Semi-Automatic Retrieval of Temperature and Density in a Magneto-Optical Trap

Dan Mickelson
Supervisor: Brett D. DePaola

July 28, 2009

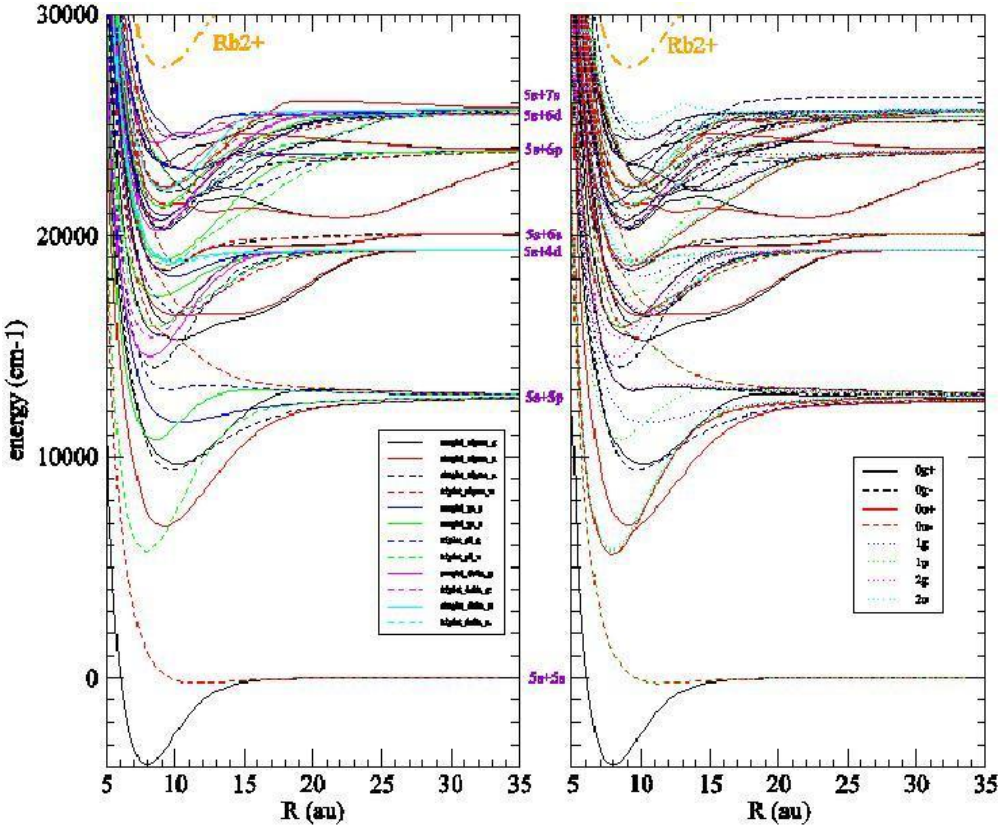
Introduction

- My Project
  - To design, construct, and test an apparatus to measure temperature and density in a MOT.
- Why am I doing this?
  - We want to better understand the conditions just before photoassociation.

Imaging beam to take measurements

Photoassociation of Molecules

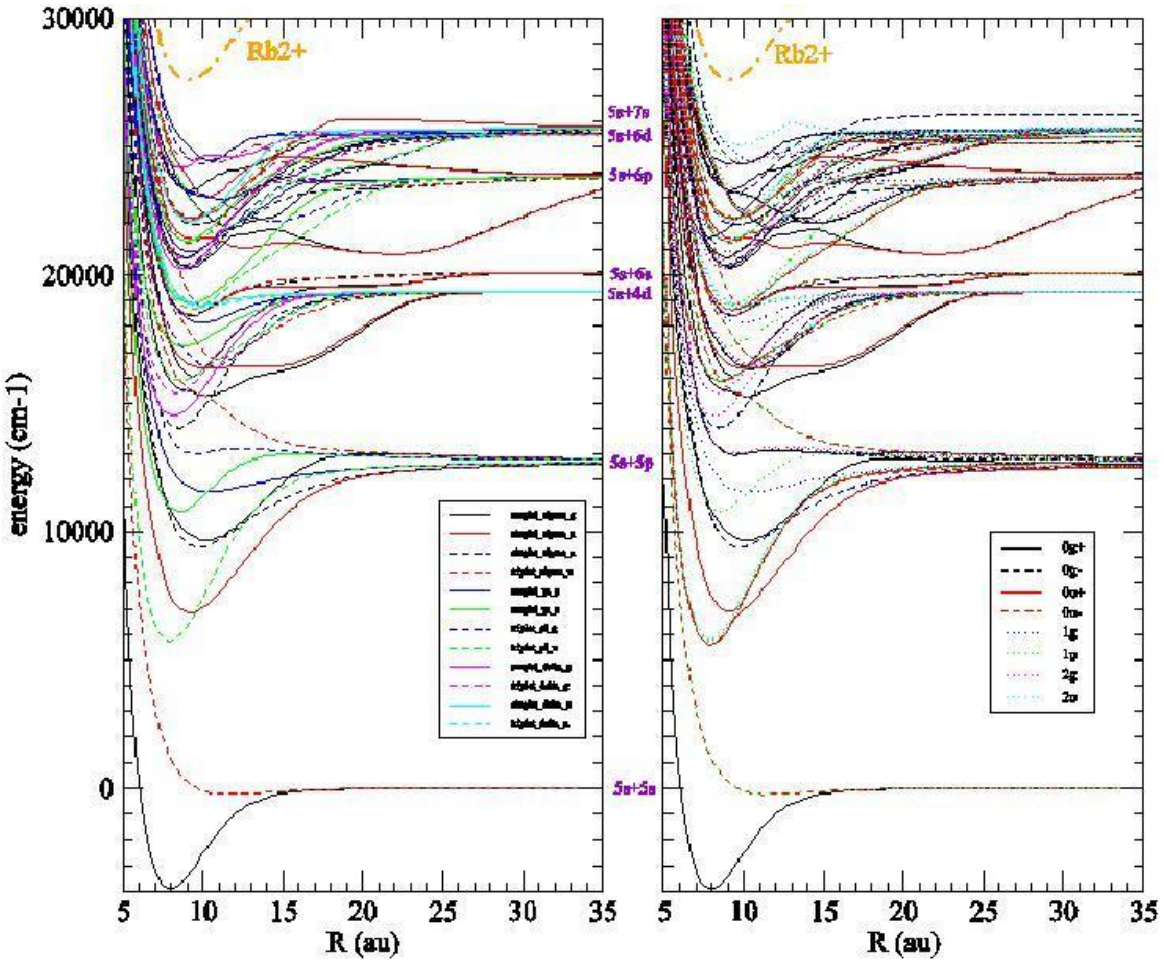
- Incident light excites a Rb atom pair
  - Excites to an excited quasi-molecule state
- A photon is then emitted
  - Results in either bound molecule, or original atom pair



Photoassociation with Excitation

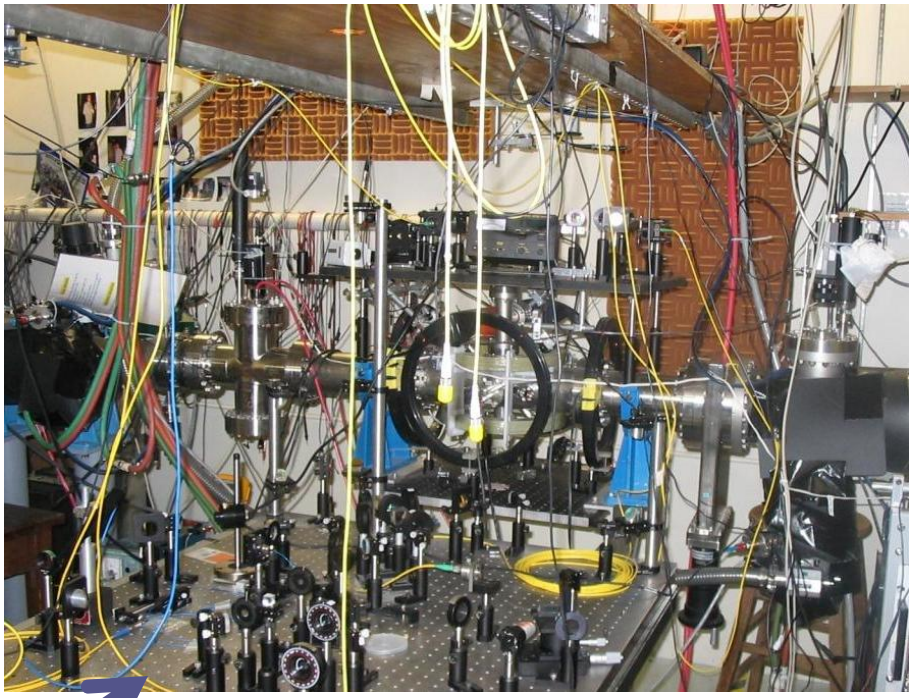
As the molecule is formed, it follows potential curves that depend on the energy state of each atom

In MOTRIMS, atoms are excited a second time and then detected by forming a molecular ion



Magneto-Optical Traps

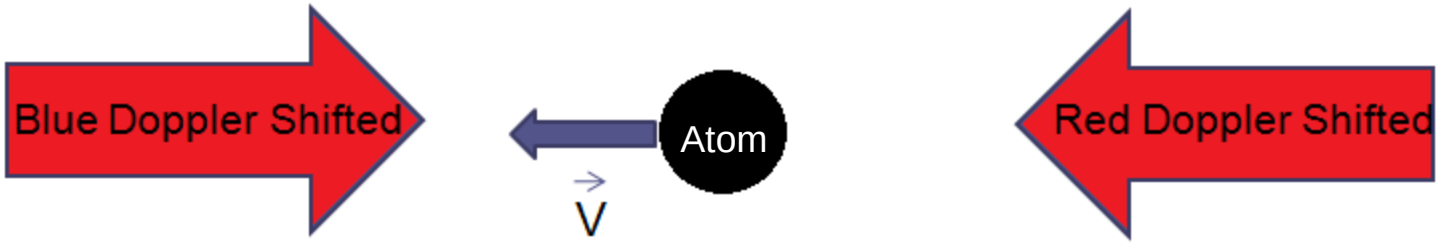
- Also known as a MOT.
- Uses a combination of sub-resonant lasers and a magnetic field gradient.
- Has a variety of applications
  - Allows to trap neutral atoms
  - Cools atoms to micro-Kelvin temperatures
  - Can be used for BEC
  - Most importantly (for us) allows for the conditions to achieve photoassociation



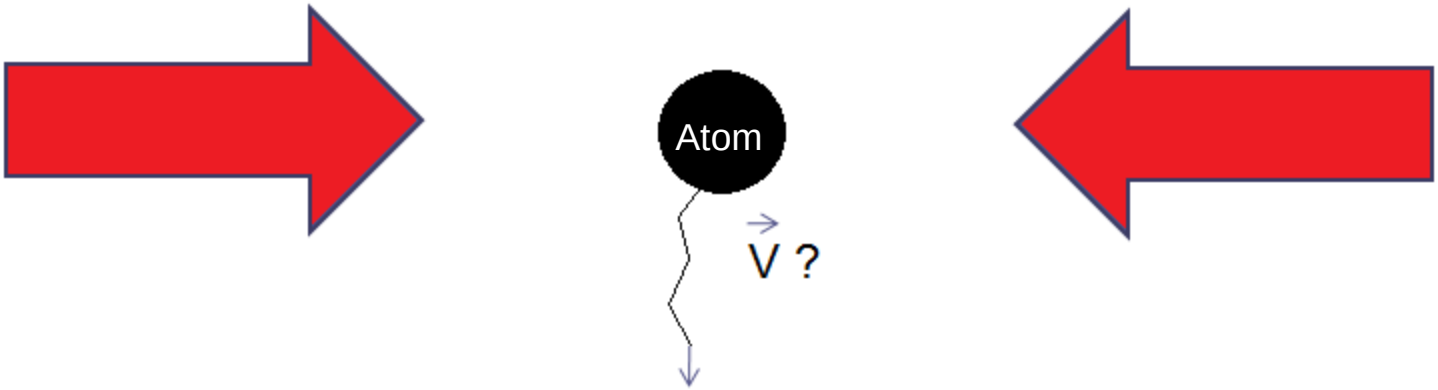
The MOTRIMS MOT

What is Happening?

Let's take a look in 1-dimension…



A photon is absorbed and the atom becomes excited—then a photon is emitted.



As this process proceeds, a net change in velocity occurs, and eventually the atom is slowed to a low speed

But There's More…

What if an atom is moving too fast or too slow?

The atoms will not see the Doppler shift into resonance, so we need to add something.

Also, we have nothing to keep the atoms trapped in the center.

Trapping the Atoms

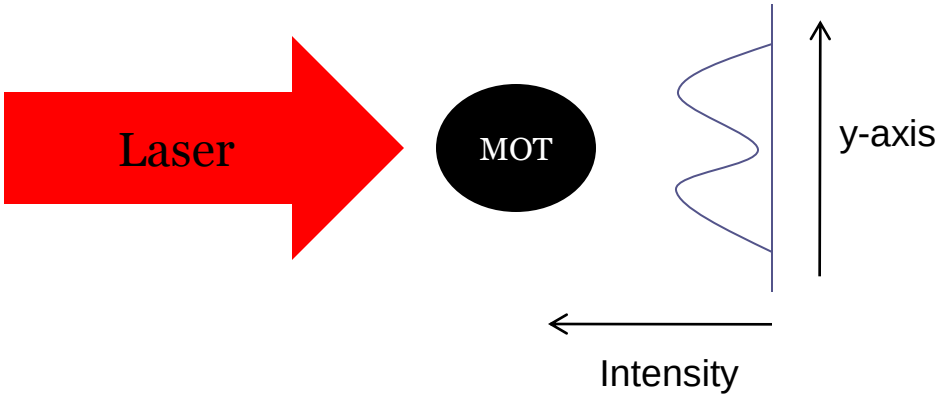
A formed MOT

- Combination of circularly polarized light and a magnetic field gradient
  - Zeeman shifts increase linearly from the center of the magnetic field
  - Magnetic field created by anti-Helmholtz coils
  - Light is circularly polarized to allow transitions that are spatially dependent

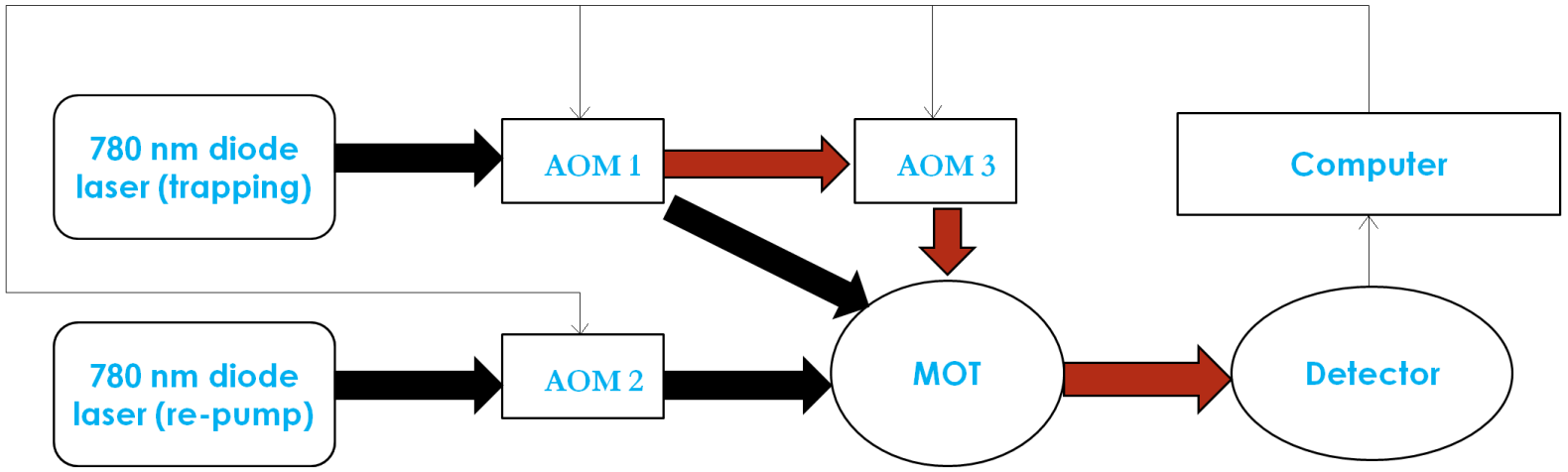
Measuring Temperature and Density

- What do we want?
  - Density measurement that is differential in both r and z.
  - Cost effective and convenient.

- How to do it:
  - The MOT image will be a "shadow" on our detector.
  - After trap is turned off, the MOT will expand corresponding to the temperature.



Schematic of Apparatus



Progress

- Sent the beam through the MOT
- Used the recycled trapping beam
- Fabricated a shutter device to fully extinguish the beam

Summary and Future Work

- Optical set-up is complete
- Probe beam is attenuated and has adjusted frequency
- Plenty of work still needs to be done
- Timing mechanism to control the CCD camera and beam
- Add a static magnetic field to define a quantization axis
- Software to store and interpret data

Thank you for Listening

A special thanks to Charles Fehrenbach, Larry Weaver, and Kristan Corwin

This work was supported by the National Science Foundation
and the U.S. Department of Energy