Quantum register with neutral caesium atoms

L. Förster, Quantum Technology, Applied Physics, University of Bonn, Germany (September 2005)

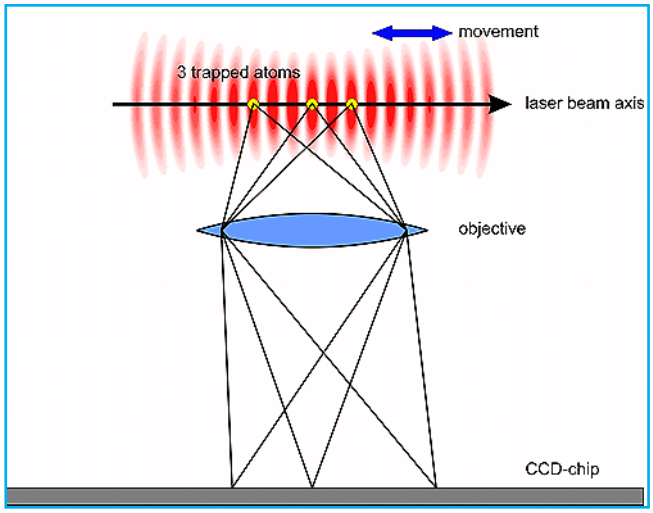
Application Note

Introduction

Neutral atoms are microscopic systems which are natural candidates for realising a qubit, the smallest information unit in a future quantum computer, in analogue to the classical bit. Our research group is operating an experimental set-up to control both the absolute position and the electronic state of trapped neutral caesium atoms.

Experimental Set-up

Using methods of laser cooling we trap a known number of few atoms using two counter propagating laser beams. They generate a standing wave intensity pattern where atoms are attracted towards the maxima. The resulting periodic potential has a separation of 532 nm between adjacent potential wells. As the atoms follow each movement of the standing wave pattern, the laser beam represents an optical conveyor belt for atoms.



Before this method can be used for active position control, the initial atom position should be known. Therefore we illuminate the string of trapped atoms and image their fluorescence light onto a CCD chip. The resulting photo yields the desired position information for each individual atom. This information is also used to selectively flip the state of each atom using microwaves. In analogue to a computer register this corresponds to setting of the value of a qubit.

Test Results

Recently, we have tested an iXon EMCCD camera DV887 DCS-FI from Andor Technology in our experimental set-up. Typical movies recorded with illumination times of respectively 50 ms, 250 ms, and 1000 ms per frame are presented below.

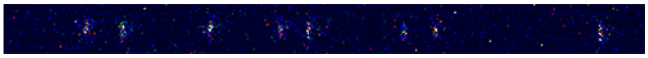
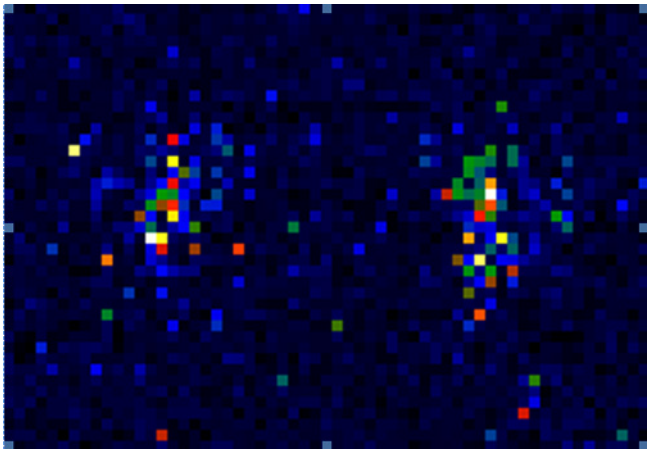
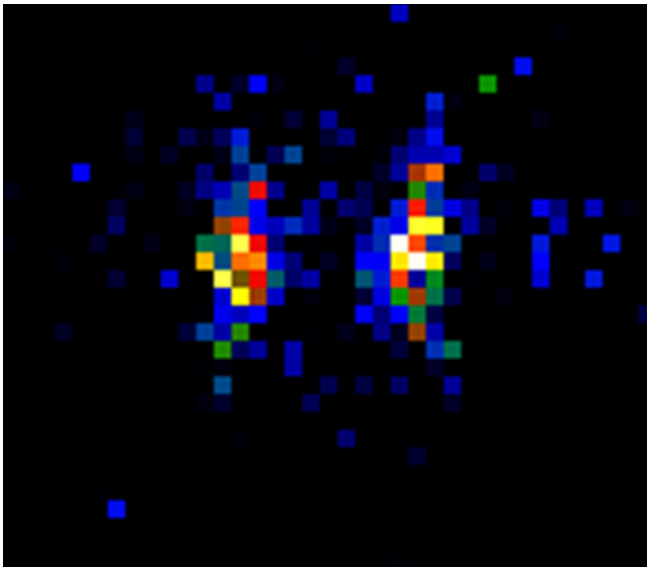


Image of whole string, exposure time 50 ms, movie in mp4 format.



Zoomed image of 2 caesium atoms.

Image of whole string, exposure time 250 ms, movie in mp4 format.



Zoomed image of 2 cesium atoms.

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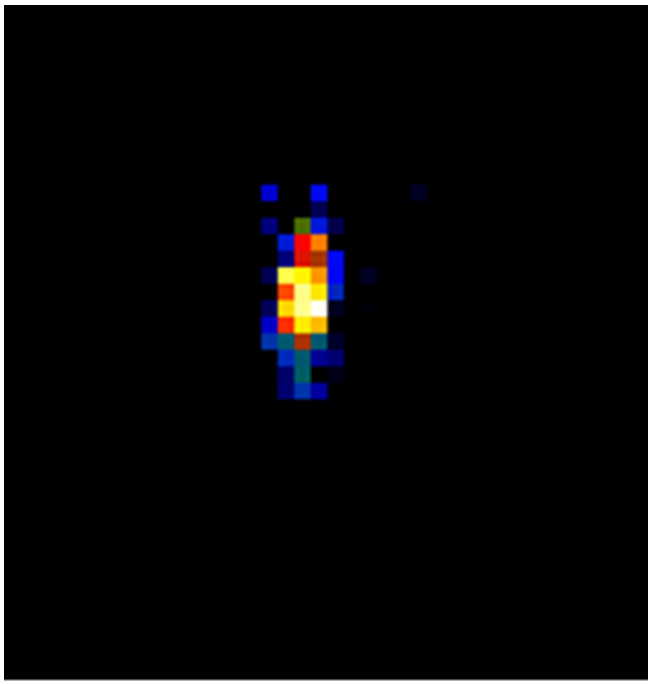
Image of whole string, exposure time 1000 ms, movie in mp4 format.



Zoomed image of 1 cesium atom

The excellent signal to noise ratio of the photos allows a precise measurement of the atom position and a good distinction of the stored atom numbers. In addition, the fast read out makes this information rapidly accessible so that it can be directly used for further manipulation of the atoms.

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