INTERNSHIP PROPOSAL

Laboratory name: **C2N (Center for Nanoscience and Nanotechnology)**
CNRS identification code: **UMR 9001**
Internship director'surname: **LANCO Loïc**
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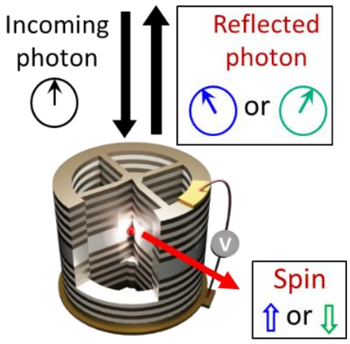
Internship location: **C2N, 10 Boulevard Thomas Gobert, Palaiseau**

Thesis possibility after internship: **YES**
Potential fundings: **EDPIF, Quant-Edu France, Quantip**

Spin-photon interfaces for quantum entanglement & quantum logic operations

This project aims at controlling the interaction between light and matter at the most fundamental level: *qubits*. To this purpose, we recently developed **an efficient interface between a single material qubit** (the spin of a single charge) and a **single photonic qubit** (the polarization of a single photon). Our interface uses the spin qubit carried by a semiconductor hole, confined in a nanometer-scale InAs quantum dot (QD), deterministically-coupled to an electrically-contacted microcavity.

As we demonstrated, a photon reflected by such a QD-cavity structure experiences a drastically-enhanced rotation of its polarization, clockwise or counter-clockwise, depending on the spin state (see figure [1]. Using deterministically-coupled spin-photon interfaces[2], and polarization state tomography experiments[3], we achieved the full reversal of the photon polarization state, controlled by a single spin[4]. Recently, **we demonstrated the optical probing of a single spin using single photons[5]**. In such experiment every single detected photon leads to a measurement back-action on the spin qubit



In the proposed internship and the following PhD thesis offer, we want to explore the perspectives of such spin-photon interfaces for quantum information. A final objective will be to demonstrate **new forms of spin-photon entanglement and photon-photon entanglement**, and develop **logic gates mediated by the spin-photon interaction**. On the way, we will also perform **fundamental quantum measurements**, and study the interaction between a spin and its solid-state matrix.

All the technological, experimental and theoretical expertise of the C2N group will be available to successfully lead this project. We welcome highly-motivated applicants with excellent background in quantum physics, optics, and/or solid state physics, and with a taste for theory and numerical simulations.

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	YES	Theoretical Physics:	NO

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[1] Arnold *et al*, Nature Commun. **6,** 6236 (2015)
[2] Hilaire *et al*, Phys. Rev. B **102**, 195402 (2020); Coste *et al*, Nature Photonics **17**, 582 (2023)
[3] Anton *et al*, Optica **4,** 1328 (2017); Hilaire *et al*, Appl. Phys. Lett. **112**, 201101 (2018)
[4] Mehdi *et al*, Nature Commun. **15**, 598 (2024)
[5] Coste *et al*, Quantum Science & Technology **8**, 025021 (2023); Gundin *et al*, arXiv:2401.14976 (2024)