Magneto-plasmonic dynamics in gold nanoparticles.

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Abstract

The static magnetic property of plasmonic materials such as gold and silver colloidal nanoparticles has been previously studied with magnetic circular dichroism (MDC) [1] and magnetic Kerr effect [2]. The results show a coupling between the surface plasmons and the external magnetic field. In the present work, using femtosecond optical pulses and a large static magnetic field, we investigate the dynamical properties of the magneto-plasmonic interaction in a single layer of self-organized gold nanoparticles.

Nanoparticles with 10 nm diameter were deposited on a sapphire substrate using the Langmuir-Blodgett technique. The strong dipolar interaction between nanoparticles induces a red shift of the surface plasmon resonance (SPR) to 645 nm as compared to the individual one (SPR at 526) [3].

The measurements of the time-resolved reflectivity and magneto-optical Kerr are performed in an external magnetic field of 10 Tesla. The nanoparticles are excited with femtosecond laser pulse with 90 $\mu J/cm^2$ and probed with white light continuum pulses generated in a sapphire crystal. The time dependent magneto-optical response reveals the strong coupling between the pump polarization helicity and the Au nanoparticles both at the interband $d \rightarrow E_F$ transition and at the surface plasmon resonance.

We model these results using two effective medium approximations (Maxwell-Garnet [4] for the short range and Bruggeman [5] for the dipolar interactions) for the reflectivity and in addition the Voigt theory to account for the magnetic response.

The time dependent dynamics is taken into account via the time-dependent temperatures of the charges and the lattice (two-temperature model). The electron temperature effect the electron damping in the Drude contribution, the occupation state near the Fermi energy and damping of the interband transition [6].

The simulations show a good agreement with the experimental results. Two main mechanisms influence the magneto-plasmon dynamics. First, the coupling between the external magnetic field and free electrons, described with the Voigt model. Second, a strong coupling between the nanoparticles and the laser field is present when the pump pulses are circularly polarized.

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