ILP6 : Magneto-Optical Trap

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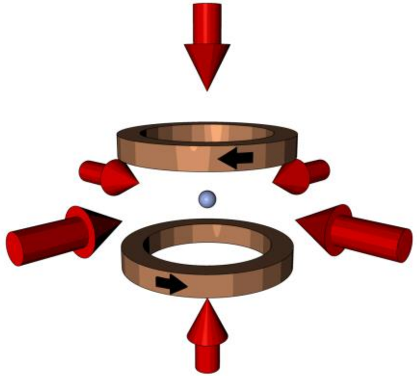
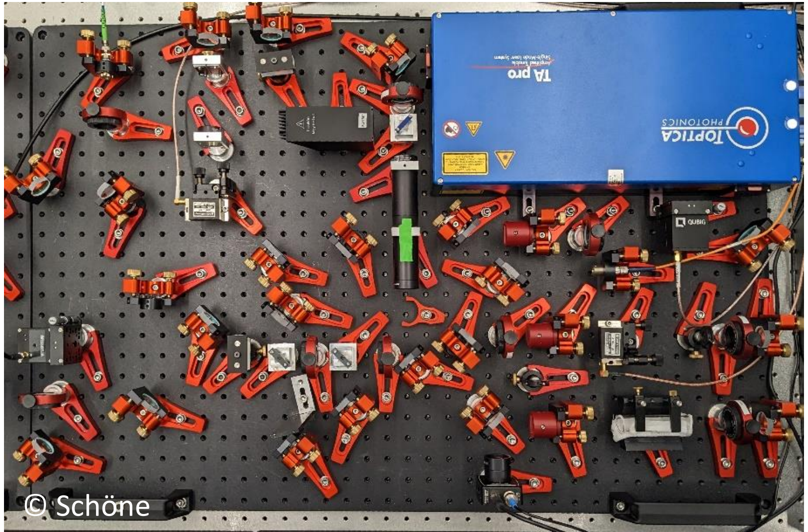
Aim of the experiment



- Experimental methods
  State-of-the-art techniques for quantum optics experiments
  State-of-the-art laser systems

- Realization and optimization of an ultracold cloud of ^{85}Rb atoms
  Laser cooling, trapping and imaging ultracold atomic clouds



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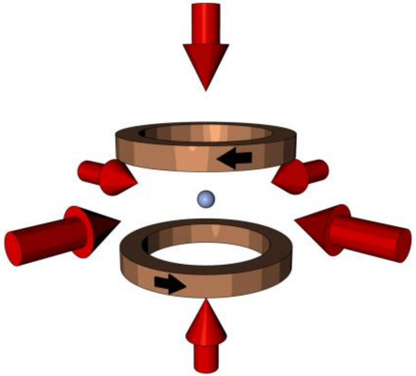


Scientific context

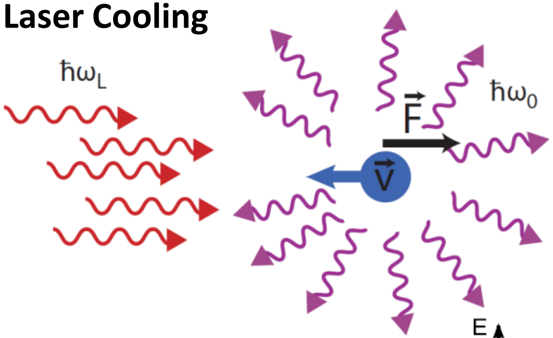
- Required lecture: P3 „Introduction to quantum and statistical physics“
- Interaction atom / photons (absorption, emission)

The Nobel Prize in Physics 1997

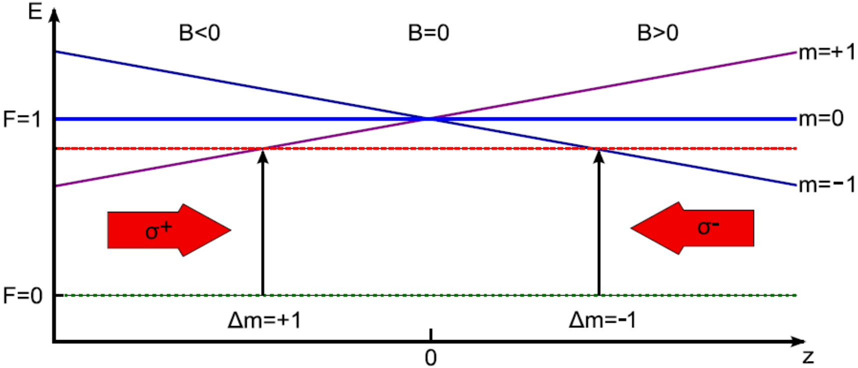
Steven Chu Prize share: 1/3	Claude Cohen-Tannoudji Prize share: 1/3	William D. Phillips Prize share: 1/3

The Nobel Prize in Physics 1997 was awarded jointly to Steven Chu, Claude Cohen-Tannoudji and William D. Phillips *"for development of methods to cool and trap atoms with laser light"*.

Laser Cooling



- Interaction atom / external magnetic field (Zeeman effect essential for trapping)



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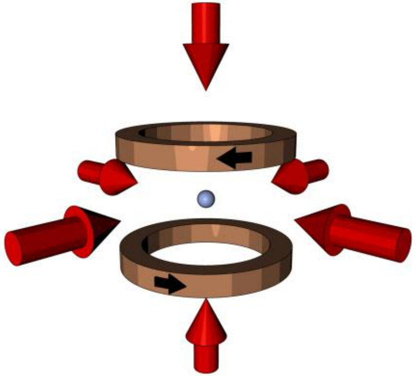
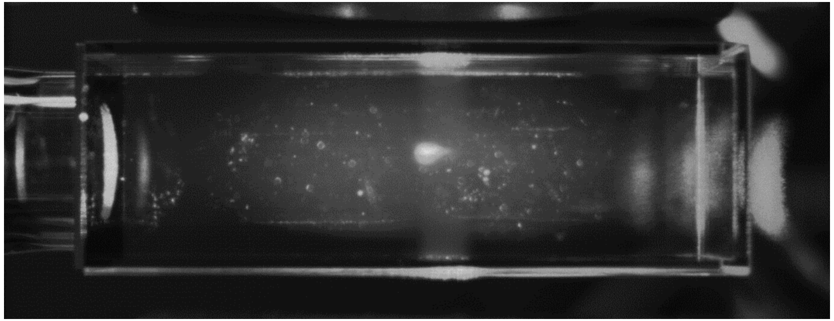
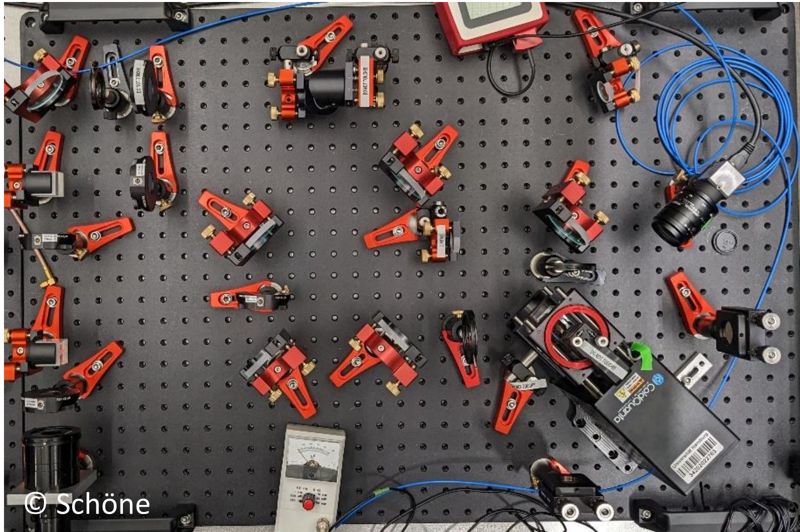
Experimental setup



- Magneto-Optical Trap
  - Vacuum chamber with Rubidium dispensers
  - Helmholtz coils (magnetic field gradient)
  - Laser system (geometrical alignment, intensity, polarization, frequencies)
- Data acquisition
  - Imaging ultracold atomic clouds (CCD camera)
  - Measurement of the temperature reached
  - Determination of the optimal cooling frequency





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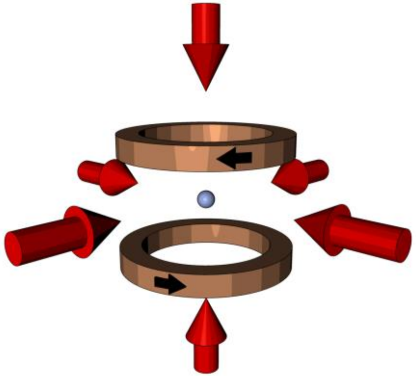
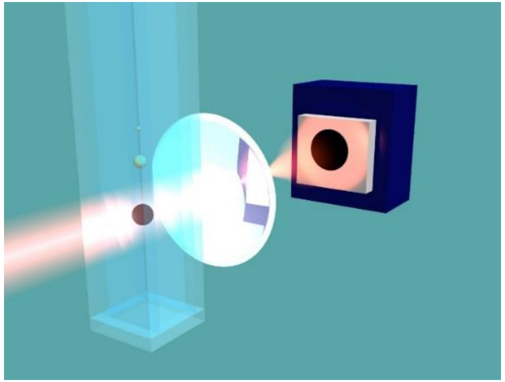
Data analysis



- Essential to obtain atom number and temperature of the cloud
- Self-written Python script to analyze the images from the CCD camera
- Data evaluation (fits, statistical errors, error propagation)
- Challenges
  - Converting pixel values to atom number (atomic scattering rates, solid angle for imaging optics)
  - Converting cloud expansion after switching off the MOT into a temperature



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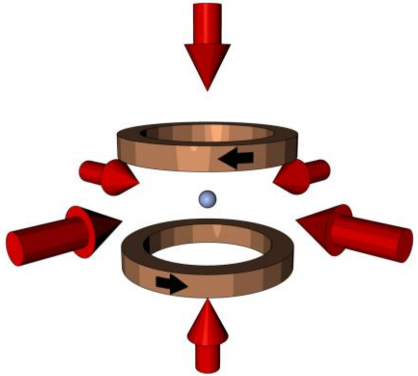
Key scientific results



- Learn
  State-of-the-art techniques for quantum optics experiments
  Laser cooling, trapping and imaging of ultracold atomic clouds

- Comparison to state-of-the-art results
  Doppler temperature $T_D = 145\ \mu K$ only achievable for perfectly balanced light forces (intensity balance, correct polarization, stray magnetic field compensated)

- Skills
  Data evaluation (fits, statistical errors, error propagation)
  Data acquisition (reduction of systematic errors with randomized measurements)
  Laboratory (laser safety, laser alignment, intensity and polarization measurement and adjustment, optical elements e.g. AOM, EOM, polarization optics)

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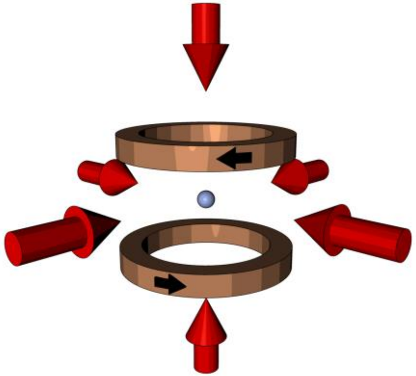

Grade your experiment

- Schedule
  Lab (3 days)
  Day 1 : Question/discussion, Lab and laser safety, Alignment of the MOT)
  Day 2 : Imaging, Measurement temperature
  Day 3 : Measurement optimal cooling frequency and own ideas
  Data evaluation (2 days)

- Grade the complexity of your experiment in a scale from 1 high -5 low

Theory / preparation	Setup / experimental	Data taking	Analysis	Protocol
3	4	4	2	3

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Link to modern research – First cooling stage for state-of-the art quantum optics experiments

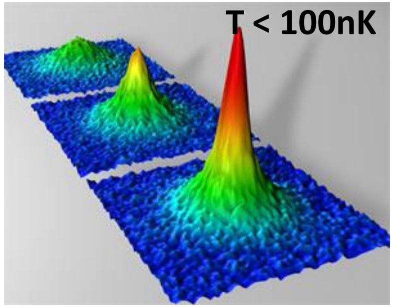
ILP / ZOQ

- Experiment

Group Hemmerich, Group Moritz, Group Sengstock

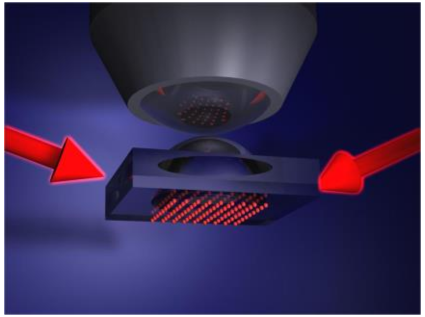
- Theory

Group Jaksch, Group Mathey, Group Schmelcher



Bose-Einstein Condensate

Quantum Computers



Cluster of excellence „CUI: Advanced Imaging of Matter“

Atoms bind together and form solids, molecules interact and react - new functionalities emerge with increasing complexity and growing system size. 160 scientists from different disciplines such as **physics**, **chemistry**, and **structural biology** have joined forces to **observe**, **understand**, and **control** these processes.

Speakers: Klaus Sengstock, Henry Chapman and Horst Weller