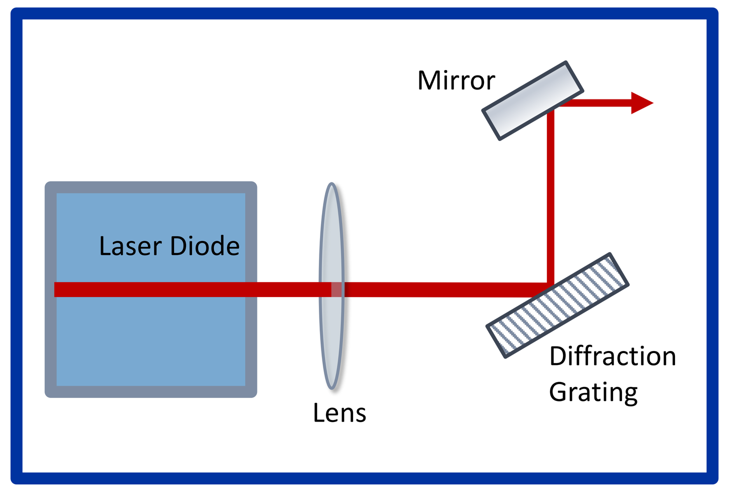
Frequency Stabilization of a Diode Laser to the Rb D2 Transition

Charlotte Zehnder, Will Bodron
Department of Physics, University of Kentucky
Research Mentors: Dr. Wolfgang Korsch

Abstract

The polarization of dense spin-polarized helium-3 targets can be measured using the Faraday Rotation of alkali metals. Small amounts of the alkali metals Rb and K will be present in the target if the helium-3 nuclei are polarized by spin exchange optical pumping. An external-cavity diode laser emitting frequencies of the D2 transitions of Rb or K will maximize the rotation of linearly polarized light due to the Faraday effect. Small magnetic fields due to the spin-polarized 3He nuclei can be measured because of this effect, given the laser's frequency remains stable over a long enough time frame. However, diode lasers will drift in frequency off the D2 resonance over time. We used a Saturated Absorption method to resolve a Doppler-Free spectrum as a reference for this frequency and optimized the peaks by leveraging polarization changes to overlap the paths of the "probe" and "pump" beams used to measure absorption. Rb85 F=3 transition provided a strong error signal optimal for the laser's Top of Fringe locking method. We successfully reduced drift by locking our laser to this transition using lock-in techniques.

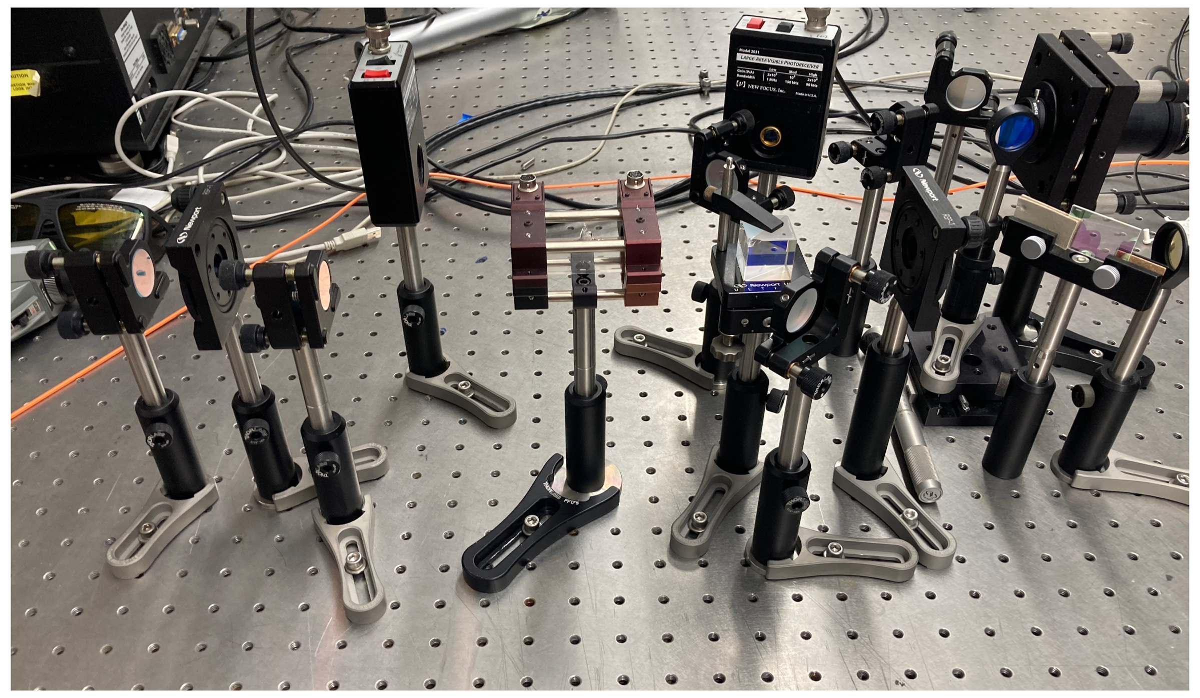
Laser Stabilization



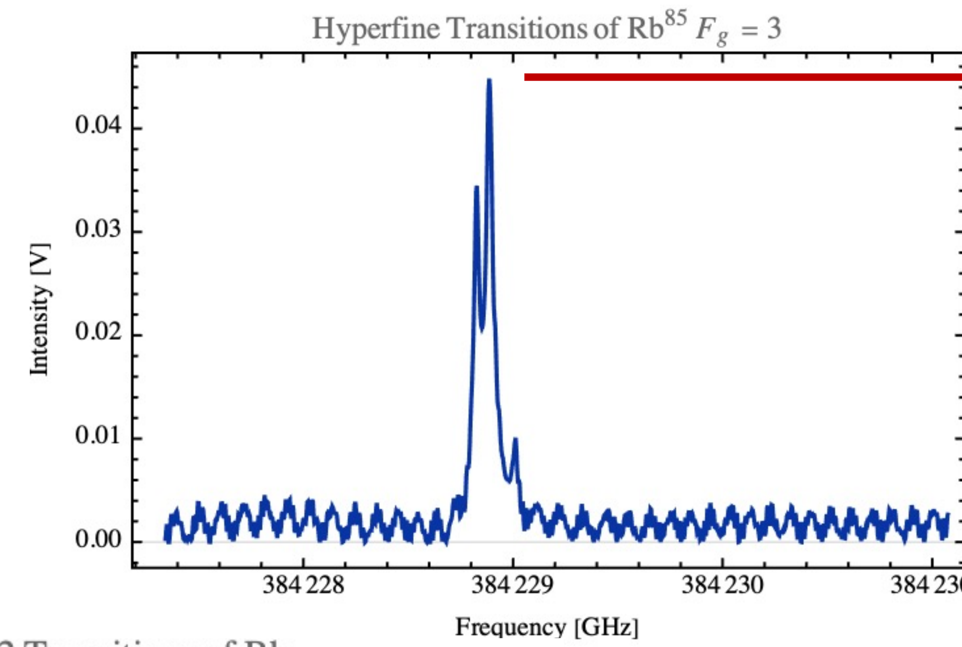
The frequency produced by diode lasers will drift over time due to environmental changes such as vibrations or temperature and humidity fluctuations. We improve the long-term frequency stability by adjusting the laser piezo voltage and current to correct for these changes.

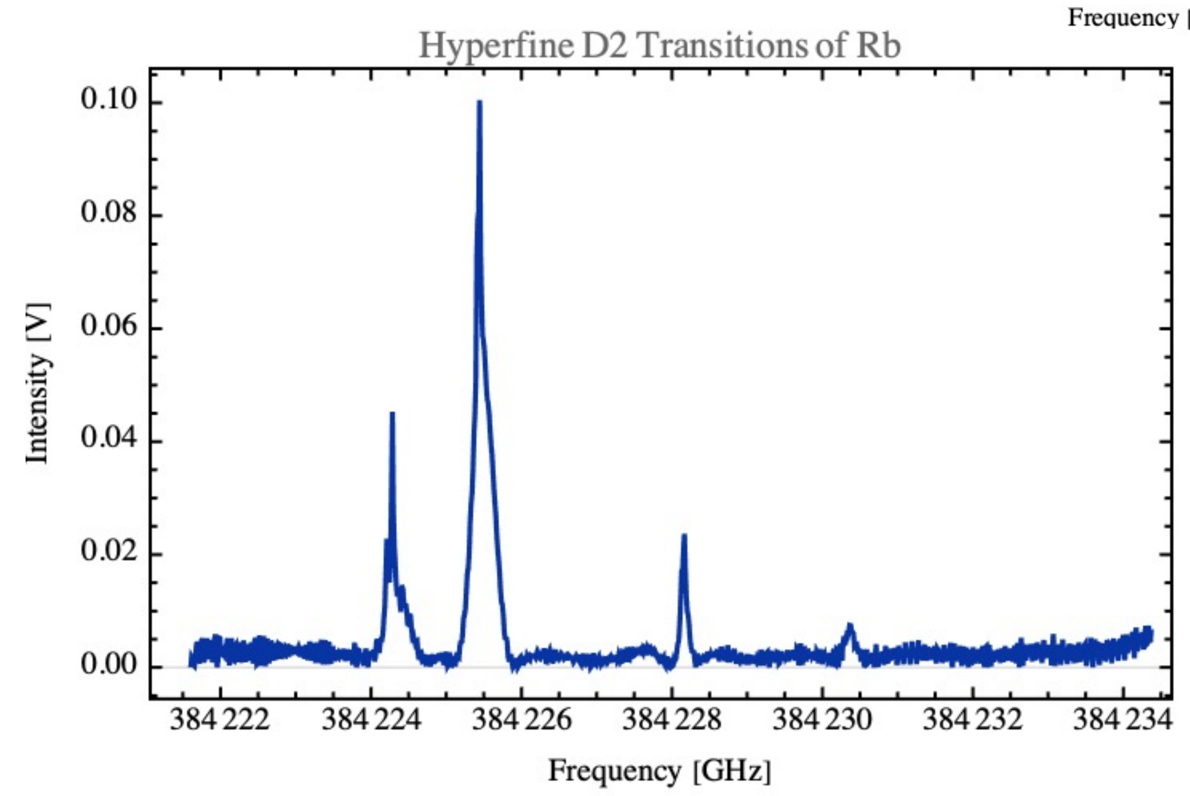
External Cavity Diode Lasers provide extra stability using a diffraction grating which reflects the desired mode back into the laser as feedback. Changing the angle of the diffraction grating will change the frequency of the laser.

Optical Set-Up



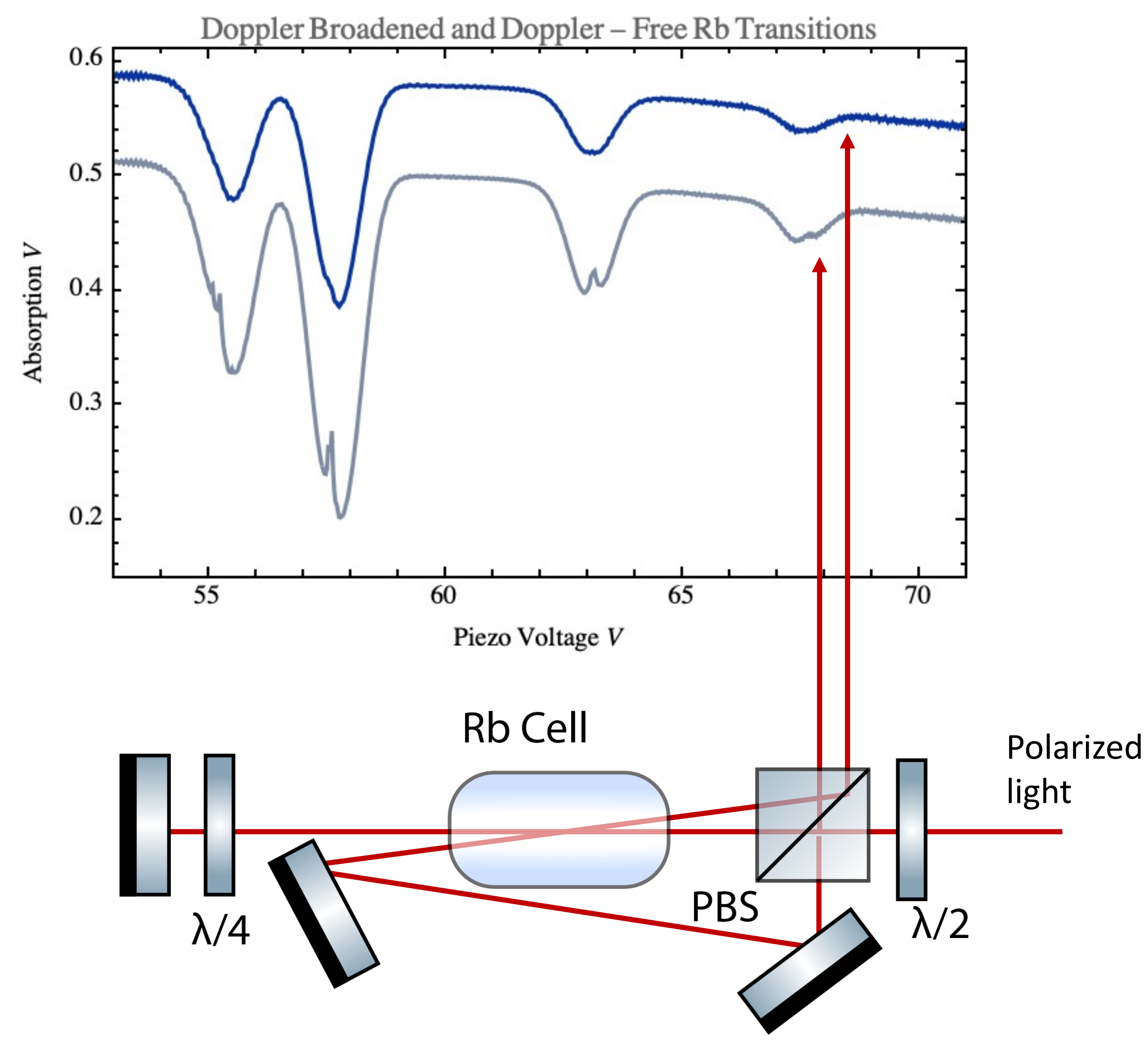
Rb Spectrum





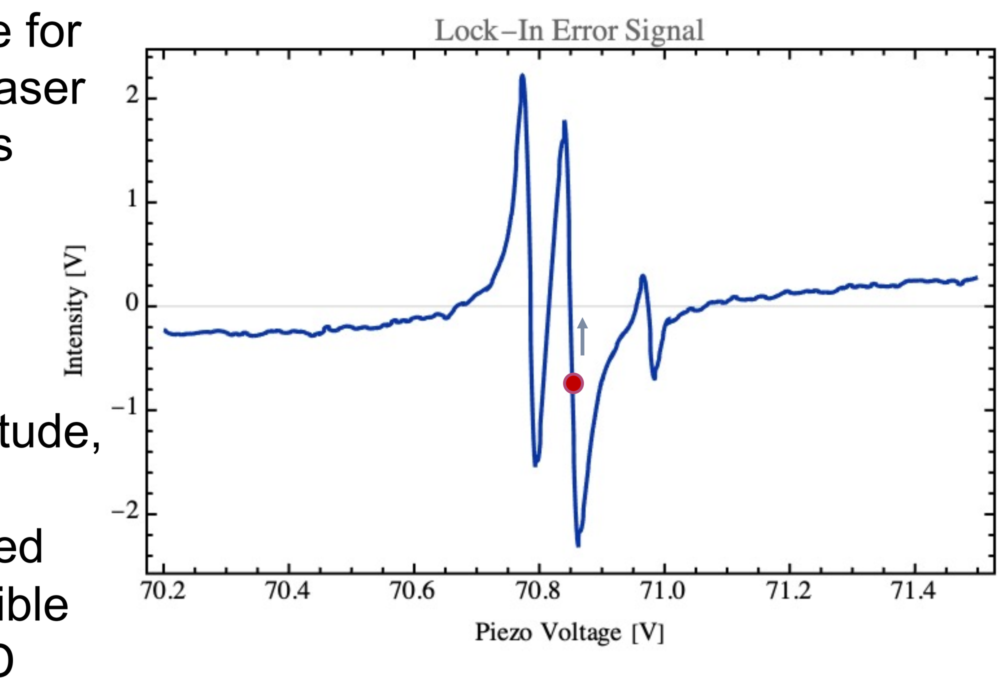
FIX SCALE

Saturated Absorption

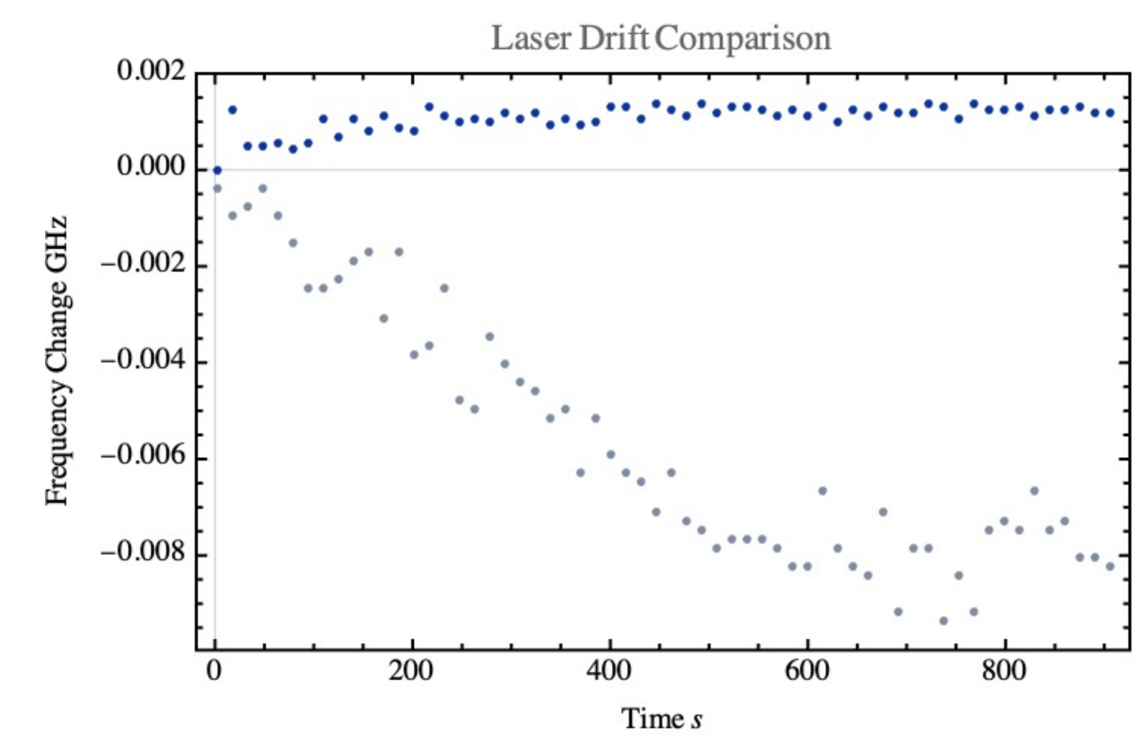


Top of Fringe Locking

We used the doppler-free peaks of Rb85 Fg=3 as a reference for our laser lock. Our infrared laser controller, the DLC Pro, uses frequency modulation and demodulation to produce an error signal proportional to Figure X. We adjusted the modulation frequency, amplitude, and phase to obtain a clean signal. The error signal served as input for the PID responsible for locking the laser. The PID controls adjust the piezo voltage and current of the laser to drive the frequency back to its lock point.



Results



We monitored the frequency drift of the locked vs. unlocked laser using a scanning Fabry Perot interferometer.

Type equation here.

Acknowledgements

This material is based upon work supported by the U.S. National Science Foundation under Award Number PHY-1950795 (UK REU) and the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Award Number DE-FG02-99ER41101."

Changes

Spectroscopy

- Check and fix scales
- Absorption y axis-> intensity
- Add in Rb spectrum & Label peaks

Results

Add in slopes for locked vs unlocked