

# Preparing coherent and squeezed states of ultra-cold atoms

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Laser light is a coherent state of photons, a superposition of Fock states that nevertheless behaves rather classically. States of light that have reduced or squeezed uncertainty in either amplitude (photon number) or phase also exist. Squeezing can allow for a more precise measurement of the squeezed degree of freedom. A gas of dilute ultra-cold atoms, with densities of order  $10^{14}$  atoms/cm<sup>3</sup> and temperatures in the nanoKelvin regime, also forms a system in which these concepts can be applied. For example, a Bose-Einstein condensate of cold atoms is thought of as a coherent state.

Unlike photons, however, atoms interact and collide with each other, introducing nonlinearities. The effect of the nonlinear interactions are particularly evident when a Bose condensate or superfluid is loaded into an optical lattice consisting of counter-propagating laser beams. These beams generate a periodic potential for the atoms and an interaction induced quantum phase transition from a superfluid to a Mott state can occur.

In this presentation I describe our investigations into the characterization of the interacting ground state of atoms in an optical lattice using the concepts of coherent and squeezed states. We focus on “collapse and revival experiments” [1], which are sensitive to the amplitude of the atom-number Fock state in a site of an optical lattice and thus can characterize the degree of squeezing [2]. For a quantitative description of collapse and revival experiments we derived a low-energy Hamiltonian where, in addition, to two-body interactions, effective three-body interactions also appear [3].

[1] S. Will, T. Best, U. Schneider, L. Hackermuller, D.-S. Luhmann, and I. Bloch, *Nature* **465**, 7295 (2010).

[2] E. Tiesinga and P.R. Johnson, *Phys. Rev. A* **83**, 063609 (2011).

[3] P. R. Johnson and E. Tiesinga and J. V. Porto and C. J. Williams, *New J. Phys.* **11**, 093022 (2009).