Design and Construction of Frequency Stabilized External Cavity Diode Lasers

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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)

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

Doppler shifting of the laser by thermal motion of atoms causes transitions to widen into Doppler peaks.
Saturated Absorption Spectroscopy

- 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.

(Georgia Tech sat. spec. lab manual)
Observing Hyperfine Splitting

Sample Spectra

Our Spectra

(Georgia Tech sat. spec. lab manual)
Dichroic Atomic Vapor Laser Locking (DAVLL)

- A magnetic field applied to the Rubidium cell causes Zeeman splitting
- Different Zeeman levels absorb different circular polarizations of light

(Tscherneck, 2008)
Dichroic Atomic Vapor Laser Locking (DAVLL)

\[ \frac{\lambda}{4} \]

Rubidium Cell

Photodiode

Polarizing beam splitter

Photodiode

Subtractor

Photodiode Signals

Absorption [V]

Frequency [V]

Subtracted Signals

Diff. Sig [V]

Frequency [V]

(Tscherneck, 2008)
Future Work: Mode-hop Suppression

Current Cavity Arrangement

- Laser Diode
- Piezoelectric Actuator
- Diffraction Grating

Mode-hop Free Cavity

- Laser Diode
- Pivot Point
- Piezoelectric Actuator
- Diffraction Grating
Future Work: MOT Construction

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

(http://www.laserfest.org/lasers/innovations.cfm)
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The Georgia Tech Saturation Spectroscopy lab manual

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