Design and Construction of Frequency Stabilized External Cavity Diode Lasers

Peter Heuer
University of Rochester

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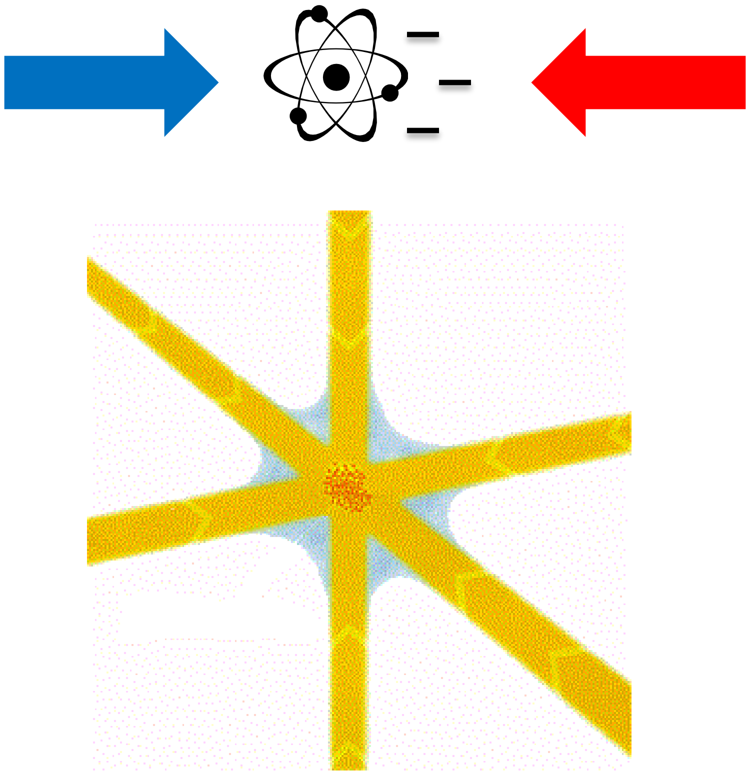
Why We Need Frequency Stabilized Lasers: Laser Cooling

Laser cooling requires lasers with:

- Narrow linewidth to precisely address individual atomic transitions
- Stable frequency over time (low frequency drift)

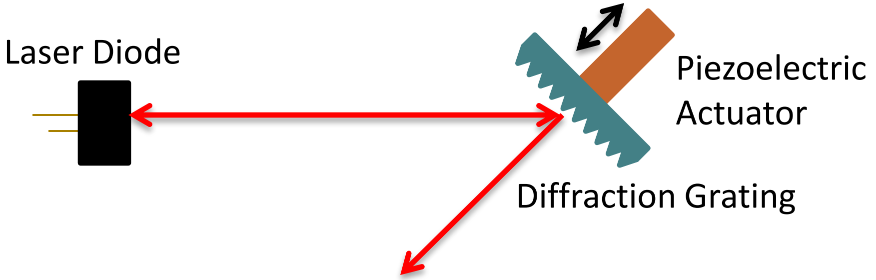


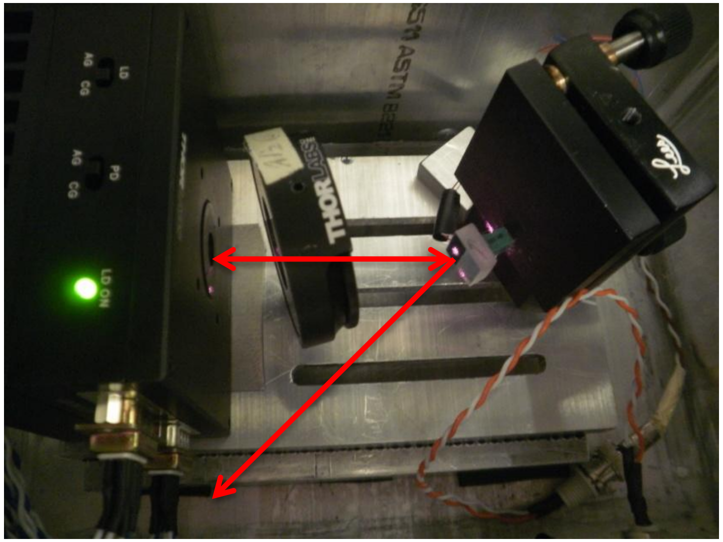
(http://www.nobelprize.org/nobel_prizes/physics/laureates/1997/illpres/trapping.html)

External Cavity Littrow Configuration

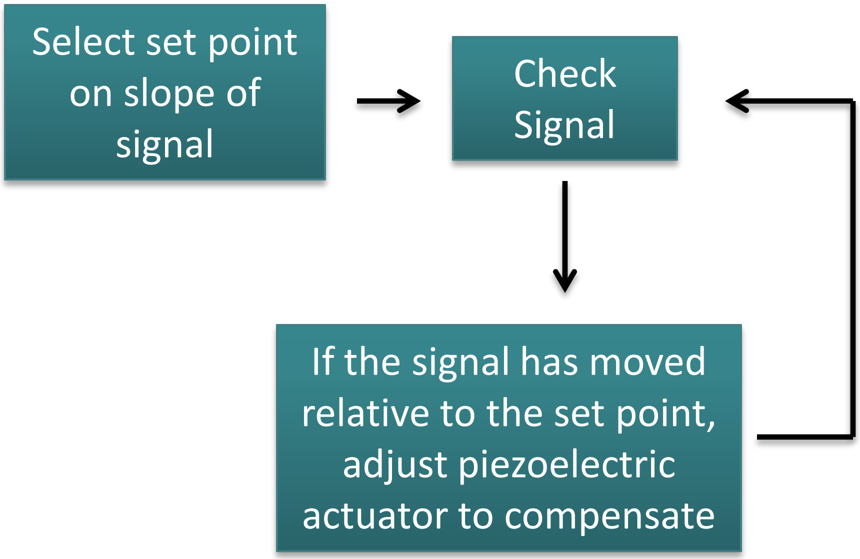
An external cavity narrows the linewidth and allows us to tune the frequency of the laser:

- The diffraction grating reflects only the chosen frequency back into the diode
- Moving the grating with the piezoelectric actuator changes the cavity length





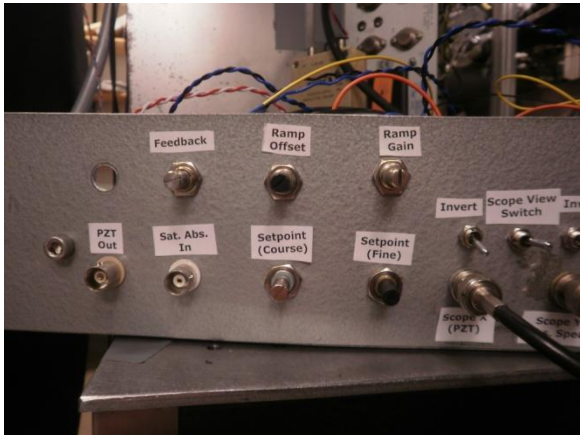
Locking a Laser

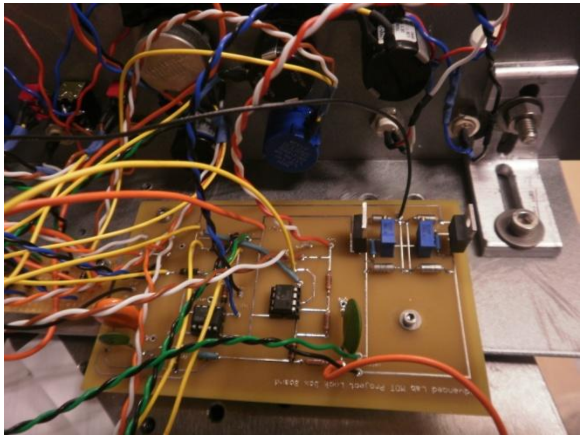


Select set point on slope of signal

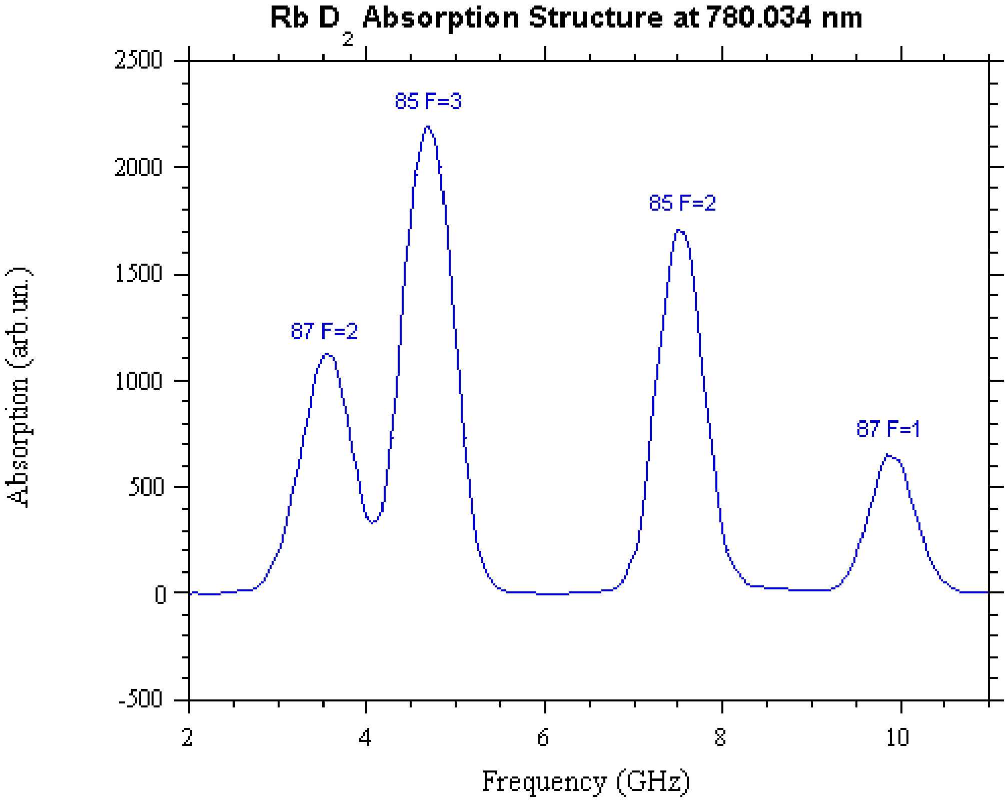
Check Signal

If the signal has moved relative to the set point, adjust piezoelectric actuator to compensate

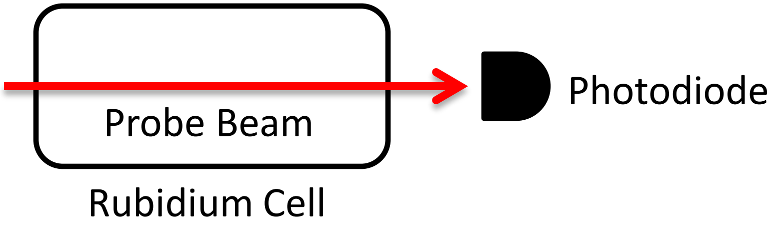




Doppler Broadening

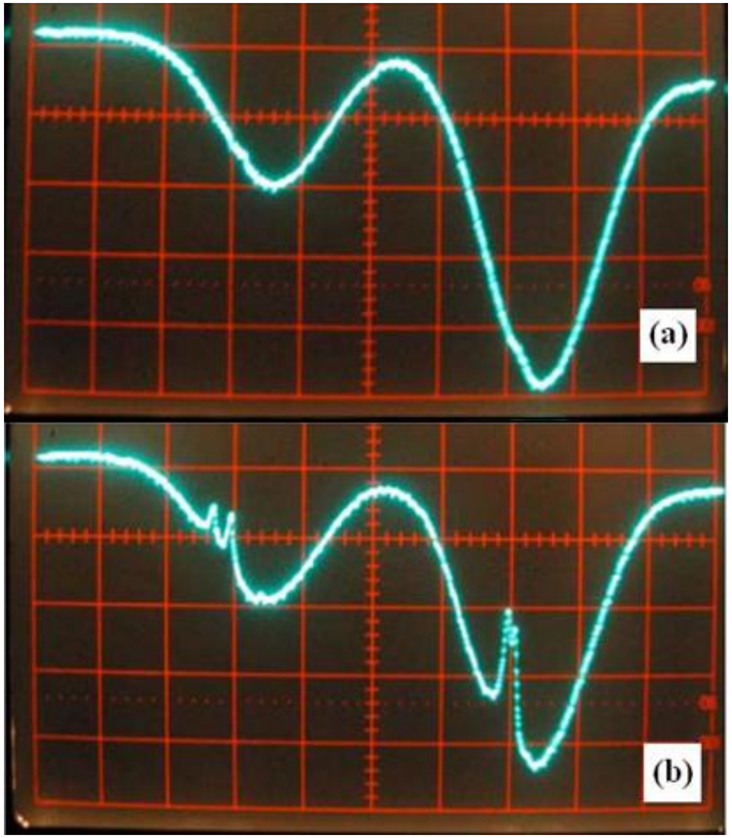


(http://digilander.libero.it/lucch/LIDRb.html)

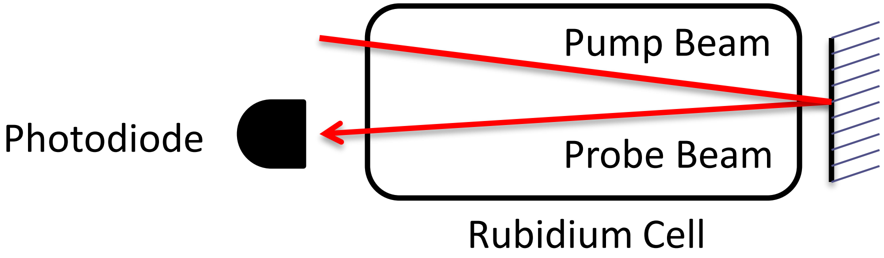


Doppler shifting of the laser by thermal motion of atoms causes transitions to widen into Doppler peaks

Saturated Absorption Spectroscopy



(Georgia Tech sat. spec. lab manual)

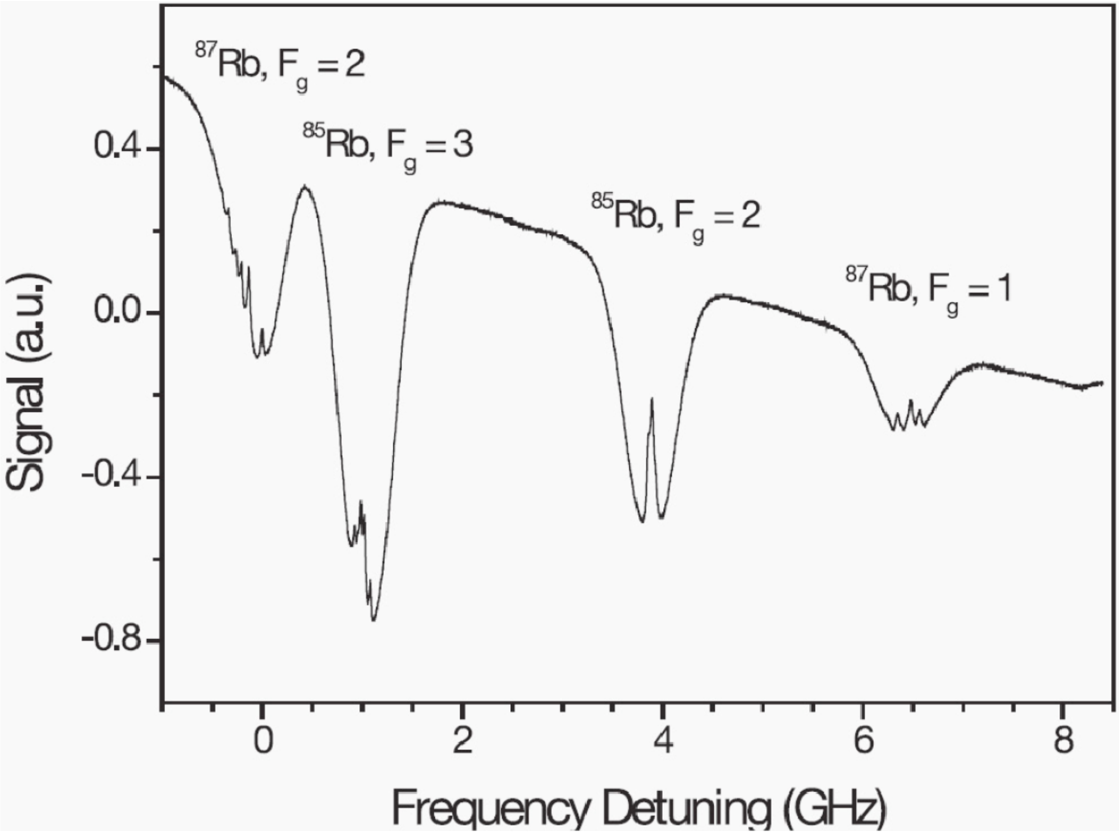


- Off resonance: beams address different atoms, both are absorbed.

- On resonance: beams both address only zero-velocity atoms. Atoms are excited by the pump beam, so the probe beam is not absorbed.

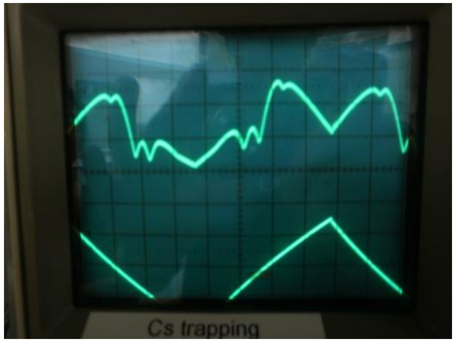
Observing Hyperfine Splitting

Sample Spectra

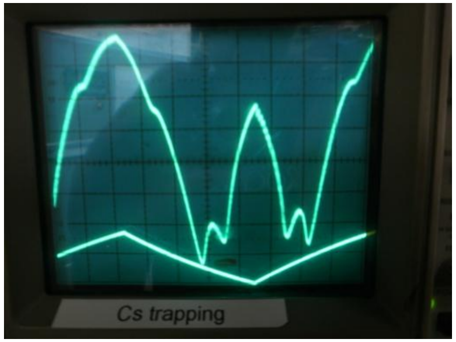


(Georgia Tech sat. spec. lab manual)

Our Spectra

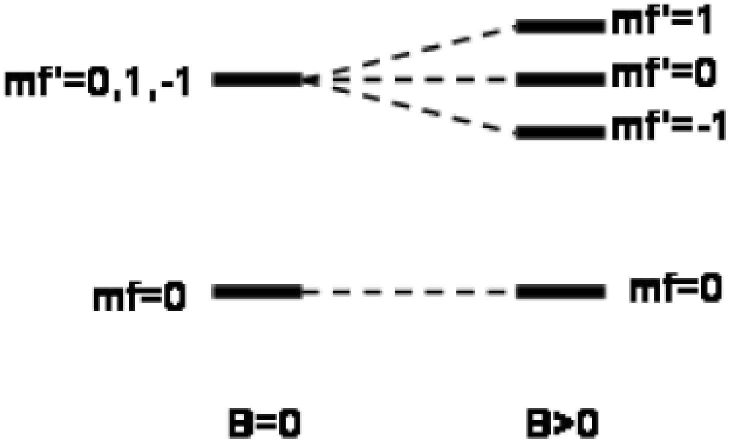


^{87}Rb, F_g = 1



^{85}Rb, F_g = 3

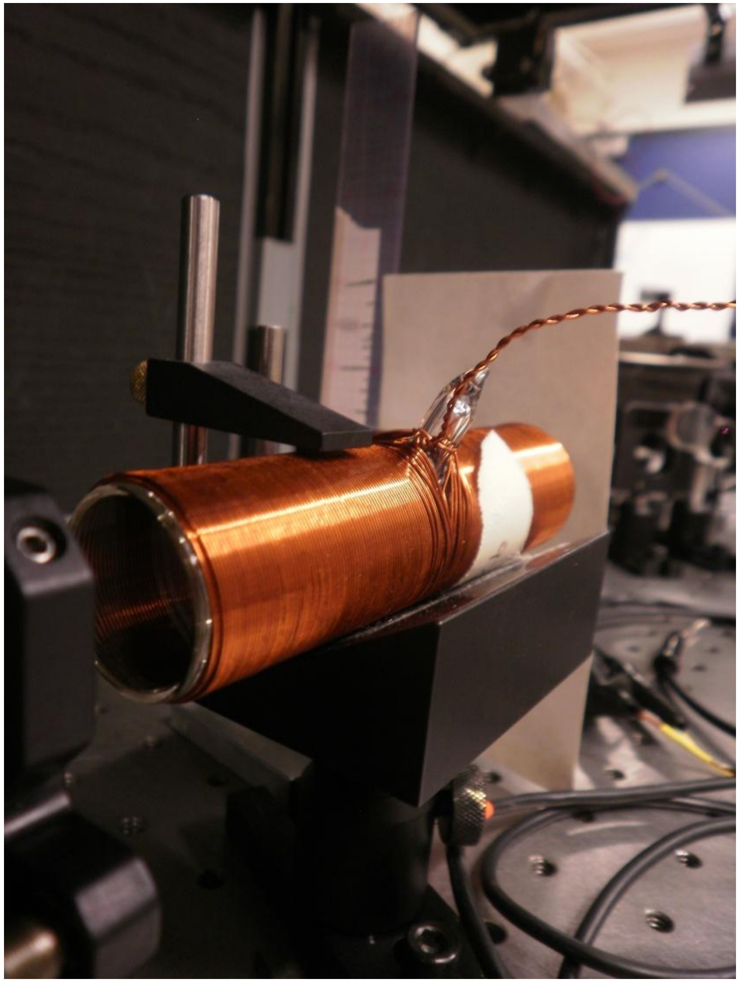
Dichroic Atomic Vapor Laser Locking (DAVLL)



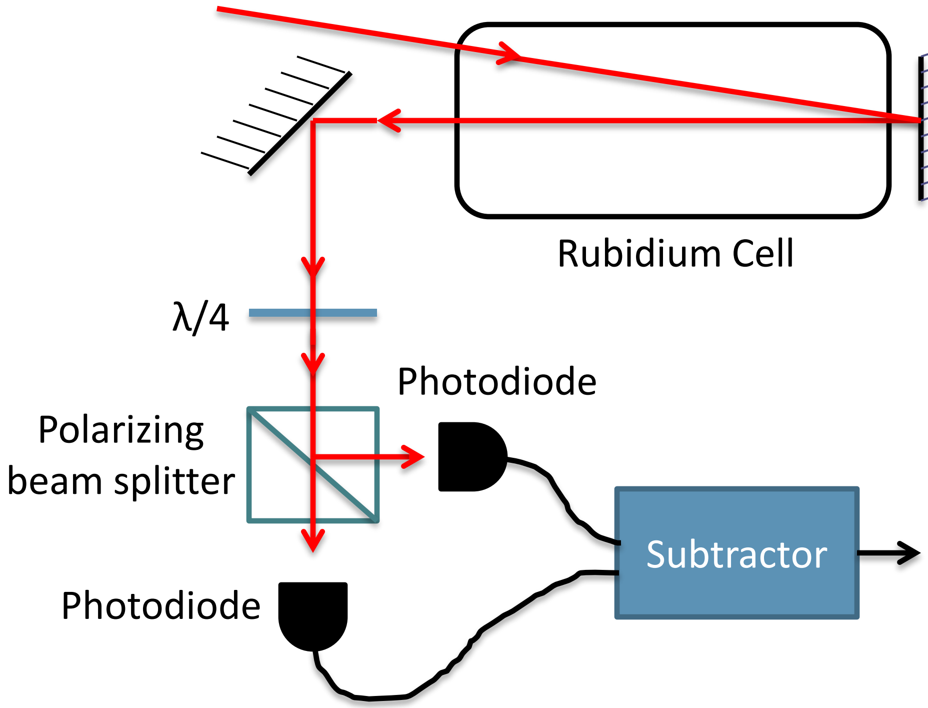
(Tscherneck, 2008)

- A magnetic field applied to the Rubidium cell causes Zeeman splitting

- Different Zeeman levels absorb different circular polarizations of light



Dichroic Atomic Vapor Laser Locking (DAVLL)



Rubidium Cell

λ/4

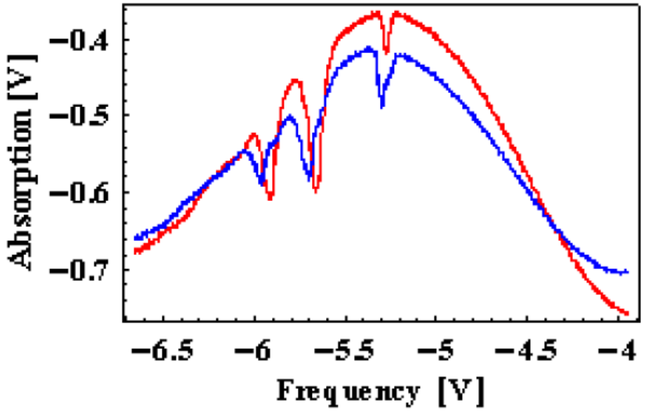
Photodiode

Polarizing beam splitter

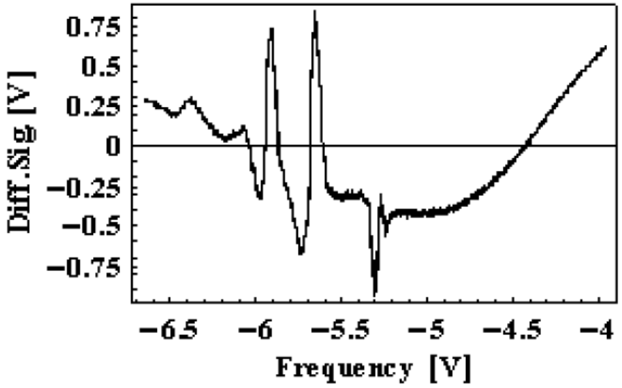
Subtractor

Photodiode

Photodiode Signals



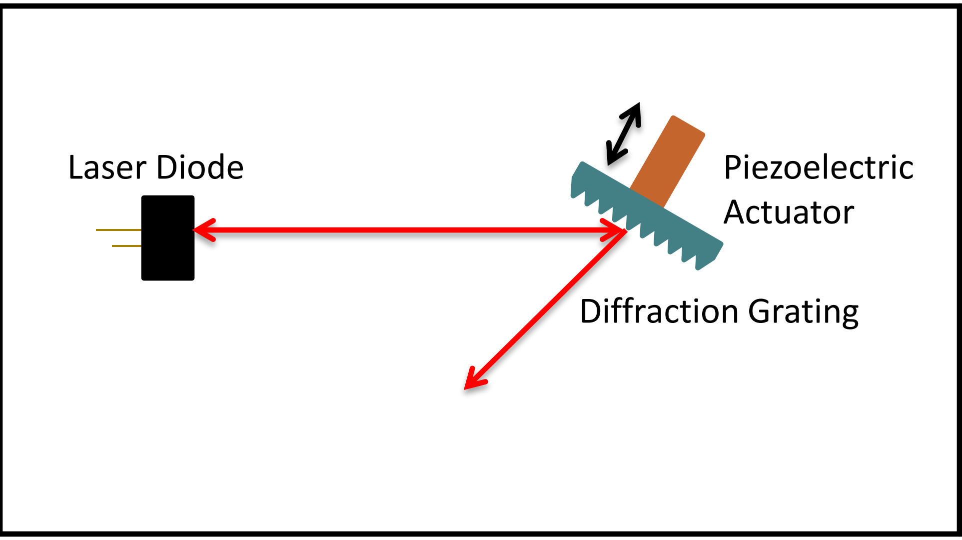
Subtracted Signals



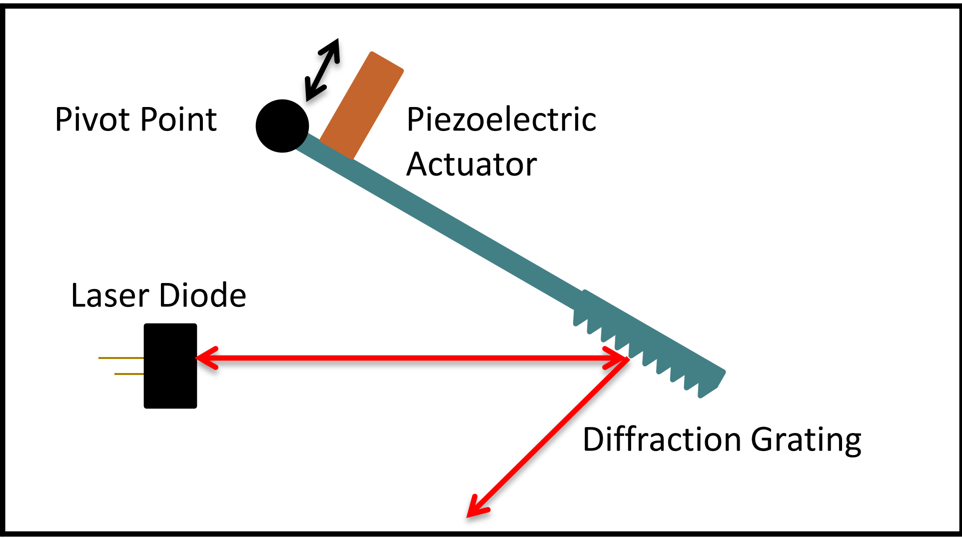
(Tscherneck, 2008)

Future Work: Mode-hop Suppression

Current Cavity Arrangement

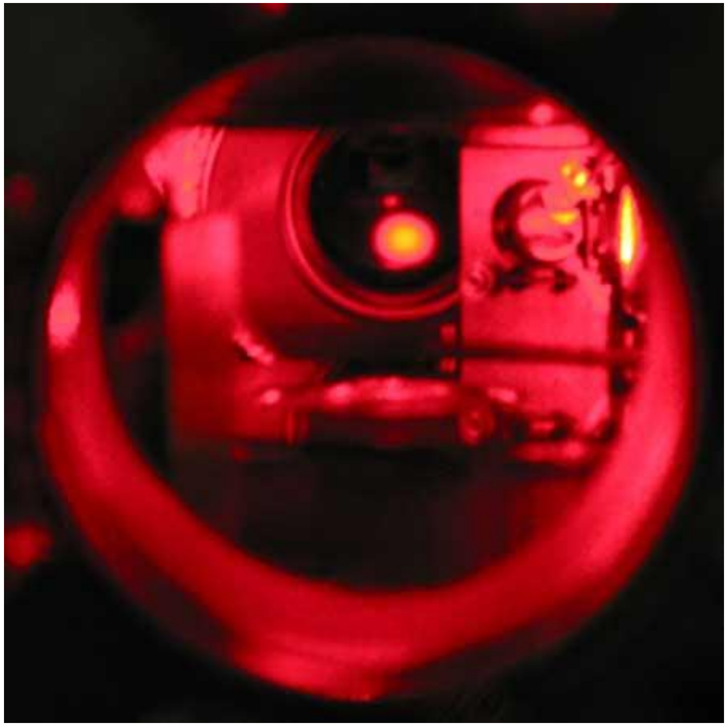


Mode-hop Free Cavity



Future Work: MOT Construction

(http://www.coldquanta.com/Products__Cold_Atoms.html)



(http://www.laserfest.org/lasers/innovations.cfm)

Acknowledgments

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- Connie Jones
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References

The Georgia Tech Saturation Spectroscopy lab manual
http://advancedlab.physics.gatech.edu/labs/SaturationSpectroscopy/SatSpecManual.pdf

“Stabilizing a Diode Laser to an External Reference” by Thijs Hoogeveen, 2003
https://www.kvi.nl/~trimp/web/Theses/ThijsHoogeveen.pdf

“Molecule Chips” by Michaela Tscherneck, 2008
https://urresearch.rochester.edu/institutionalPublicationPublicView.action?institutionalItemId=5635&versionNumber=1

M. De Labachelerie and G. Passedat. “Mode-hop suppression of Littrow grating-tuned lasers.” *Applied Optics* 32.3 (1993): 269-274