Internship offer

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Atomic source for a quantum simulator based on ytterbium

Scientific project:

New experimental platforms based on (one-electron) alkali atoms, individually controlled in optical tweezer arrays and excited to Rydberg states, have recently proven to be competitive quantum simulators [1]. Within this framework, a few teams have lately implemented alkaline-earth species in order to benefit from their specific two-electron internal structure, with very promising performances [2]. Perhaps the most exciting outlook offered by these species is the coherent optical manipulation of Rydberg states enabled by the presence of the second electron, a technique called isolated core excitation (ICE). This possibility was just demonstrated by the "Cold Rydberg atoms" team at LAC [3] using its apparatus dedicated to the study of Rydberg excitations of ytterbium [4], opening new perspectives towards applications in quantum simulation and quantum computing. Following this achievement, the team was granted an ANR funding for a project coordinated by S. Lepoutre: the aim is to build a quantum simulator based on ytterbium atoms trapped in optical tweezer arrays, and demonstrate the capabilities of the ICE technique with proof-of-concepts for the manipulation of quantum information using this new tool.

[1] A. Browaey, et al., *Many-body physics with individually controlled Rydberg atoms*, Nature Physics **16**, 132 (2020).
[2] I.S. Madjarov, et al., *High-fidelity entanglement and detection of alkaline-earth Rydberg atoms*, Nature Physics **16**, 857 (2020).
[3] K.-L. Pham, et al., *Coherent Light Shift on Alkaline-Earth Rydberg Atoms from Isolated Core Excitation without Autoionization*, PRX Quantum **3**, 020327 (2022) (open source).
[4] H. Lehec, et al., *Laser and microwave spectroscopy of even-parity Rydberg states…*, Phys. Rev. A 98, 062506 (2018).

Methods and techniques:

Works on the project will start in january with the complete review of the apparatus towards the standards of ultracold atoms, needed for the future integration of optical tweezer arrays and upgrade as a quantum simulator. **The intern will participate in the improvement of the atomic source, inspired from the results in [5]**. It will familiarize her/him with the techniques used in the domain of cold and ultracold atom experiments, for instance the atomic oven or the laser technologies used for cooling and diagnosis.

[5] E. Wodey, et al., *A robust, high-flux source of laser-cooled ytterbium atoms*, J. Phys. B **54**, 035301 (2021).

Possibility to go on with a PhD ? YES. This internship shall result in a PhD dedicated to the realization of the project.
Envisaged fellowship ? 1.5 year funding is available in the ANR grant. The remaining 1.5 year shall be obtained by other means (e.g. EDOM doctoral school) before the PhD contract starts.