Master 2: International Centre for Fundamental Physics
INTERNSHIP PROPOSAL

Laboratory name: **Jeunes Equipes de Physique du Collège de France**
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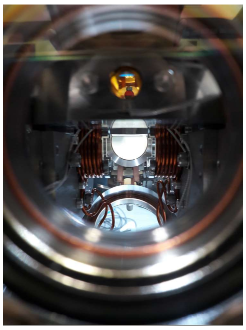
Thesis possibility after internship: Yes   Funding: ED stipend, CIFAR (1/2 thesis)

Cavity-enhanced quantum engineering of light with cold Rydberg atoms



We recently built a new platform for quantum engineering of light, capable to create efficient interactions between optical photons, tunable in range, strength and dimensionality. To induce these interactions, we transiently convert the photons into Rydberg polaritons inside a cold gas of Rb atoms trapped inside a "twisted" optical resonator with a controllable geometry. By controlling the resonator's and the cloud's parameters, we can manipulate photons propagating in free space or confined inside the resonator, and control the dimension and the shape of the space they explore.

This platform can be used to test the limits of fundamental no-go theorems in quantum logic, perform quantum measurements impossible with current techniques, and generate non-classical multi-mode states of free-propagating light. Moreover, it gives us access to a regime where intracavity photons form a strongly correlated quantum fluid, making this setup is ideally suited for real-time, single-particle-resolved investigations of topological effects appearing in condensed-matter systems. Currently, we are benchmarking its performance as a single-photon source.

The M2 internship will aim at gaining control over the collective internal state of the atomic cloud and use it as a single "super-atom" with an enhanced coupling to the cavity. The following steps will be to produce non-classical "Schrödinger's cat" states of free-propagating light in a deterministic way. We will then investigate the possibility to implement a deterministic two-photon logic gate using this platform, before moving towards a multi-photon, multi-mode regime of strongly correlated quantum photonic fluids. The project is mainly experimental, with a strong theoretical component.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

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