Master Matière Condensée et Nanophysique

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Title: Harmonic generation using metallic nanoparticles

Recent years have witnessed a remarkable surge in interest for the electronic properties of new materials, particularly when excited by electromagnetic radiation. This is a very vast domain of research that encompasses all sorts of nano-objects (metallic films and nanoparticles, carbon nanotubes, semiconductor quantum dots,…), new materials like graphene, as well as metamaterials whose structure can be engineered so as to display some particular optical properties. In this project, we will focus our attention on metallic nanoparticles (NPs).

Standard methods to study the electron response – such as the density functional theory or Hartree-Fock equations – are computationally very costly in terms of run time and memory storage. Here, we propose to develop and implement a set of *quantum hydrodynamic* (QHD) models that are sufficiently simple to be run on standard computers (desktop PC or small university cluster), but contain enough physics to study the electron response beyond the Mie model – in particular nonlinear, nonlocal, and quantum effects. Using this approach, several configurations of nano-objects will be studied, starting from the simpler case of an isolated metallic NP, and later moving to dimers and trimers of NPs.

The principal goal of the project will be to investigate the electronic response of the NP to an intense laser pulse. The resulting dynamics leads to the emission of electromagnetic radiation from the oscillating electrons, with a possibly broad spectrum containing many higher order harmonics. The generation of higher harmonics is a crucial step to generate ever shorter electromagnetic pulses, well into the attosecond domain, which has many fundamental and practical applications.

The student's role will be to implement the QHD code in the simplest case of a single NP and test earlier results obtained in our group using a simpler approach [1].

References

[1] J. Hurst, F. Haas, G. Manfredi, P.-A. Hervieux, *High-harmonic generation by non-linear resonant excitation of surface plasmon modes in metallic nanoparticles*, Phys. Rev. B **89**, 161111(R) (2014).