ITHACA COLLEGE
School of Humanities and Sciences
Department of Physics

Final Report : SPS Undergraduate Research Award
December 7, 2011
Building a Magneto-Optical Trap

Introduction

Members of the Ithaca College chapter of SPS have embarked upon building a low-cost MOT as outlined in the Carl Wieman papers [1,2,3]. SPS members—under the guidance of Professor Bruce Thompson--have also been advised by Evan Salim a former Ithaca College physics student who is now a Ph.D candidate working with atom traps at the University of Colorado, Boulder. We are starting with a two laser MOT, and we expect to be able to cool and trap atoms of Rb (both the 85 and 87 isotopes) and characterize the number and density of the trapped atoms. According to the Wieman papers, our apparatus should be able to trap 4 x 10^7 atoms[1].

When not in use for research, the MOT will also be used as a laboratory experiment for students. Both the saturated absorption spectroscopy and the MOT itself will yield valuable experience for all of our SPS and other undergraduate students here at Ithaca College. It will provide previously unavailable research opportunities for our students, and it will allow all students here to learn about optics, quantum mechanics, and spectroscopy.

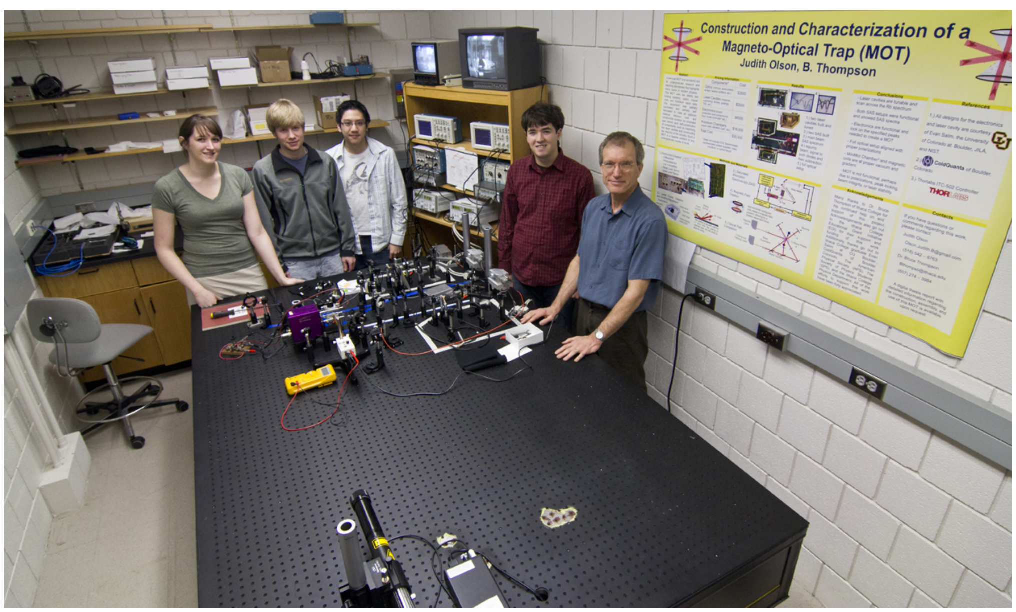

Figure 1: Team members (L to R) Judith Olson, Ryan Jefferis, Josh Cheng, Chris Stathis, Professor Bruce Thompson in the early stages of the project. Not pictured are Drake Builta and Ivan Tso

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Budget

Items to complete the MOT					
Quantity	**Item**	**Vendor**	**Part #**	**Price**	**Cost**
10	Mounting base	Thorlabs	BA1S	5.20	52.00
6	Post holder 3”	Thorlabs	PH3	8.27	49.62
4	Post holder 2”	Thorlabs	PH2	7.70	30.80
5	Post 2”	Thorlabs	TR2	5.19	25.95
4	Post 3”	Thorlabs	TR3	5.42	21.68
2	Waveplate & beamsplitter holders	Thorlabs	FP01	40.30	80.60
8	Mirror mounts 1"	Thorlabs	KMS	33.50	268.00
4	Mirror holder 1"	Thorlabs	MH25	12.20	48.80
1	Right angle bracket	Thorlabs	XT34RA2	20.30	20.30
5	Mirror 1" broadband dielectric	Thorlabs	BB1-E02	75.10	375.50
1	KPC lens -15mm	Thorlabs	LA1540-B	27.90	27.90
1	KPX lens +150mm	Thorlabs	LA1433-B	27.20	27.20
1	Beamsplitter Pelicle 45/55 1” coated	Thorlabs	BP145B2	155.40	155.40
1	Polarizing beamsplitter cube	Thorlabs	PBS252	200.00	200.00
1	Beamsplitter cube mount	Thorlabs	KM100P	59.20	59.20
1	Cube to mount holder	Thorlabs	PM2	14.70	14.70
1	½ wave plate 1” mounted	Thorlabs	WPMH10M-780	300.00	300.00
1	Mount to rotate ½ wave plate	Thorlabs	RSP1C	98.00	98.00
1	Prism mirror 1” broadband dielectric	Thorlabs	MRA25-E02	144.20	144.20
				Total Cost:	***1999.85***

Results

On September 2, 2011 we had our first trapped cloud of cold Rubidium 87 atoms. The cloud lasted for 5 seconds, and further tuning and refinements of the apparatus is now allowing us to stabilize a cloud for several hours. Figures 2-4 show our filling rate and cloud creation.

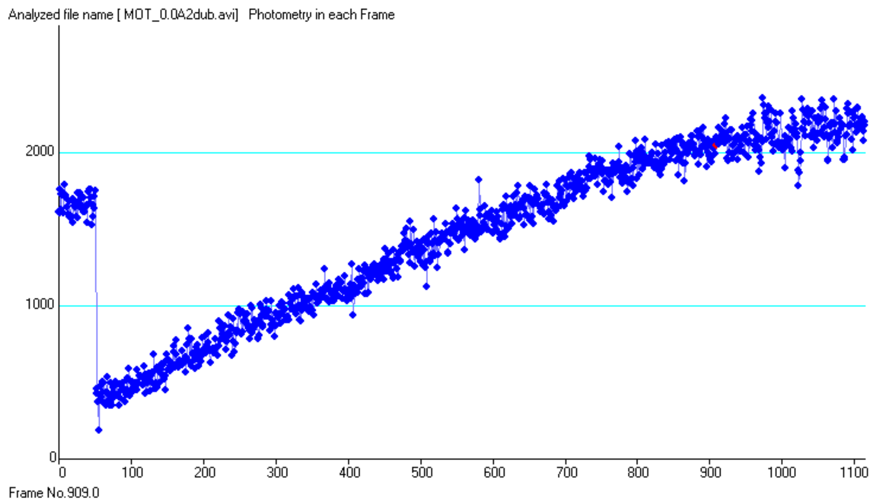

Figure 2: This graph shows the filling rate of Rubidium 87 atoms into the trap in a very high vacuum measured by a video recording. The horizontal scale is the video frame that was taken at a frame rate of 10 per second. The vertical is the spatially integrated intensity in arbitrary units. The trap field was on at the start, turned off to empty the trap, then turned on to start trapping the atoms again. The filling time constant of about 50 seconds is also the lifetime of a single atom in the trap.

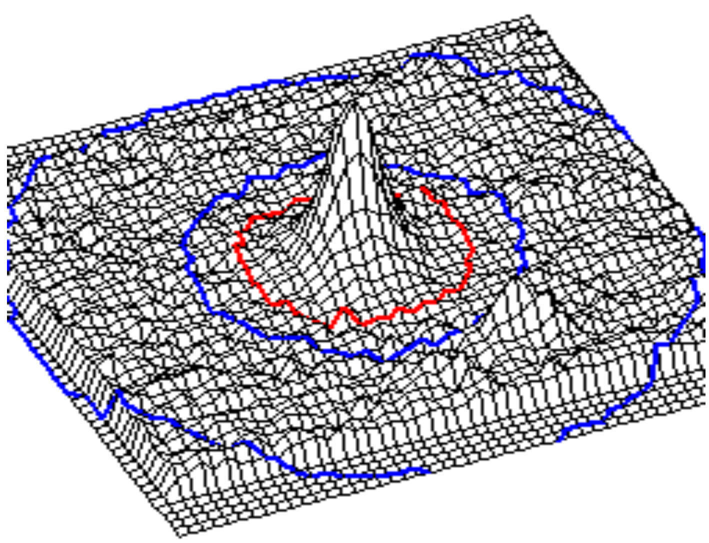

Figure 3: This figure shows the analysis of one video frame taken of a small cloud of Rubidium 87 atoms in the MOT. The peak shows the expected Gaussian spatial distribution. Not so obvious is that the peak is asymmetric due to the fact that the

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horizontal trapping field gradient is ½ of the vertical field in the Maxwell gradient coil configuration.

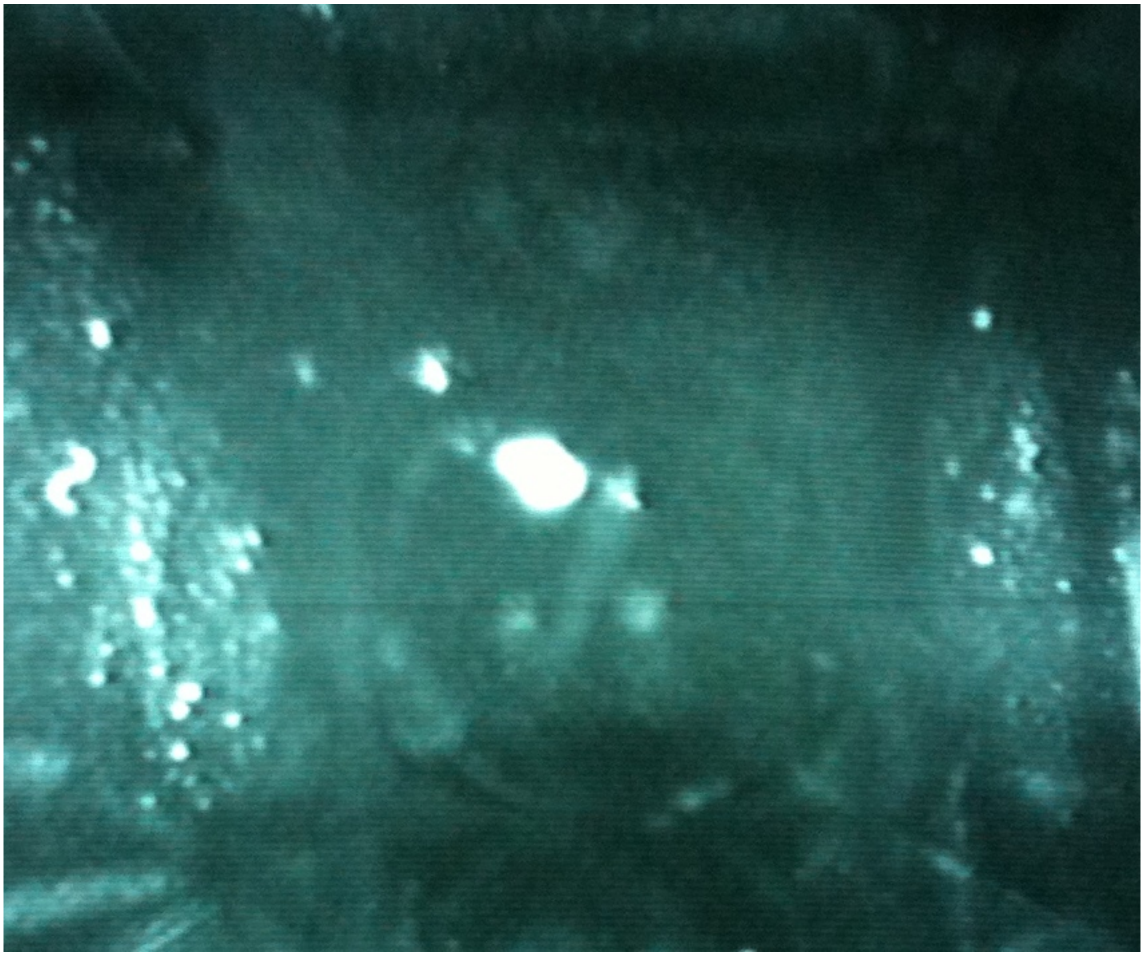

Figure 4: A picture of the first trapped cloud of cold Rubidium 87 atoms in the Ithaca College MOT taken on September 2, 2011. It lasted for about 5 seconds. Further tuning and refinements of the equipment allows us to stabilize a cloud for several hours.

Future Work

Future plans for the equipment include both further research projects with students and the development of advanced teaching laboratory experiments. Research projects include spatial characterization of the trapping beam, spatial characterization of the MOT cloud, measuring the number of atoms in the cloud as a function of beam and magnetic field intensity, further measurements of the filling rate as a function of chamber pressure, beam intensity and magnetic field, and measurement of the cloud temperature. Planned laboratory experiments include characterization of the laser diode, doppler-free saturated absorption spectroscopy and spectroscopy of slow atoms.

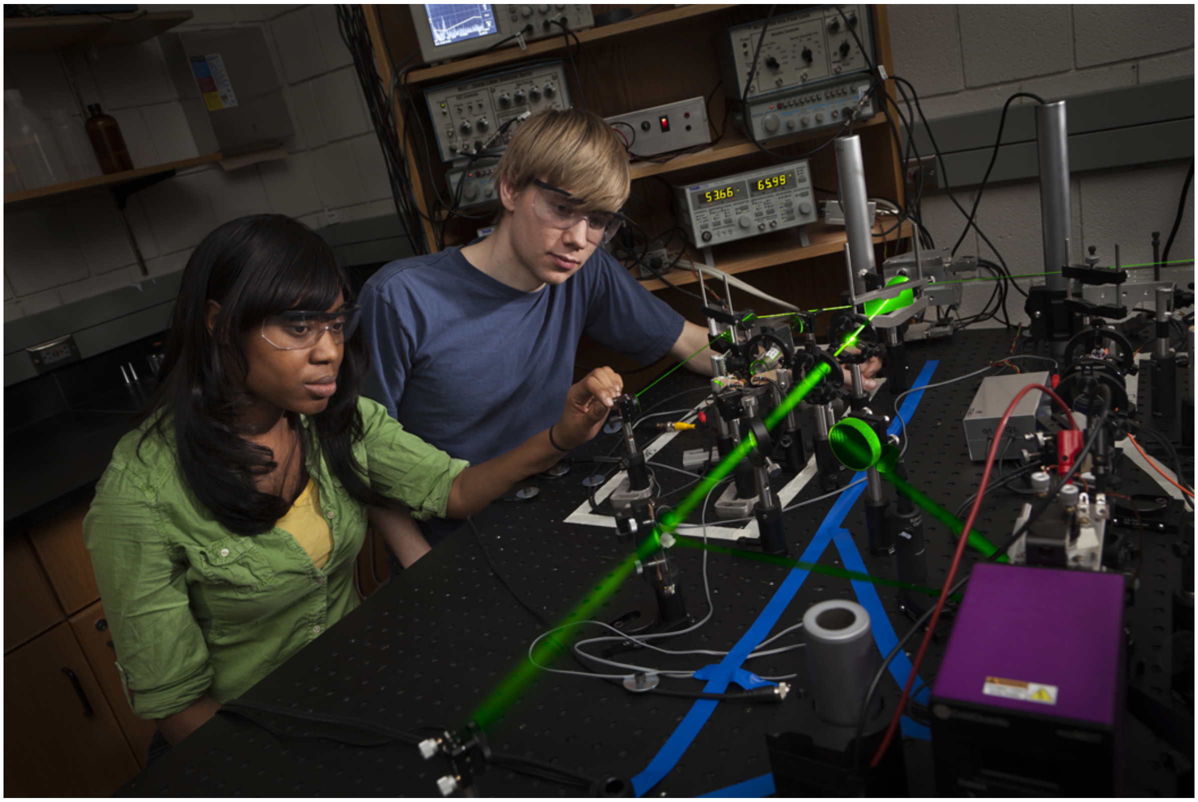

Figure 5: Our MOT was also the subject of a professional photo shoot by our marketing and communications division. Jodi-Ann Mclean and Ryan Jefferis are pictured in this composite image that is now part of Ithaca College's official photographic database. [Note: because this photograph is part of our official collection we had to receive permission to include it in this report. This photo is not intended for reproduction or to be used for any promotional purposes. All rights reserved Ithaca College. Photo courtesy of Ithaca College/by Bill Truslow]

Final Thoughts

Thank you to SPS for providing these funds to help our department provide modern physics experiences for the SPS students and for the rest of the physics majors.

References

1. Wieman, Carl, Gwenn Flowers and Sarah Gilbert, "Inexpensive laser cooling and trapping experiment for undergraduate laboratories." Am. J. Phys. Vol. 63, 317-330, 1995.

2. MacAdam, K.B., A. Steinbach and C. Wieman, "A narrow-band tunable diode laser system with grating feedback, and a saturated absorption spectrometer for CS and Rb", Am. J. Phys. Vol. 60, 1098-1111, 1992.

3. Wieman, Carl E. and Leo Hollberg, "Using diode lasers for atomic physics", Rev. Sci. Instrum. Vol 62, 1-20, Jan. 1991.