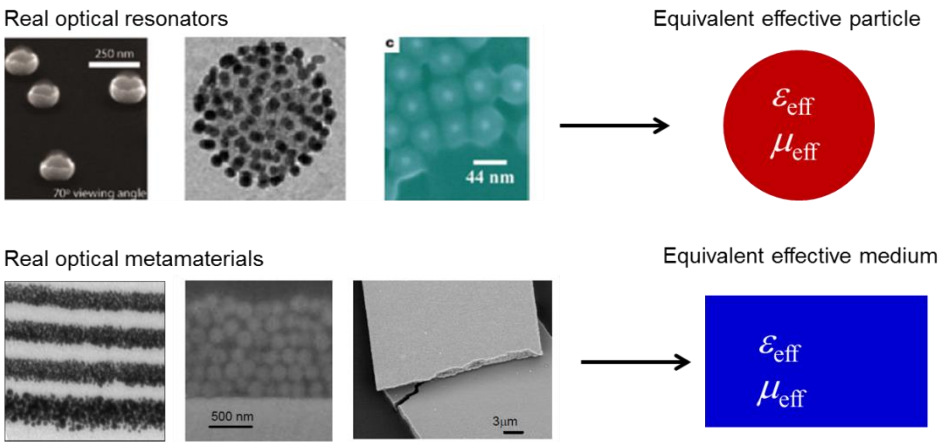
Electromagnetic Modeling of optical resonators and large assemblies of optical resonators



Metamaterials

Metamaterials are homogenous assemblies of artificial sub-wavelength resonators (meta-atoms) with extraordinary effective medium properties. The electromagnetic properties of a material are determined by the electric permittivity ε and the magnetic permeability μ. Natural optical materials do not exhibit any intrinsic magnetic response of atomic or molecular origin. However, it is possible for instance to build artificial composite resonators that do have a magnetic response at a much larger scale than the atomic scale, such that a material made of these resonators will exhibit an effective magnetic response μ_{eff}. A famous example of extraordinary optical property is negative refraction, which requires that ε_{eff} and μ_{eff} be simultaneously negative. By cleverly conceiving artificial optical resonators the dipolar electric and magnetic resonances can be precisely adjusted and new values of ε_{eff} and μ_{eff} can be explored. Such possibilities enable a great number of remarkable devices such as the invisibility cloak and the hyper-lens (a lens that can image objects well beyond the diffraction limit).

Research et the Centre de Recherche Paul Pascal (CRPP)

Recent progress in colloïdal engineering has enabled the Centre de Recherche Pau Pascal and its collaborators to synthesize complex nanoparticles, some which greatly resemble theoretical proposals of meta-atoms. The large optical responses of these meta-atoms is often based on plasmonic or Mie resonances. Furthermore, CRPP has several self-assembly techniques, which makes it possible to assemble these nanoparticles into large volumes of bulk material. This opens a large field of exploration for optical metamaterials, based on a *bottom-up* approach that is radically different to more classical *top-down* approaches that use the micro-electronics fabrication facilities.

Internship work

In this context, predicting both the individual response and the bulk collective response of these complex nanoparticles is paramount. The *Metamaterials* team at CRPP wishes to explore novel approaches in simulating the responses of actual plasmonic and Mie nano-resonators, which aims at drastically reducing the geometrical complexity of the numerical problem so as to reduce the computational load. Part of the work will consist in determining the effective properties of a hypothetical spherical particle that best reproduces the scattering behavior of the real particle and to test this approach by simulating 2D and 3D periodic arrangements of both the real and hypothetical particle. In the end, this should enable to determine ε_{eff} and μ_{eff} of the metamaterial. Comparison to experimental realizations will be possible. **Softwares used :** Matlab, COMSOL Multiphysics (Finite Element Method). **Key words :** optical metamaterials, electromagnetism, homogenization, scattering

Contacts

Alexandre Baron (alexandre.baron@u-bordeaux.fr)