POLIMA
Center for Polariton-driven Light-Matter Interactions

SDU
Mads Clausen Institute

PROJECT TITLE

Reconfigurable chiral polaritonic environments

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PROJECT DESCRIPTION

Chirality is the property of an object not being superposable onto its mirror image, like our left and right hands [1]. This property is ubiquitous in nature, as it relates with the (self)assembly of molecules to form e.g. proteins; different orientations of the assembly can lead to different binding to the human body and thus biocompatibility. In optics, chirality manifests through the polarisation of light, and how it interacts with the sample: right- or left-circularly polarised light is absorbed differently by chiral objects, meaning that one can optically characterise a sample through its *circular dichroism (CD)*, i.e. the difference in absorption for the two polarisations. Objects with such *optical activity* can be exploited as building blocks for detectors, polarisers, or single-photon sources with specific spin [2].

Polaritons are the hybrid light–matter entities that emerge from the strong coupling of light with a dipole-carrying excitation in matter. For instance, when excitons in organic molecules interact with an optically resonant structure (e.g. the helix in Fig. 1), the excitonic and optical states couple like two harmonic oscillators, leading to two new eigenmodes, separated in frequency. Observing this hybridization in CD promises to be a more accurate technique for characterising the chirality of a molecule, and a flexible template for generating light with the desired polarisation [3].

The aim of this project is to build on Ref. [3] and theoretically explore optimal architectures for the formation of chiral polaritons. Depending on the student's interests and experience, this might be done either analytically, with idealised systems, or numerically (e.g. with COMSOL or in-house multiple-scattering/boundary element methods), with the intention to find large and tuneable hybridisation gaps in the CD spectra of composite nanostructures.

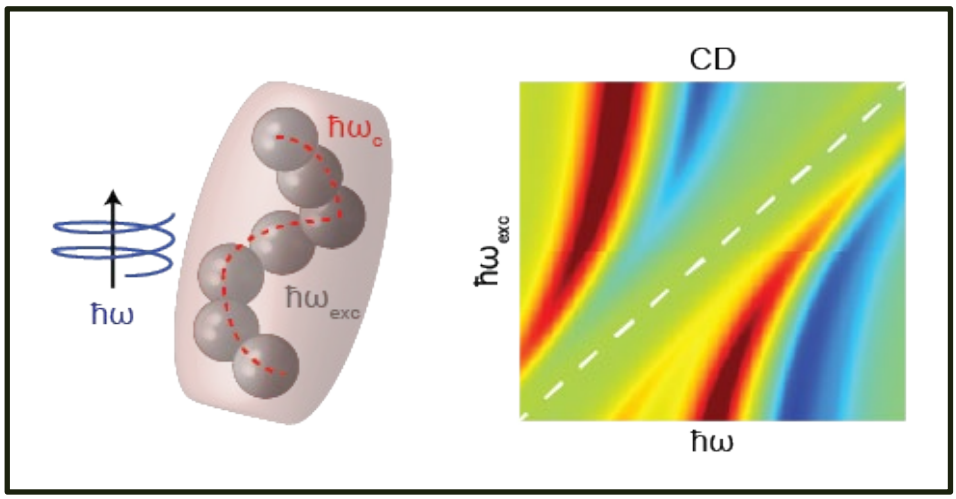


Figure 1: A chiral object (here a helix of metallic nanoparticles) embedded in an excitonic matrix, and the hybrid chiral polaritonic resonances observed in its CD spectrum.

[1] L. D. Barron, *Molecular Light Scattering and Optical Activity* (Cambridge University Press, 2004).
[2] V. K. Valev et al., *Chirality and chiroptical effects in plasmonic nanostructures: fundamentals, recent progress, and outlook*, Adv. Mater. **25**, 2517 (2013).
[3] P. E. Stamatopoulou et al., *Reconfigurable chirality with achiral excitonic materials in the strong-coupling regime*, Nanoscale **14**, 17581 (2022).