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: A new experimental apparatus for quantum simulation and computing with arrays of trapped Rydberg atoms

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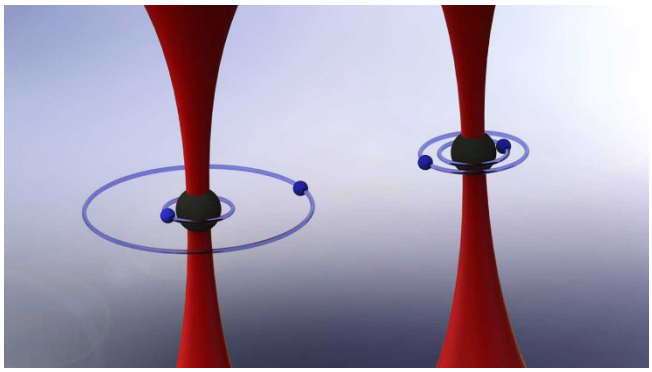
Keywords: ultracold quantum gases, quantum simulation and computing, Rydberg atoms.

Summary of the subject (maximum 1 page):

The last years have seen the emergence of a new platform for quantum technologies based on ultracold neutral atoms. It consists of arrays of single atoms trapped using optical tweezers, which allows one to arrange them with almost arbitrary geometries. The atom positions are fixed by the traps, but they can be made to interact by exciting them to Rydberg states. Rydberg atom arrays are becoming a competitive platform for digital quantum computing. Compared to trapped ions or superconducting qubits, the setups are relatively simple, the geometry and connectivity can be adjusted quite easily, and there is a clear roadmap to scale up their size. Moreover, these systems constitute an ideal platform for the quantum simulation of spin Hamiltonians, which can be used to solve both fundamental physics problems and to address practical optimization tasks.

In our group at ICFO, we are just starting the design and construction of a new Rydberg atom array experiment for quantum simulation. As atomic species we will use strontium, which is an alkali-earth atom with two valence electrons in its outer shell. This brings several technical advantages, such as better cooling and detection efficiencies, easier excitation to the Rydberg state, and the possibility to trap the Rydberg states with the non-excited electron. Our long-term plan is to use our atom arrays to address hard quantum problems of quantum magnetism, and to exploit them to realize lattice gauge theories originally proposed in the high-energy physics context.



In this project, the master student will join a completely new laboratory and will have the opportunity to participate in the design and construction of the experimental apparatus from the very beginning, together with a PhD student. Depending on the advancement of the project, possible tasks are the construction of a laser system for the laser cooling of strontium, the frequency stabilization of various lasers on the strontium atomic transitions, the design, construction and test of magnetic field coils, the design, assembly and test of electrodes to control the external electric fields, etc. This will be a very experimental project, during which the student will be exposed to a broad range of atomic physics concepts and experimental techniques (optical laser setups, ultra-high vacuum, spectroscopy, electronics, etc.) by joining an emergent research field.

Objectives:

Integrate in the new Rydberg team of our group, and participate in the design and construction of a new experimental apparatus. Depending on the advancement of the experiment, possible tasks are the construction of a laser system for the laser cooling of strontium, the frequency stabilization of various lasers on the strontium atomic transitions, the design, construction and test of magnetic field coils, the design, assembly and test of electrodes to control the external electric fields, 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 (optics, electronics, ultra-high vacuum technology and computer control), as well as in theoretical atomic, quantum, statistical, and condensed matter physics. This project is particularly well suited for very experimentally oriented students.

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