Trapping of Ultracold ^{87}Rb F=1 Atoms in a 10 μm-Period Magnetic Lattice

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Periodic magnetic lattices provide a promising alternative to optical lattices for trapping and manipulating periodic arrays of ultracold atoms and have the potential advantages of no spontaneous emission, low technical noise, low heating rates, highly stable and reproducible potentials, and allowing *in situ* evaporative cooling and RF spectroscopy on the trapped atoms [1-3].

Previously [2], ^{87}Rb atoms in the $|F = 2, m_F = +2\rangle$ ground state were successfully loaded into a 10 μm-period 1D permanent magnetic lattice constructed on an atom chip. Heating due to adiabatic compression in the tight traps and insufficient axial confinement limited the temperature of the trapped atoms to $\sim$ 300 μK and the trap lifetime to $\sim$0.5 s.

We have recently performed experiments for ^{87}Rb atoms optically pumped into the low-field seeking $|F = 1, m_F = -1\rangle$ ground state to reduce three-body recombination, to increase the lifetime of the atoms in the traps and to reach lower temperatures by evaporative cooling in the lattice. F=1 atoms in a Z-wire trap are loaded into a shallow lattice created by the field from the permanent magnetic microstructure and the bias field from a Z-wire current. After evaporative cooling in the Z-wire trap, $\sim 1 \times 10^6$ atoms are transferred into about 100 sites of the magnetic lattice. Further evaporative cooling in the lattice yields $\sim 3 \times 10^5$ atoms at temperatures of $\sim$1.5 μK, which is close to the BEC transition temperature, and with a trap lifetime of $\sim$ 12 s. Under these conditions, and with improved imaging optics, it is now possible, using *in situ* absorption imaging, to spatially resolve the clouds, each consisting of about 3000 ultracold atoms trapped in individual lattice sites $\sim$10 μm below the chip surface in the 10 μm-period magnetic lattice (Fig. 1).

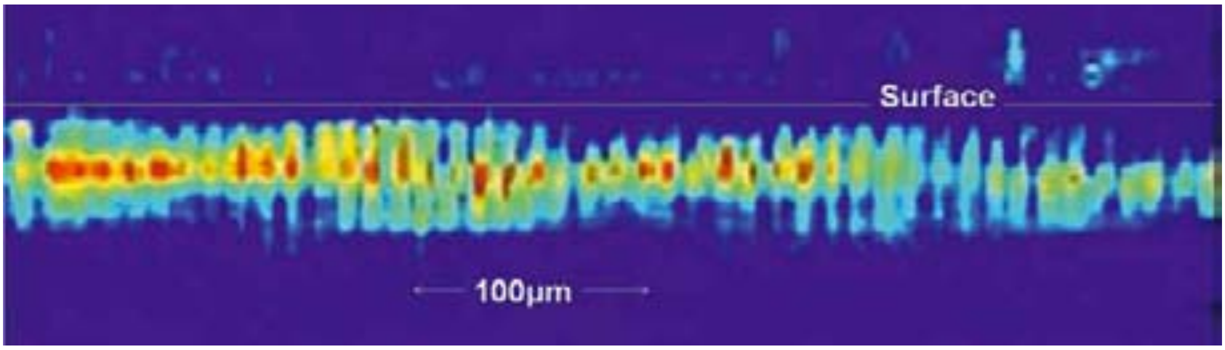

Fig. 1: Fig. 1: Sideview *in situ* absorption image of ^{87}Rb F=1 atoms trapped in a 10 μm-period 1D magnetic lattice. (Pixel size: 3 μm.)

Future experiments include evaporative cooling the trapped atoms to degeneracy to produce multiple BECs in the magnetic lattice, studying decoherence times for a two-component (F=1, F=2) ultracold gas by Ramsey interferometry at distances down to a few microns from the chip surface, and implementing a 2D magnetic lattice [1] with periods down to 1 - 4 μm to perform quantum tunnelling experiments in a magnetic lattice.

References

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