INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire Charles Fabry
CNRS identification code: UMR8501
Internship director'surname: Denis BOIRON
e-mail: denis.boiron@institutoptique.fr Phone number: 0164533354
Web page:
https://www.lcf.institutoptique.fr/groupes-de-recherche/gaz-quantiques/experiences/quantum-atom-optics
Internship location: Institut d'Optique, Palaiseau

Thesis possibility after internship: YES
Funding: NO

Simulating the cosmologic reheating phase with quantum gases

In cosmology, the early phases after the big bang start with the inflation of the universe, then the preheating phase where pairs of particles/anti-particles are produced and then the reheating phase where these particles interact and thermalize. Since the work of Unruh [1] we know the basic ingredients of these scenarios could be simulated in quantum fluids. In a series of recent papers [2,3,4] we have shown that we could simulate the preheating phase where pairs of phonons are produced from a Bose-Einstein condensate. We have been able to demonstrate that these phonons are entangled at short times but observe a departure from entanglement at longer times as expected in the preheating - reheating phases. The aim of the internship is to participate to experiments where we will focus on the analog of the reheating phase. The work will consist on taking experimental data and analyzing them. Several observations are expected: production of phonons pairs of high energy stimulated by phonon pairs of lower energy (so called secondary peaks), thermalization of phonons, backreaction on the condensate.
We already unintentionally observed secondary peaks. The work will start on this observable before going to the others.
Depending on the candidate appetence, numerical simulations could be part of the internship.

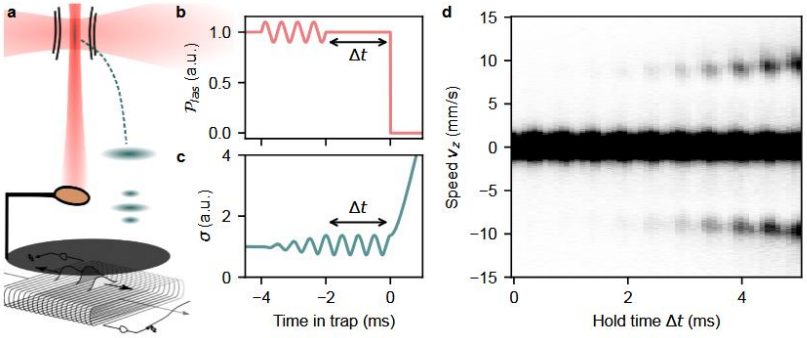

Figure: After excitation, a Bose-Einstein condensate (at 0 velocity) oscillate transversely during a hold time Δt. For long enough time we observe the production of phonons with velocities +/- 10 mm/s that are entangled.

[1]W. G. Unruh, Phys. Rev.Lett. 46, 1351 (1981)
[2] V. Gondret et al, Phys. Rev. Lett. 135, 100201 (2025)
[3] V. Gondret et al, arXiv:2506.22024
[4] V. Gondret et al, arXiv:2508.01654

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