonstrated that magnetic dipole could also be found in a certain class of materials, as in lanthanide ions. Moreover, it was shown that by manipulating the magnetic local density of states sensed by those ions, the fluorescent emission of the magnetic dipolar transitions could be enhanced or decreased with respect to their electric counterpart [3]. In here, we demonstrate experimentally, in perfect agreement with numerical simulations, the manipulation of magnetic and electric dipolar transitions by means of plasmonic cavities. Using a near-field scanning optical microscope (NSOM), we bring in close proximity to plasmonic cavities made of aluminum, a nanoparticle doped with trivalent europium (figure 1a), allowing perfect control over the interactions between the emitter and the nanostructures. In this study, we show an increase, as well as a decrease, of the electric and magnetic signal from the emitter (figure 1b), according to the particle position inside the cavities. Furthermore, by scanning the particle over the nanostructures, we also retrieve the spatial distribution of both the electric and magnetic radiative local density of state (LDOS) at the surface of the cavities (figure 1c). We believe that this work paves the way to a profound understanding of ‘magnetic light’ and matter interactions and in particular toward the design of nanostructures to boost these interactions.

Figure 1. a, Illustration of the NSOM experimental setup. b, Experimental branching ratio associated with electric (red) and magnetic (green) dipolar transitions of the Eu3+, according to the particle position inside the cavity. c, 2D experimental maps of the radiative magnetic LDOS along the cavity.