

Spatial evolution of the phase and spin-echo rephasing in a two-component BEC

A. I. Sidorov

ARC Centre of Excellence for Quantum-Atom Optics and
Centre for Atom Optics and Ultrafast Spectroscopy,
Swinburne University of Technology,
Melbourne, Victoria, Australia

e-mail: asidorov@swin.edu.au

Abstract

Knowledge of phase dynamics in matter waves is the critical factor in studying BEC coherence for potential applications of BEC interferometers. We observe interesting spatial evolution of the relative phase in an elongated condensate [1]. Our two-component system is comprised of the $|F = 1, m_F = -1\rangle$ and $|F = 2, m_F = 1\rangle$ hyperfine ground states of ^{87}Rb , magnetically trapped on an atom chip and interrogated via two-photon Ramsey interferometry. The phase evolution is strongly influenced by intra- and inter-species nonlinear interactions.

The first $\pi/2$ pulse prepares the system in a non-equilibrium state and the subsequent nonlinear evolution of each component leads to the relative phase becoming inhomogeneous along the axial coordinate, varying by 2π across the condensate after 95 ms of evolution. The second $\pi/2$ pulse locally converts spatial variations of the phase into the spatial variations (fringes) of the atomic density of each state which change with the evolution time (Fig. 1). The spatial dependence of the relative phase manifests in inhomogeneous dephasing of the condensate wavefunction along the axial dimension and, as a result, we observe relatively fast decay of Ramsey interference fringes (decay time ~ 70 ms). Inhomogeneity of the relative phase of the condensate wavefunction is the dominant mechanism for the loss of the Ramsey fringes, rather than decoherence due to coupling to the environment or quantum phase diffusion.

Reversing of the mean-field-induced dephasing is

achieved using the application of a spin-echo pulse sequence at appropriate times. We observe the recovery of the interference contrast and extended coherence time.

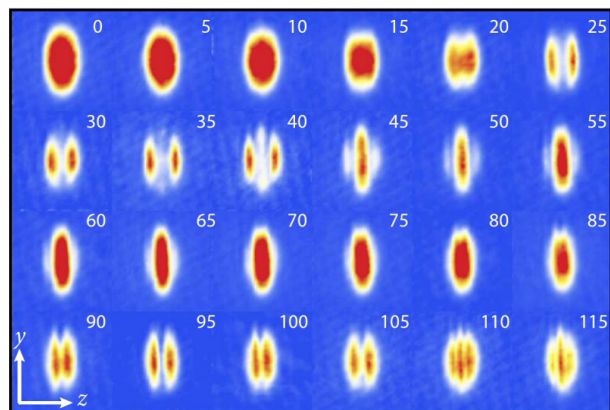


Fig. 1: Single shot absorption images of the condensate in the state $|F = 2, m_F = +1\rangle$ taken after 20 ms of free fall and expansion with varying Ramsey interferometry time (in ms).

Keywords: BOSE-EINSTEIN CONDENSATE, MATTER-WAVE INTERFERENCE, DECOHERENCE

References

- [1] R.P. Anderson, C. Ticknor, A.I. Sidorov, and B.V. Hall, Phys. Rev. A **80**, 023603 (2009).