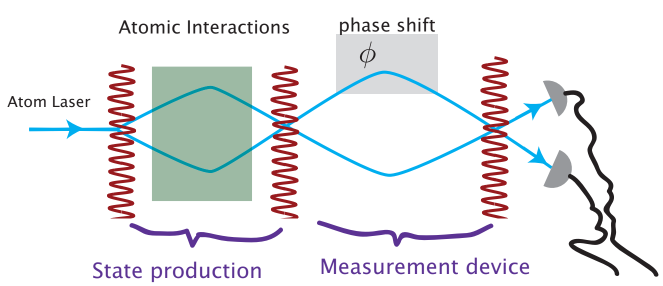
# Squeezing the most out of your atom laser: What is the best way to squeeze an atom laser for precision measurement?

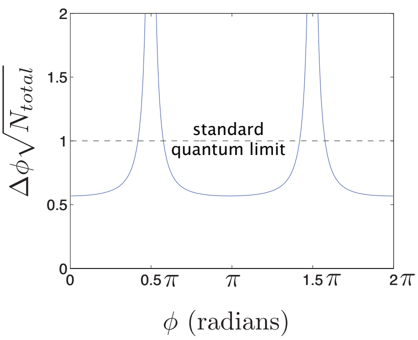
S. A. Haine[1], M. T. Johnsson[2], and J. C. Close[2]
[1]*School of Mathematics and Physics, ACQAO, UQ*
[2]*Research School of Physics and Engineering, ACQAO, ANU*

An atom laser is a device which produces a matterwave with a well defined frequency, amplitude, and phase. 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 two 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. However, the quantum states which are easiest to create and observe nonclassical effects in, are not necessarily the best for increasing the sensitivity of phase measurements. We have been investigating how best to use these techniques to enhance the sensitivity of phase measurements.

Naively one might assume that the atom-atom interactions do nothing but degrade the sensitivity of a phase measurement, as this interaction leads to phase diffusion. However, by careful choice of parameters, including the beamsplitter ratios, this phase diffused state can be transformed into a state with relative phase squeezing, which leads to an enhancement in the sensitivity of phase measurements. This is analogous to optical homodyning. The phase diffusion caused by the atom-atom interactions in the measurement interferometer do degrade the sensitivity, but for appropriate choice of parameters, an overall increase in sensitivity when compared to a coherent state can still be obtained.




Left: Scheme to enhance the sensitivity of an atom laser interferometer. The first interferometer creates a state with relative phase squeezing via the kerr interaction, and the second interferometer acts as the measurement device. Right: Enhancement in sensitivity as compared to a coherent state.

## References

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