Precision Spectroscopy in Thallium

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Overview

Goals

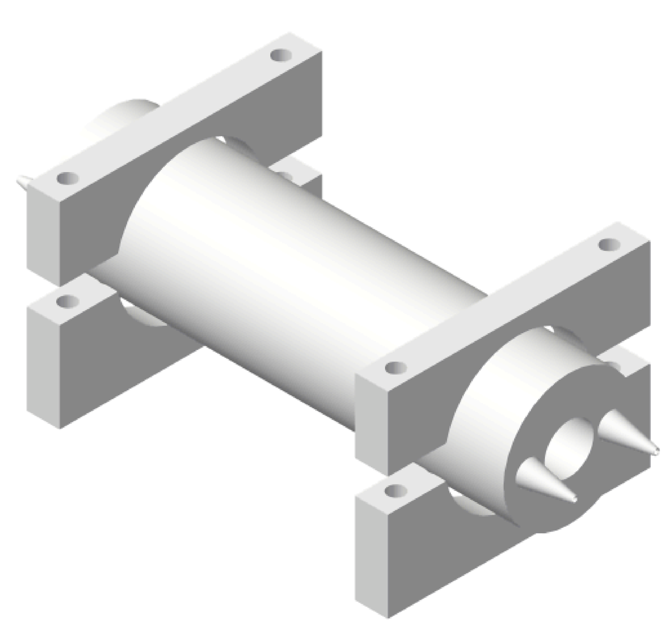
- Probe fundamental physics through the study of a weak fine structure atomic transition ($6p_{1/2}$ to $6p_{3/2}$) in thallium.
- Provide experimental verification for physicists modeling thallium wavefunctions theoretically.

Tools

- Atoms in vapor cells (evacuated sealed glass tubes containing Tl) and in the atomic beam apparatus.
- Diode lasers of many colors (specifically 1283 nm for this transition) and related optics.
- Signal processing electronics:
  - > Lock In Amplifiers
  - > PID Controllers
  - > Oscilloscopes
  - > Computers
  - > Differential Amplifier
- Vacuum chambers, pumps, and related plumping.

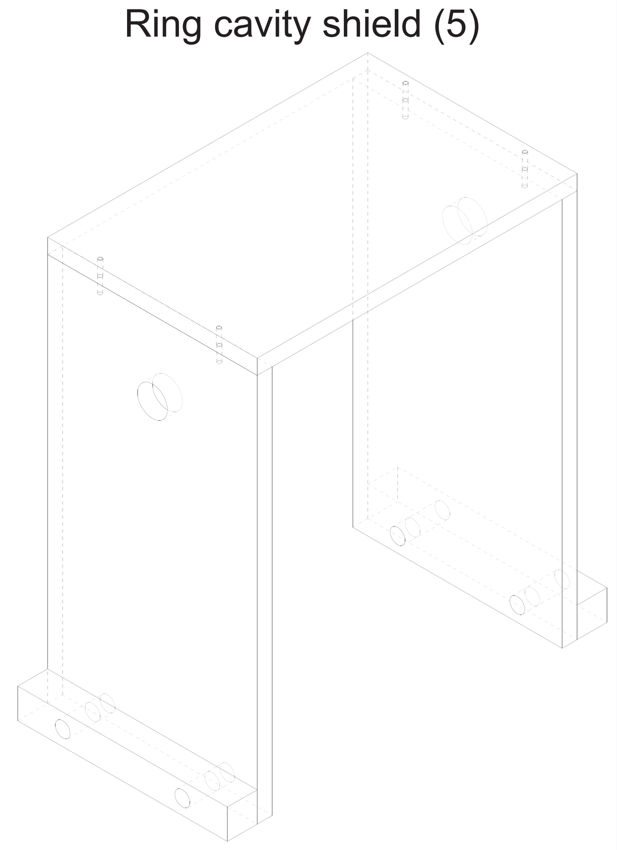
Ancillary Projects

Designing new or improved equipment is an integral part of our work. Two recent projects we designed and the skilled machinists in the Williams Science Shop constructed were a new water cooled solenoid for our laser locking system and a shield to protect our ring cavity mirrors from any stray thallium.

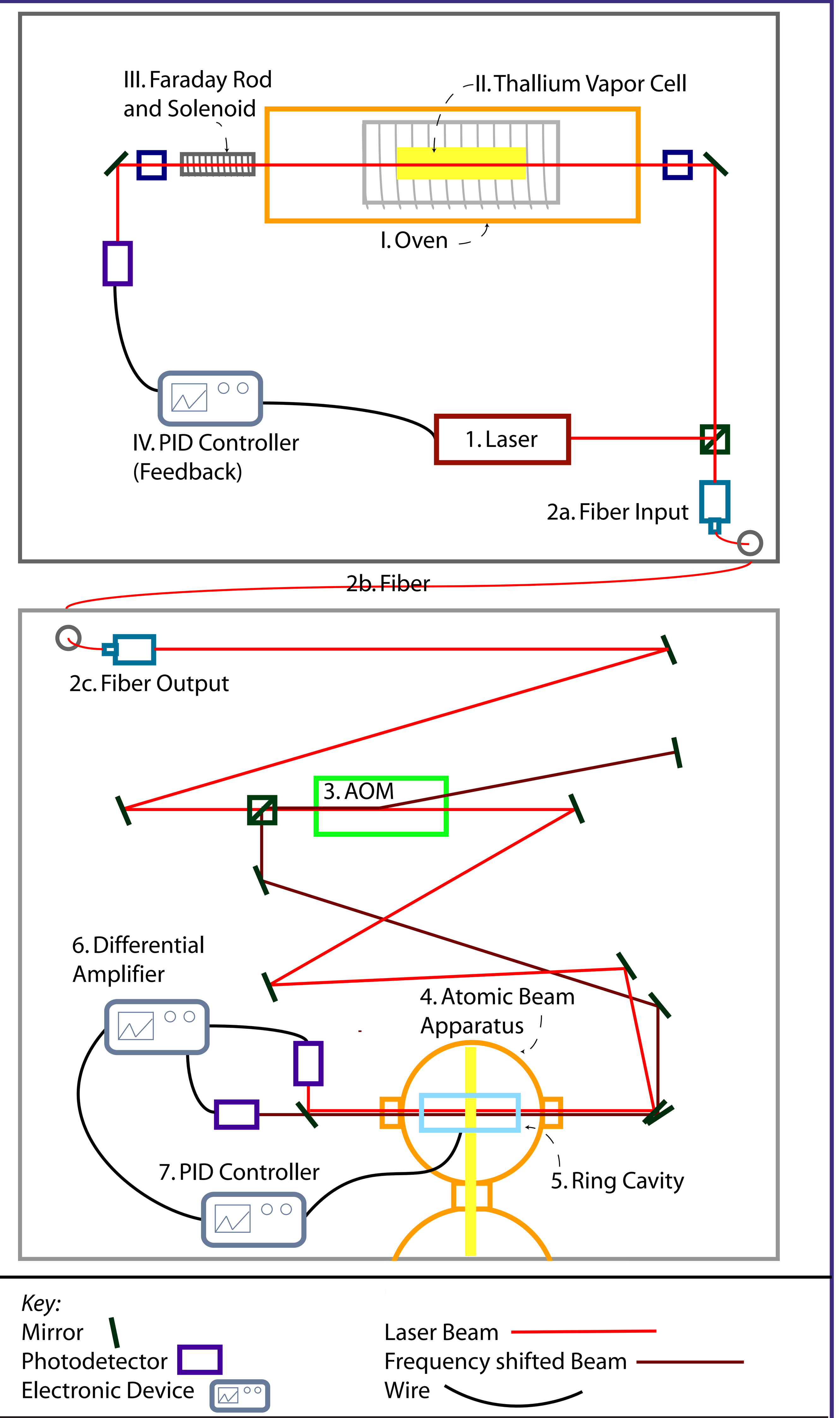


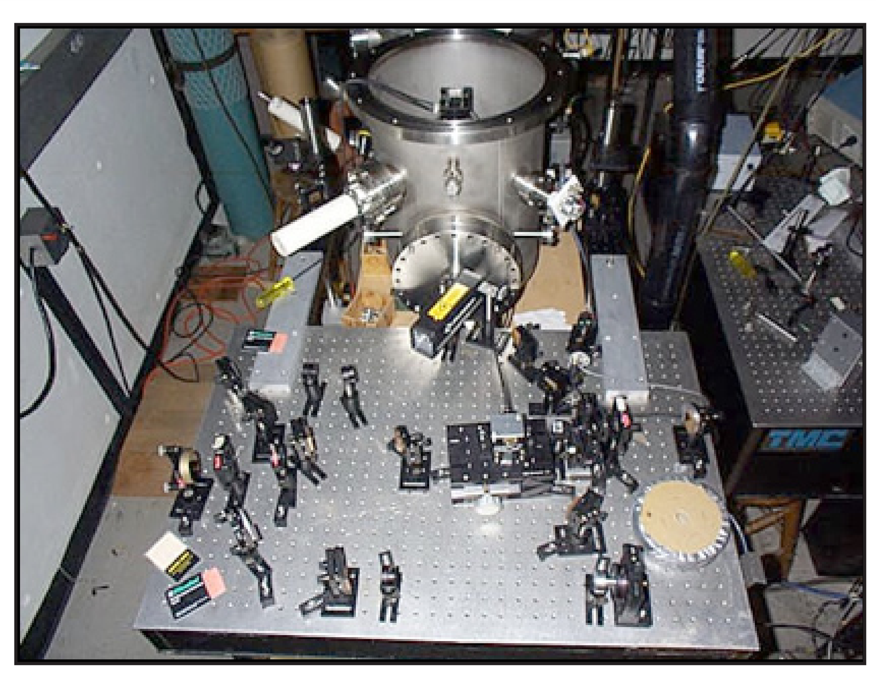
Solenoid (III)

Ring cavity shield (5)



Experimental Setup





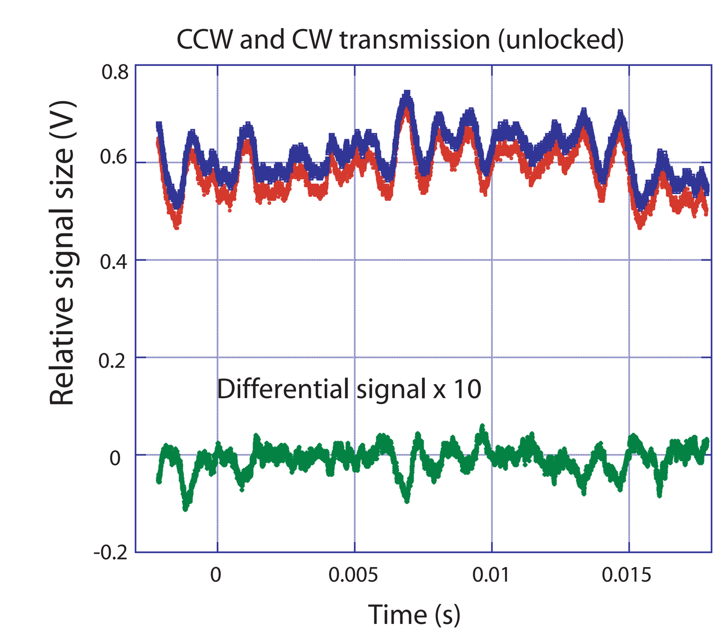
Optics table and Atomic Beam Apparatus (2c - 5)

Techniques for Precision

Differential Signal Processing

(1) Light leaves our diode laser.
(2) The light enters a fiber to transfer to another table.
(3) The beam is split and frequency shifted at an Acoustic Optical Modulator (AOM).
(4) Both beams are sent into our atomic beam apparatus, a vacuum chamber with an oven designed to send a stream of atoms perpendicular to the laser beams.
(5) The laser beams travel in opposite directions around the ring cavity where they also travel through the thallium beam.

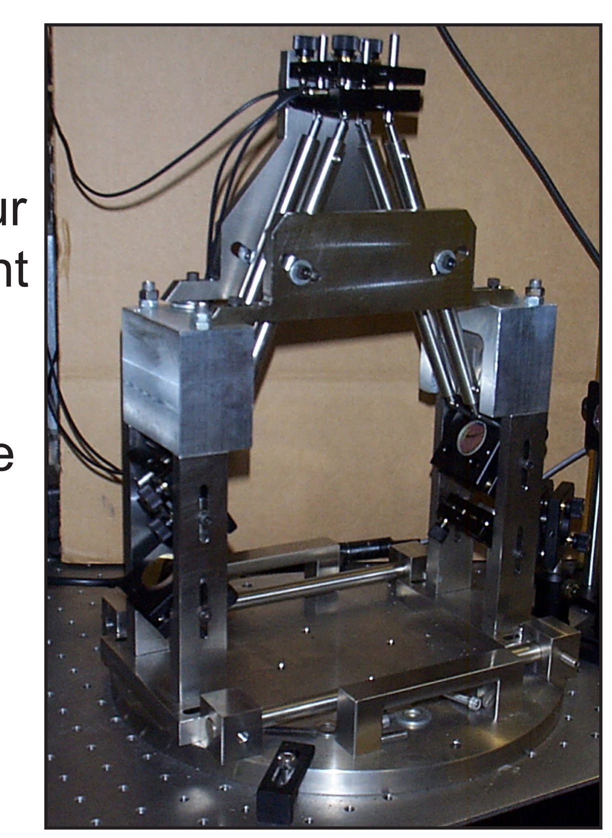
Both signals are detected and the difference *is recorded. Thus, any noise common to both beams (due to fluctuations in the cavity or laser) is largely removed.*



Common mode rejection of noise induced by nearby fan. Note that the differential signal is better than a factor of ten cleaner than either individual signal.

Laser and Ring Cavity Locking

The frequency of the laser is stabilized to further improve our signal. We send part of our light into an oven (I) with a thallium vapor cell (II) and exploit the Faraday rotation caused by the atoms to produce an error signal (IV) that is fed back to the laser, correcting its frequency. The ring cavity is stabilized by correcting the position of the top mirror slightly in response to a drifting signal.



Fabry-Perot Ring Cavity (5)