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Detecting Magneto-Optically Trapped Atoms using Velocity Mapped Ion Imaging

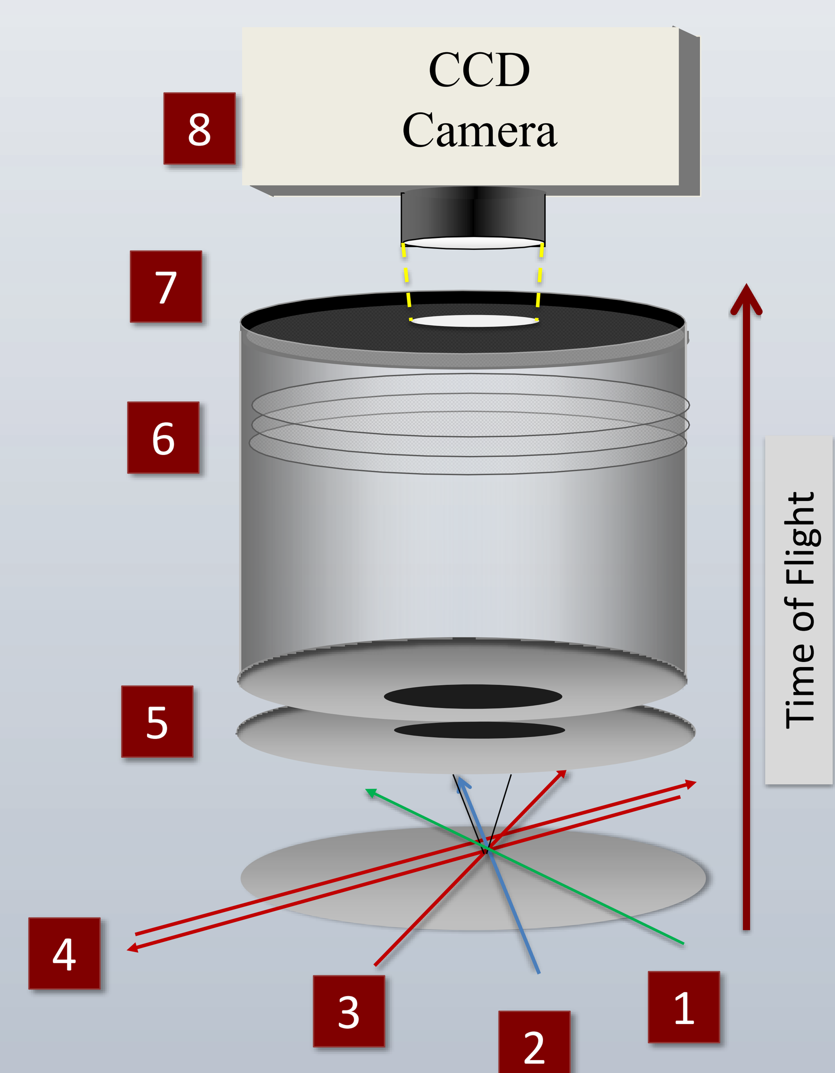
Caitlin Montcrieffe, CSUEB, B.S. Applied Physics, June 30
Lori Culberson, Jennie Guzman, Dave Chandler, Org #8353, Combustion Chemistry Department

Abstract

We strive to cool and trap metastable, krypton atoms while utilizing velocity mapped ion imaging (VMII) to detect the atoms. As a first step, we are investigating the influence of our cooling laser (811 nm) on the krypton velocity distribution. To do this, three lasers are used to prepare and ionize our krypton sample; the ions are subsequently detected by the velocity mapped ion imaging.

Experimental Process

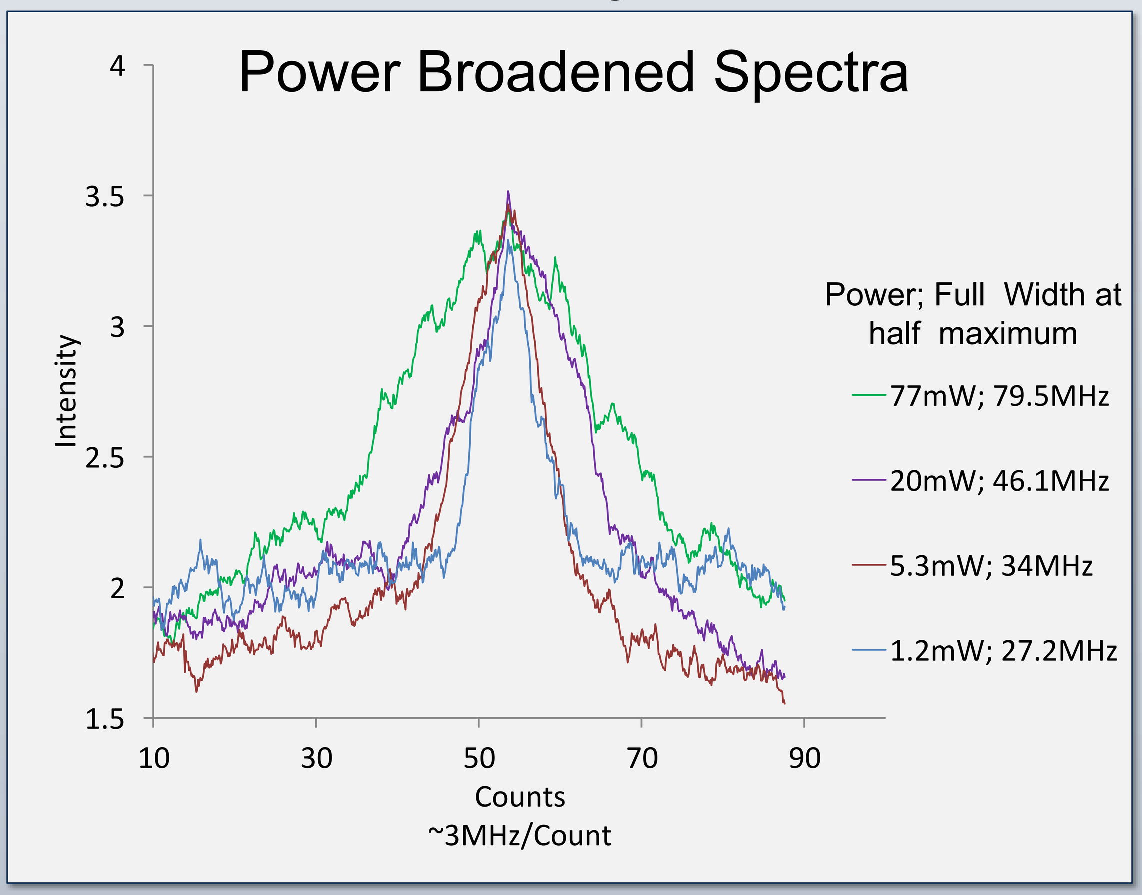
1. Krypton gas beam
2. Overlapped 214 nm light and 266 nm light
3. 811 nm beam that travels ⊥ to atomic beam
4. Path of 811 nm light that's partially collinear with atomic beam
5. Charged, electrostatic lenses project ions upward
6. Ions collide with each multichannel plate, multiply and emit more ions
7. Internal phosphor screen projects an image of each ion
8. Each pixel corresponds to particular velocity



Progress

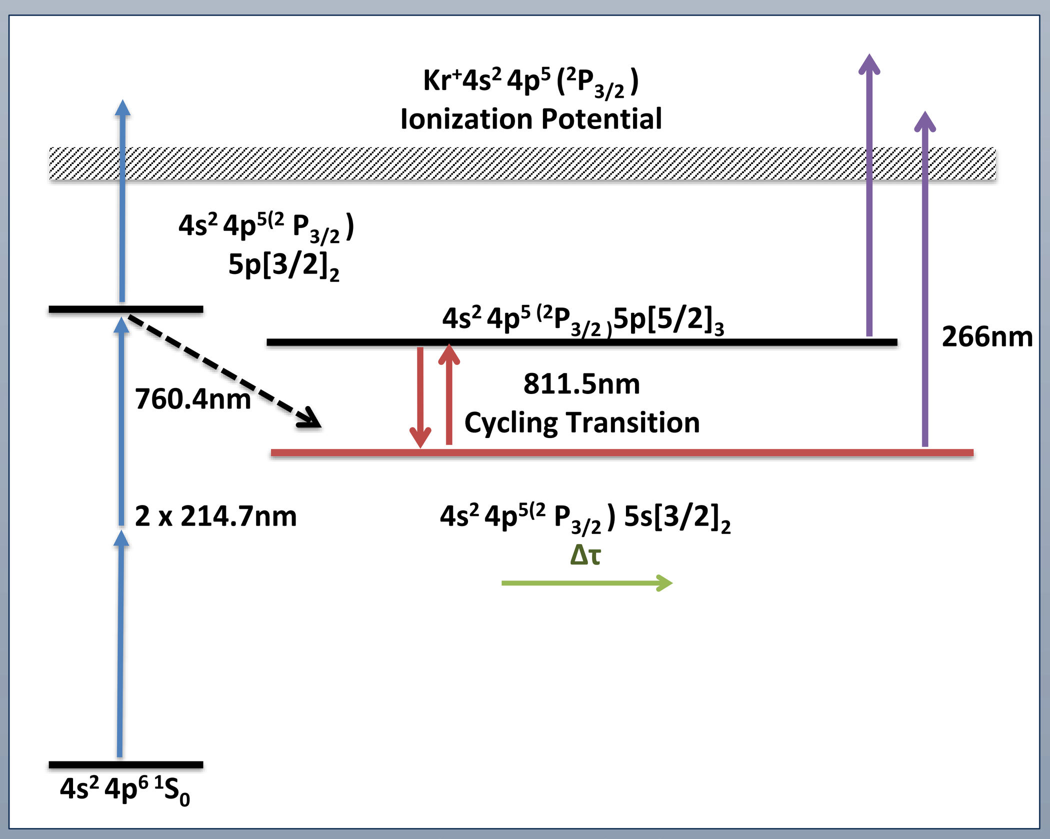
Characterizing the width of the cycling transition of metastable krypton

- Data was collected using a photomultiplier tube while scanning the frequency of the 811 nm laser light



- The natural line width of the transition is ~Γ=5.3 MHz; by varying the power of the 811 nm light, we can roughly evaluate the effect of power broadening on this transition
- The minimum observed width is ~20 Mhz
- The discrepancy in widths could be attributed to Doppler broadening

Creating Metastable States of Krypton

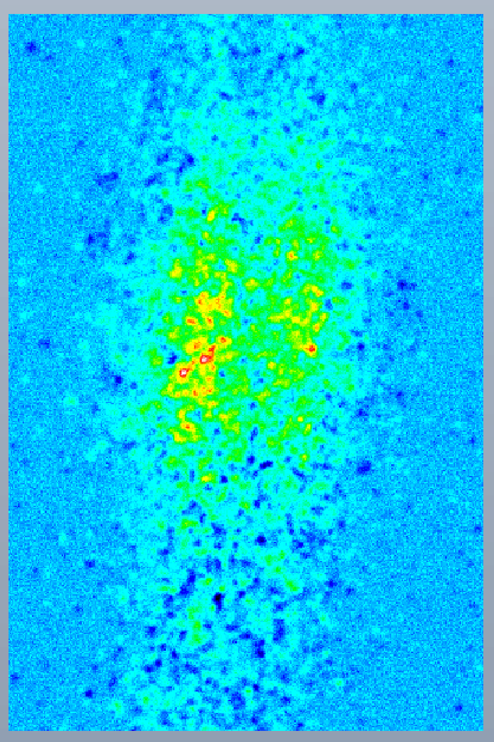


Low-lying energy levels

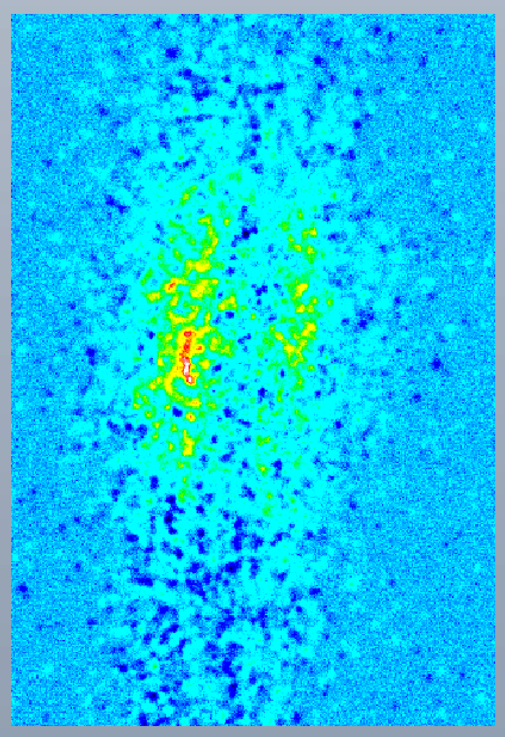
- Lowest two energy levels or krypton require ~100 nm photons which is not experimentally feasible
- To circumvent this complication we utilize a 2-photon transition

The influence of the 811 nm laser on the velocity distribution using VMII

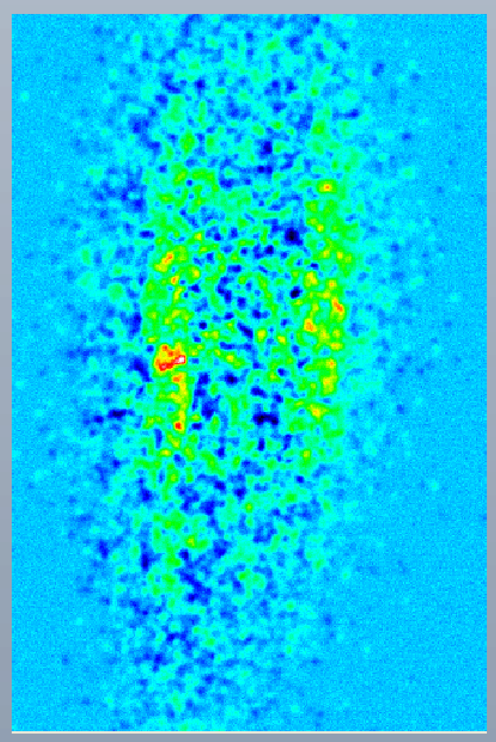
- Images of thermal krypton were taken using a CCD at different frequencies of the 811 nm laser



$\omega_L \approx \omega_{Trans}$



$\omega_L > \omega_{Trans}$
By $\sim 1\Gamma$

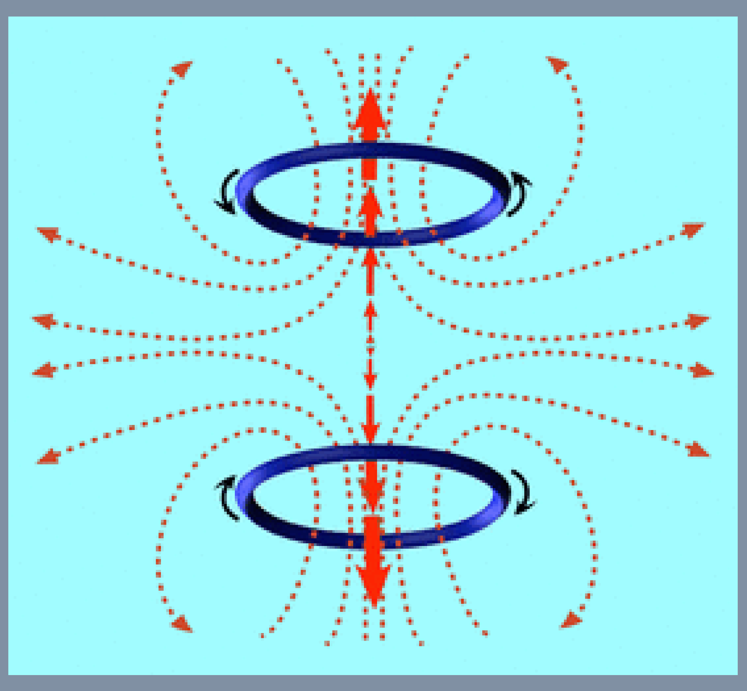


$\omega_L \gg \omega_{Trans}$
By $\sim 10\Gamma$

Future Endeavors

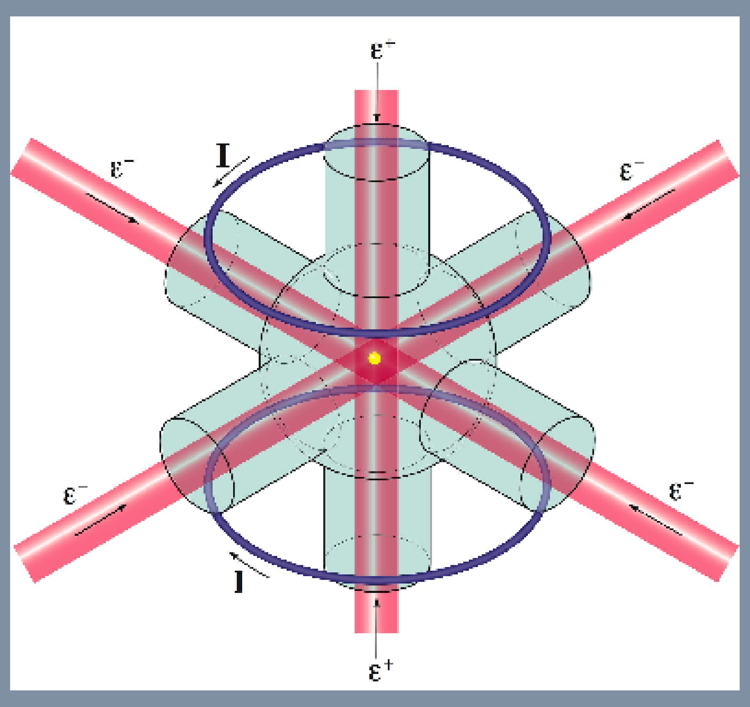
The next step is to cool and trap the atoms using a combination of optical and magnetic fields. This spatial configuration of the fields is referred to as a Magneto-Optical Trap (MOT). Using the MOT, we anticipate cooling the atoms to micro-Kelvin temperatures.

Magnetic Field



- Two coils with directionally opposite current
- Groups the atoms at the center of the chamber
- Restoring force $F = -\kappa x$
- Constraints:
  - Radius
  - Separation b/t coils
  - Current supply
  - N- turns

Optical Field



- 3 pairs of counter-propagating laser beams
- Red detuned
- Damping force $F = -\beta\dot{x}$
- Constraints:
  - 2 pairs of laser beams due to chamber geometry

Together the fields create a system where the atoms preferentially absorb photons where the net momentum change is always oriented towards the center of the trap.

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