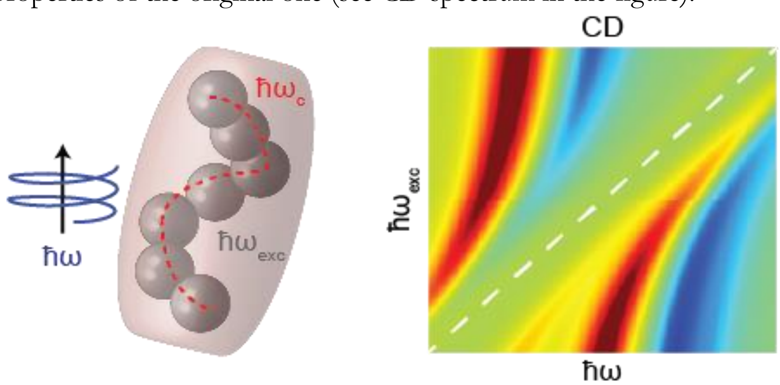
Draft of Bachelor/Master project. For more options, visit polima.org.

Project title: Design and analysis of reconfigurable chiral polaritonic environments	
Proposed by: Christos Tserkezis	Possible supervisor(s): Christos Tserkezis

PROJECT DESCRIPTION:

Chirality, i.e. the property of an object not being superimposable onto its mirror image (like our left and right hands), is encountered widely in nature. It relates to all kind of biological samples, where a simple difference in handedness (whether the sample has a left- or a right-handed orientation) can lead to significantly different properties and (bio)compatibilities. One the most important techniques for identifying the handedness of an object is circular dichroism (CD) spectroscopy, where the object interacts with left- or right- circularly polarised light, and the difference in absorption between the two polarisations provides the desired information [1]. At the same time, research in optical and quantum sciences requires, more and more frequently, platforms that exhibit this kind of *optical activity* themselves, as building blocks for detectors, polarisers, or even single-photon sources [2]. Consequently, the ability to enhance and accurately control the chiroptical response of nanostructures acquires wide interdisciplinary importance. In a recent work [3], we showed that this kind of control can be achieved by the interaction of chiral objects with resonant achiral environments, such as organic molecules supporting collective excitonic resonances (see sketch in the figure). The interaction of the different optical modes supported by the two components (chiral object/excitonic matrix) leads to hybrid half-light—half-matter states, known as polaritons, which are accompanied by the splitting of resonances in the spectra of any observable into two hybrid resonances that maintain the properties of the original one (see CD spectrum in the figure).



The aim of this project is to build on Ref. [3] and explore, theoretically, optimal architectures for this hybridisation. At a first step the student will study and reproduce the equivalent of Mie theory for chiral objects [4]. This is an extremely efficient, accurate, and computationally cheap tool to study light scattering and build an understanding of the underlying physics. Subsequently, the student will use commercial software (e.g. Comsol) to study different templates where the analytical findings can be enhanced, and the response of the system (either as an antenna for circularly polarised light, or as a detector for structural chirality) can be engineered, with the aim of identifying systems where the two hybrid resonances maintain the CD enhancement and handedness of the structure.

[1] L. D. Barron – Molecular Light Scattering and Optical Activity (Cambridge University Press, 2004).
[2] V. K. Valev et al. – Adv. Mater. **25**, 2517 (2013).
[3] P. E. Stamatopoulou et al. – Nanoscale **14**, 17581 (2022).
[4] C. F. Bohren and D. R. Huffman – *Absorption and Scattering of Light by Small Particles* (Wiley, 1983).