THE COOLEST PLACE AT NPL

Witold Chalupczak
Cooling and trapping

1979 Doppler Cooling
1987 Magneto-optical trap
1988 Sisyphus cooling
1989 Atomic fountain
1989 Nobel Prize: Norman Ramsey, Hans G. Dehmelt, Wolfgang Paul
1990 Atom optics
1993 Dark spontaneous-force optical trap
1992 Quantized motion of atoms in the optical lattice
1995 Evaporation cooling of magnetically cooled atoms
1995 Bose Einstein Condensation in a dilute atomic vapour
1996 Degenerate Fermi gas
1997 Nobel Prize: Steven Chu, Claude Cohen-Tannoudji, William D. Phillips
1998 Formation of cold molecules by photoassociation
2000 Atom Chip
2001 All-optical formation of BEC
2001 Nobel Prize: Eric A. Cornell, Wolfgang Ketterle, Carl E. Wieman
2004 Mott transition
Outline

- Laser cooling and trapping of atoms
- Quantum control
- Looking Forward
Cooling
Optical lattice
Optical Lattices - Periodic potential wells created by the light shift of the ground state.
Optical lattice 1D, 2D, 3D
Cooling atoms down to 200 nK
Atomic Fountain

- pulsed operation
- $10^8$ atoms in MOT
- launch temperature $2.5 \, \mu K$
- up to 1 m high
- $10^5 - 10^6$ atoms detected

Quantum control

Internal structure of the atom

Trapping of atoms

INTERACTION  SHIFT  TRAPPING
Magnetic trapping

- Wire
- Bias field
Magnetic trapping

JILA (USA)

IC (UK)

MPI (Germany)
Atom chip clock (MPI)

\[ \sigma(\tau) = 1.7 \cdot 10^{-11} \tau^{-1/2} / \sqrt{\text{Hz}} \]
Electric trapping

University of Tokyo
This interest is motivated in part by the practical need (...) and in part by the esthetic appeal of controlling the positions and velocities of collection of atomic particles to within the limits imposed by quantum fluctuations.

Acknowledgments

Henderson Dale
Marra Giuseppe
Ovchinnikov Yuri
Szymaniec Krzysztof