	Name of the post doc: **DESALEGN Gezahegn** Title of the post-doc: **Coupling of Plasmonic nanostructure to (Magnetic) Semiconductors: Control of Optical Properties for energy efficiency** Dates (start/end): **15/10/2017 – 09/11/2018**
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Context and objectives

Nanoplasmonics is an emerging research field that studies light-matter interactions mediated by resonant excitations of surface plasmons in metallic nanostructures. Metal nanoparticles with sizes smaller than the wavelength of visible light show strong resonances for light scattering and absorption, due to the excitation of localized surface plasmons.

On the other hand, ferromagnetic semiconductors are semiconductor materials that exhibit both ferromagnetism and useful semiconductor properties. They have been studied for decades owing to the variety of applications they offer through their coupled spin and charge degrees of freedom.

The original idea of this project is to benefit from the advantages of both systems by considering a hybrid structure where a ferromagnetic semiconductor (FMS) is coupled to an assembly of metallic nanoparticles (MNP), the latter being either deposited on the top of the former or embedded in it.

Indeed, when light interacts with the metallic nanoparticles, strong optical absorption is observed due the excitation of surface plasmons. These quasi-particles are themselves a source of electromagnetic radiation, which interacts with the FMS, thus openning new channels for energy conversion and transfer. More precisely, the coupling of the plasmons to the spin and charge degrees of freedom of the FMS provide us with a new handle on the optical properties of the whole system.

Approach

We adopt a microscopic approach and build a Hamiltonian for the whole system.

- The FMS is first treated as a one-band conduction electron gas coupled to the subsystem of localized spins. The latter and the conduction electrons are coupled via the well characterized *sd* interaction.

- The MNP assembly is treated as an (organized or disordered) ensemble of point scatterers and taken into account in the whole Hamiltonian as sources of a nonuniform and time-dependent (plasmonic) electromagnetic field.

- We use the advanced technique of Green's functions to describe the various correlation functions and physical observables such as the (modified) spin-wave spectrum, dynamic susceptibility and dielectric function. Two approaches are used for computing the various Green's functions: i) the techniques of Quantum Field Theory and Feynman diagrams, and ii) the method of equations of motion.

Main results

- We have formulated the problem and built the system Hamiltonian
- We have obtained the (coupled) equations of motion of the spin Green's function and spin-electron vertex function.
- We have computed the (modified dynamic susceptibility) that describes the effect of the plasmonic sources on the magnetic and transport properties of the FMS.

- We are computing the dielectric function (the density-density correlation function) and analyzing the physics rendered by the various observables, we have obtained (e.g. the dynamic susceptibility). In particular, we analyze the effects of the plasmonic field on the spin-wave branches, especially the optical one.