# Atom Interferometry below the standard quantum limit

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Atom lasers, when used as the source for an atom interferometer, show promise for increased sensitivity of electric, magnetic, and gravitation fields, as well as rotations and accelerations. The use of massive particles over photons offers the possibility of many orders of magnitude increase in the sensitivity of these devices, due to the slower propagation speed of atoms. However, as the flux of these devices is limited, quantum noise will set a fundamental limit to the sensitivity that these devices can achieve. For classical sources, this limit is $\Delta\phi = 1/\sqrt{N}$ [1].

A way to get around this limit is to use nonclassical states, such as squeezed states and entangled states. We have previously proposed 2 schemes for producing squeezed and entangled atom lasers. The first of these schemes relied on the transfer of the quantum state of an optical beam to an atomic beam, and the second scheme used the nonlinear atomic interactions and atomic interference to create squeezed states.

Recently there have been two experiments demonstrating atom interferometry with sensitivity below the standard quantum limit [2, 3]. Both of these experiments used a double interferometer scheme, where the first interferometer is used to prepare the phase-squeezed state, via nonlinear de-phasing of the relative phase. The second interferometer uses this squeezing to perform a phase measurement with sensitivity which surpasses the standard quantum limit. However, both of these experiments used a small number of atoms (approximately a few thousand), so the absolute sensitivity of the phase measurement is not as precise as for a large number interferometer operating above the standard quantum limit.

We have investigated if it is possible to perform a similar experiment, but with a much larger number of atoms. We found that although the scattering properties of $^{87}$Rb aren't favourable for Kerr squeezing experiments, that a $50\%$ enhancement over the standard quantum limit was achievable with $10^6$ atoms [4].

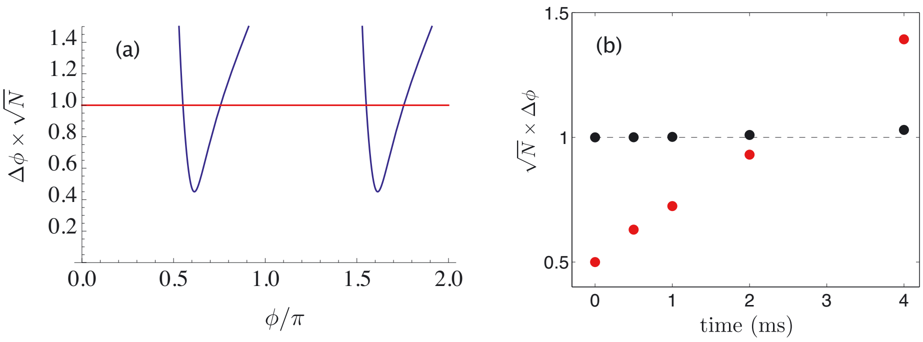


Fig. 1: (a) Phase sensitivity of a large atom number interferometer when Kerr squeezing is employed. (b) Phase sensitivity as a function of hold time of the second interferometer for a squeezed state (red circles) and a uncorrelated state (black circles). The Phase squeezed state de-coheres at a faster rate.

## References

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