Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Dates: April 2023 – July or September 2023

Laboratory: Ultracold Quantum Gases
Institution: ICFO
City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis: Characterization and transverse laser cooling of a strontium atomic source

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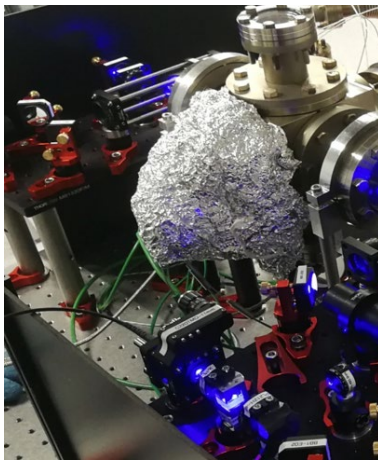
Keywords: ultracold quantum gases, quantum simulation, Bose-Einstein condensates, degenerate Fermi gases, optical lattices, quantum gas microscope, quantum magnetism, spectroscopy, laser cooling.

Summary of the subject (maximum 1 page):

Ultracold atomic gases have emerged in the last two decades as a highly versatile platform for the study of quantum many-body physics. Their control, which uses external magnetic fields and laser-based optical potentials, allows one to tune the dimensionality of the system, its interactions, and bring it to the strongly interacting regime. This has enabled the realization of fundamental models of condensed-matter physics such as the Hubbard model, originally conceived for the description of correlated electrons in solids.

In our lab at ICFO, we work with degenerate quantum gases of atomic strontium. Strontium belongs to the earth-alkaline elements and displays many exciting properties for its use in the quantum simulation of Hubbard models. For example, it features a fermionic isotope, strontium-87, with a nuclear spin of $I = 9/2$, i.e., with 10 different spin states. This allows the study of so-called SU(N) quantum magnetism, which extends beyond the SU(2) magnetism of pure electrons in solids.



A central element of the experimental apparatus in such labs is the atomic source. It is desirable to have a high-flux atomic source, since it allows to cool and trap large atomic clouds. Designing such a source for strontium is challenging, since it must operate at temperatures above 500 ºC, and requires nozzles based on microcapillary arrays.

In this project, a master student will perform an in-depth characterization of the properties of an atomic beam coming from an already built atomic source. This will involve the experimental study of the system via laser spectroscopy as well as the theoretical modelling of the atomic flux. The student will acquire experimental skills on optical laser setups, ultra-high vacuum and atomic physics. The improvements realized in the project will later be introduced to the main experiment, where they will provide an excellent starting point for the preparation of ultracold quantum gases of strontium.

Objectives:

Characterize an atomic source of strontium using laser spectroscopy; Compare its performances to numerical simulations; Devise strategies to increase its brightness using transverse laser cooling and Zeeman slowing; Implement them in a test setup, which will require developing a laser setup, stabilizing the frequency of the lasers, etc.

Additional information (if needed):

* Required skills: We are looking for candidates with a good background in quantum optics and atomic physics, and a strong motivation for setting up and conducting challenging experiments in a team of three to four people. We offer training in a broad range of cutting-edge experimental techniques (from optics, electronics, ultra-high vacuum technology and computer control to laser cooling and trapping), as well as in theoretical atomic, quantum, statistical, and condensed matter physics.

* Miscellaneous: The Master project is funded. More details can be found in jobs.icfo.eu