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A Confocal Fabry Perot Etalon for Laser Frequency Analysis

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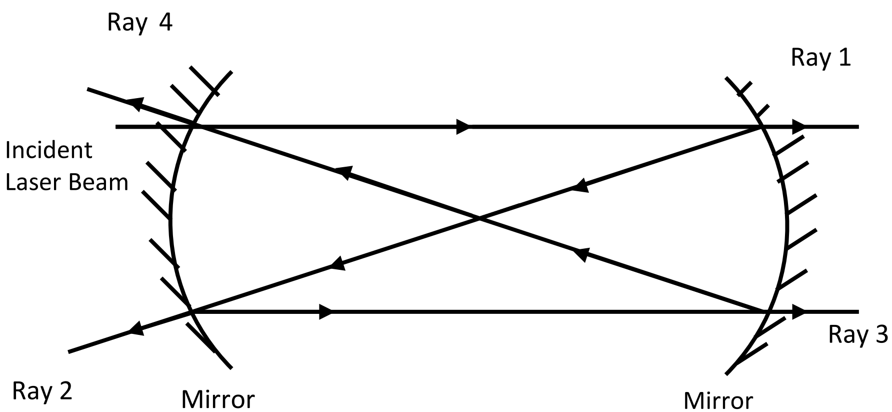
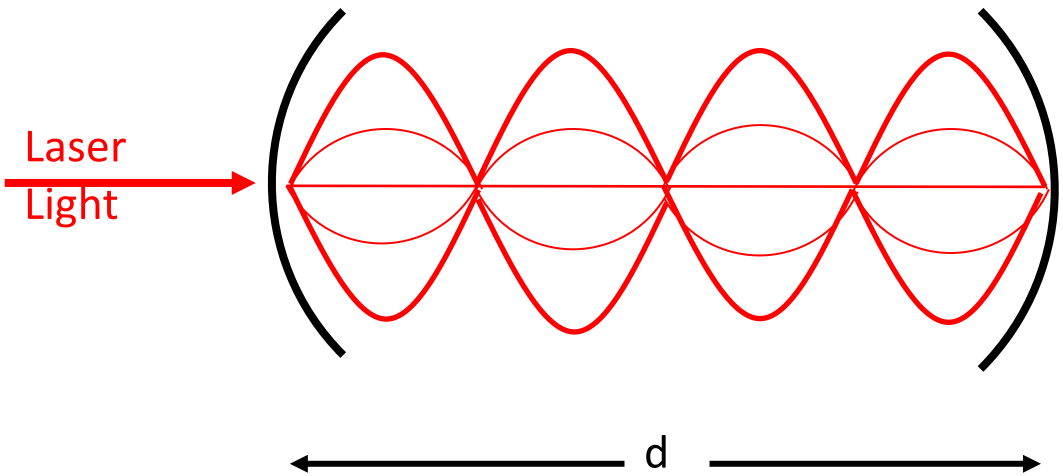
Introduction: What is a Fabry Perot Etalon?



- Cavity formed by two highly reflective mirrors
- Mirrors could be flat (planar) or curved
- If laser light is incident on the cavity and if the laser light has the correct frequency, the light will couple into the cavity

- Our Fabry Perot etalon can be used to calibrate the frequency of a laser beam coupled into the etalon. This laser can then be used in atomic physics experiments

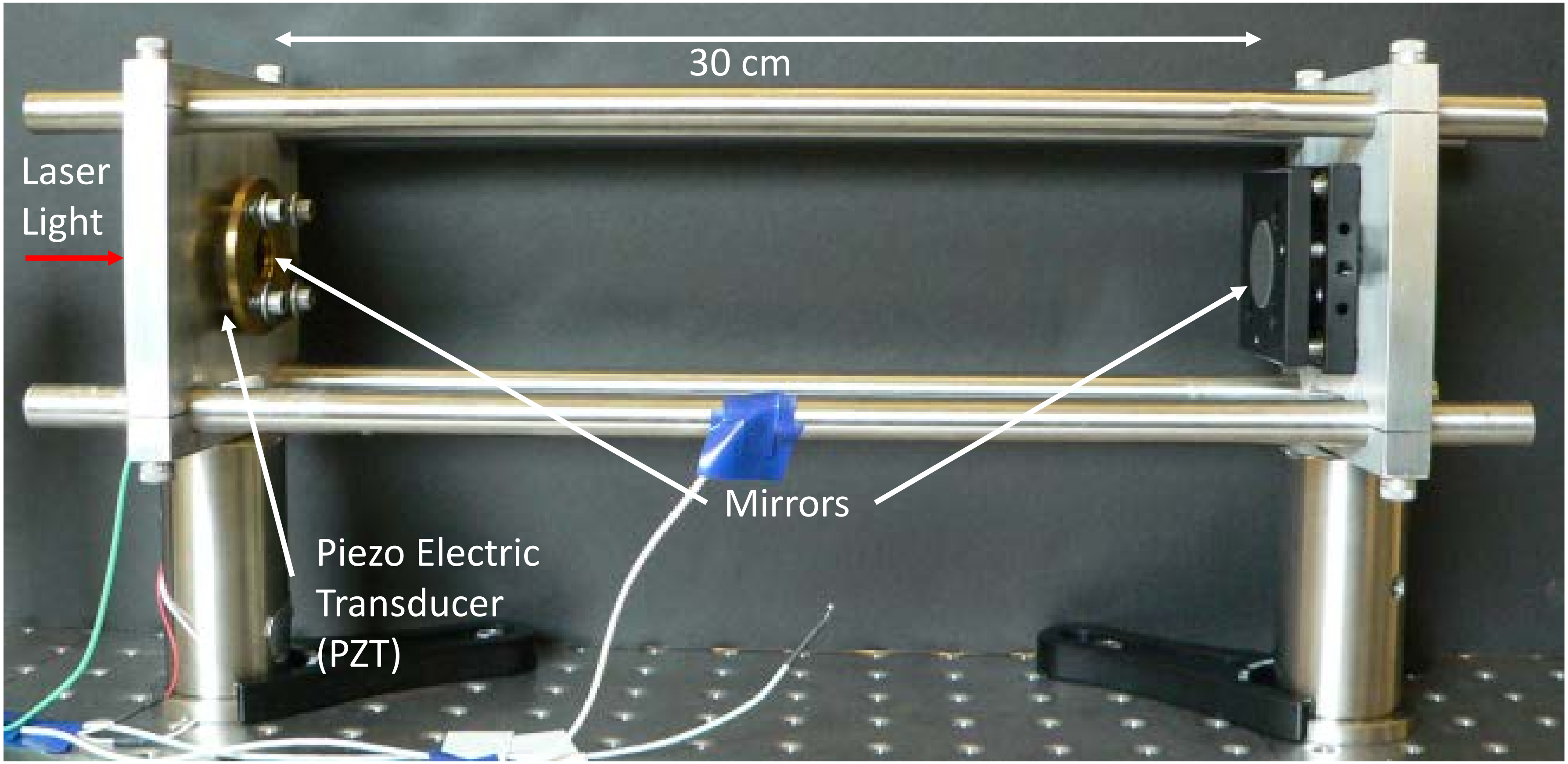
Confocal Fabry Perot Etalon



- Particular laser frequencies get into the cavity while others are rejected
- Resonance between laser light and cavity when
  - $n\lambda_n = 4d, n = 1,2,3 \ldots$
  - $f_{n+1} - f_n = \frac{c}{4d} = \mathrm{FSR}$

- Measure d tells us the FSR used to calibrate the frequency of our laser

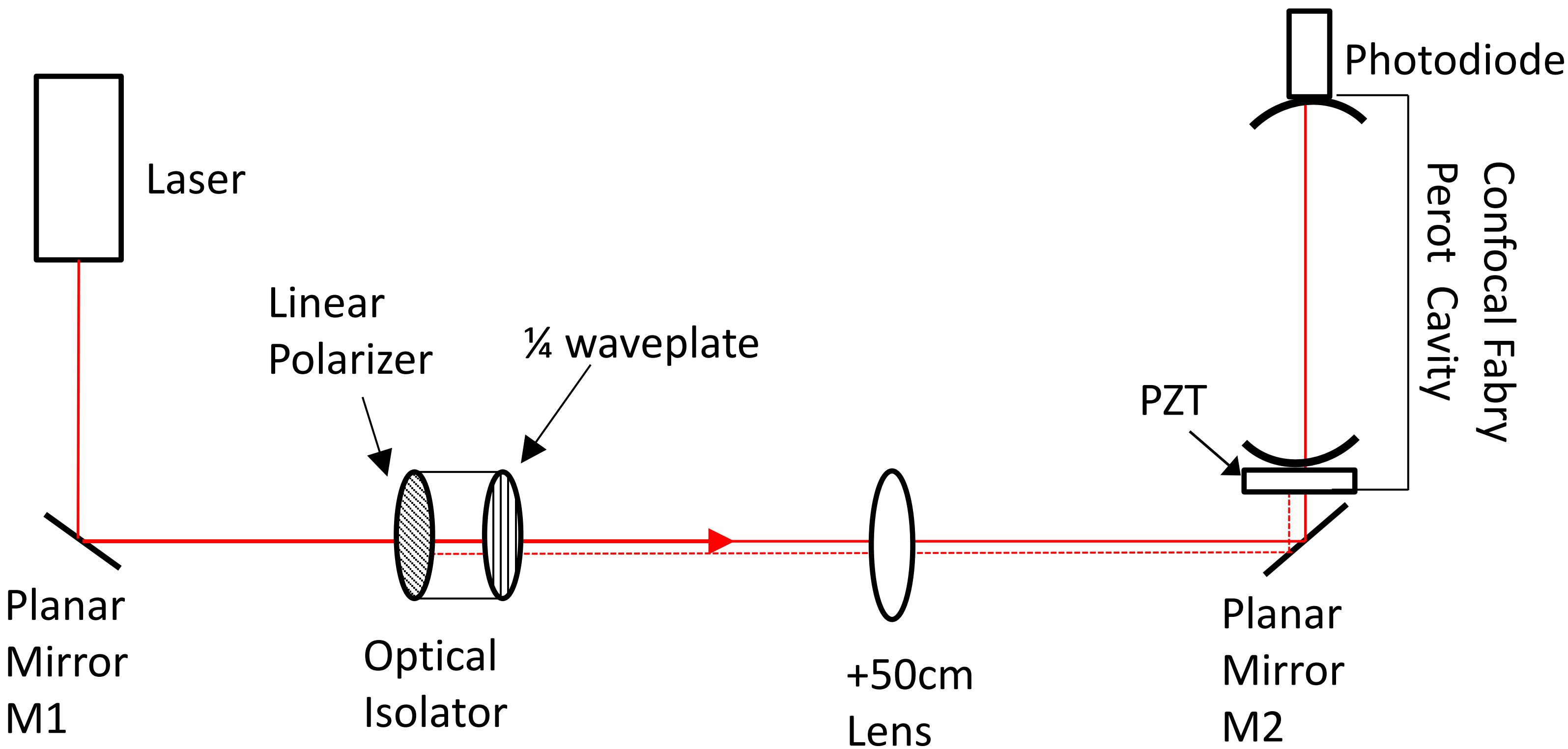
Our Fabry Perot Etalon



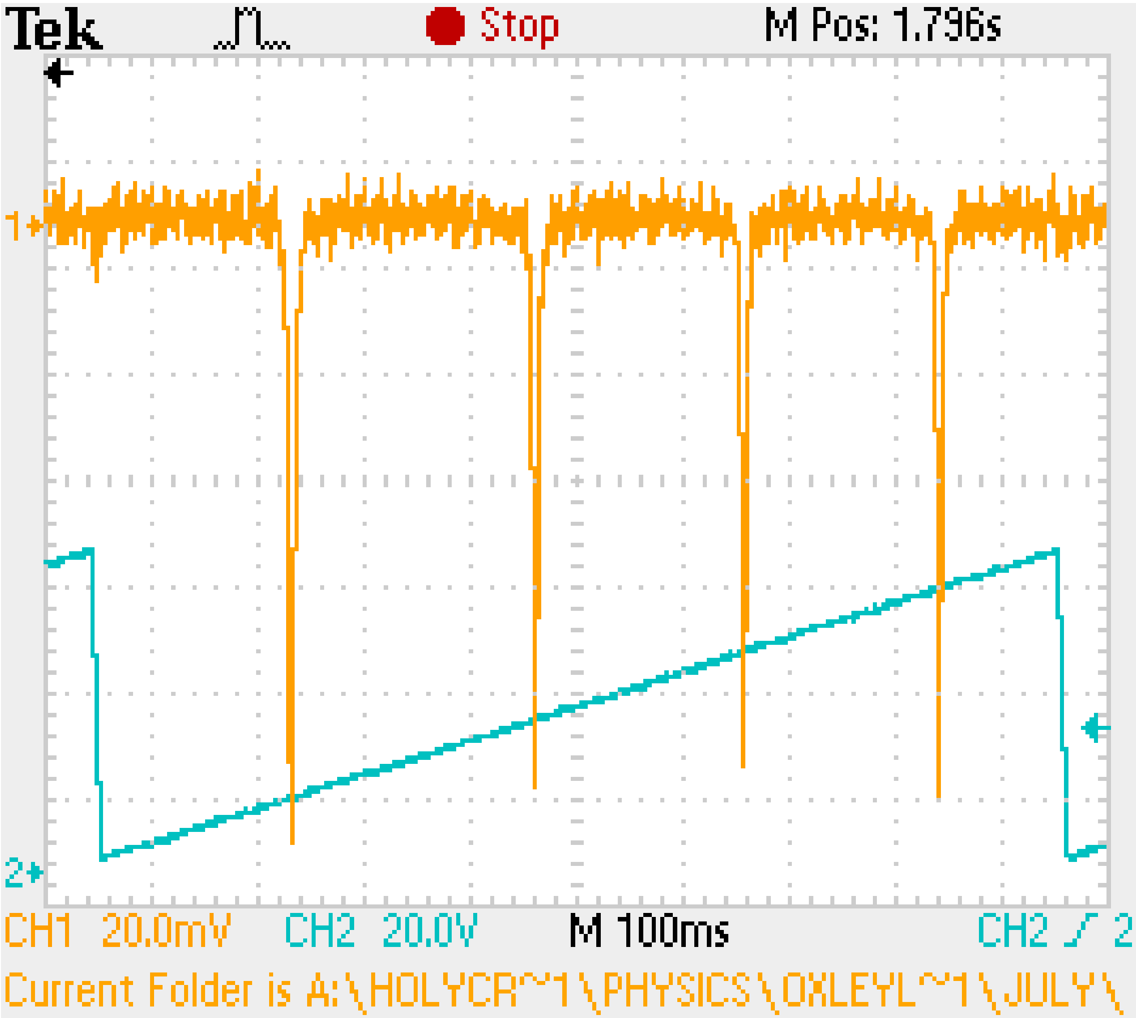
Operation Methods

- Method 1
  - Keep laser frequency fixed and scan the cavity length, d
    - Testing of the cavity done with this method
- Method 2
  - Keep d fixed and scan the laser frequency
    - This method is used to determining atomic physics experiment laser frequency

Experimental Setup



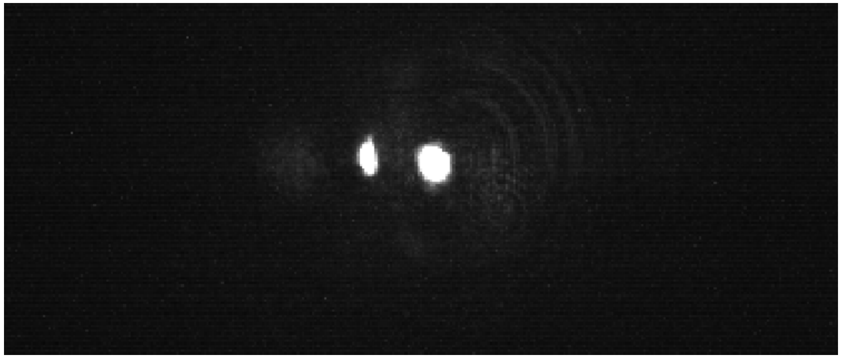
Method 1



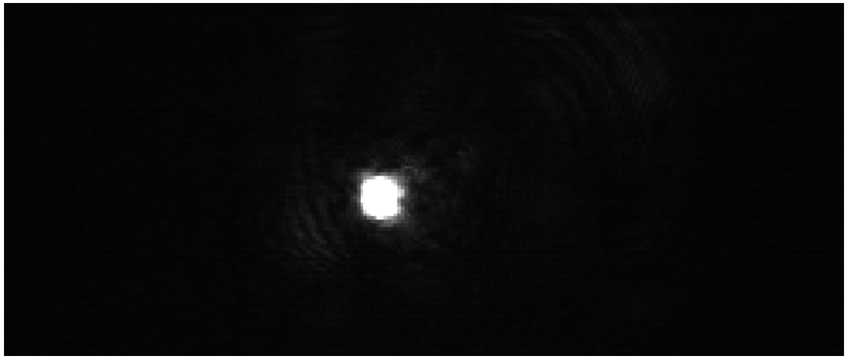
- Depiction of the data taken from oscilloscope
- Yellow peak =signal from the photodiode
- Blue peak = linearly increasing voltage applied over time to the PZT to linearly change cavity length d

Alignment of laser into Fabry Perot Etalon

Removed the photodiode and put camera in place

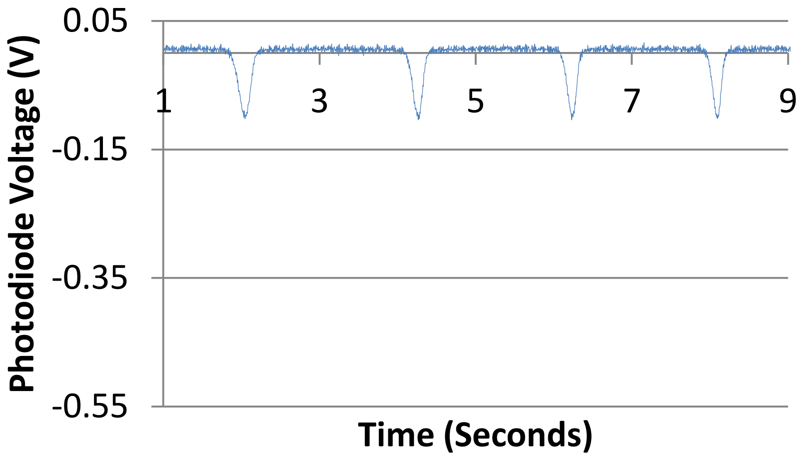


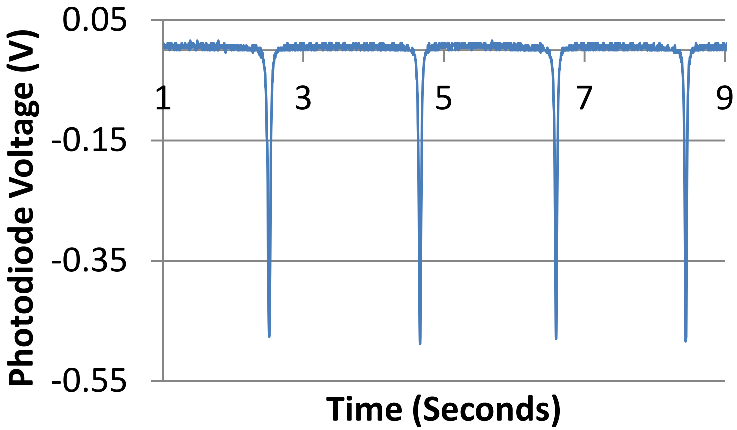
Photograph of the transmission through the cavity with input beam misaligned with the cavity.



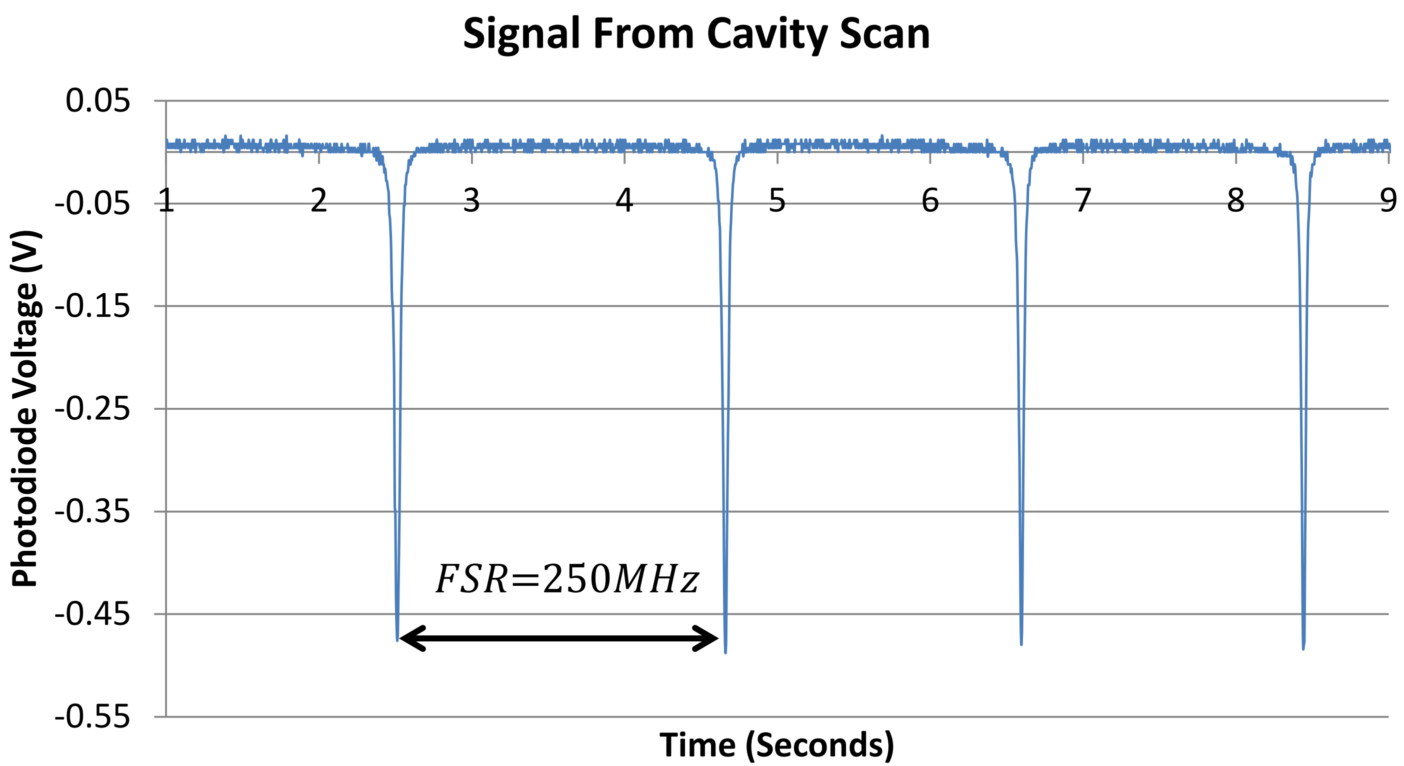
Photograph of the transmission through the cavity with input beam aligned with the cavity.

Photodiode inserted back into place

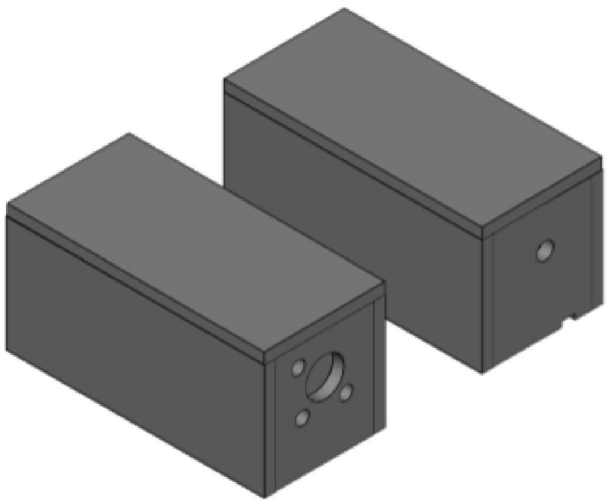




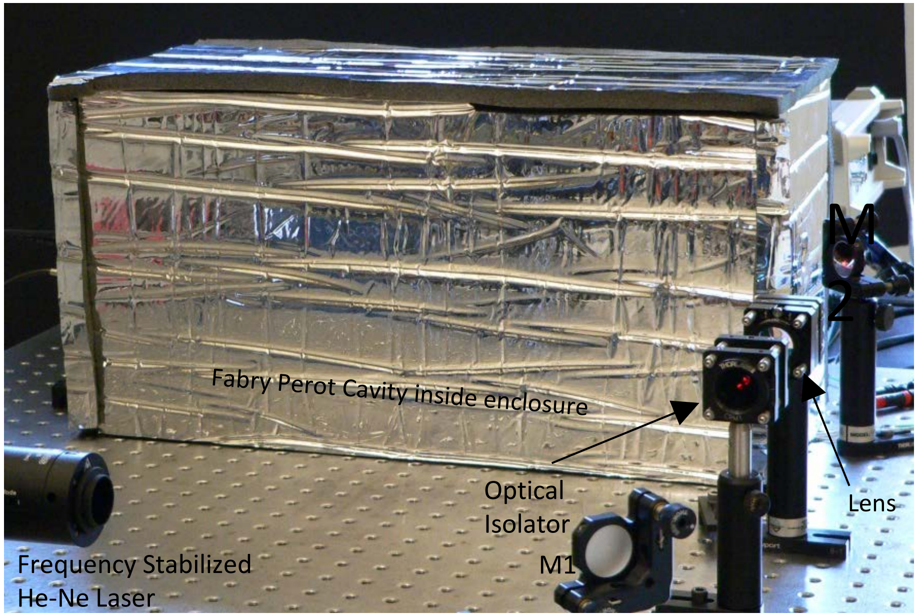
Photodiode Signal



Minimizing Cavity Length Drift

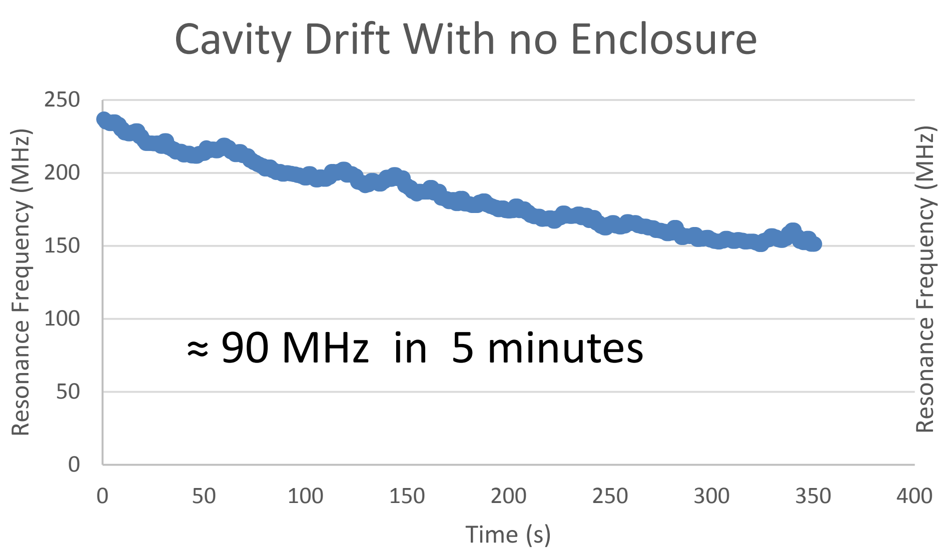


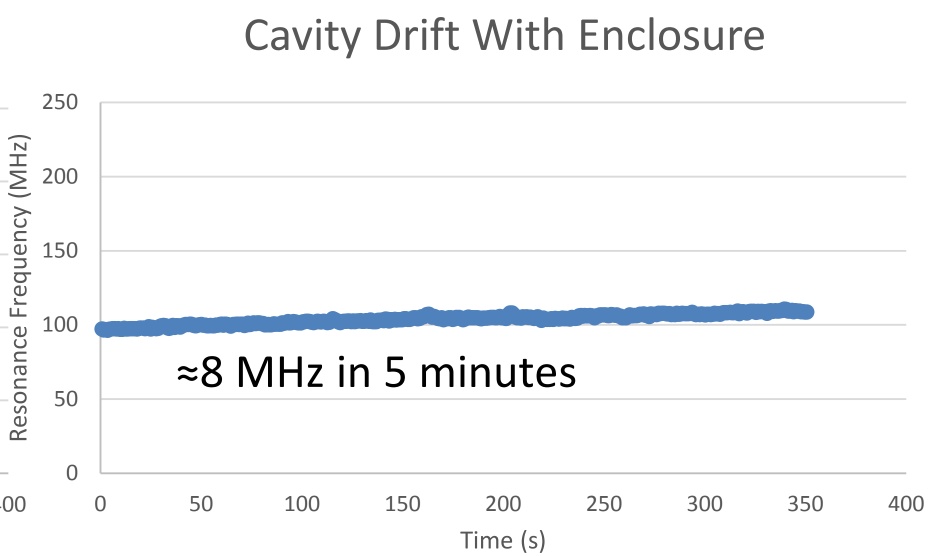
Schematic of Fabry Perot cavity enclosure to prevent air currents and temperature drifts which would disturb the Fabry Perot cavity's stability .



Visualization of laboratory setup with the thermally insulated enclosure covering the Fabry Perot cavity.

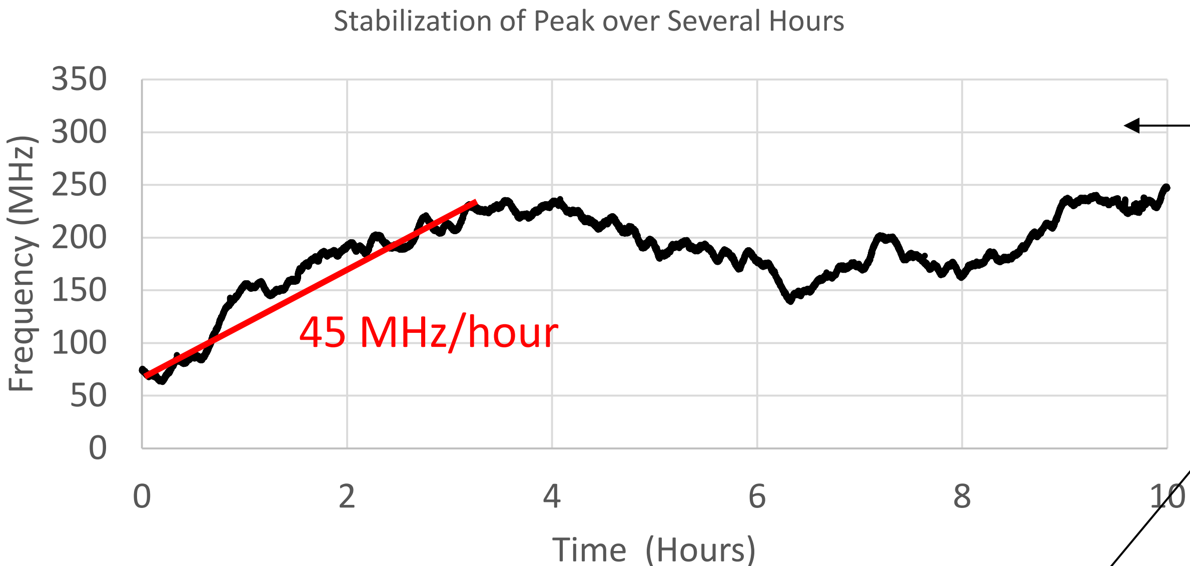
Improvement due to Enclosure



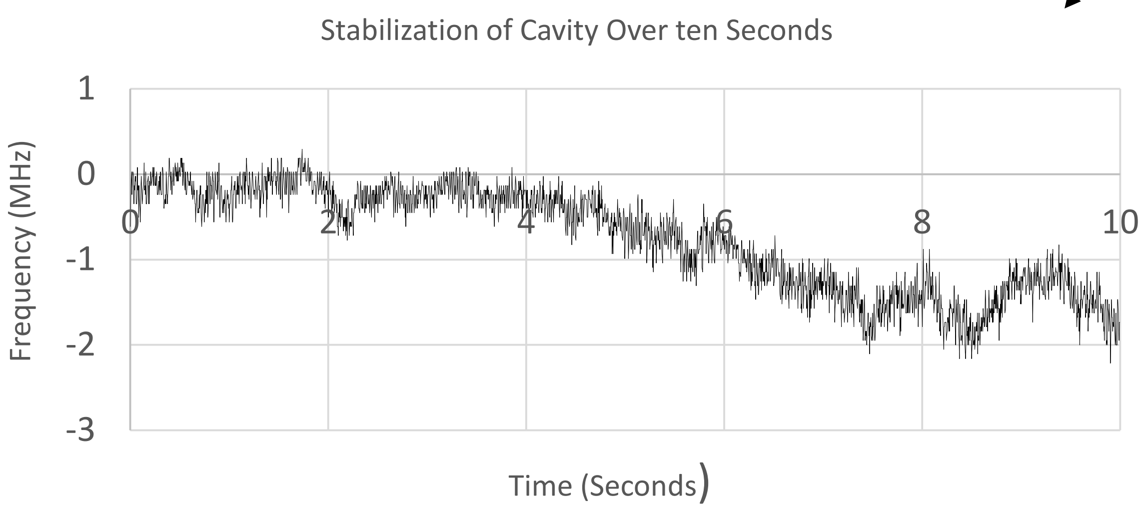


- Significant reduction in cavity drift when enclosure is on the cavity

Short and Long Term Drift

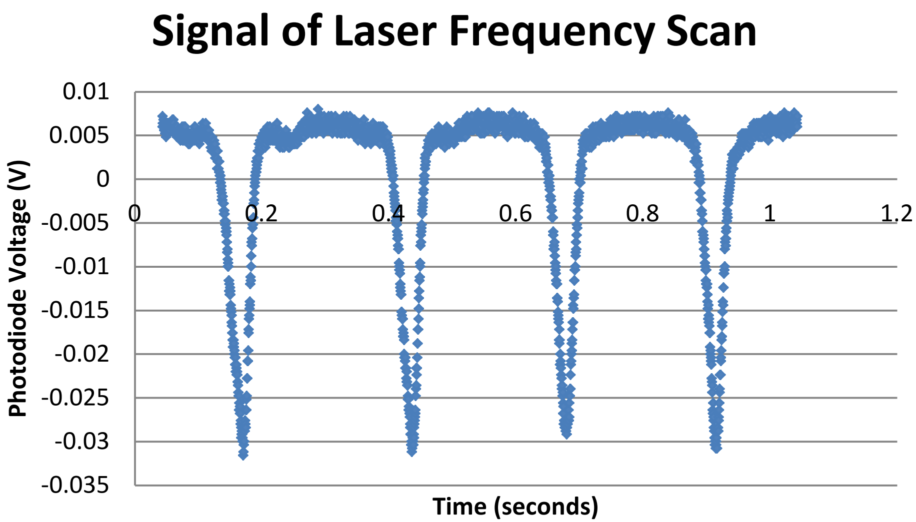


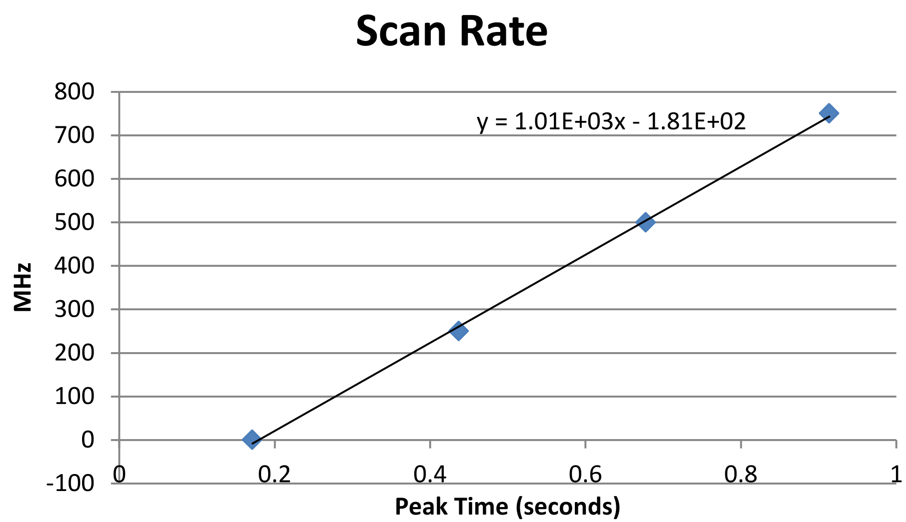
- ~50 MHz/ Hour long term drift
- < 2MHz over an interval of 10 seconds



- These drifts are small enough to allow the Fabry Perot Cavity to successfully calibrate the atomic physics laser

Frequency Scan of Atomic Physics Laser (Method 2)





- Frequency Scan of the Atomic Physics Laser allows for successful frequency analysis of beam used in atomic physics experiments
- Scan Rate = 1013 MHz/sec

Thank You

- Research Advisor – Professor Paul Oxley
- College of the Holy Cross Department of Physics