INTERNSHIP PROPOSAL

(One page maximum)

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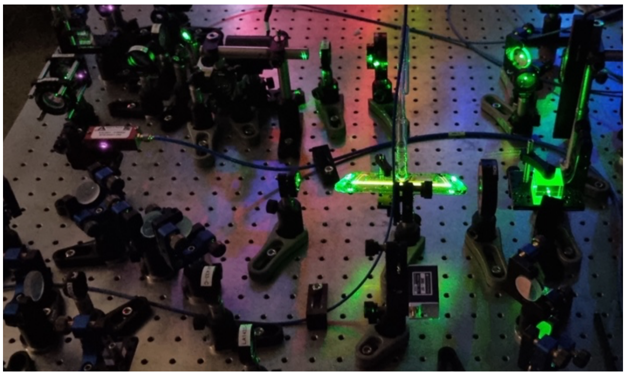
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Producing a degenerate Fermi gas of metastable Helium-3

The Helium lattice apparatus at Institut d'Optique is running with the bosonic species Helium-4. Exploiting the single-atom-resolved detection in the momentum [1], we have studied various effects in interacting lattice Bose gases (see for instance [2]). Interestingly, this detection method also applies to the fermionic species Helium-3 as it relies on the large internal energy stored in the metastable state where Helium atoms – both Helium-3 and Helium-4 – are brought to quantum degeneracy. Our plan is to add the fermionic species Helium-3 to the existing apparatus to study the rich physics of interacting lattice fermions.

Studying lattice metastable Helium-3 ($^3He^*$) necessitates to reach the low temperature regime and produce a degenerate Fermi gas. To this aim, we will realize a magneto-optical trap (MOT) of $^3He^*$ and then cool the fermionic gas using the bosonic gas $^4He^*$ as coolant. Thanks to the large scattering length between the fermionic and bosonic species, the sympathetic cooling of $^3He^*$ with $^4He^*$ is known to be very efficient [3]. Finally, we will obtain a degenerate Fermi gas in the crossed optical dipole trap where we produce Bose-Einstein condensates with Helium-4 [4]. The central objective of the internship is to achieve these goals.



Helium-3 is a rare and expensive atomic species. We are thus completing the building of a vacuum system to recycle the gas and of a spectroscopy to lock the lasers (left picture). During the internship, the candidate will setup the optical table for the cooling lasers. She/he will proceed with the realization of $^3He^*$ MOT and then, of a degenerate Fermi gas. These works will be achieved in collaboration with the other team members.

The internship paves the way to a PhD thesis on the study lattice fermions and Fermi-Hubbard physics.

References

[1] H. Cayla, C. Carcy, Q. Bouton, R. Chang, G. Carleo, M. Mancini and D. Clément - Phys. Rev. A **97**, 061609 (2018).
[2] C. Carcy et al. Phys. Rev. X **9**, 041028 (2019); A. Tenart et al. Nature Physics **17**, 1364 (2021); C. Carcy et al. Phys. Rev. Lett. **126**, 045301 (2021); G. Hercé et al. Phys. Rev. Research **5**, L012037 (2023).
[3] J. M. McNamara, T. Jeltes, A. S. Tychkov, W. Hogervorst, and W. Vassen - Phys. Rev. Lett. **97**, 080404 (2006)
[4] Q. Bouton, R. Chang, A. L. Hoendervanger, F. Nogrette, A. Aspect, C. I. Westbrook, and D. Clément Phys. Rev. A **91**, 061402(R) (2015)

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: YES