

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire Charles Fabry

CNRS identification code: UMR8501

Internship director's surname: Denis BOIRON

e-mail: denis.boiron@institutoptique.fr

Phone number: 0164533354

Web page:

<https://www.lcf.institutoptique.fr/groupe-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 the currently accepted cosmology scenario, the universe rapidly inflates, and then begins to oscillate in a phase called preheating in which pairs of entangled particles/anti-particles are produced. Subsequently, these particles interact and thermalize in the "reheating" phase. Since the work of Unruh [1] we know the basic ingredients of these scenarios can be simulated in quantum fluids. In a series of recent papers [2,3,4] we have shown that we can simulate the preheating phase producing entangled phonons from an oscillating Bose-Einstein condensate. After a sufficiently long time the entanglement disappears. This behavior is expected but the details have yet to be carefully characterized. 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 of taking and analyzing experimental data. Several observations are planned: production of phonon pairs of high energy stimulated by phonon pairs of lower energy (so called secondary peaks), thermalization of phonons, backreaction on the condensate.

We have already made preliminary observations of secondary peaks, and the next step will be to analyze them in detail. We will then begin to study thermalization. Depending on the candidate's interests, the work could include numerical simulations.

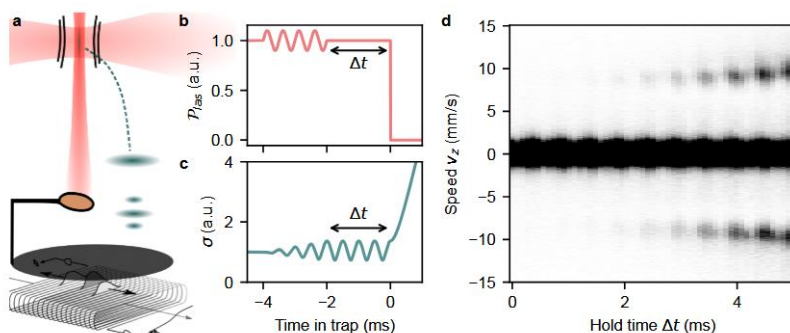


Figure: A Bose-Einstein condensate is excited transversely during a hold time Δt . Phonons are observed as exponentially growing sidebands at ± 10 mm/s in the spectrum of flight times to the detector (the dark disk in the first panel).

[1] W. G. Unruh, Phys. Rev. Lett. 46, 1351 (1981)

[2] V. Gondret et al, Phys. Rev. Lett. 135, 100201 (2025), arXiv: 2503.09555

[3] V. Gondret et al, Phys. Rev. Lett. 135, 240603 (2025), [arXiv:2506.22024](https://arxiv.org/abs/2506.22024)

[4] V. Gondret et al, C. R. Phys. 25, 1 (2024), [arXiv:2508.01654](https://arxiv.org/abs/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