Towards laser spectroscopy of atomic tritium

Jan Haack[1], Julian J. Krauth[1], Stefan Schmidt[1], Marcel Willig[1], Rishi Horn[1] and Randolf Pohl[1]

[1] Johannes Gutenberg-Universität, Mainz

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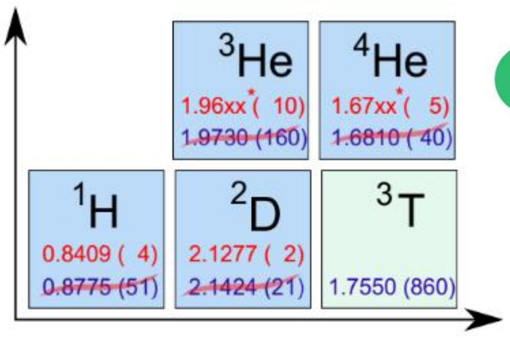
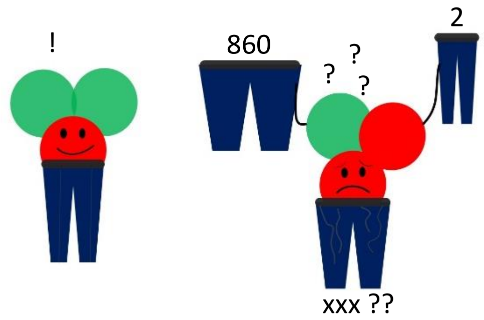
Motivation

- Charge radii of proton, deuteron, helion and alpha have recently been improved 10x [5]
- Triton is the "missing link" between Z=1 and Z=2
- Needs an accurate measurement of 1S -2S isotope shift
- 1kHz accuracy results in 300x improved triton charge radius
- allows study of 3-nucleon forces
- standard techniques for hydrogen cooling don't seem suitable with tritium [1][2]
- a general storage device for hydrogen-like atoms

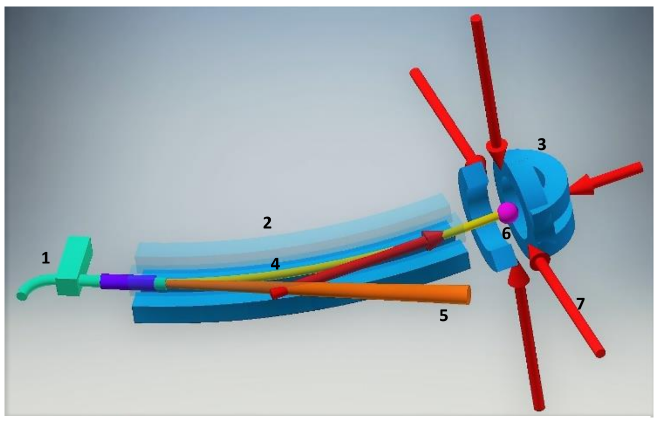




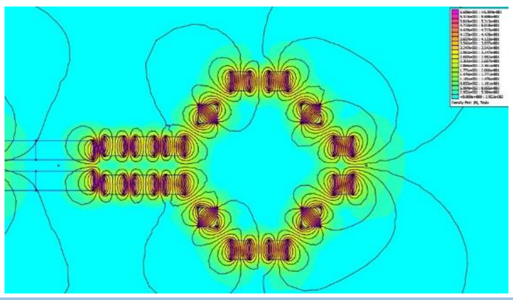
Triton desperately trying to find its accurate radius, while ^{3}He is already happy

Experimental idea

A cold nozzle based on a Walraven design [1] releases atomic tritium at 4.2K (~ 170 m/s mean velocity). The subsequent magnetic guide works both as a confinement as well as a velocity selector. Slow tritium atoms impact the ^{6}Li-MOT and are cooled enough to be stored in the magnetic bottle. Once the tritium is stored the ^{6}Li is pushed out of the bottle and laser spectroscopy can be done with the tritium.

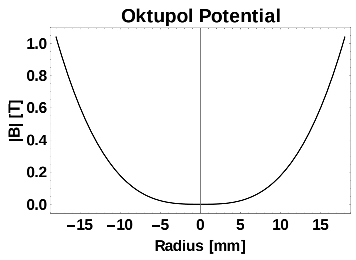


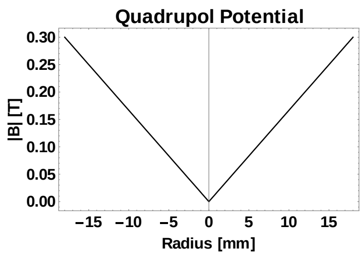
1: Hydrogen nozzle, 2: magnetic Quadrupol, 3: magnetic Trap, 4: Hydrogen Beam, 5: untrapped hydrogen, 6: Li6-MOT, 7: MOT beams



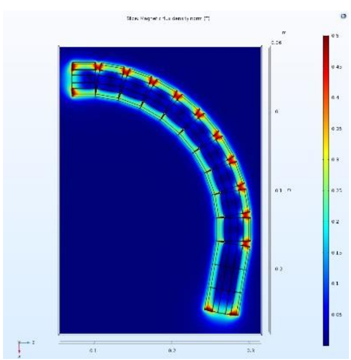
FEMM-simulation field map of possible trap configuration with permanent magnets

- guiding and speed selection of atomic tritium with a magnetic multipole guide [3]
- cooling with a ^{6}Li-MOT as a buffer gas [4]
- full magnetic storage of T in a magnetic bottle
- laser spectroscopy of tritium
- testing stages with atomic hydrogen

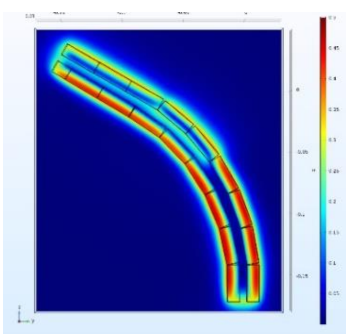




Current state

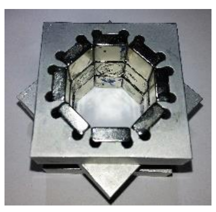


COMSOL simulation of magnetic field density in possible octupole guide design

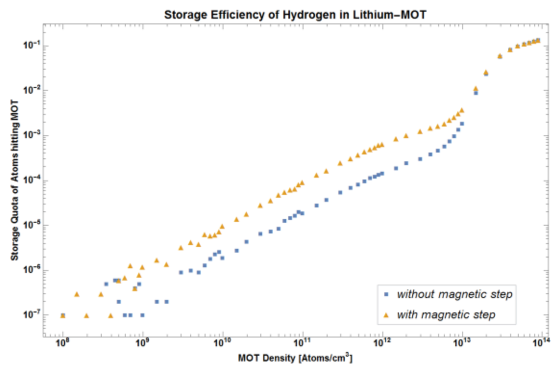


COMSOL simulation of magnetic field strength in possible quadrupole guide design

- Simulations for storage efficiency giving promising results
- Designs of magnetic guides nearly done
- Chamber and experimental set-up in the making
- Re-run of simulations in preparation



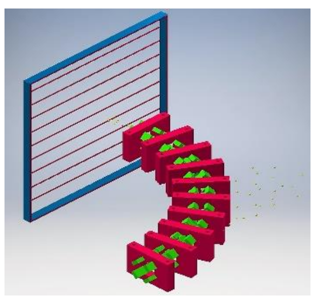
Elements of the octupole guide prototype built from aluminium and off-the-shelf NdFeB-permanent magnets



Simulated fraction of hydrogen atoms stored in the magnetic bottle depending on the density of the MOT; the magnetic step refers to the higher magnetic potential atoms must pass to get into the trap

Future plans

- Setting up chamber with required equipment
- Building nozzle
- Building simple hydrogen-detection system
- Testing quadrupole / octupole guide
- Setting up ^{6}Li-MOT
- Collision experiments



Detection of guided hydrogen atoms after the velocity selector via wolfram wire chamber resistance measurement

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[1] J. Walraven, Isaac F. Silvera RSI **53**, 1167-1181 (1982)
[2] F. Merkt et.al. PRA **75**, 031402 (2007)
[3] E. Abraham et.al. PRA **68**, 023403 (2003)
[4] R. Côté et.al. PRL **84**, 2806 (2000)
[5] A. Amroun et.al. NPA **579**, 596-626 (1994)