MASTER 2 INTERNSHIP / PHD THESIS

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Quantum magnetism of ultracold fermions in optical lattices

We offer an experimental internship and a PhD in the field of ultracold atoms. Our research topic is quantum magnetism, i.e., the collective behavior of ensembles of interacting spin-carrying particles. We experiment on ensembles of strontium atoms, arranged on a periodic structure created by interfering laser beams: an optical lattice potential. Our aim is to study the conditions for the emergence of antiferromagnetic ordering. We will be able to realize situations analogous to those encountered by electrons (of spin ½) in crystalline materials, but also situations that strongly contrast with those, as a consequence of the spin 9/2 of our atomic species. For studies of magnetism, atomic physics offers an interesting new set of tools; in particular, the narrow lines of Sr, of use to atomic clocks, will be exploited in original protocols to prepare alternating-spin textures and thus study the low-energy behavior of our system.

Our experiment produces since 2019 degenerate fermionic quantum gases of ^{87}Sr. We are presently building the optical lattice, such that our system will realize the antiferromagnetic Heisenberg Hamiltonian. The internship project, and its extension into a PhD thesis, will be the following:

- The intern will be responsible for installing a high-resolution imaging system (~1.2 µm) orthogonal to the lattice planes. A homemade mechanical support with fine position and angle adjustments, required for aberration-free imaging, will be designed and built.

- The intern will contribute to loading the sample in the optical lattice. The first objective will be to load the ground Bloch band. The imaging system will enable measurements of the quasi-momentum distribution. We aim at reaching two distinct physical regimes: the band insulator, with a sample polarized in a single spin state; and the Mott insulator ensured by interactions, with an unpolarized sample.

If the progresses allow it, we will start the implementation of our protocols for preparing low-energy spin textures, that relies on a laser system already built. The response of the sample to these manipulations, e.g. their degree of reversibility, will provide insight into the low-energy magnetic properties of the system. We will then have reached the core of the PhD project.

The project is built in strong connection with a second experiment in our group (quantum magnetism with dipolar chromium atoms), and a theory activity in our group (P. Pedri) and at ENS Lyon (T. Roscilde). The internship will provide an introduction to the essential experimental tools of cold atom experiments (lasers, optics, optomechanics, electronics), and will include an important part of team work on the setup that produces the degenerate gases.

The internship can act as an introduction to a PhD thesis on the Sr experiment. In September 2021, the new PhD student will work with a 3rd-year PhD student, and two permanent researchers on the Sr experiment.

Group webpage and recent publications : http://www-lpl.univ-paris13.fr/gqm/
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