Optically trapped atom interferometry using the clock transition of large ^{87}Rb Bose-Einstein condensates

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We recently produced a Ramsey-type atom interferometer operating with an optically trapped sample of 10^6 Bose-condensed ^{87}Rb atoms. We investigate this interferometer experimentally and theoretically with an eye to the construction of future high precision atomic sensors [1]. Our results indicate that, with further experimental refinements, it will be possible to produce and measure the output of a sub-shot-noise limited, large atom number BEC-based interferometer.

The optical trap allows us to couple the $|F = 1, m_F = 0\rangle \rightarrow |F = 2, m_F = 0\rangle$ clock states using a single photon 6.8 GHz microwave transition, while state selective readout is achieved with absorption imaging. We observe that the $|F = 1, m_F = 0\rangle$ and $|F = 2, m_F = 0\rangle$ states are fully miscible on the timescale of the experiment, in contrast to the magnetic states $|F = 1, m_F = -1\rangle, |F = 2, m_F = 1\rangle$ typically used in chip experiments. We analyse the process of absorption imaging and show that it is possible to observe atom number variance directly, with a signal-to-noise ratio ten times better than the atomic projection noise limit on 10^6 condensate atoms. We discuss the technical and fundamental noise sources that limit our current system, and outline the improvements that can be made.

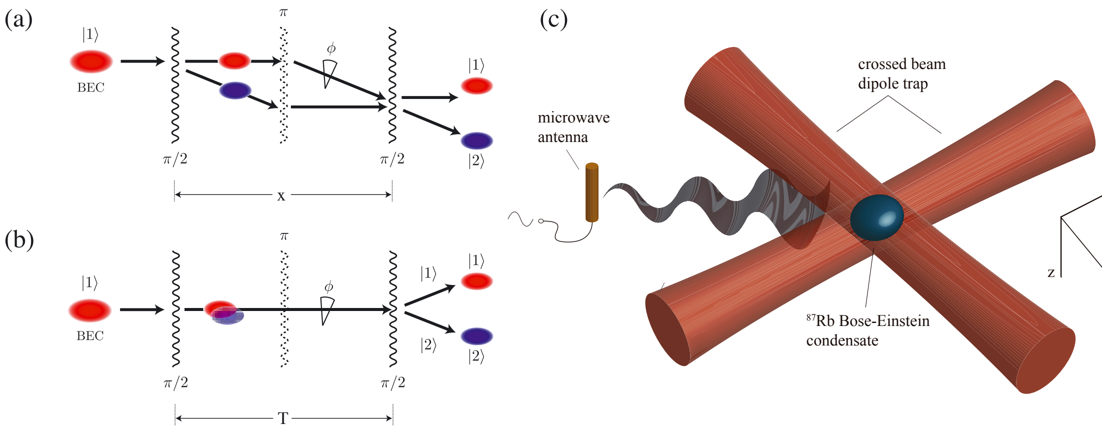

Figure 1: The Ramsey interferometer scheme. An atomic wavepacket is split into two components, allowed to evolve for a time T, and then recombined. The atoms can be coupled to a different internal state, remaining spatially overlapped, or can be coupled to another momentum state, so that the interferometer encloses an area. (a) A spatial Ramsey interferometer is sensitive to inertial effects. (b) The subject of this paper: a temporal Ramsey interferometer is sensitive to state dependent phase shifts. A π pulse allows reflection for the separated beam path interferometer and imposes a 'spin echo' effect for the trapped system. (c) The experimental setup. A single photon microwave transition drives internal state transitions in a BEC held in a crossed dipole trap.

References

[1] P. A. Altin *et al.*, arXiv:1011.4713v3 (2010).