# Towards building and loading a Ioffe trap using a 2D MOT

Benedikt Tscharn, Hendrik-Lukas Schumacher, Gregor Schwendler, Marcel Willig, Randolf Pohl

Johannes Gutenberg-Universität Mainz, Institut für Physik/QUANTUM & Exzellenzcluster PRISMA+

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## Objectives

Investigation of fundamental nuclear properties such as nuclear radius, transition energies and effects like quantum interference by

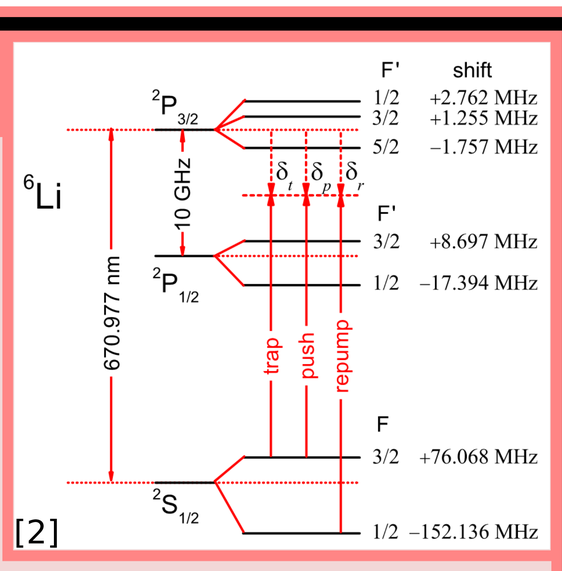
- performing high-precision laser spectroscopy on cold $^6$Li atoms
- using ultra-cold Lithium as buffer gas for cooling atomic hydrogen for spectroscopy [1]

## Laser systems

MOT:
Sirah Matisse 2 TX-light
Ti:Sa CW ring laser with external cavity stabilization
100mW per beam

Push:
Self-built ECDL with TA
1-10mW

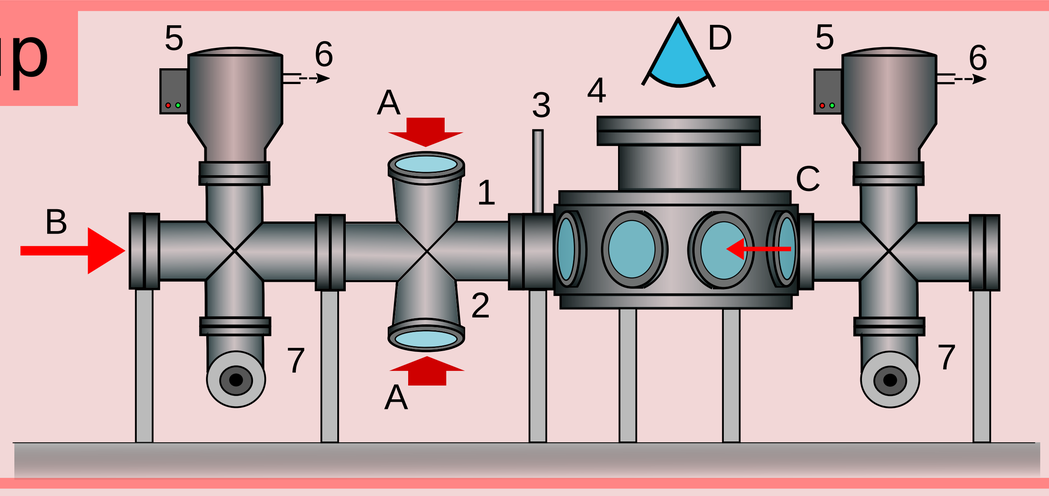
Probe:
Toptica TA pro
~12mW




Doppler-free absorption spectroscopy at two Lithium vapour cells as frequency reference for locking and scanning push and probe laser.

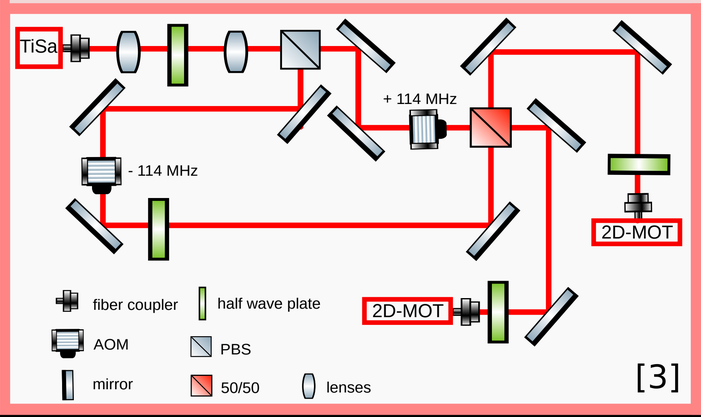
Same setup for MOT and Probe laser:
Running at frequencies between the two addressed transitions.
Shifted by 114MHz up and down -> repump and trap/probe.

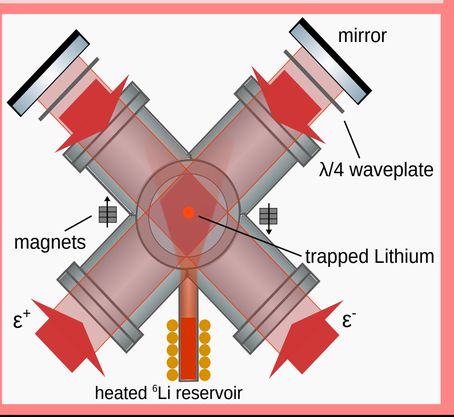
## Setup




1. Double-cross with MOT
2. Lithium oven (behind cross bar)
3. Vacuum valve
4. Spectroscopy chamber
5. Turbo pump
6. To pre-pump
7. Vacuum gauges

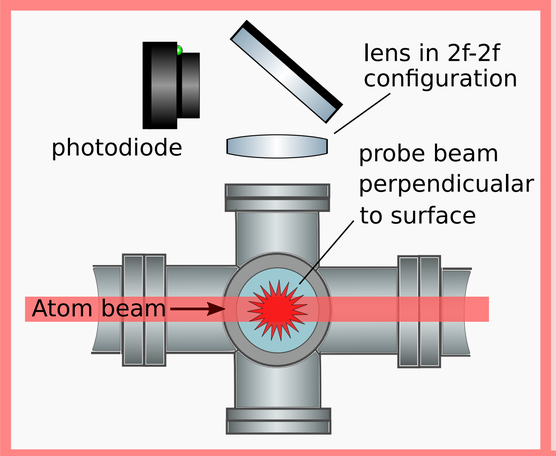
A. MOT beams: trap, repump
B. Push beam
C. Spectroscopy beam
D. Fluorescence measurement diode




## Atom Beam Velocity

Fluorescence spectroscopy with orthogonal, backreflected probe & repump laser.

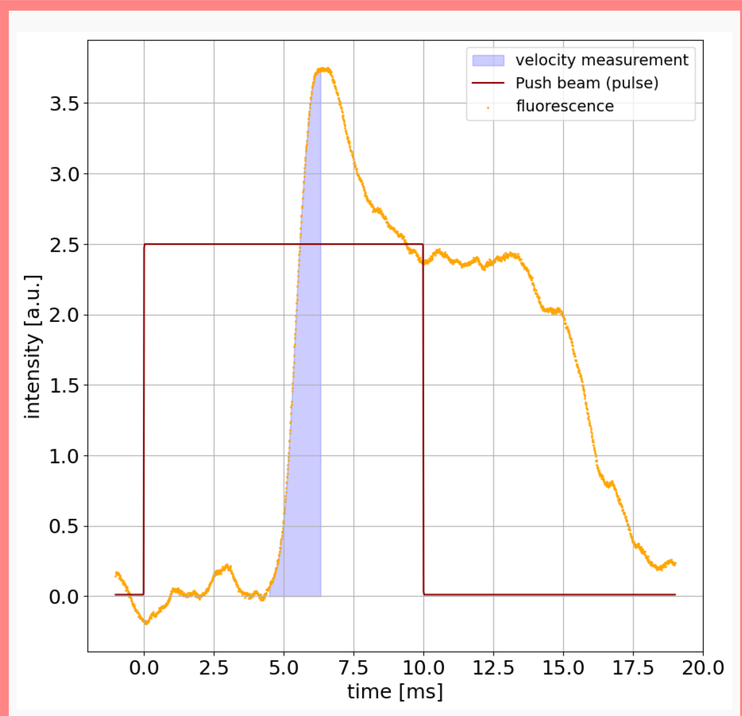



Heterodyne measurement:
Chopper probe beam with AOM
Demodulation with lock-in amplifier.

Push beam pulsed with AOM.
P = 800µW

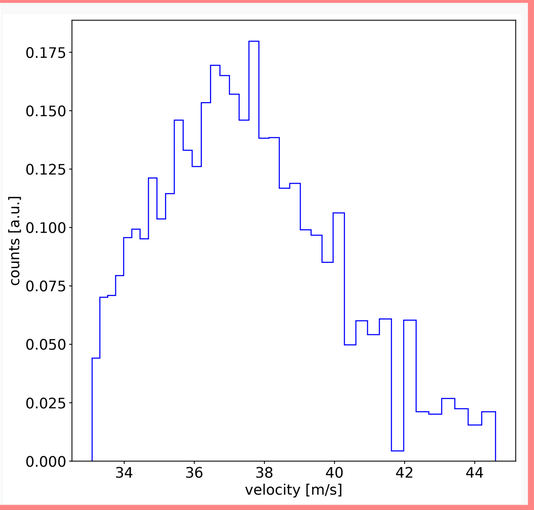
Time-of-flight measurement gives atom velocity distribution.

Equilibrium between loading and unloading the MOT.

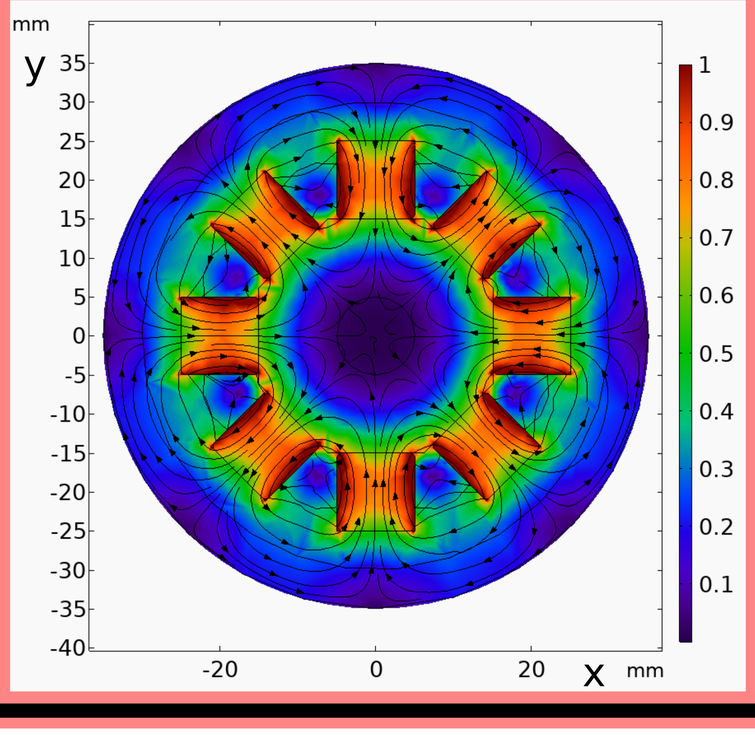



Velocity distribution taken from blue area.

Faster at higher push power.




## Magnetic Trap

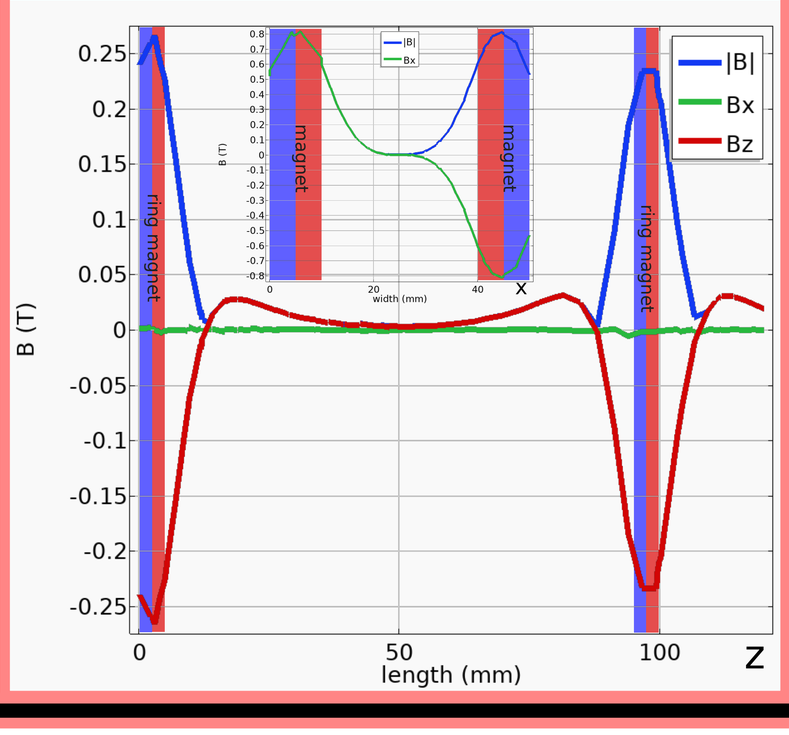



Spin-polarisation by magnetic field leads to attraction or repulsion.

$$\vec{F} = -\vec{\nabla} \cdot \vec{\mu} \cdot \vec{B}$$

Trap low-field-seekers in magnetic 'bath tub'
Prevent Majorana spin-flips with non-zero Bz-component. [4]

The octopole layout provides a high gradient and a wide low-field range in the center.




For more information about our research, visit our website and feel free to contact us.

https://www.agpohl.physik.uni-mainz.de/downloads/dpg-tagungen/dpg-fruhjahrstagung-2023/

Sources

[1] S. Schmidt et al. "The next generation of laser spectroscopy experiments using light muonic atoms" in J. Phys.: Conf. Ser. pp 012010 (2018).
[2] T.G. Tiecke et al. "A high-flux 2D MOT source for cold lithium atoms" in Phys. Rev. A Vol. 80. No.1 (2009).
[3] H.-L. Schumacher "Two-dimensional magneto-optical Trap for Lithium Atoms". Master thesis JGU Mainz (2023).
[4] J. Tollet et al. "Permanent magnet trap for cold atoms" in Phs. Rev. A Vol. 51. No. 1 (1995).