

Title of the project: **Chiral superradiance emission**

Supervisor(s): **G. Colas des Francs**

Laboratory / Department / Team : ICB / Photonics departments

Collaborations: **E. Dujardin**

Scientific Context : Superradiance refers to a collective emission phenomenon where excited atoms in a subwavelength volume emit coherently. This phenomenon originates from spontaneous phase locking of the atomic dipoles through a same mode and is very similar to the building of cooperative emission in a laser amplifier [1]. Superradiant emission promises applications in narrow-linewidth lasers and quantum memories. Additional control can be achieved considering specific configurations. For instance, plasmon enhanced superradiance occurs when an assembly of emitters collectively couple to a metallic nanosphere, opening the doors to fast and bright optical nanosources [2].

In this work, we will theoretically and numerically investigate a particular arrangement of the emitters, namely helical so that chiral emission is expected [3]. First, we will adopt a classical approach, where light emission is described by the radiation of oscillating dipoles. This will allow us to establish several characteristics of the collective emission (emission rate, polarization, optical chirality, ...). Secondly, we will consider a fully quantum optics approach, that solely permits to describe the superradiance dynamics. It worth mentioning that both formalisms rely on Green's tensor so that classical and quantum approaches are complementary, facilitating numerical simulations progression but also ensure easier understanding of the superradiant process.

This work is purely theoretical but will permit to define optimized parameters for which efficient chiral superradiance occurs. Indeed, part of our team (E. Dujardin) has recently developed a protein origami method that permits realization of helical arrangement of emitters. If pertinent, the optimized configurations will be considered for future experimental characterization.

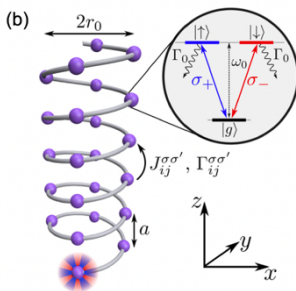


Fig. 1 Quantum model of chiral superadiance. From ref. [3].

References

- [1] *Superradiance: an essay on the theory of collective spontaneous emission*, M. Gross and S. Haroche, Phys. Rep. **93**, 301 (1982).
- [2] *Cooperative emission in quantum plasmonics superradiance*, H. Varguet, S. Guérin, H. Jauslin, G. Colas des Francs, Phys. Rev. B **100**, 041115(R) (2019).
- [3] *Chirality dependent photon transport and helical superradiance*. J. Peter, S. Ostermann, S. F. Yelin, Phys. Rev. Res. **6**, 023200 (2024).

Type of project (theory/experiment): Theory and umerical simulation

Required skills: quantum optics, nanophotonics