BEC group LPL / Université Sorbonne Paris Nord / CNRS

M2 internship proposal in the field of cold atoms

Non-equilibrium dynamics of degenerate 1D Bose gases

At sufficiently low temperatures and densities, it is possible to experimentally produce quantum systems in which two spatial degrees of freedom are effectively frozen. These systems are therefore **one-dimensional** and exhibit various phenomena that have no equivalent in higher dimensions. In particular, degenerate 1D Bose gases with repulsive interactions and driven out of equilibrium develop sound waves called phonons, but also density defects that can propagate without dispersion. These so-called **gray or dark solitons** are difficult to observe in situ, but leave a clear signature in the momentum distribution of the gas [1]. Recent numerical works from our team [2] have studied how this distribution evolves when the amplitude of the drive is increased leading to a higher density of solitons within the system. These theoretical predictions have yet to be confirmed experimentally.

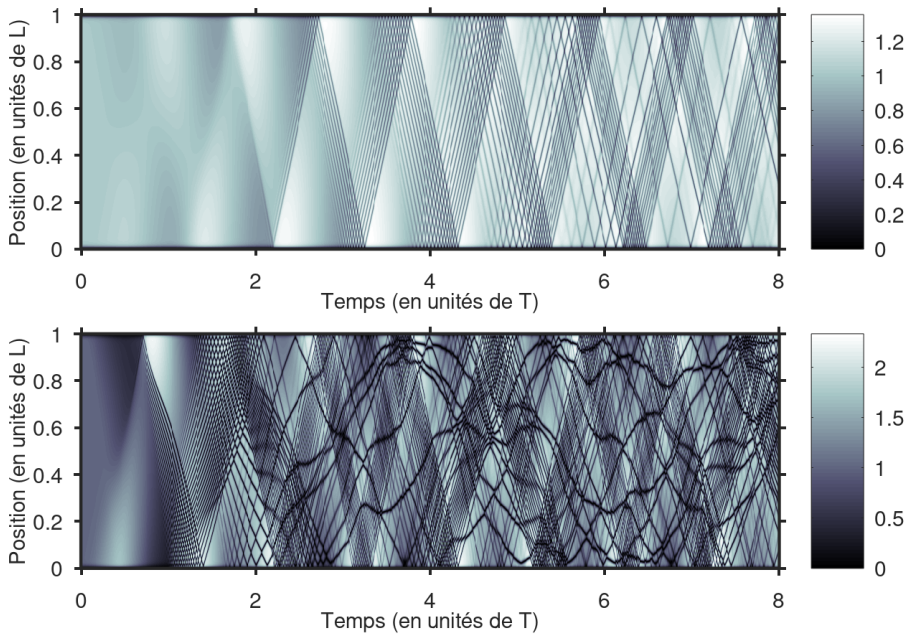

FIGURE 1 – Time evolution of the density of a one-dimensional Bose gas subjected to a low-amplitude drive (top graph) / high-amplitude drive (bottom graph). The black stripes corresponding to dark or gray solitons are clearly visible. Adapted from [2].

The BEC group at LPL has developed an experiment in which degenerate gases of **sodium** atoms are trapped in the static magnetic field induced by micro-wires, beneath an atom chip, in a highly elongated confinement. This setup routinely produces degenerate 1D Bose gases. Nevertheless several technical upgrades are required in order to accurately measure the momentum distribution of soliton gases. The internship aims to implement a novel imaging setup, which will involve upgrading the corresponding optical system together with real time control of the experiment and data analysis. To carry out these tasks, the intern will work closely with a postdoc and two experienced researchers.

The internship can be followed by a PhD thesis on the same subject whose funding is already secured.

[1] M. Schmidt et al., NJP 14 075005 (2012)

[2] M. Ballu, PhD thesis, Université Sorbonne Paris Nord (2024)

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