On the following pages you will find the abstract and poster I presented at the 53rd. Annual Meeting of the American Physical Society Division of Atomic Molecular and Optical Physics (DAMOP). I hope this provides further context to the research experience discussed in my Statement of Purpose.

On the following pages you will find the abstract and poster I presented at the 53rd. Annual Meeting of the American Physical Society Division of Atomic Molecular and Optical Physics (DAMOP). Additionally, you will find a link to the git repository where the described software is stored. I hope this provides further context to the research experience discussed in my Statement of Purpose.

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Session V01: Poster Session III (4:00-6:00pm, EDT)
4:00 PM, Thursday, June 2, 2022
Room: Grand Ballroom C

Abstract: V01.00104 : A python-based software for wavelength stabilization of external cavity diode lasers*

Abstract

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The Middlebury College ion trapping group is building a lab to trap atomic ytterbium ions for quantum information and spectroscopy experiments. We report on the development of a software program to wavelength stabilize our lab's multiple external cavity diode lasers (ECDLs) using feedback from a commercial wavemeter. By connecting to a Fizeau wavelength meter and multiplexed fiberoptic switch (Bristol Instruments), the python-based and open-source software can monitor the wavelength of multiple lasers simultaneously relative to their respective lock points. A proportional-integral-derivative (PID) algorithm calculates a correction voltage, generates it through connection to a DAC device (LabJack), and sends it to the ECDL piezo for feedback at rates of up to 30 Hz. The software includes robust features, including independent control of up to four lasers through a graphical user interface, the ability to rapidly toggle each laser between two different lock points, and wavelength monitoring via trend plots. The software has been demonstrated on both commercial and home built ECDLs, effectively eliminating their long-term wavelength drift. This long-term stability may be accompanied by an increase in the short-term noise by to 33% compared to when the lock is off, although additional testing relative to other frequency references is still needed to verify these results.

*We acknowledge funding from Middlebury College and the NSF MRI Program (Award #2018573).

A Python-based Software for Wavelength Stabilization of External Cavity Diode Lasers

Middlebury College

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What does it do?

•Connects to up to 4 external cavity diode lasers (ECDLs), a wavelength meter and a digital to analog converter (DAC)

•Reads the wavelength of one ECDL, and uses a proportional, integral, derivative (PID) algorithm to generate a correction

•The correction is sent to the DAC and converted into a voltage which is then sent to the ECDL's piezo for wavelength correction

•It then switches to the next ECDL connected and repeats the same process up to 30 times per second.

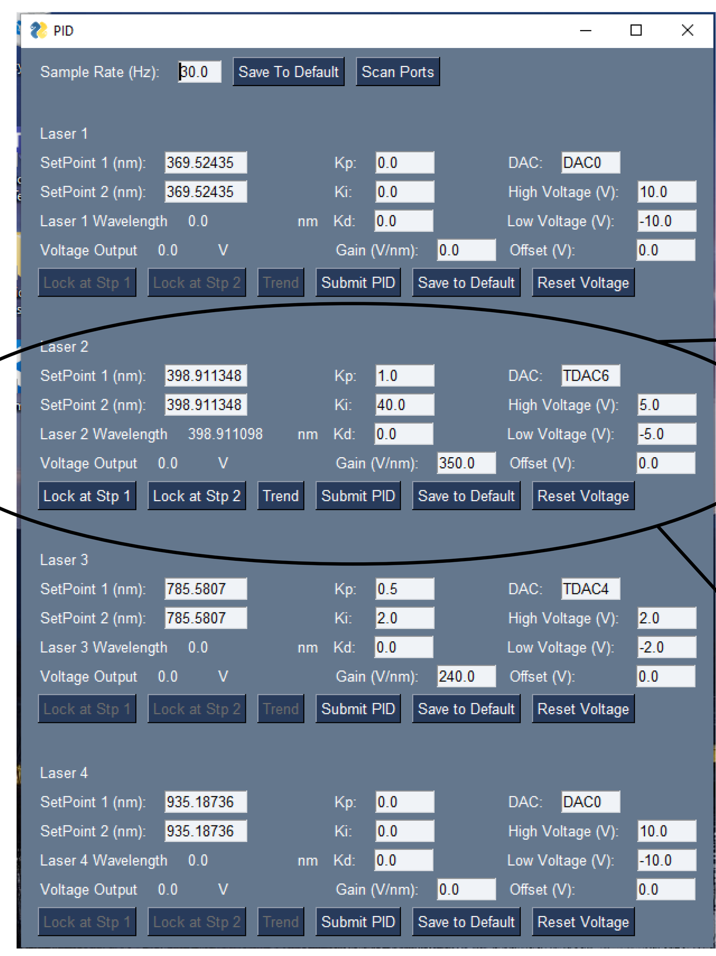


Figure 1. The software's graphical user interface, running with one ECDL connected but no PID lock running. Detail at right.

Why is it needed?

Research lasers (EDCLs) require stable wavelength operation for planned ytterbium ion trapping and spectroscopy experiments in the Middlebury Ion Trapping Lab (see **Figure 3**)

This custom software uses existing equipment to establish robust, low-bandwidth feedback to stabilized simultaneous laser's wavelength across the entire visible spectrum.

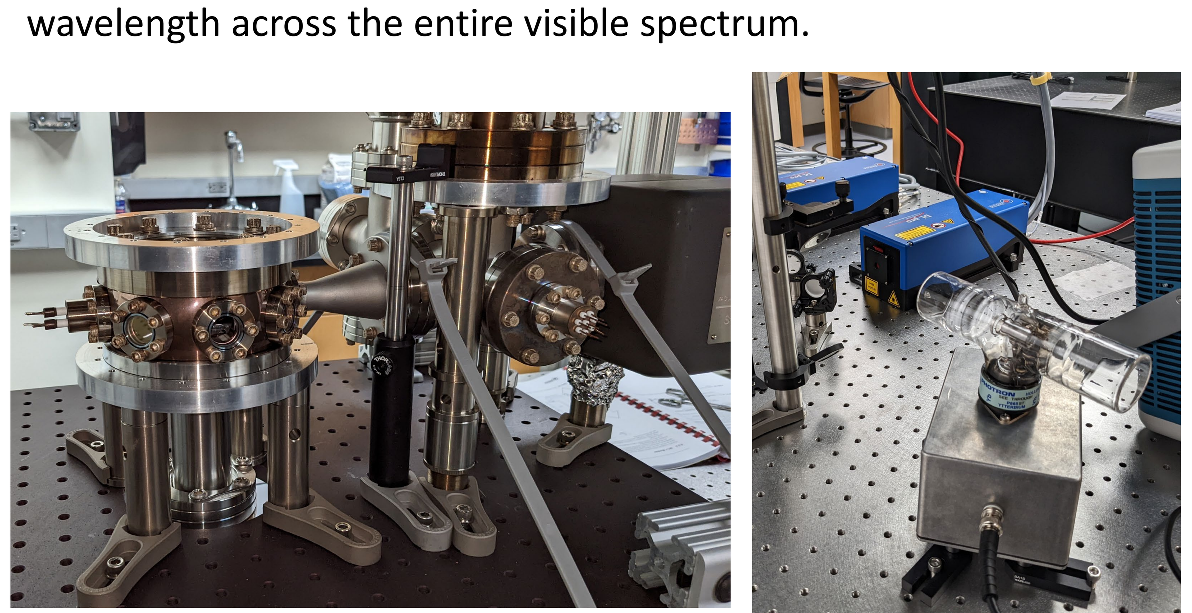


Figure 3. (left) A four-rod ion trap in an ultra-high vacuum chamber. (right) A see-through hollow cathode lamp with Toptica DL Pro ECDLs being configured for absorption and optogalvanic spectroscopy.

The software!

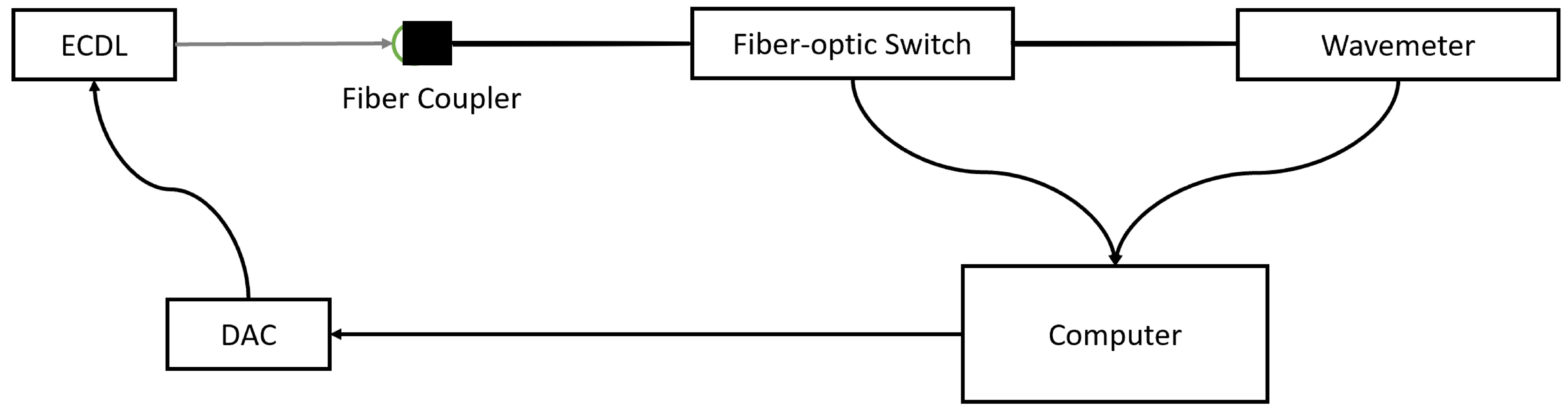
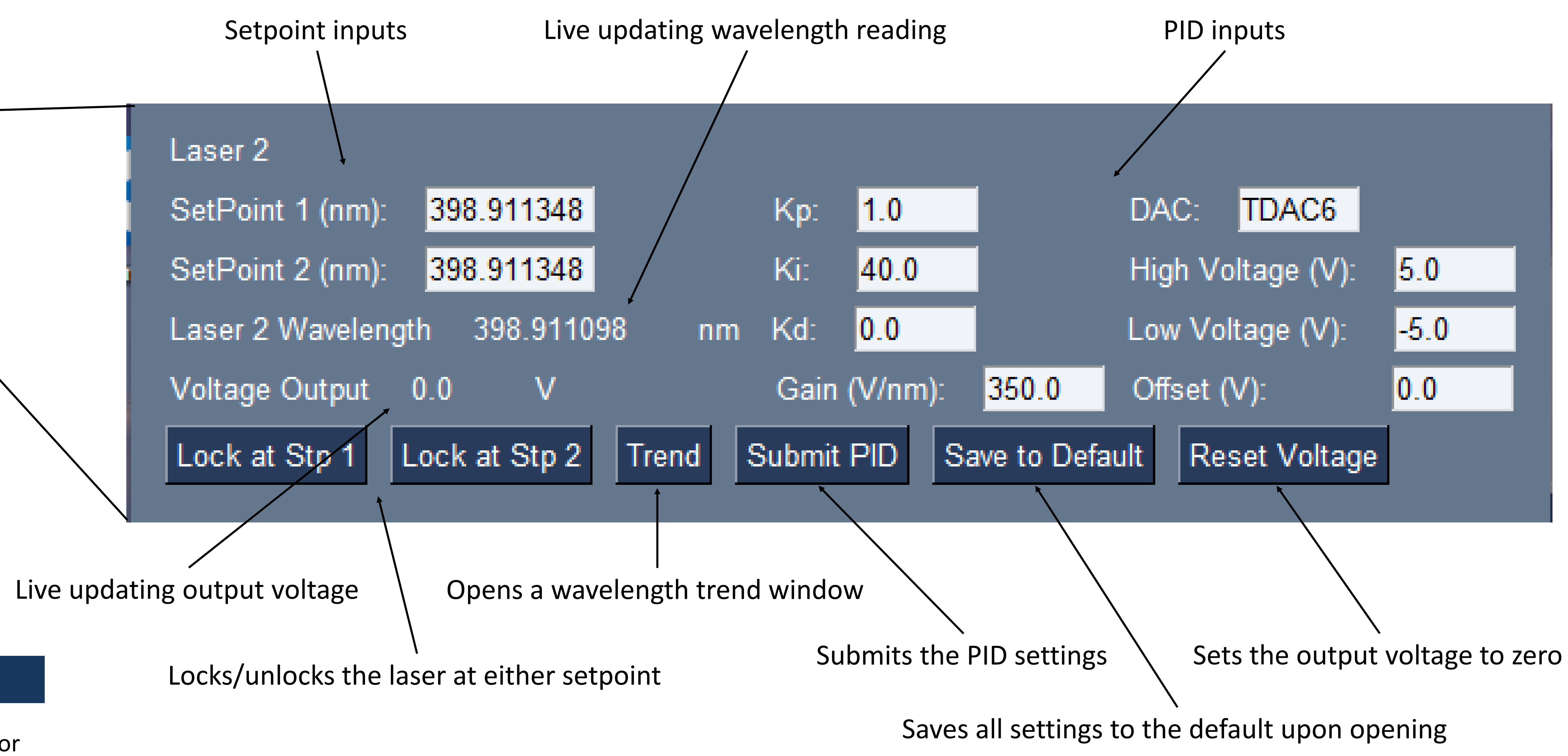


Figure 2. A schematic of the ECDL connected to the locking software



Features

- Connects to the wavemeter (Bristol Instruments 871A), fiber switch (Bristol Instruments FOS8) and DAC (LabJack T4) with a button press
- Automatically determines the which ECDL should be paired with which default PID settings (with option to update defaults after tuning)
- Ability to toggle between two different locking setpoints as well as leave ECDL unlocked
- Live updates the wavelength of each connected ECDL
- Option for live updating trend plot in either GHz or nm
  - Ability to pause and clear the plot
  - Displays mean and standard deviation of wavelength/frequency since last cleared
- Corrects for wavelength reading errors from the wavemeter

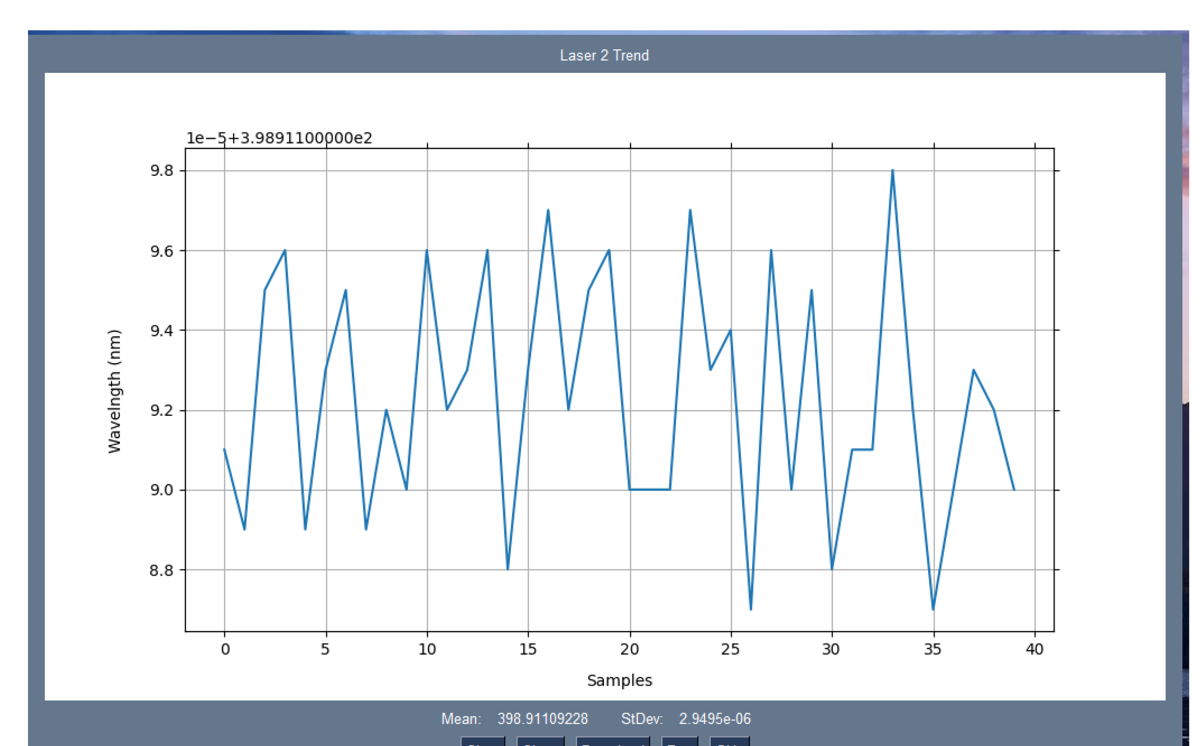


Figure 4. Live trend window for a connected ECDL (unlocked). Contains a live reading of the mean and standard deviation. Buttons to clear the plot/mean/standard deviation, close the window, download the data, pause/run the trend plotting, and switch the readings between GHz and nm.

How well does it stabilize?

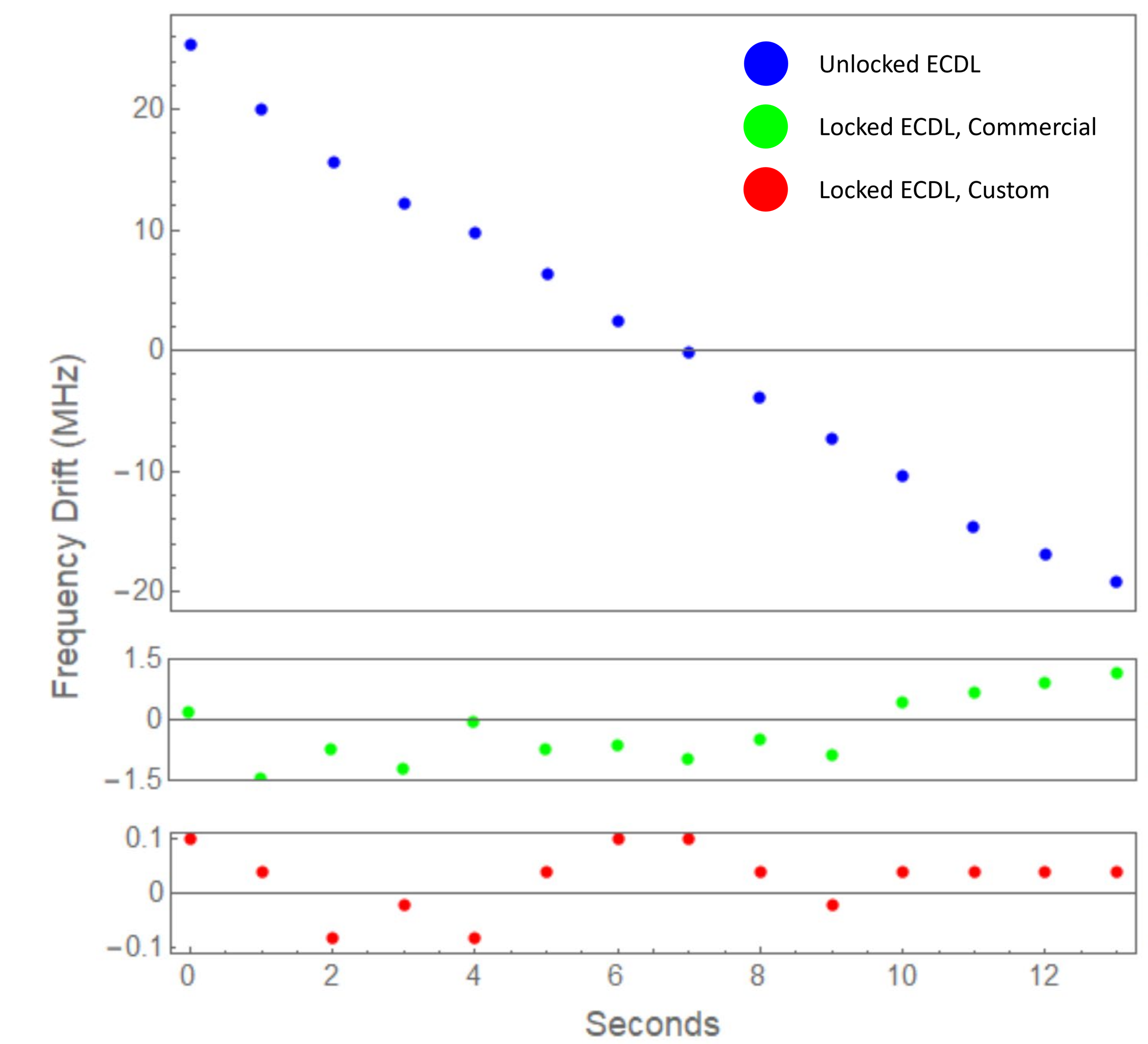


Figure 6. Plotted on a non-equivalent vertical scale, the frequency fluctuations of the free-running diode laser are displayed (blue), as well as the residual noise of the locked laser, locked with both a commercially available PID algorithm (green) and the custom algorithm in this software (red). The PID parameters used are as follows: Kp = 1, Ki = 40, Kd = 0. These data are down sampled through use of an average to show one data point per second. The wavemeter lock eliminates long-term drift in the 399 nm DL Pro laser under test.

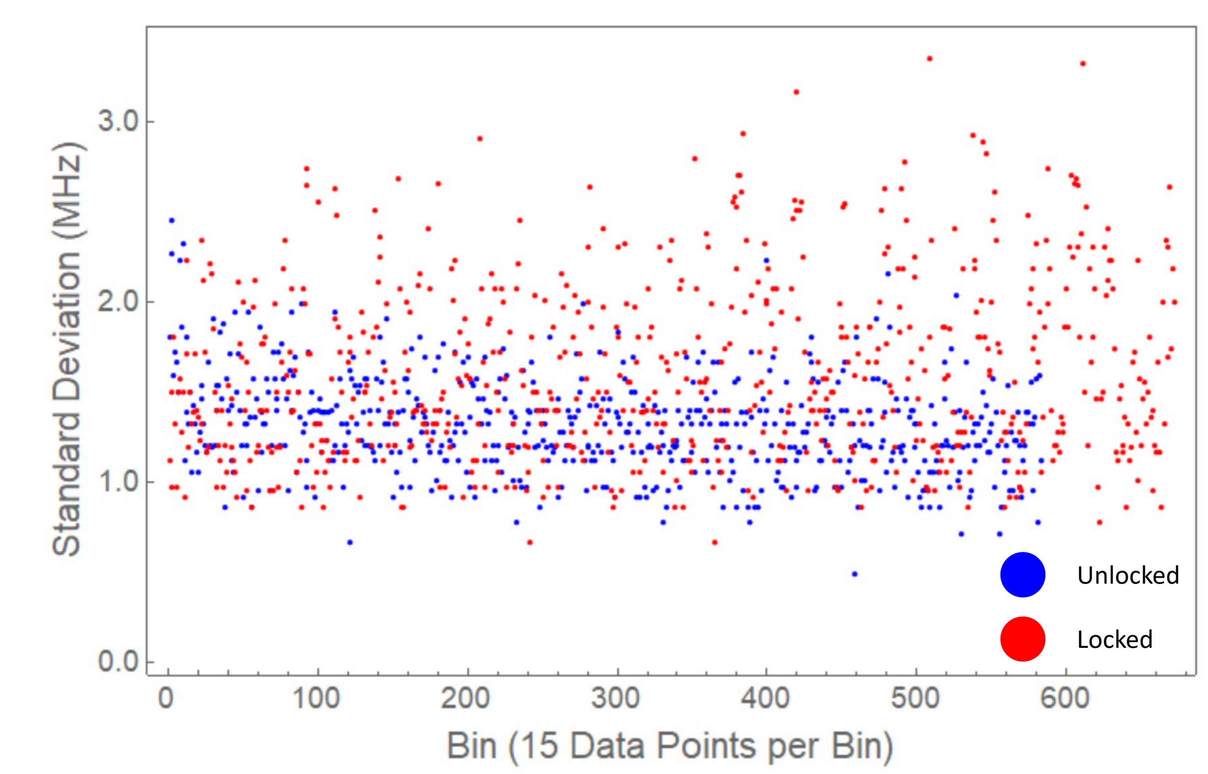


Figure 7. The standard deviation of the wavelength with a bin size of 1 second, sampling at a rate of 15Hz. The mean standard deviation over this short-term is 33% higher with the ECDL locked vs. unlocked. This could be due to the PID gain parameters. More testing is needed, as well as testing at wavelengths.

ACKNOWLEDGEMENTS

Contributors: **JT** wrote the software and collected and analyzed the data shown. **TZ** built an ECDL to test the software. **JL** built the HCL spectroscopy setup in Fig. 3. **PH** conceived and advised the project. Both **JT** and **PH** drafted this poster.

Funding: This work was supported by Middlebury College and the NSF MRI Program (Award #2018573)