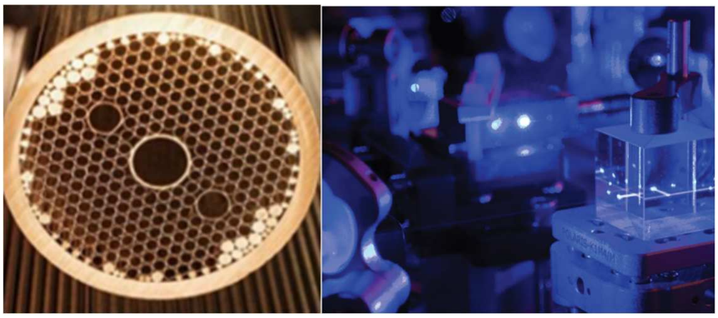
PhD Position offer

EMERGENT PHYSICS IN A TRAVELING WAVE CAVITY AND IN A HOLLOW CORE FIBER

Keywords : Hollow Core Photonic Crystal Fibers, Ultra-cold atoms, BEC, self-organization phenomena, cavity QED
Location : Institut d'Optique d'Aquitaine, Talence, France
Starting date : Between 09/2020 and 11/2020
Duration: Three years
Thesis advisor : Dr. A. Bertoldi (andrea.bertoldi@institutoptique.fr)
Co-advisor : Dr. M.J. Milla Rodrigo (maria.milla-rodrigo@alphanov.com)



The experiment BIARO (French acronym for Bose-Einstein Condensate and Atom Interferometry in a High Finesse Resonator) produces Bose-condensed atomic samples by evaporatively cooling rubidium 87 atoms in the intra-cavity radiation field at 1560 nm [1]. The cavity is also resonant at 780 nm where rubidium has a strong dipolar transition: the experiment can thus realize the regime of cavity QED with degenerate gases, allowing for the exploration of atom-field entanglement, photon mediated long-range interactions, and phonon-like excitations with controllable properties.

Self-emergence phenomena, like glassiness and crystallization, have been extensively studied using pumped condensed atomic sampled, coupled to a high finesse optical resonator [2]. These experiments use standing wave cavities, which imposes the resonator geometry to the lattice being formed by the atoms. Adopting degenerate multimode cavities will open new horizons to study order emergence effects, where compliant lattices between atoms and light would show a dynamical evolution [3]; crystal defects and frustration could be studied with such a system.

In the framework of a collaboration with Prof. H. Ritsch at the University of Innsbruck, we are trying to demonstrate self-ordering effects in our traveling wave cavity. The system will implement a second order phase transition: the homogeneous phase represented by the BEC will lose its translation invariance because of the intra-cavity optical lattice and will be forced to crystallize.

The same physics context, i.e. spontaneous order emergence with the crystal phase acting as a free continuous parameter, can be studied in quasi 1D systems, and we plan to exploit in this sense hollow core photonic fibers (HCPF) in two different configurations:

1. a standing wave cavity where the mode is guided by the HCPF;

2. a HCPF without mirrors at its ends, to obtain self-ordering effects in the absence of boundary conditions pre-selecting the spatial light modes, as theoretically studied in [4].

The PhD student will join the effort to demonstrate self-ordering in the traveling wave resonator, and will develop the new vacuum setup hosting a HCPF section in ultra-high vacuum, where the same concepts will be investigated with a quasi 1D system. To this purpose, we must first develop a loading procedure for the cold rubidium atoms in the HCB, adapting the scheme based on dark state cooling that we just developed on BIARO [5]. Once the cold and potentially ultra-cold atomic sample will be available in the HCF, we will target self-ordering phenomena in this exotic configuration.

This thesis also includes a challenging technological development on advanced fibers processing. The PhD will be financed through a CIFRE collaboration with ALPhANOV, a company with a strong expertise in photonic and more specifically in the functionalisation of HCPFs for the realisation of vapor-filled vapor cells for frequency references. The selected candidate will spend a significant amount of time developing the HC-fiber component developments at ALPhANOV and will benefit from the various equipment and knowledge of the platform for fiber laser development. The student will work in collaboration with the other members of the Cold Atoms in Bordeaux team, and more in detail with the colleagues of MIGA (demonstrator for gravitational wave detection with atom interferometry), ICE (weak equivalence principle onboard a 0-g plane) and Strontium experiment (single photon atom interferometry, gradiometry, fiber laser development).

Main duties

- Run ultra-cold rubidium atom experiment
- Design opto-electronic / electronic / optic / vacuum systems
- Data analysis and modelling
- Process HCPF for advanced connectorization and functionnalization

Candidate profile

We are looking for a highly motivated student to work in a stimulating environment, on a research project at the frontier between fundamental physics and applied science. Previous master-level knowledge of atom physics, optics, electronics, and photonics will be welcome. Additional experience in optical fiber handling and processing (splicing, polishing, etc) is a plus but not a requirement.

Salary : Following CIFRE official recommendations

Applications from EU countries will be strongly favored for confidentiality reasons

Interested candidate should send a letter of motivation, a resume and 2 reference letters to maria.milla-rodrigo@alphanov.com and andrea.bertoldi@institutoptique.fr