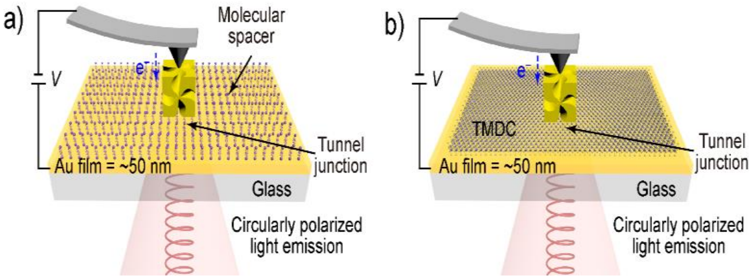
ANR-funded Ph.D. thesis available

Electrically-excited CHIral nanoCavities (ChiC)

Chiral structures, whose initial and mirror structural images cannot be superimposed, interact differently with left-handed and right-handed circularly polarized light. This is called the "chiroptical response". Chirality is a crucial property for many essential molecules in biology. Most often, however, the corresponding chiroptical response is very weak. Gold plasmonic nanoparticles, on the other hand, have a relatively strong chiroptical response. A plasmonic nanocavity is formed when a nanoscale gap separates a noble metal nanoparticle from a metallic substrate (see Fig. 1a). The electromagnetic field in such a nanocavity is dramatically enhanced, thanks to the plasmonic resonances which "concentrate" the electromagnetic field. The main idea of this project is thus to apply this principle to *chiral* plasmonic cavities and thus enhance the chiral interactions between light and matter.

The goal of this internship is to locally and electrically excite chiral plasmonic nanocavites, with the goal of using them to enhance the chiral properties of **a new class of two-dimensional semiconductors called TMDs (transition metal dichalcogenides)**. The long-term goal of the project is a new computational framework called "valleytronics". Examples of the types of samples to be studied are shown in the figure below. What makes the studied nanoparticles "plasmonic" is that they may support *localized surface plasmons*, i.e., collective surface electron oscillations coupled to an electromagnetic wave. In order to locally excite "right-handed" and "left-handed" nanocavities, and subsequently detect right-handed or left-handed circularly polarized light, we will complete the electric circuit using the conducting tip of an atomic force microscope (AFM). These experiments raise many fundamental questions; in particular, may the polarization of the emitted light be controlled by the "handedness"' of the particle?

During this thesis, the student will acquire experience in (i) atomic force microscopy (imaging of the chiral structures and excitation) (ii) optical microscopy (the detection and analysis of the emitted light) and (iii) the theory of plasmonics and TMDs ("valleytronics").



a) A chiral plasmonic nanocavity is formed between a chiral gold nanoparticle and a thin gold film. When a voltage difference is applied between the particle and film via the tip of an atomic force microscope, the resulting inelastic tunneling electrons excite the existing plasmonic modes of the system (which subsequently decay as circularly polarized photons). b) This sample geometry and excitation method will be used to preferentially excite the luminescence of a particular circular polarization from a TMD monolayer.

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For more information about our work:

https://www.youtube.com/watch?v=nqqpkWicR2k (in French)
https://www.youtube.com/watch?v=bZAs1W25_dQ (in French)
http://www.ismo.u-psud.fr/spip.php?rubrique199 (available in French and English)