Master Physique — Condensed Matter and Nanophysics
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Orbital magnetism in gold nanoparticles

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Due to their small sizes, metallic nanoparticles show spectacular quantum effects that are absent in the bulk. Most of these effects stem from the confinement of the electronic eigenstates, which is important because of the relatively large surface-to-volume ratio in particles with nanometric sizes. The resulting size effects show up in many of the physical properties of metallic clusters, e.g., in their abundance spectra, static dipole polarizabilities, ionization potentials, and optical and plasmonic properties [1].

An aspect that attracted considerable attention over the last decade is the unusual magnetic behavior of gold nanoparticles [2]. Indeed, while gold is diamagnetic in the bulk, several experiments have shown that ensembles of gold nanoparticles capped with organic ligands can present a ferromagnetic-like behavior of the magnetization, up to room temperature or above. Other samples show a paramagnetic-like behavior, and some others a diamagnetism which is typically stronger than in the bulk. These different magnetic properties that fluctuate from sample to sample, as well as the underlying mechanisms giving rise to these features are a source of intense debate in the litterature [3].

A possible interpretation of these experiments that we wish to investigate in this theoretical Master thesis is if these features may be explained by orbital magnetism. The latter is a purely quantum-mechanical effect, first studied by Landau in bulk electron gases. While the corresponding magnetic susceptibilities are minute in the bulk, the situation is strikingly different in finite mesoscopic systems where such susceptibilities can be very large [4].

The aim of this internship is to theoretically investigate the orbital magnetism of metallic nanoparticle assemblies employing semiclassical [5] as well as many-body techniques. The nanoparticles will be at first considered to be independent from each other, and interaction effects will be incorporated at a later stage of the internship. The student will work in the Theoretical Mesoscopic Physics Team[1] at IPCMS (Rodolfo Jalabert, Guillaume Weick and Dietmar Weinmann) and in close contact with experimentalists conducting experiments on assemblies of gold nanoparticles at IPCMS. For more information, please contact Guillaume Weick (email: guillaume.weick@ipcms.unistra.fr, phone: 03.88.10.72.62).

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