Thu-102

Quantum gas microscope of ytterbium atoms

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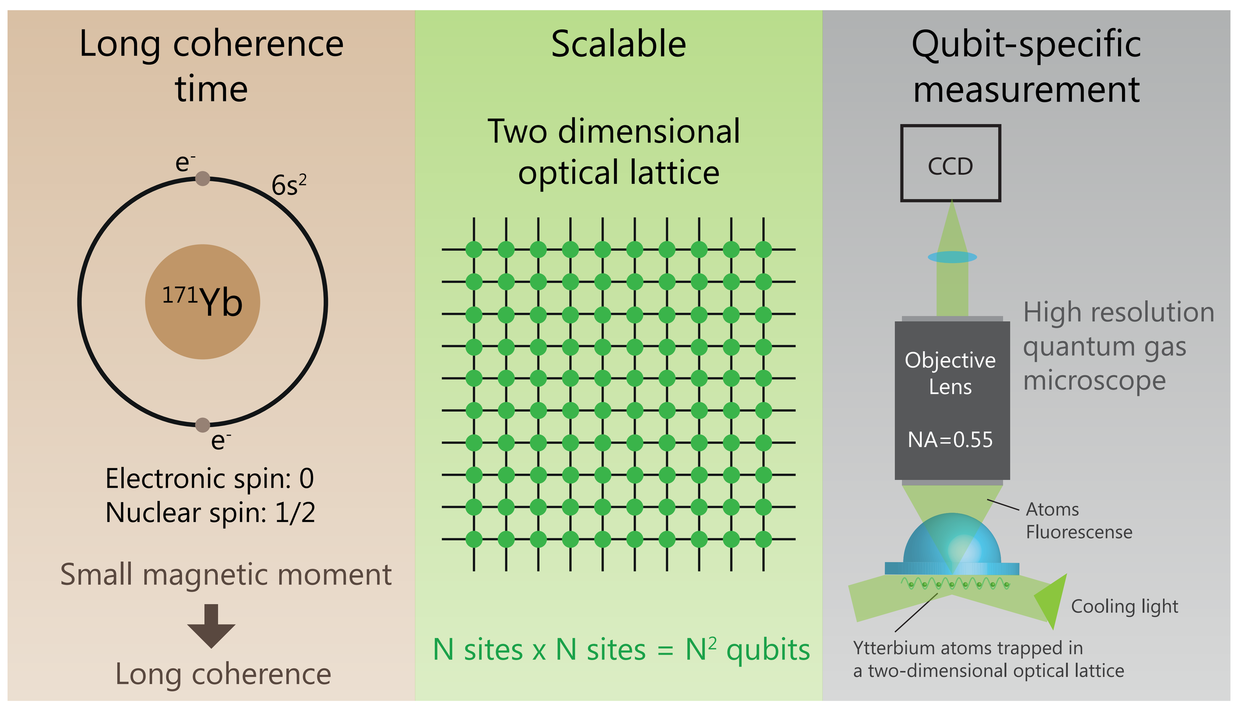
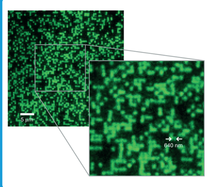
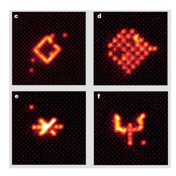
Objective

What do we need to create a quantum computer?



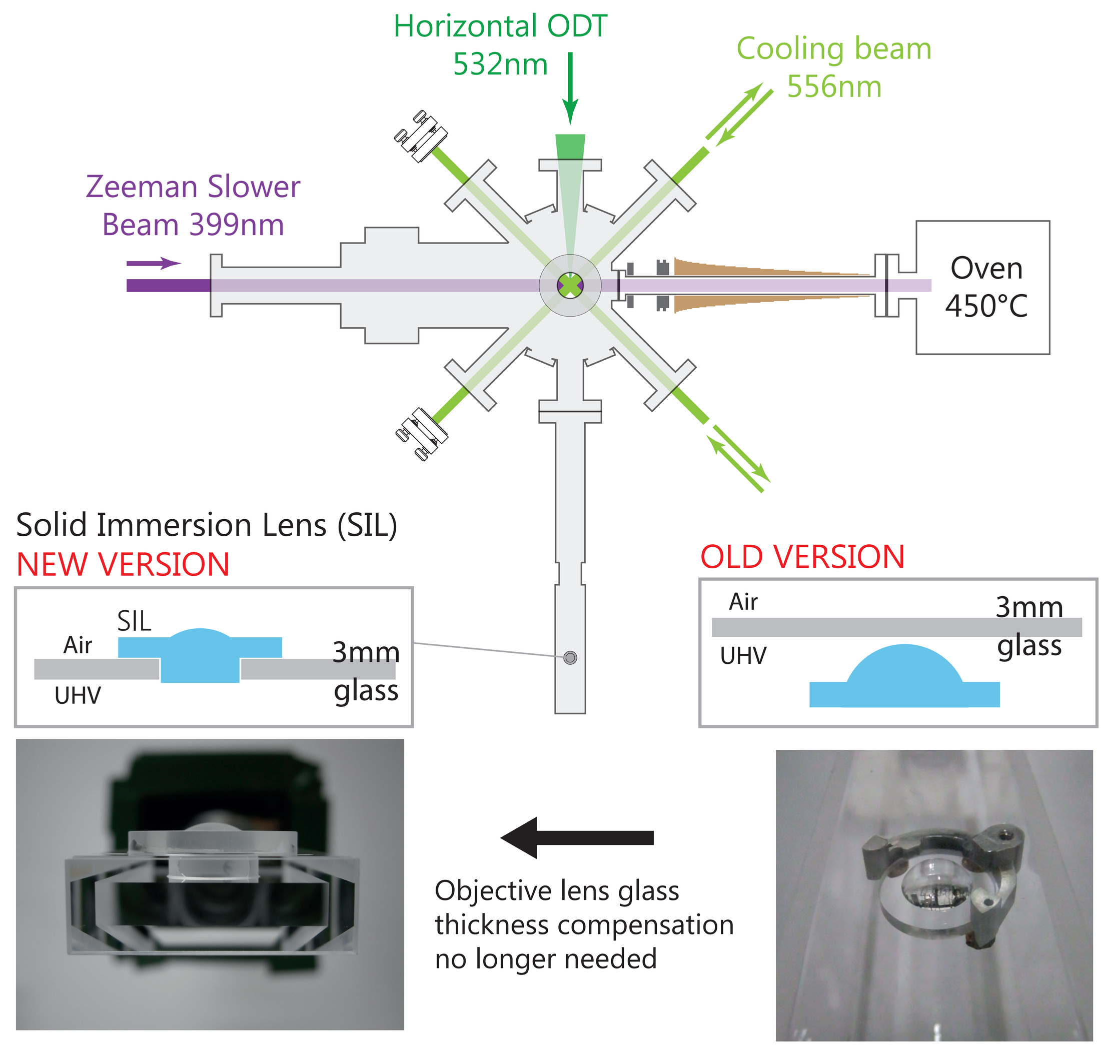


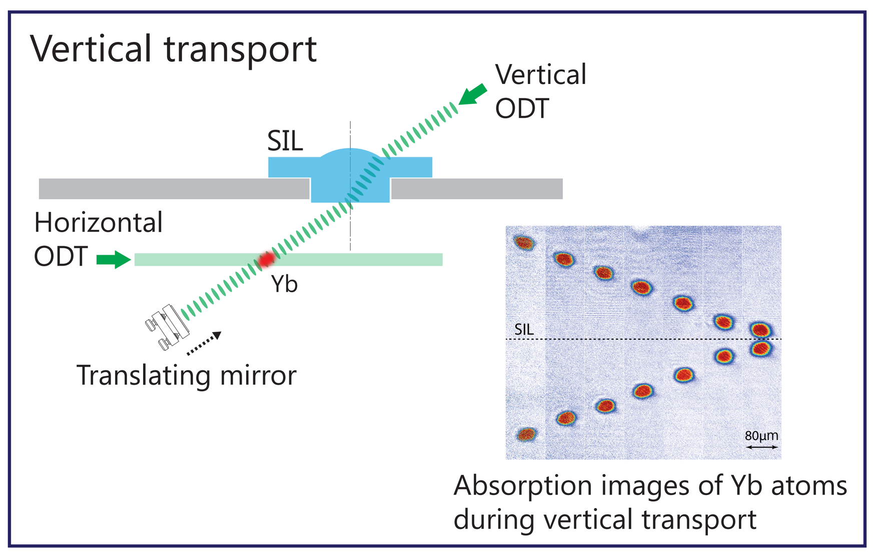
[1] A quantum gas microscope for detecting single atoms in a Hubbard-regime optical lattice
W. S. Bakr, J. I. Gillen, A. Peng, S. Fölling & M. Greiner
Nature **462**, 74-77 (2009)

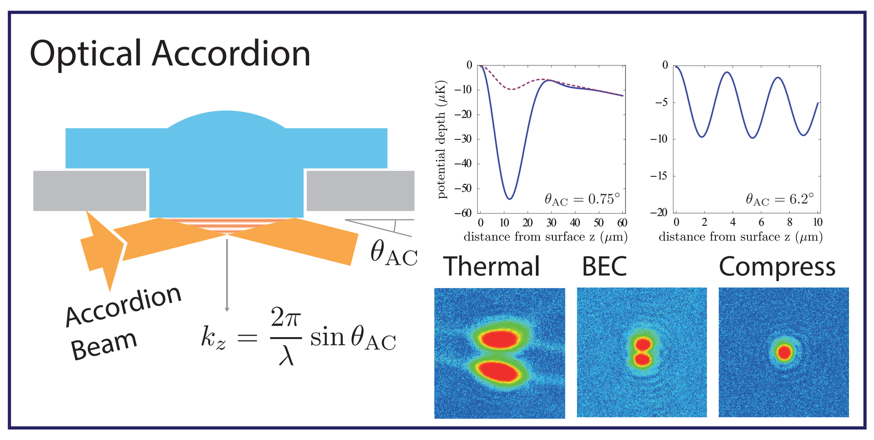


[2] Single-spin addressing in an atomic Mott insulator
C. Weitenberg, M. Endres, C. F. Sherson, M. Cheneau, P. Schauß, T. Fukuhara, I. Bloch & S. Kuhr
Nature **471**, 319-324 (2011)

How to transport atoms to the SIL?



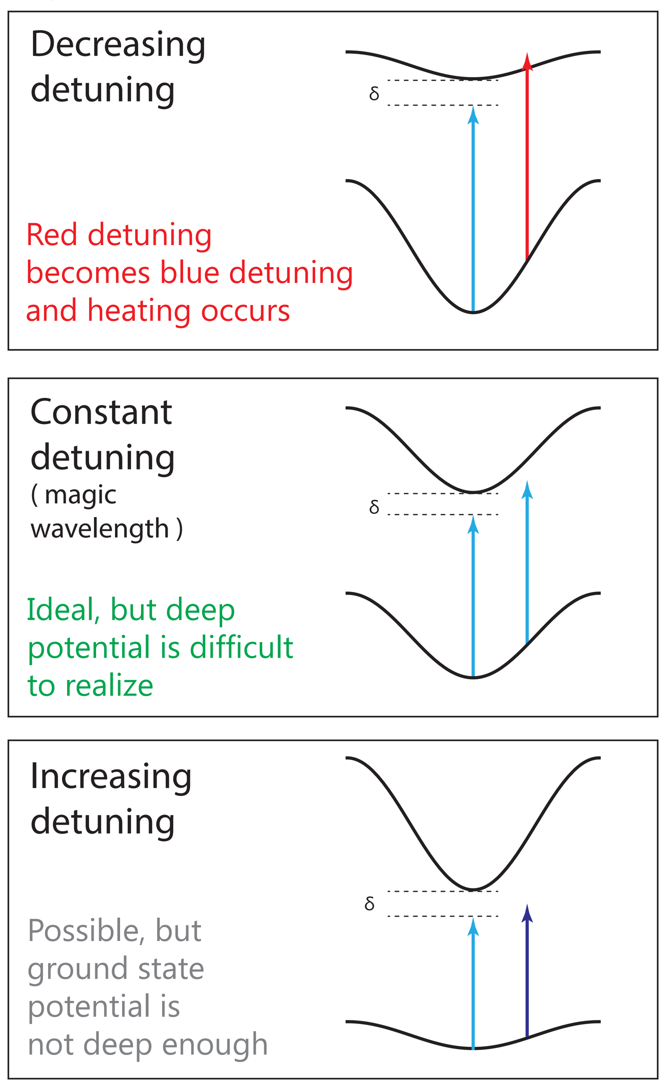




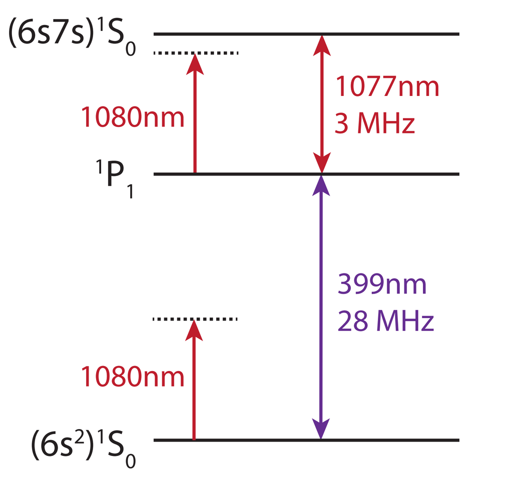
M. Miranda, A. Nakamoto, Y. Okuyama, A. Noguchi, M. Ueda, and M. Kozuma
All-optical transport and compression of ytterbium atoms into the surface of a solid immersion lens.
Phys. Rev. A 86, 063615 (2012)

Fluorescense imaging of atoms in a optical lattice

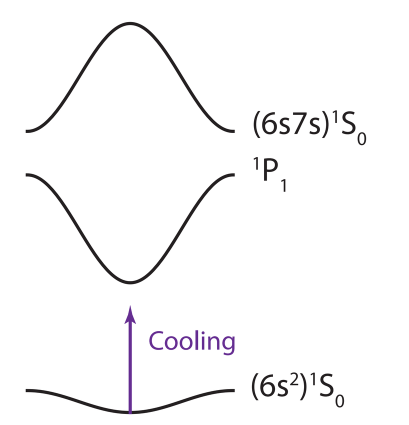
Doppler cooling of atoms in a two-dimensional optical lattice. Three basic categories of potential shapes.



Increasing detuning lattice with Yb can be created using a lattice wavelength near resonant to the excited $^1P_1 \rightarrow (6s7s)^1S_0$ transition.



Potential in the excited $^1P_1$ state is 300 times deeper than the ground state potential



If the cooling light is ON, the population in the $^1P_1$ state is nearly 0.5, and the atom experiences a strong potential.

If the cooling light is OFF, the atom experiences a weak potential. This potential is ideal for evaporated cooling and creating Mott insulators.

Computer simulation

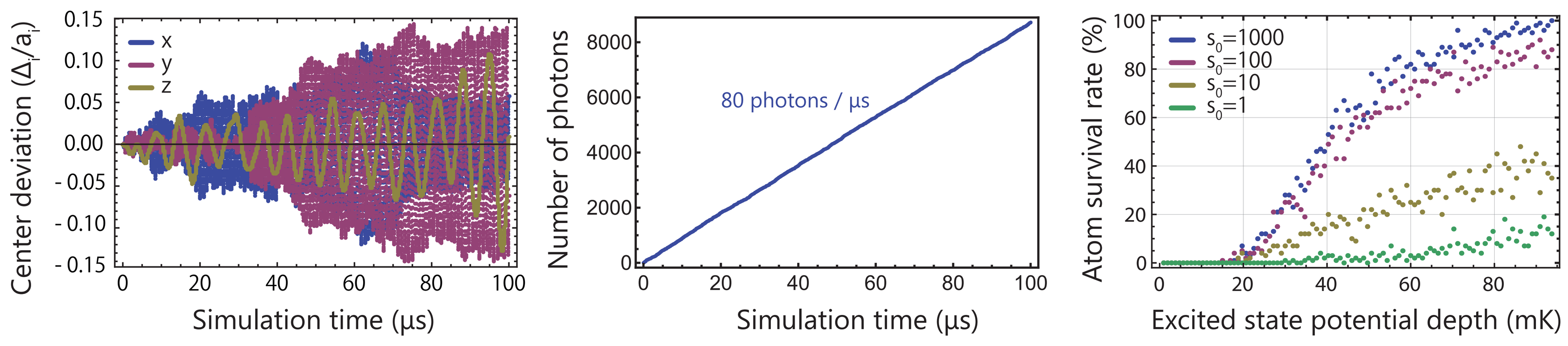
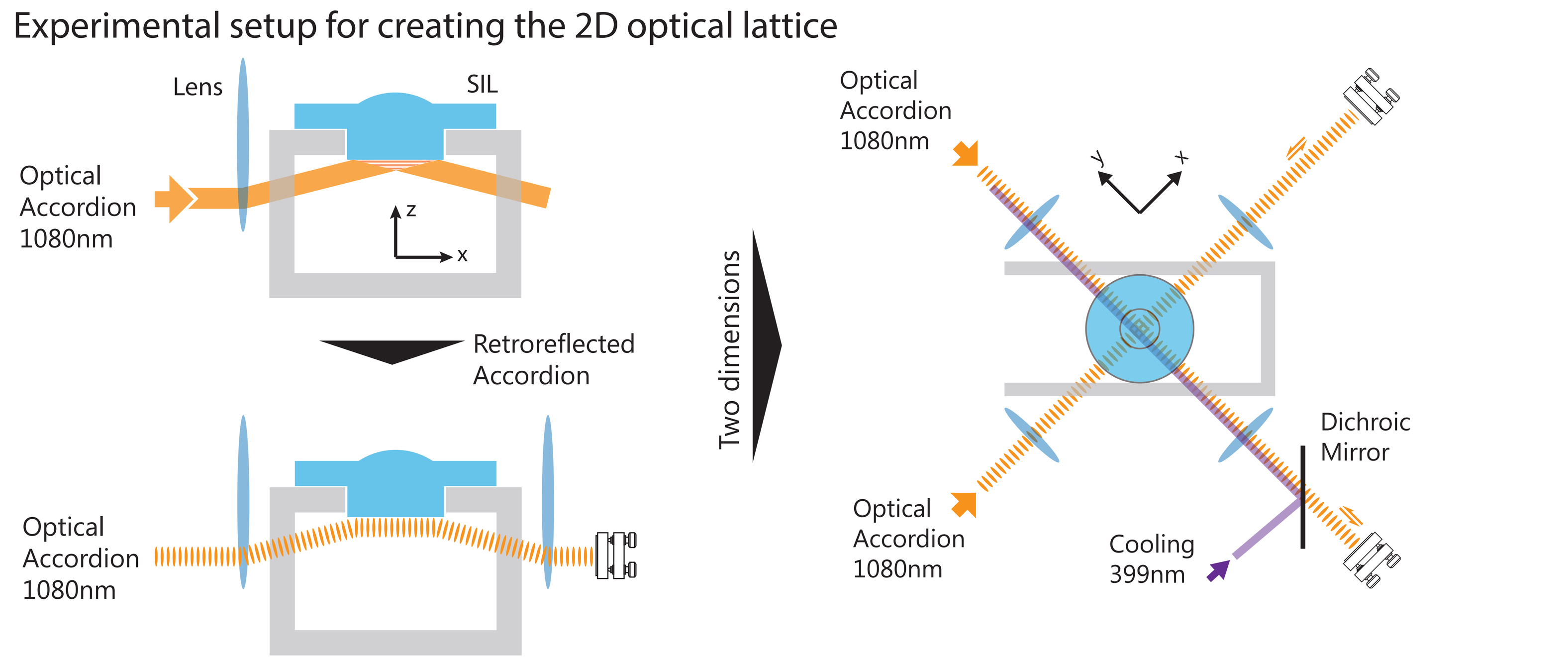


Figure 1. Simulation of an atom trapped in a two-dimensional optical lattice with an incident cooling light. Left: Deviation of the atom in each direction Δ_i relative to the lattice spacing a_i. Middle: Number of spontaneous emissions due to the incident cooling light. Right: Percentage of atoms that remain trapped after 100μs for different lattice potential depths. s0 is the saturation intensity of the cooling light.

Experimental setup for creating the 2D optical lattice



Results

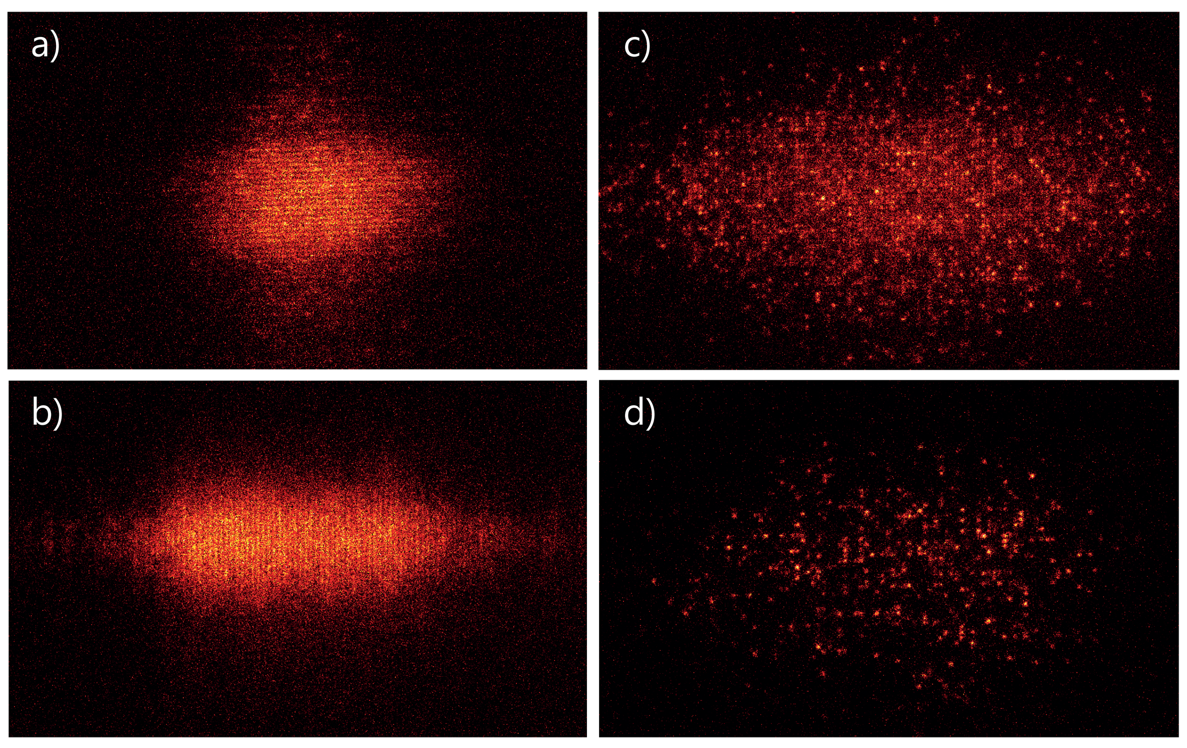


Figure 2. (False color) Typical fluorescense raw images of the atoms trapped in the optical lattice. a) b) One-dimensional optical lattice in the horizontal and vertical (x and y) directions. c) Fluorescense in the case of a filled lattice and d) sparse filled two-dimensional optical lattices.

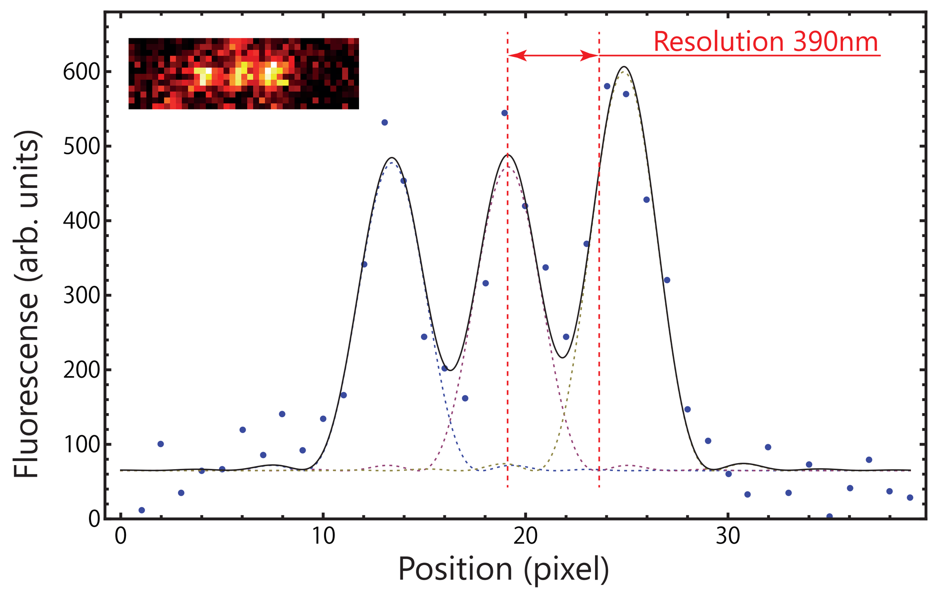


Figure 3. Intensity profile through the center axis of the image generated by three consecutive sites. The airy function fitting shows a resolution of 390 nm. The expected resolution for our microscope system with a NA of 0.8 is 270 nm.

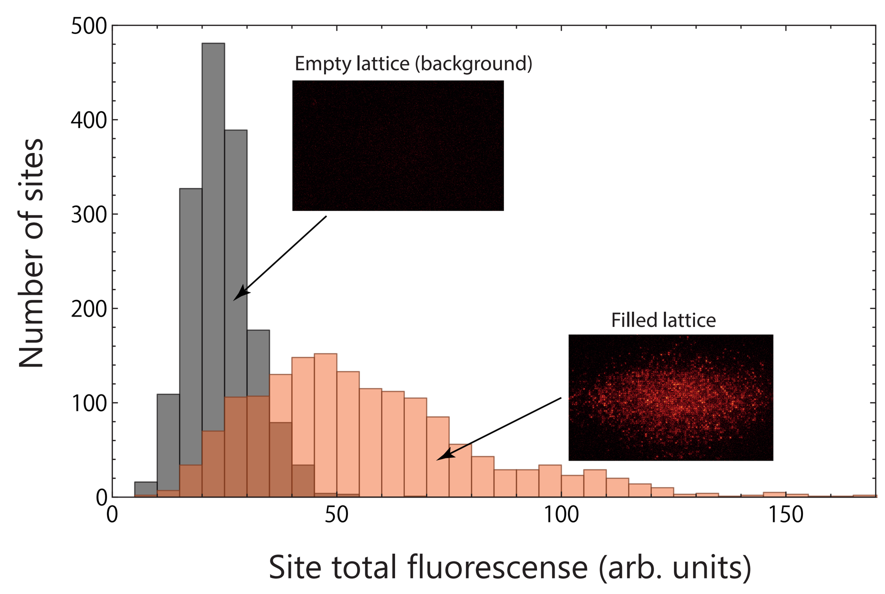


Figure 4. Fluorescense intensity histogram of atoms trapped in the two-dimensional optical lattice measured over 1620 sites. Black: empty lattice (background) histogram and orange: center portion of a filled lattice histogram.

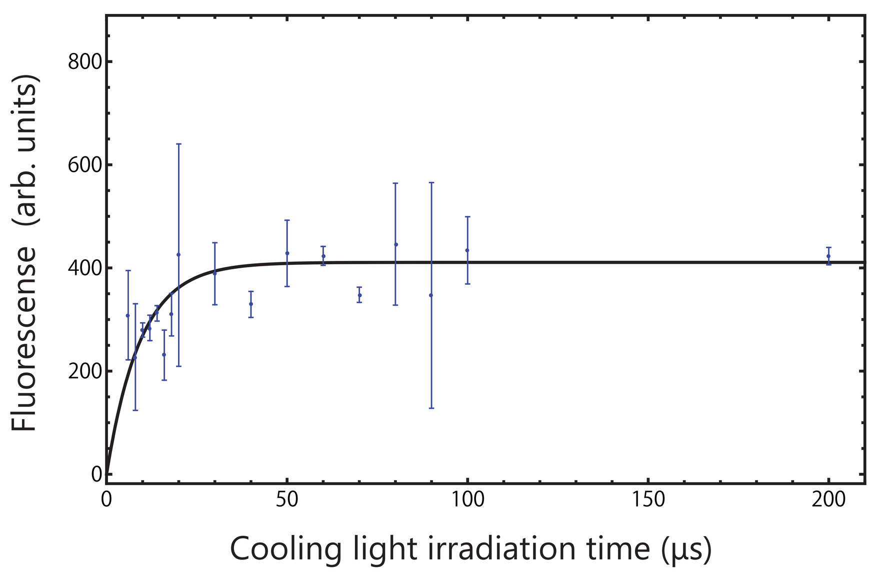


Figure 5. Variation in total fluorescense when changing the cooling light irradiation time. Curve is fitted considering the number of atoms decay exponentially. The resultant lifetime was 10 μs.

Our group

Tokyo Institute of Technology

Source: Wikipedia

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