Toward an External Cavity Diode Laser

Caleb Locklear and W.D. Brandon
The University of North Carolina-Pembroke
Dept. of Chemistry and Physics

Abstract

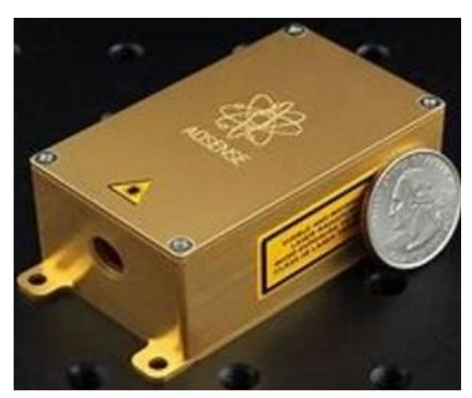
Since their inception (circa 1990) inexpensive and robust external cavity diode lasers (ECDLs) have replaced many of the tunable lasers (e.g., Titanium Sapphire laser and complex pump/dye laser configurations) as the workhorse laser in many atomic physics labs. Their versatility and ever-increasing deployment in applications such as absorption spectroscopy, laser cooling, and mode locking makes the ECDL an essential device in a modern physics lab and cutting-edge engineering. Therefore, it is imperative for physicists (students and instructors) to implement ECDLs and gain practical knowledge about them.

Extended Cavity Diode Laser (ECDL)

What is an ECDL?
External Cavity Diode Laser (ECDL) is a non-monolithic, diode laser in which the laser cavity (resonator) is completed with external optical elements. Hence the name, "External Cavity…" also appropriate, "Extended Cavity…".

How is an ECDL different that an ordinary diode laser?

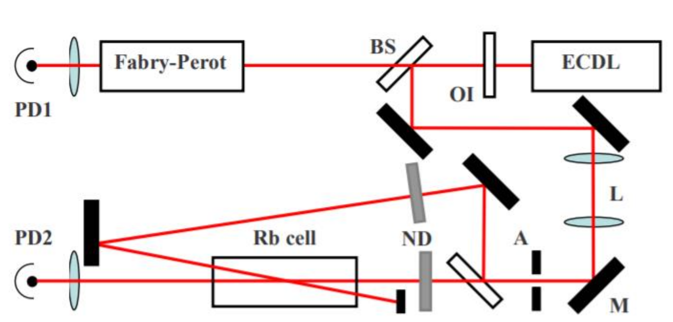
- Regular diode lasers are less complex than an ECDL.
- ECDL's have many optical components such as: piezos, diffraction gratings, additional opto-mechanical mounting hardware, and complex electrical devices to increase stability.
- A diffraction grating, located outside the diode laser, is at the heart of the design



Commercial unit – controllers not shown

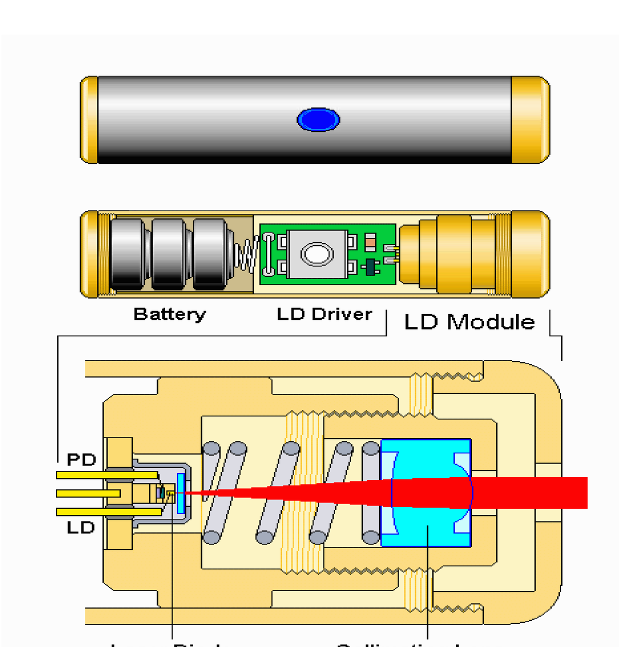
ECDL Applications include…

- Laser Pumping
  - Fiber Laser Pumping
  - Diode Pumped Solid State Laser
- Spectroscopy
  - Dichroic Vapor Spectroscopy
  - Raman Spectroscopy
  - Coherent Anti-Strokes Raman Spectroscopy
- Differential Absorption
- Mode Locking and Atomic Clocks (Earth and Space Based)

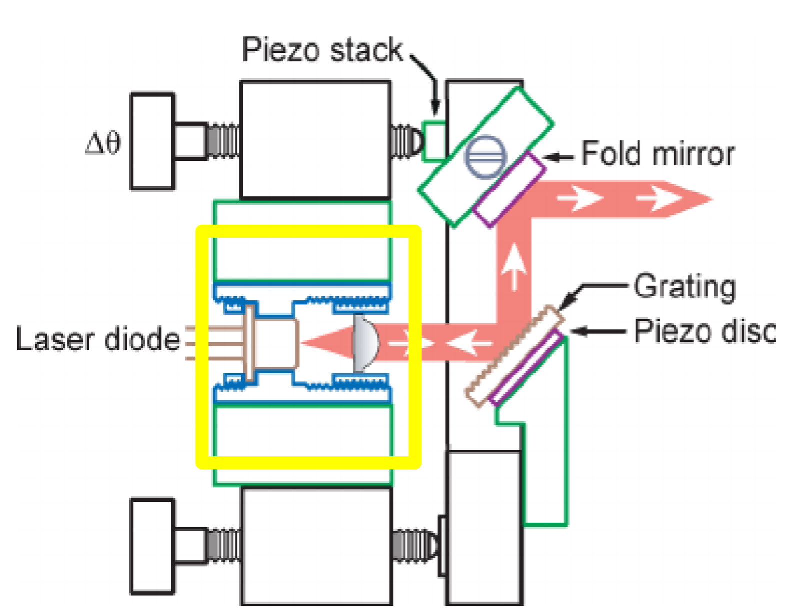


Our first goal is to "mode lock" an ECDL using Rb vapor, as illustrated by this basic design.

ECDL: Littrow Design



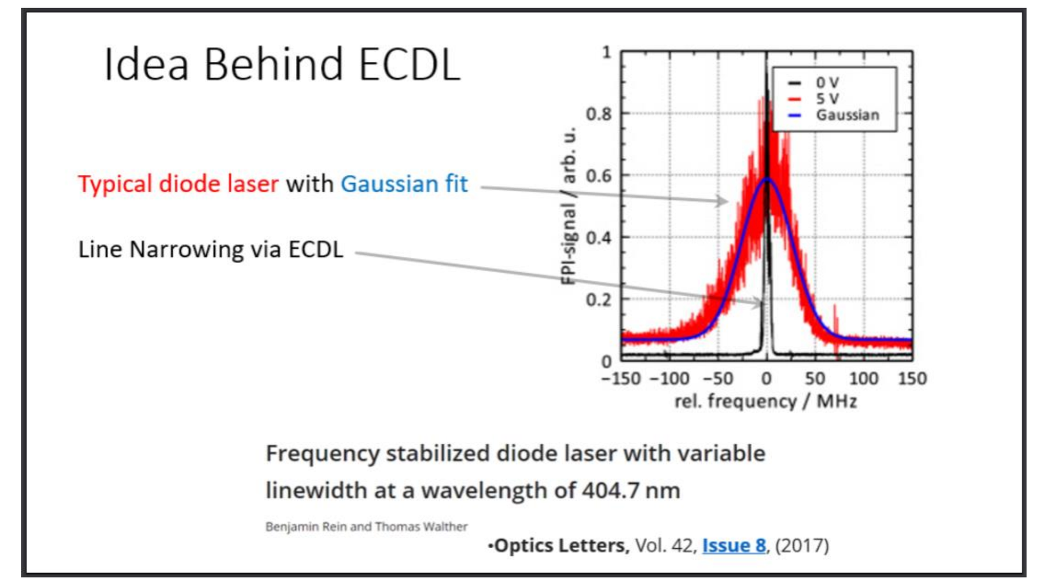
Typical Red Laser Pointer

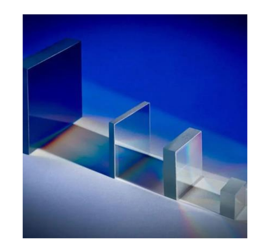


ECDL (Littrow) design. The laser diode and collimator are shown in the yellow box.

ECDL: Littrow Design (continued)

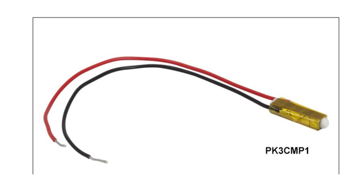
The main attribute of ECDL output is spectral line narrowing. The figure shown to the right shows laser bandwidths associated with a typical laser along with the significant decreased laser bandwidth of an ECDL. Shown below are some of the components needed to successfully build an ECDL.



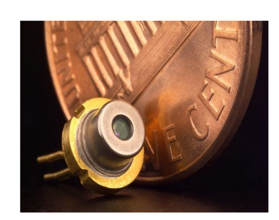


Diffraction Gratings

Optomechanical Mounts/Devices



Piezo Stack



Diode Laser 5.6mm, TO-18

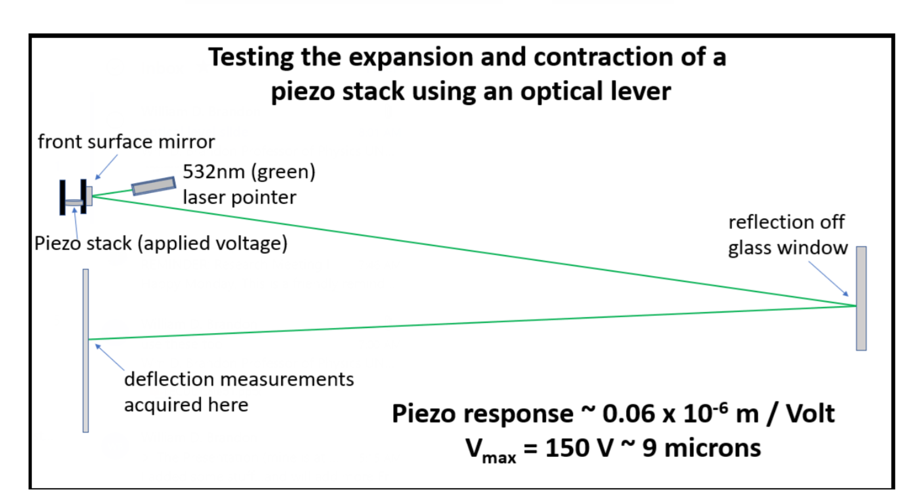
Piezo Disc

Design and Implementation

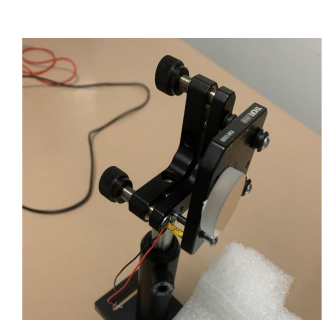
Requirements:

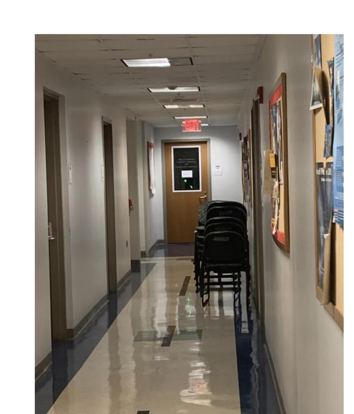
- reading published papers, researching components, products, and supplies involved in the design, construction and deployment of an **ECDL**.
- locating and identifying useful devices, aided by consultation with project engineers of various companies.

Characterizing the Piezo Stack
We used an optical lever to conclude that our piezo stack was working by utilizing four power supplies in series (total of 120V). A supply voltage causes the length of the piezo stack to expand and contract. Its natural length is 10mm but expands by 9.2μm (microns) at 150V, the maximum voltage it can withstand.



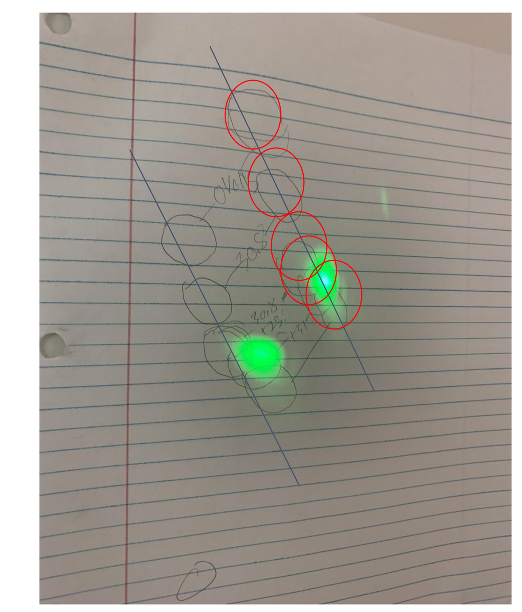
Components Used to Test Piezo Stack



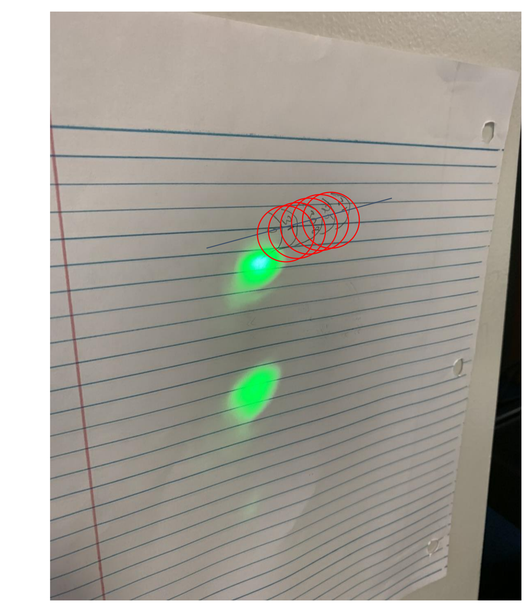


Design and Implementation: (continued)

Results of Piezo Stack Testing: Initial results were not so good, as indicated by the vertical component of deflection (lower left figure). After a slight modification to the mounting springs, the deflection was seen to be overwhelmingly horizontal (lower right figure), as desired.



Red circles indicate deflections corresponding to 30V increments.

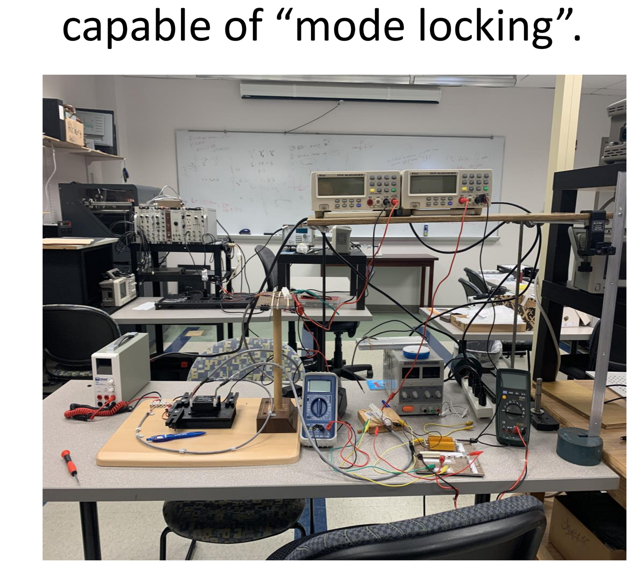


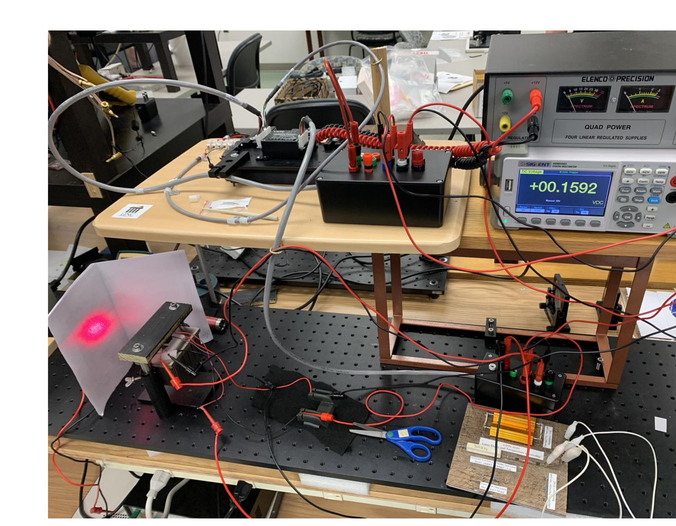
The LDTC1020 Laser Diode Current and Temperature Controller
In addition to micro-alignment of the piezo stack for wavelength tuning, a fully functional ECDL requires stabilization of the laser intensity output. Precision control of both the injection current and temperature of the laser diode is achieved with electronics. We decided on a dual current and temperature controller, an LDTC1020 (~$600.00), a module in which laser stabilization is achieved via proportional-integral-derivative (PID) electronic circuitry.

Prototype UNCP ECDL Testing Facility

Constructing a Testing Facility

- A simulation board was designed and fabricated to carefully adjust the outputs of the LDTC1020 utilizing appropriate parameters to control various diode lasers.
- The unit has been implemented into the new Engineering R&D lab as a platform to continue the ECDL research, in addition to providing advanced teaching labs, the latter required a much-improved user manual for the LDTC1020.
- While significant progress was made, about six more weeks of fabrication and testing are needed to produce an ECDL system capable of "mode locking".





Acknowledgements

Thanks to all Rise staff members or the for the opportunity and support for this research program.