Plasmon-Induced Magneto-Optical Activity in Nanosized Gold Disks

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The excitation of surface plasmons has proven a very useful means to raise other physical phenomena like in surface Raman scattering (SERS), fluorescence emission, high harmonic generation or the magnetooptical Kerr effect (MOKE). Focusing on the MOKE, it has been shown that the influence of surface plasmons can lead to a noticeable enhancement of the magneto-optical (MO) actitivity for ferromagnetic nanoparticles[1], or more for combinations of noble metal-ferromagnetic nanofilms and nanodisks[2,3].

When considering MO activity together with plasmonic excitations, the nanostructures developed requiered the incorporation of a ferromagnetic material to benefit from their high MO response at very low magnetic fields. So far, no attempt on nanostructures consisting exclusively in noble metals has been made since the magnetic field required to obtain a measurable response is expected to exceed those experimentally available (more than 100T). However, the excitation of a surface plasmon in a metal could lead to a drastic reduction of the magnetic field necessary to be able to observe MO activity in noble metal structures. This is the scope of this work, where we present for the first time the MO response of a series of pure gold nanostructures[4].

We apply a magnetic of 0.8T to analyze the Kerr rotation and ellipticity of disordered gold nanodisks and nanoholes obtained from continuous gold films grown over a glass substrate using colloidal lithography. We show that the MO response is controlled by the surface plasmon excitation, its spectral position depending on the aspect ratio of the particles/holes. Figure 1 shows that a peak and an S-like structure for the Kerr rotation and ellipticity respectively appear at the same energy region where the surface plasmon is excited. As the diameter of the nanodisks/holes increases, these features shift to lower energies (higher wavelengths), in accordance with the modification of the spectral position of the plasmon excitation due to the variation of the aspect ratio. We will show that this effect is due to the increase of the magnetic Lorentz force induced by the large collective movement of the conduction electrons in the nanostructures when the LSPR is excited. To understand the physical mechanism of the effect, we will rely on a simple approach based on the polarizability of a metal nanoparticle in the presence of a static magnetic field. The emergence of MO effects in pure plasmonic nanostructures may then find important applications in plasmonic modulators or in the improvement of the biosensing performance of metal nanostructures [5].

References:

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Figures:

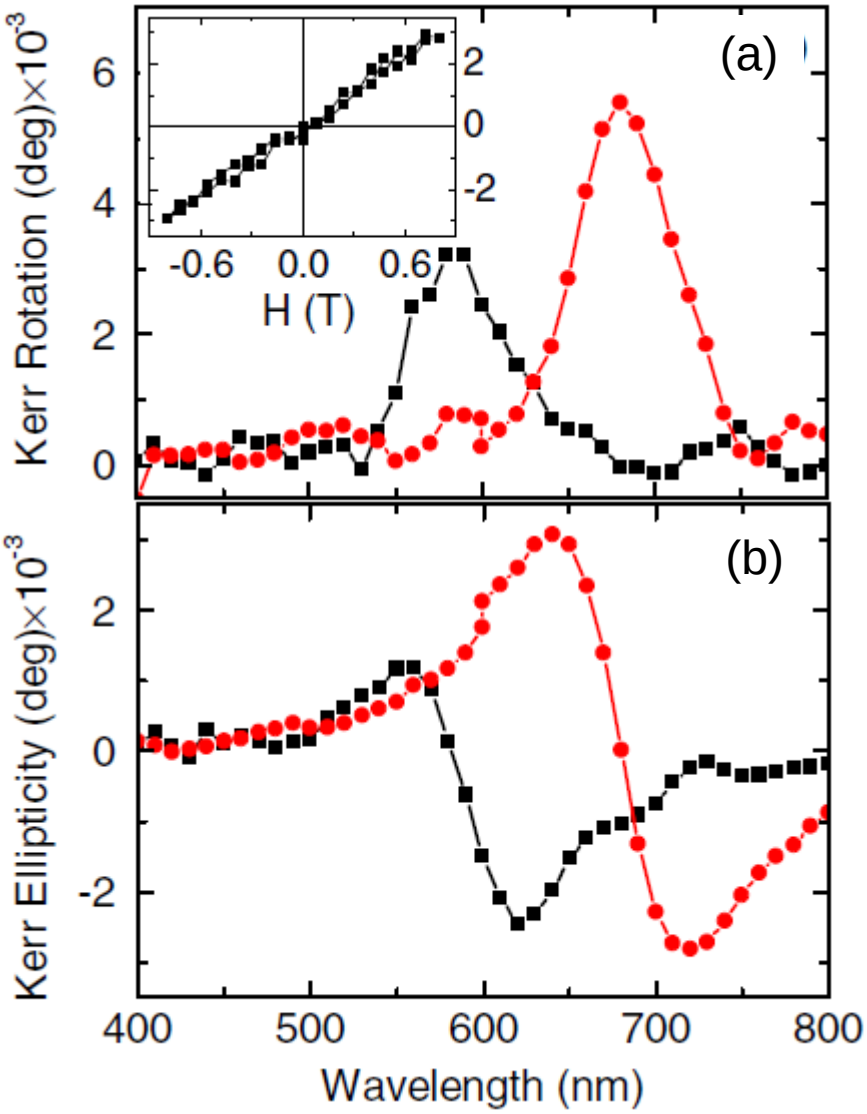

Fig. 1: MO Kerr rotation (a) and ellipticity (b) of gold nanodisks (D=70nm, h= 32nm) (squares) and (D=20nm, h= 20nm) (circles). The inset in (a) represents the Kerr rotation variation as a function of the magnetic field for the Au nanodisks with D=70nm, h= 32nm.