

Quantum noise and long coherence time of an interacting Bose-Einstein condensate

M. Egorov¹, R. P. Anderson^{1,2}, V. Ivannikov¹, B. Opanchuk¹, P. Drummond¹, B. V. Hall¹,
and A. I. Sidorov¹

¹Centre for Atom Optics and Ultrafast Spectroscopy, ACQAO, SUT

²School of Physics, Monash University

We observe the coherence of an interacting Bose-Einstein condensate (BEC) surviving for an unprecedented time in a trapped Ramsey interferometer [1]. A two-component ^{87}Rb BEC is magnetically trapped on an atom chip in the internal states $|F = 1, m_F = -1\rangle$ and $|F = 2, m_F = 1\rangle$ which are coupled via a two-photon MW-RF transition. In the Ramsey sequence (Fig. 1a) the first $\pi/2$ pulse excites collective oscillations of the components. The relative phase initially becomes spatially inhomogeneous but the dynamics in the second half of the cycle reverses this, so that it is again uniform across the condensate. This periodic mean-field driven dephasing and rephasing of the BEC is observed through measurements of the visibility of interferometric fringes (Fig. 1b). We also apply a conventional spin echo technique (Fig. 1c) to reverse the relative phase evolution and compensate for asymmetric losses of the internal states by inverting the populations. Maximum revivals of the visibility are observed (Fig. 1d) if the π pulse is applied at the end of the collective oscillation when the relative phase is uniform along the condensate. The mean-field model correctly predicts the period of the visibility revivals (red dotted lines) but overestimates their magnitudes in both sequences. A truncated Wigner model (black solid and blue dashed lines) [1] is used to account for the dynamical quantum noise, and is in excellent quantitative agreement with our observations. Visibility decay in the spin echo sequence reveals a long coherence time of 2.5 s. We speculate that in our observations coherence is limited by fragmentation of the interacting BEC in addition to quantum phase diffusion.

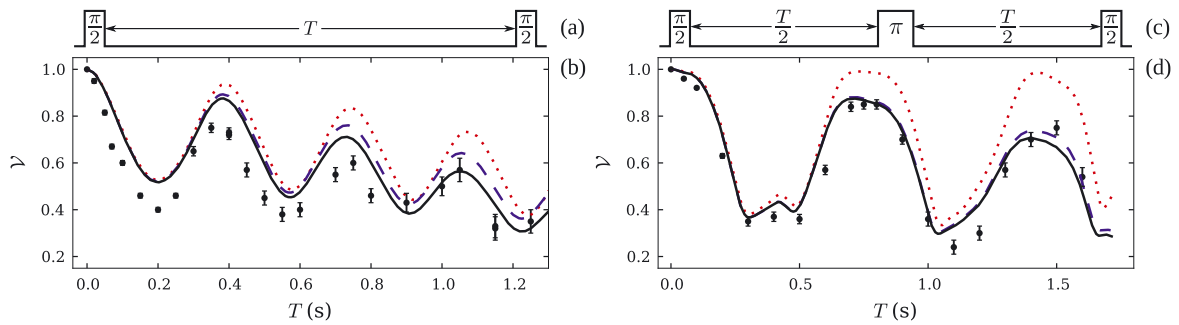


Fig. 1: Measured visibility \mathcal{V} (filled circles) in Ramsey (a) and spin echo (c) sequences as a function of the evolution time T (b, d). Curves correspond to simulations using coupled Gross-Pitaevskii equations (red dotted line), truncated Wigner model without (blue dashed line) and with (black solid line) classical noise.

References

- [1] M. Egorov, R. P. Anderson, V. Ivannikov, B. Opanchuk, P. Drummond, B. V. Hall, and A. I. Sidorov, arXiv: 1012.3813 (2010).