Sub-Poissonian atom number fluctuations by three-body loss in mesoscopic ensembles

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Abstract

The study and control of particle number fluctuations has revealed a rich variety of intriguing quantum phenomena in ultracold quantum gases, such as atom (anti)bunching effects, manybody correlations, squeezing and entanglement. In these experiments the random loss of atoms is generally considered deleterious. We show, however, that threebody loss of trapped atoms naturally leads to sub-Poissonian atom number fluctuations, analogous to intensity squeezing in optics [1].

We prepare hundreds of dense ultracold ensembles in a two-dimensional array of magnetic microtraps on an atom chip, which subsequently undergo rapid threebody decay [2]. The shot-to-shot fluctuations of the number of atoms per trap are subPoissonian, for ensembles comprising 50–300 atoms. The effects of residual imaging noise are greatly reduced through the application of spatial correlation analysis which exploits the lattice geometry and provides a way to isolate the atom number fluctuations. Our results are in very good agreement with a simple model which takes into account the fluctuations. This shows that threebody loss processes can be used for the preparation of small and well-defined numbers of atoms in each trap.

We expect this to be an ideal system for the study of collective excitations produced via laser excited Rydberg states for quantum information processing with neutral atoms [3]. Such mesoscopic ensembles would benefit from a $\sqrt{N}$ collective enhancement of the Rabi frequency over single atoms for fast quantum operations, and have desirable properties for the generation of many-particle entangled states or as a resource for quantum metrology.

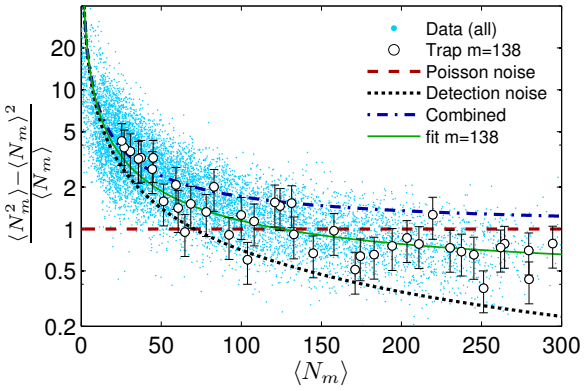

Figure 1: Atom number fluctuations measured for each of 245 individual lattice sites during three body decay. Open circles indicate the measurements for a selected trap.

Keywords: MESOSCOPIC, THREE-BODY, SQUEEZING, MICROTRAP, ATOM CHIP, ENSEMBLES, FLUCTUATIONS

References

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