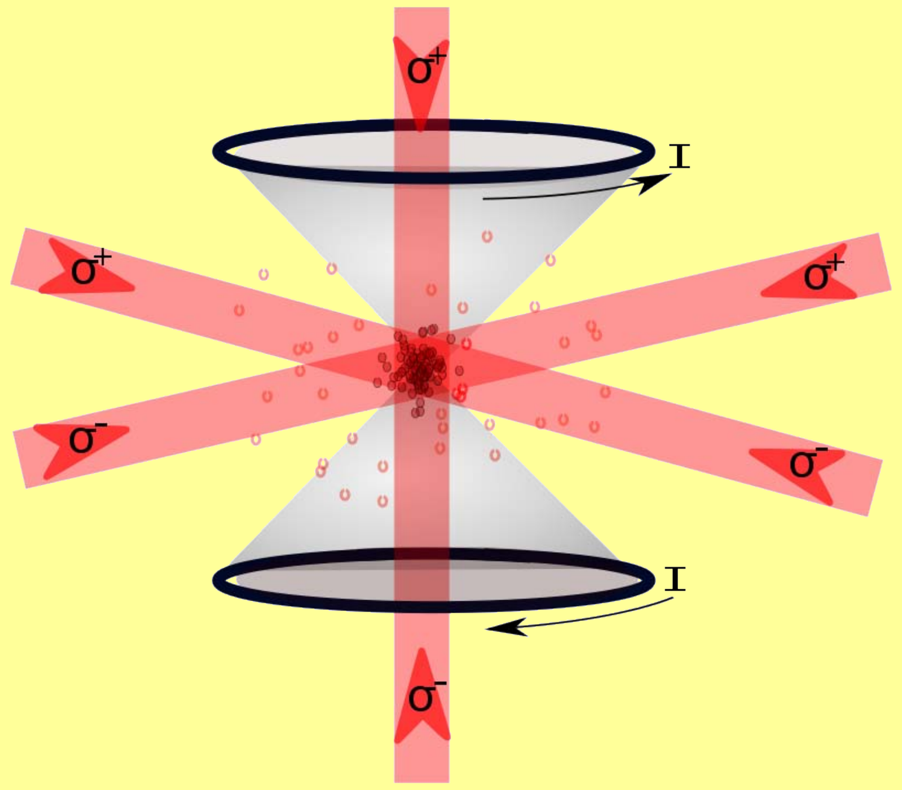


Neophytes Build a Magneto-Optical Trap

ITHACA COLLEGE

Judith B. Olson, Bruce Thompson

Written Report and Thesis Available at: http://faculty.ithaca.edu/bthompso/docs/

Abstract

A Magneto-Optical Trap (MOT) is a wonderful tool for undergraduate research and teaching laboratories that highlights many topics in modern physics. Our poster describes the design decisions and process that resulted in an operational MOT using the resources and time available at an undergraduate institution. By building many components and purchasing others, we were able to complete the MOT in approximately two years at a cost of about $40,000. Neither of us had experience with optical systems prior to starting work on the project. Recommendations are given for a phased build of a MOT.

MOT Techniques

Experimental Technique	Where Applied
Machining	Laser cavity parts Optical supports
Electronics Design, Layout, & Construction	Diode current control Diode temperature control Sidelock servo Peaklock servo Photodiode amplifier Differential photodetector
Optics	Saturated Absorption Spectroscopy (SAS) Beam shaping Beam splitting Beam polarization
Vacuum Systems	SAS Rb cell MOT cell
Computer Programming	System control for measurements

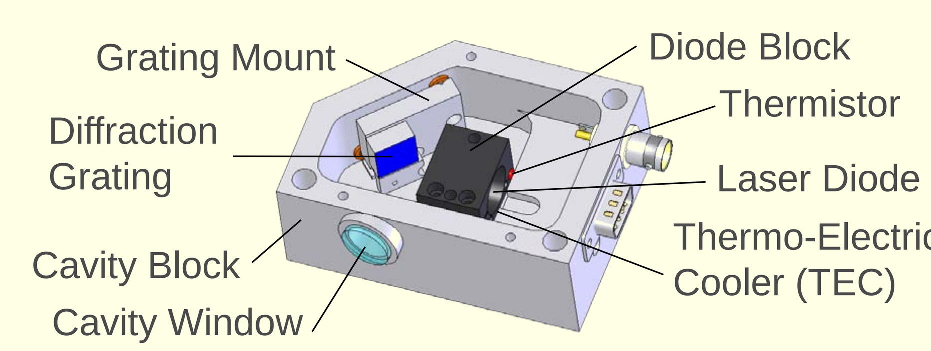
MOT Education Uses

Area	Principle/Concept
Extended Cavity Diode Laser (ECDL)	Semiconductor physics Internal lasing modes 2-D aperture diffraction Beam collimation Diffraction gratings Extended cavity modes Resonant feedback Electrical feedback via grating and diode control
Laser Light & Interactions	Stimulated emission & coherence Linear & circular polarization Absorption; stimulated & spontaneous emission Photon momentum Photon angular momentum
Optical Components	Partial reflection & beamsplitters Polarizing beamsplitters Beam expander optics Half & quarter waveplates
Rubidium Characteristics	Shell structure & alkali metals Vapor pressure Isotopic composition Nuclear spin Atomic energy levels Fine splitting Hyperfine splitting
Optical Molasses	Kinetic gas theory Photon scattering Doppler shift
Magneto-Optical Trap	Maxwell coil magnetic field (anti-Helmholtz) Electronic magnetic moment Zeeman splitting Mechanics of atom trajectories
MOT Cloud Characteristics	Atom count & number density Capture rates & lifetime in the cloud Doppler & recoil temperature
Going Further with the Project	Evaporative cooling Magnetic compression RF cooling Bose-Einstein Condensation

Three Phase Construction

I. Extended Cavity Diode Laser (ECDL)

1.) ECDL



2.) Electronics: Temperature and Current Control via ITC-502™

THORLABS

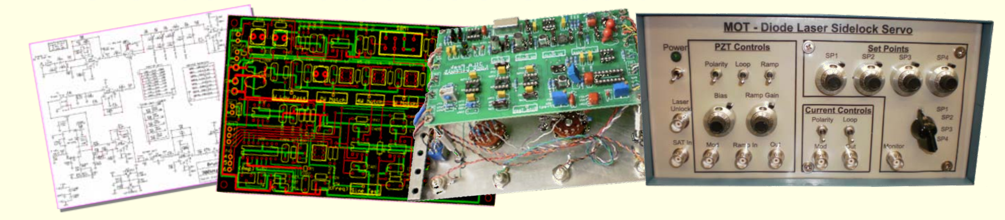
3.) Photodiode Sensor

Measurements: Laser diode characteristics
ECDL characteristics

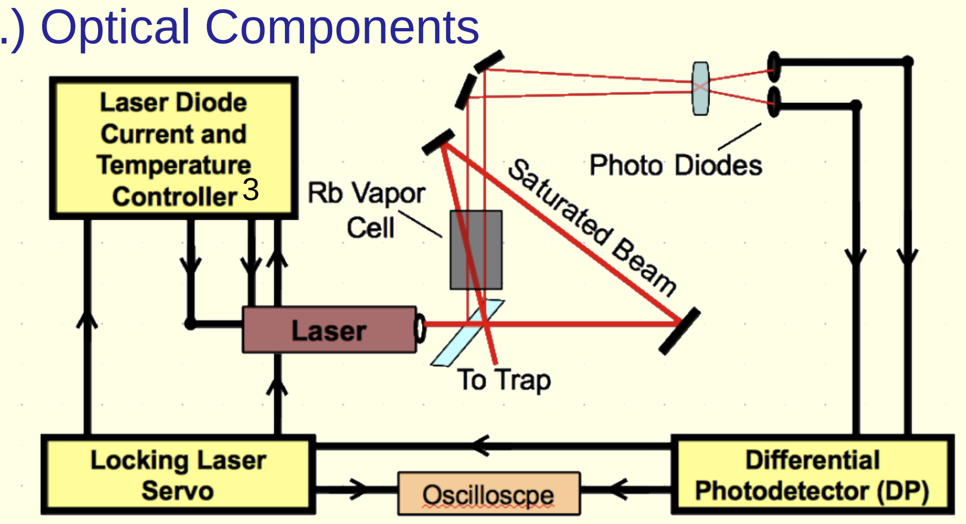
Approx. Cost: $3,000

II. Saturated Absorption Spectroscopy

1.) One working ECDL
2.) Rubidium Reference Vapor Cell
3.) Electronics: Side-Lock Servo and Differential Photodiode Circuit



4.) Optical Components



Measurements: Doppler broadened spectrum
Doppler-free spectrum

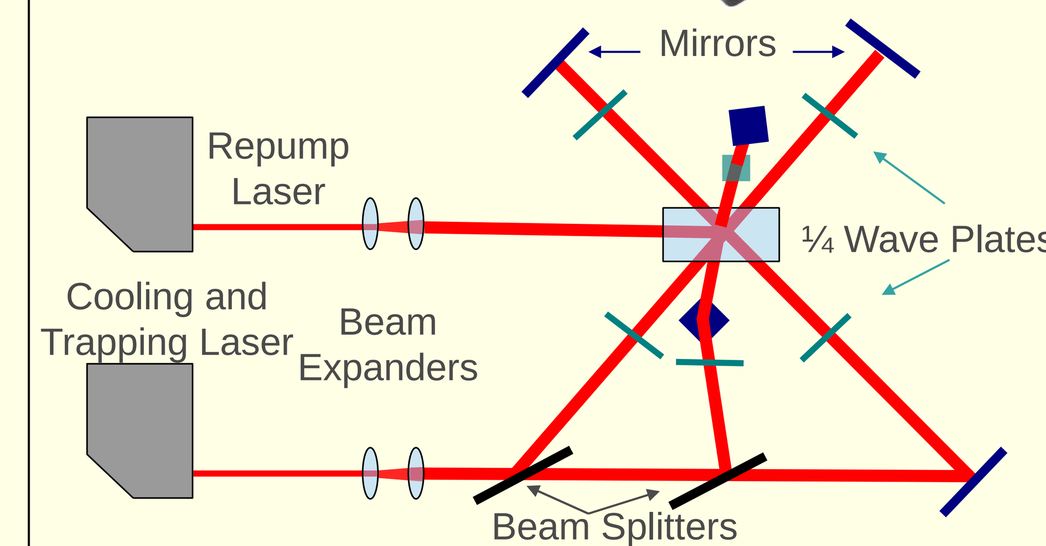
Cost: $3,000 previous + 2,000

III. Magneto-Optical Trap (MOT)

1.) Two Working SAS Systems
2.) Rb MOT Chamber - miniMOT™

ColdQuanta

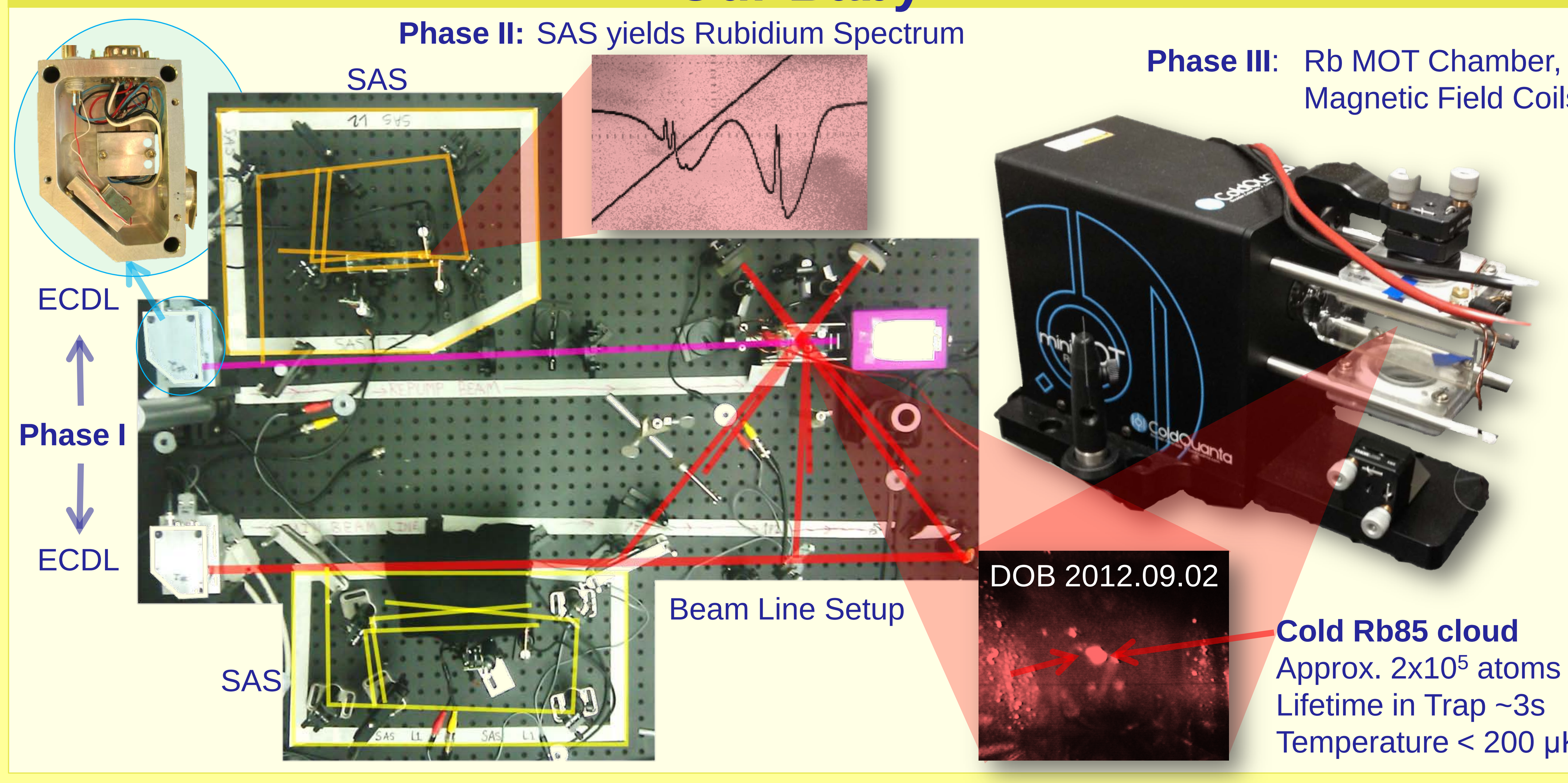
3.) Magnetic Coils
4.) Optical Components



Measurements: Create the cold cloud
Cloud characteristics

Cost: $10,000 previous + $25,000 ≈ $35,000

Our Baby



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Contacts

Question/Comments? Contact:
Judith Olson: Judith.Olson@Colorado.edu
Bruce Thompson: Bthompso@ithaca.edu

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