780nm and 940nm Diode Laser Construction

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Objectives

Construct three diode lasers:

- two with wavelength **780nm** corresponding to the $4p^6 5s\ ^2S_{1/2} \rightarrow 4p^6 5p^2\ P^\circ_{3/2}$ in Rubidium
- one with wavelength **940nm** corresponding to the $6s^2 6p^2\ ^3P_0 \rightarrow 6s^2 6p_2\ ^3P_2$ in Lead

Each laser must be able to:

- Lase stably at the desired frequency
- Scan over a range of frequencies (10Ghz) without mode hopping

Optics

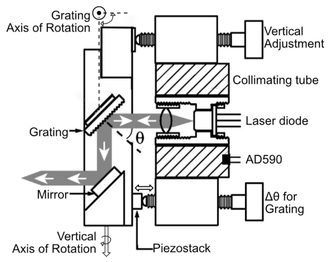
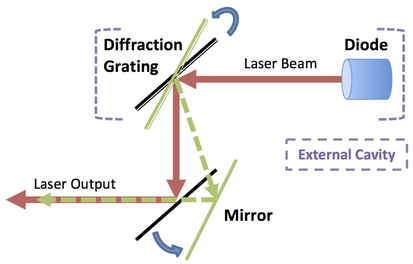
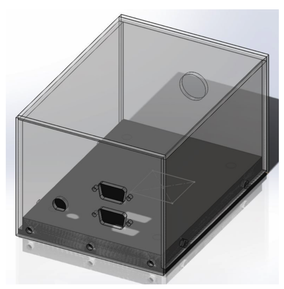


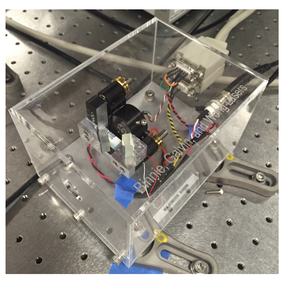
Figure 1: Design based on Hawthorn *et al.* contains an internal and external cavity in which light emitted from the diode is amplified. [1]



- Adjusting piezo stack (PZT) voltage, diode current and/or diode temperature changes the laser's frequency

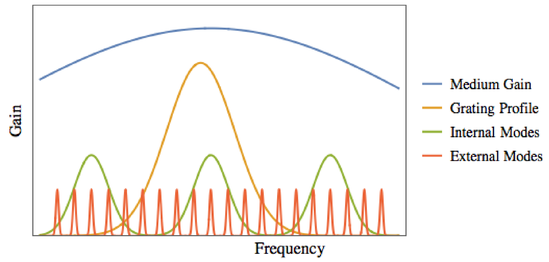
Laser Enclosure





Frequency & Feed Forward

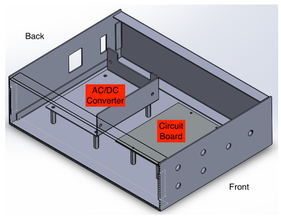
Figure 2: Lasing occurs at the frequency where gain is maximized

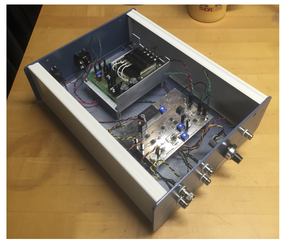


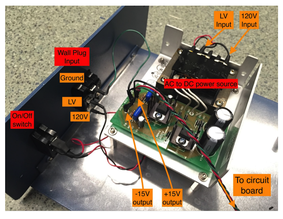
- Changing only one parameter to adjust frequency over a large range would cause mode hops
- Changing the diode current proportionally when the PZT voltage is adjusted, expands the range without mode hops → "Feed Forward"

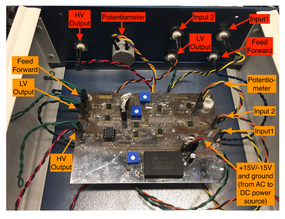
Electronics

Custom PZT Driver

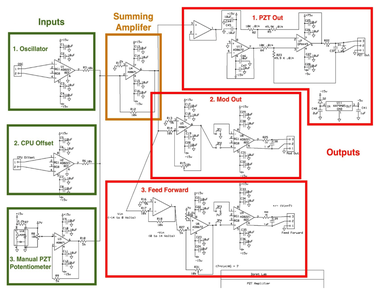


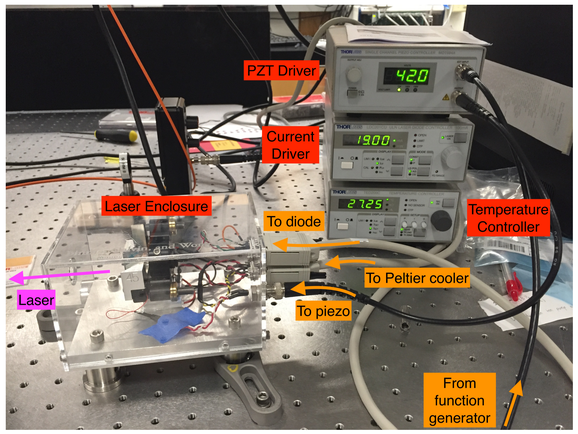






Circuit Diagram





Calibration and Performance

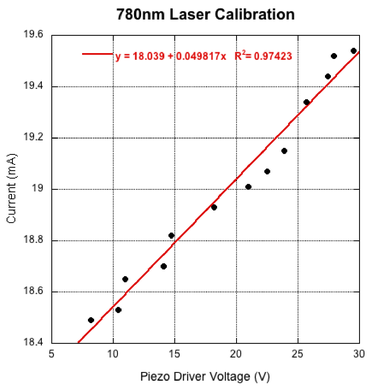
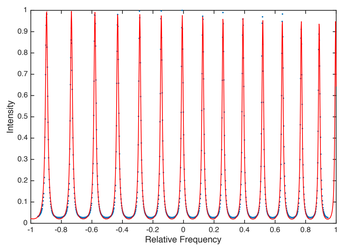


Figure 3: Piezo voltage was increased until laser frequency mode hops, then current was adjusted until laser hops back

- From graph slope: diode current must increase by 0.05mA for every 1V increase in piezo voltage for the laser to tune smoothly over a large range

Figure 4: Scanning the laser through a fabry perot cavity, an interference pattern of symetric peaks shows that it is lasing at only one frequency



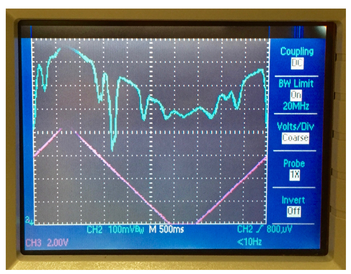
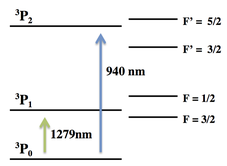


Figure 5: A successful scan of Rubidium using the 780nm laser showing four spectral lines. This laser will be used by students in Physics 301

Future Work

- 940nm laser will be used to measure transition amplitude, hyperfine splitting and optical rotation in ^{207}Pb, ^{208}Pb and natural lead

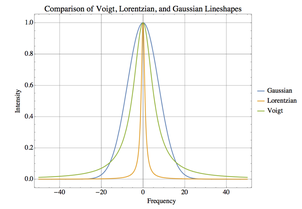


Related Work

- Reeves *et al.* measured 1279nm transition isotope shifts [5]
- Persson measured $^3P_1$, $^3P_2$ hyperfine splitting constants [4]

Simulations

- Pb absorption line shape is a convolution of Gaussian and Lorentzian components [3, 2]



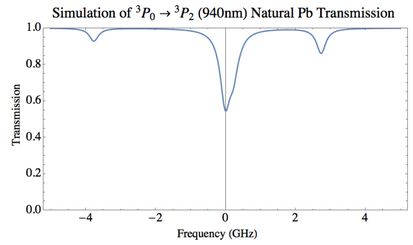
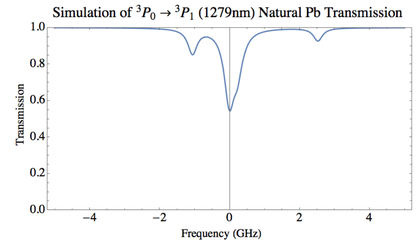


Figure 6: Simulation assuming optical depth to be 1 and natural line width to be 30Hz (HWHM) [3]



References

[1] C. J. Hawthorn, K. P. Weber, and R. E. Scholten, Rev. Sci. Instrum. **72**, 12 (2001).

[2] D. L. Butts, Bachelor's thesis, Williams College (2006)

[3] D. M. Meekhof, PhD thesis, University of Washington (1994)

[4] J. R. Perssen, arXiv:1407.0818v2

[5] J. M. Reeves, and E. N. Fortson, Phys. Rev. A **44**, 3 (1991)