Toward Locking a Ti:sapph Laser for use in Stimulated Raman Adiabatic Passage

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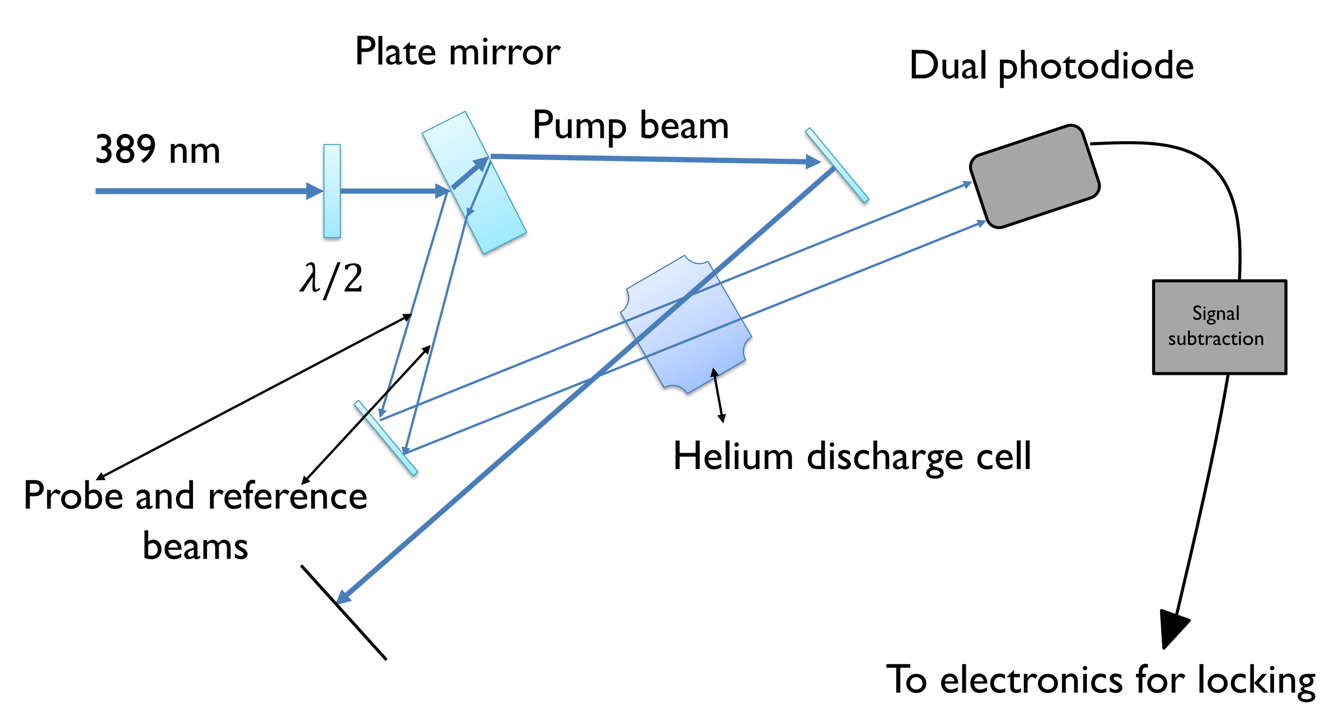
INTRODUCTION

The stimulated Raman adiabatic passage (STIRAP) technique allows for efficient population transfer between atomic states. Production of helium Rydberg atoms requires specific wavelengths of light and highly stable laser systems. Precise control over laser frequency and stability is achieved via two locking systems:

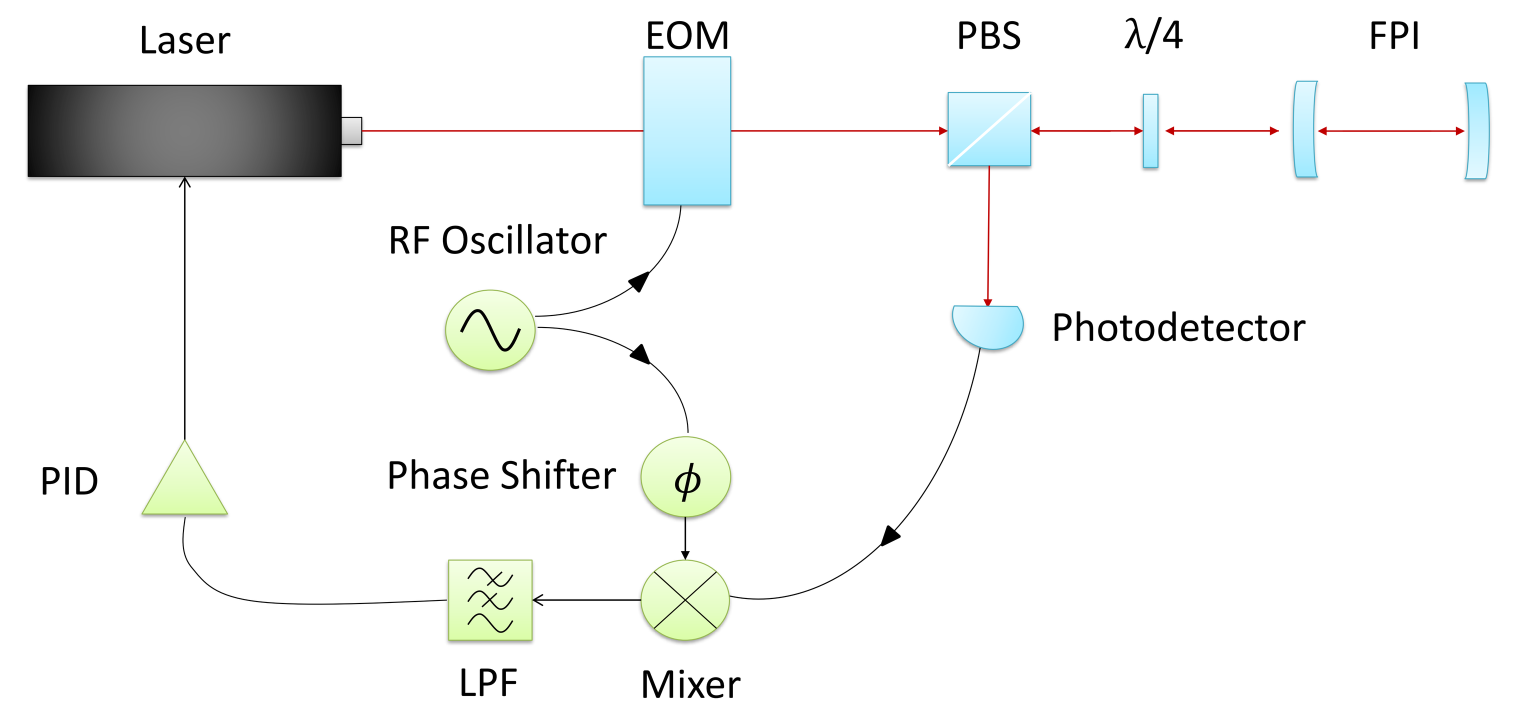
- Saturated absorption spectroscopy (SAS) is used to compare laser frequency to the resonance frequency of an atomic transition.
- The Pound-Drever-Hall (PDH) technique produces feedback on short time scales by using a stable Fabry-Perot reference cavity to produce an error signal.

SATURATED ABSORPTION SPECTROSCOPY

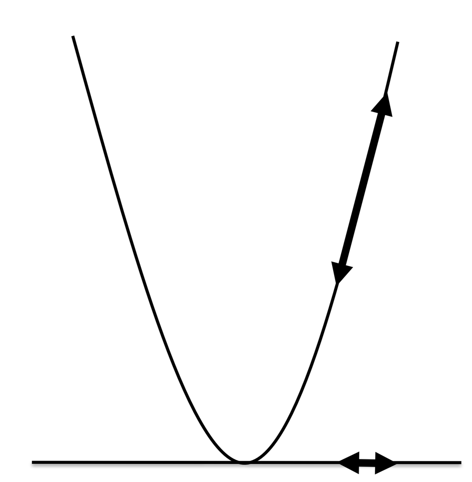


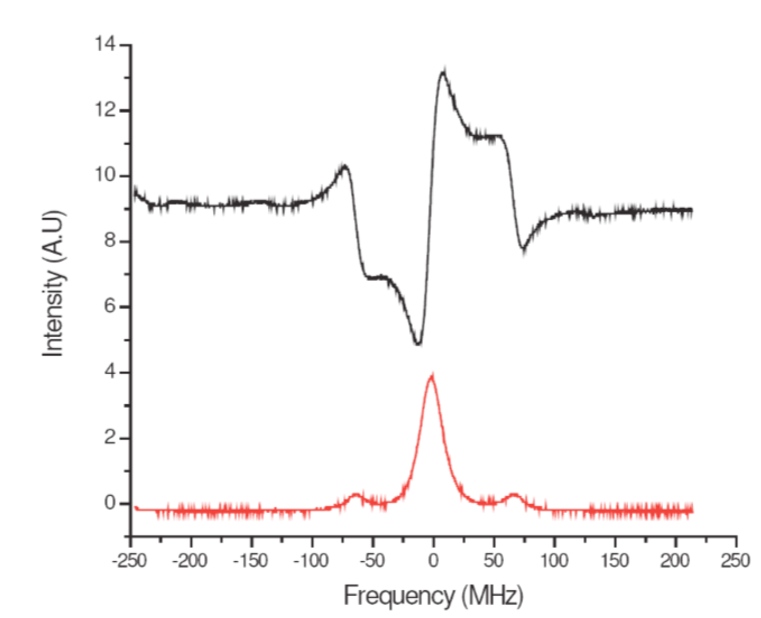
- Pump and probe beams with equal frequencies counter-propagate and overlap inside the atomic gas cell.
- The pump beam promotes atoms into the higher energy state., depopulating the initial state.
- Absorption is analyzed for different atomic velocity groups related to different detunings from resonance.
- Scanning across resonance, probe beam transmission peaks due to depopulation in the initial state

POUND-DREVER-HALL



- An RF oscillator drives an electro-optic modulator at frequency Ω. The central carrier, at frequency ω, is phase modulated.
- Light reflected from the off resonance Fabry-Perot interferometer is sent to a photodetector.

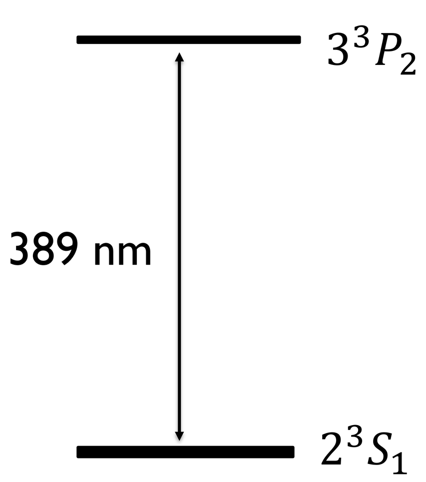




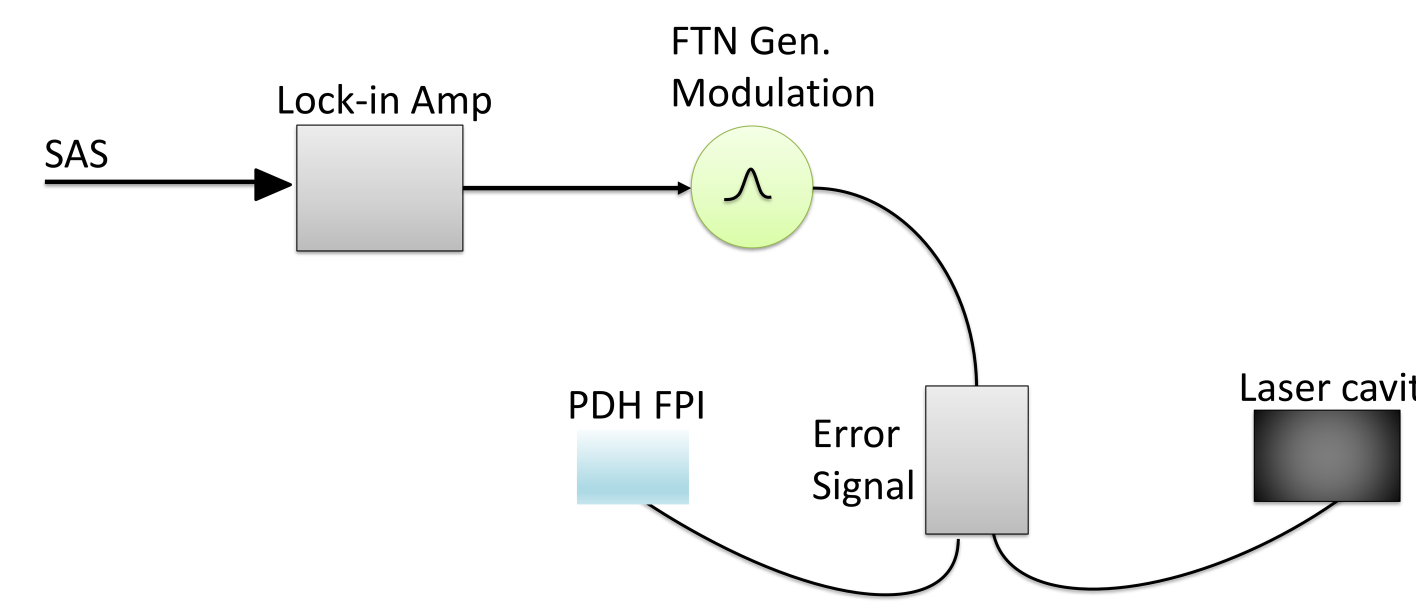
- The reflected intensity from the Fabry-Perot is symmetric. A small modulation in frequency provides a new signal which tells us which side of resonance our laser light is on.
- This asymmetric error signal, containing phase information, is electronically isolated.
- A proportional-integral-derivative controller continuously processes the error signal and sends its output to a piezoelectric transducer (PZT) in the laser cavity. The PZT mechanically adjusts the length of the cavity, correcting for frequency fluctuation.

DISCUSSION AND NEXT STEPS

The transition of interest is, 2^3S_1 to 3^3P_2 in He. This requires 389 nm light.



- To search for the signal, the laser sweeps over 120 MHz and wavelength is manually adjusted
- Once found, the signal must be amplified
- The laser frequency is modulated to produce an error signal.
- The laser is locked by feeding the error signal back into its cavity



CONCLUSION

Combining the atomic reference frequency provided by the SAS with the fast feedback of PDH, a high degree of laser frequency precision and stability can be achieved. Currently, work is being done to increase and stabilize the laser scan, which cannot scan far enough to excite He atoms in the 2^3S_1 state to 3^3P_2.

REFERENCES & ACKNOWLEDGEMENTS

[1] Lu, X. (2011). *Excitation of Helium to Rydberg States Using STIRAP* (Doctoral dissertation), Stony Brook University, Stony Brook, NY.

[2] Sun, Y. (2013). *Stimulated Raman Adiabatic Passage between Metastable and Rydberg States of Helium* (Doctoral dissertation), Stony Brook University, Stony Brook, NY.

[3] Black, E. D. An introduction to Pound-Drever-Hall laser frequency stabilization. Am. J. Phys. 69, 79–87 (2001).

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