

Laser Enhancement by External Optical Signal

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Background

Erbium experiment
Laser cooling using 401nm spectral line



(Gadway lab, UIUC)

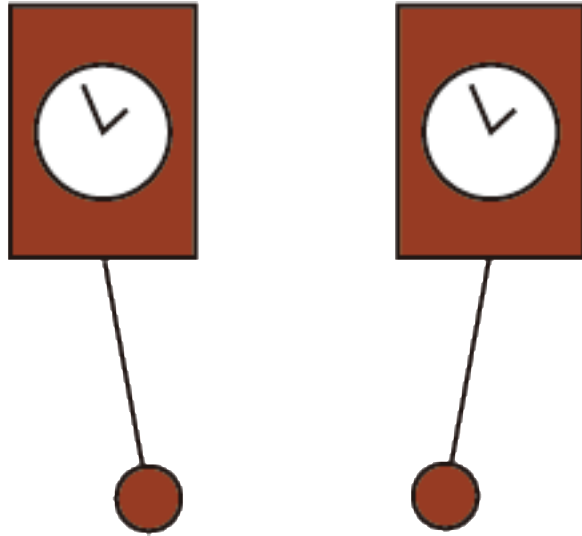
Issue

How to get the laser source with enough power at desired frequency?

Methods

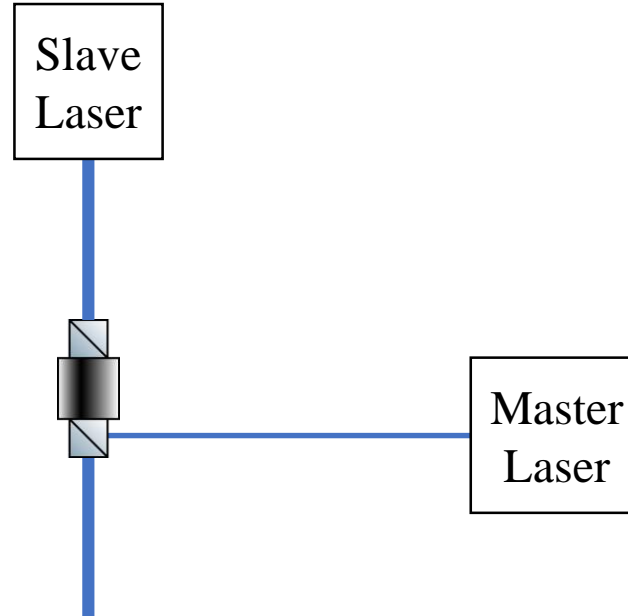
1. Buy expensive laser source
2. Frequency doubling
3. Injection locking

Injection Locking



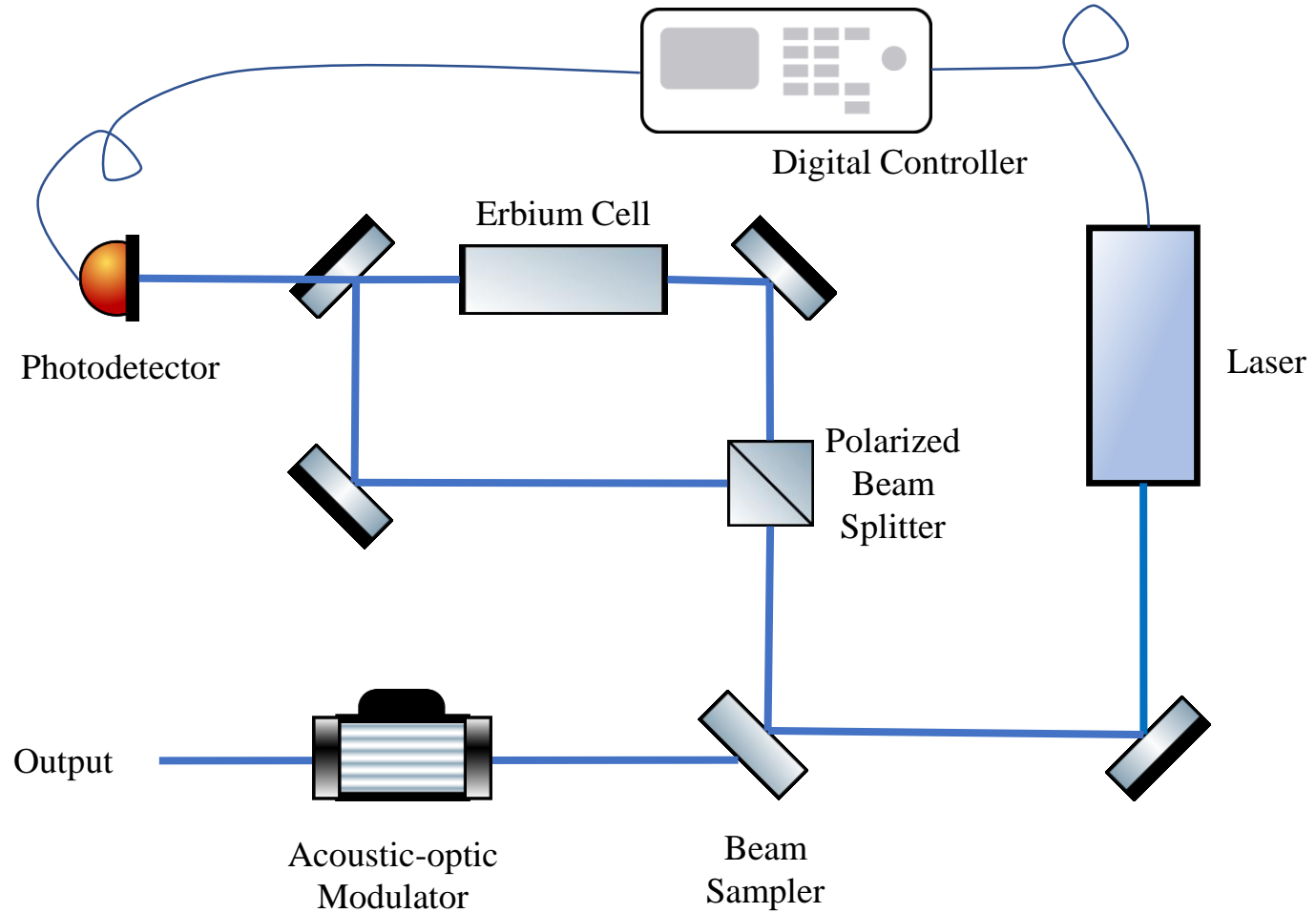
Injection Locking

Basic Apparatus



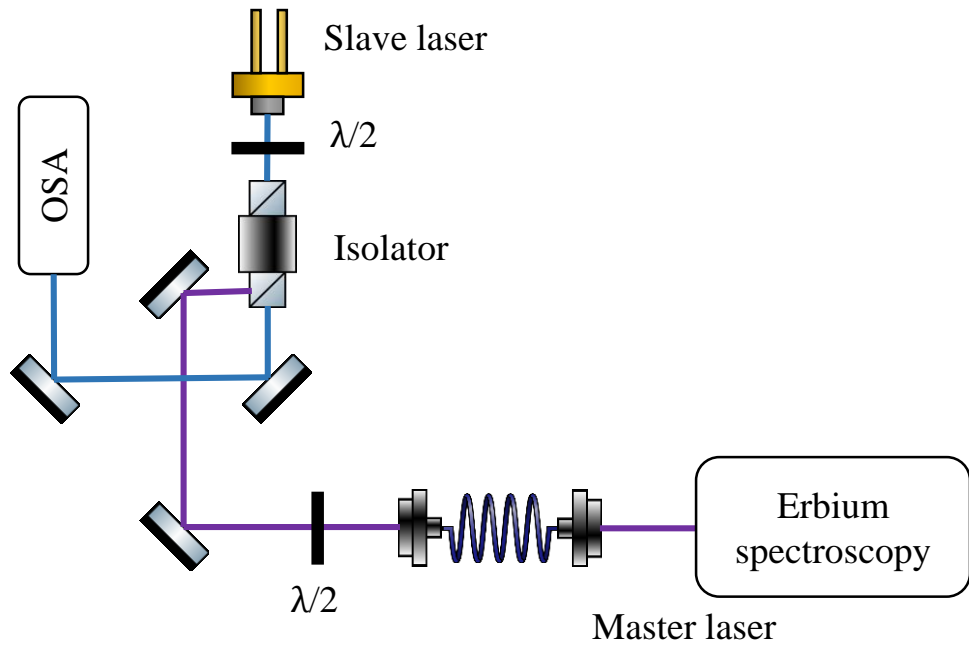
Injection Locking

Master laser

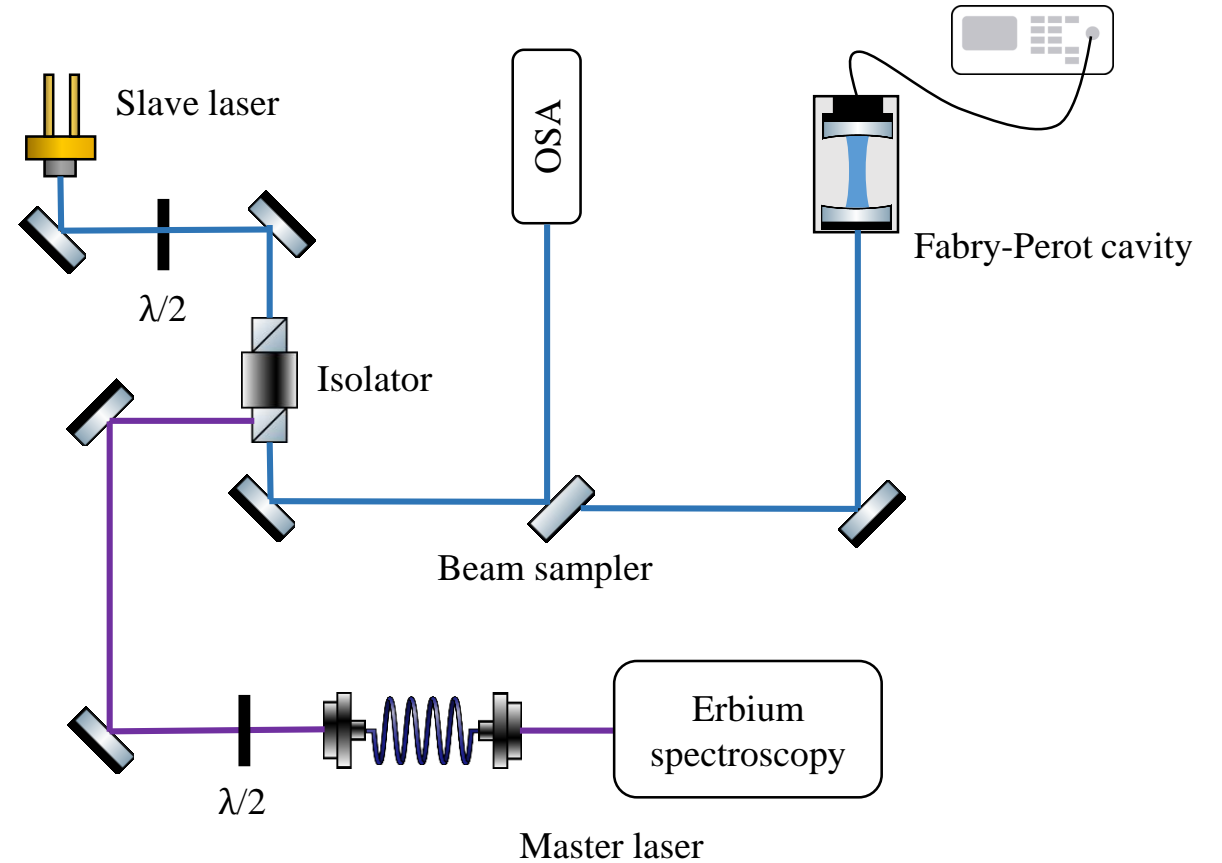


Injection Locking

Slave laser & Master laser



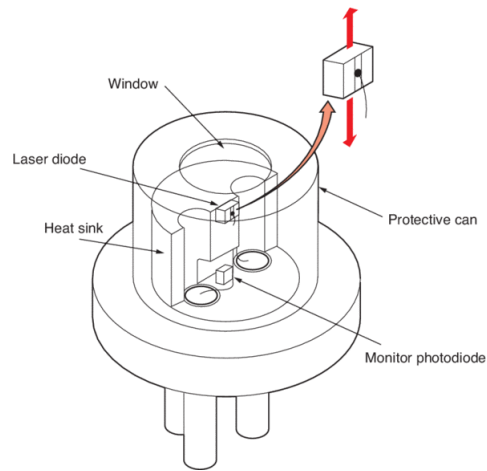
Multi-mode



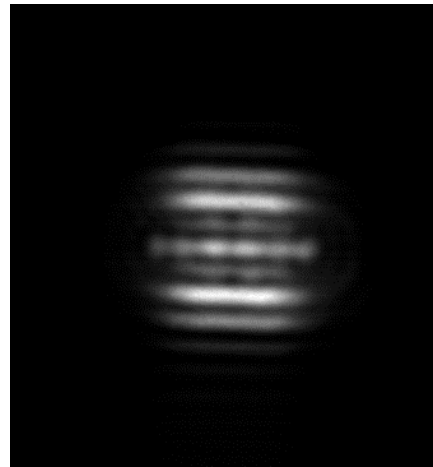
Single-mode

Injection Locking

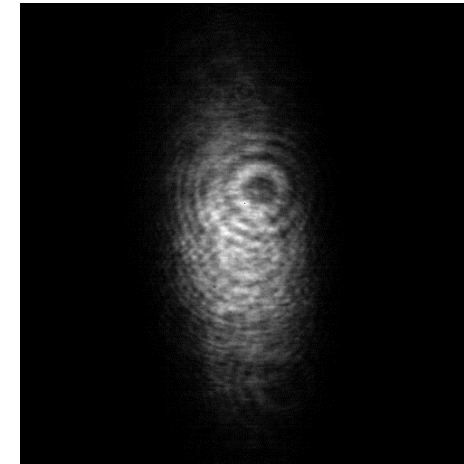
Mode Matching & Wavelength Overlapping



Can-style laser diode
(Newport.com, 2017)



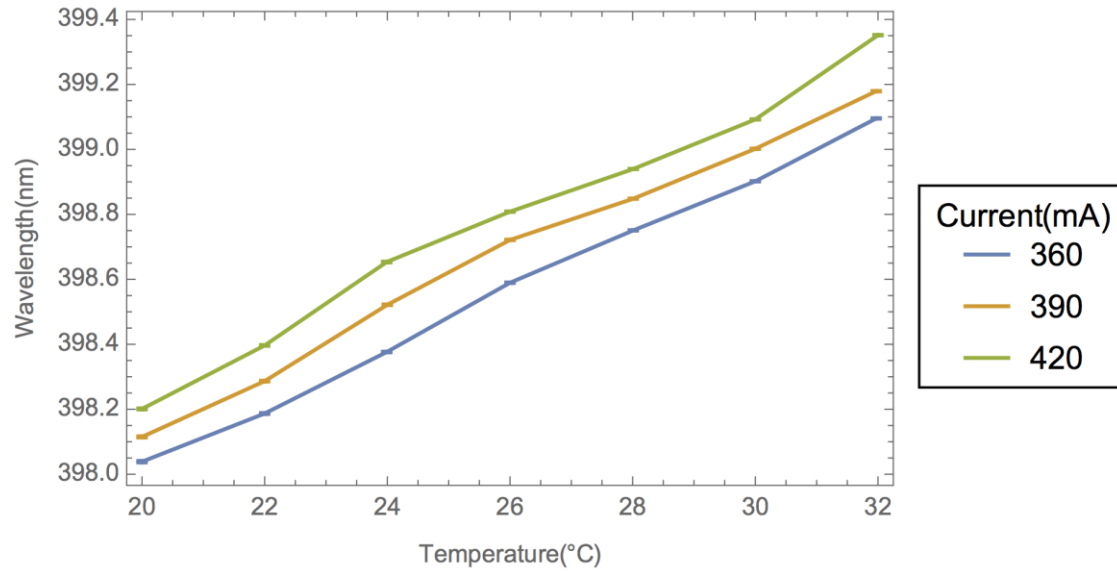
Multi-mode



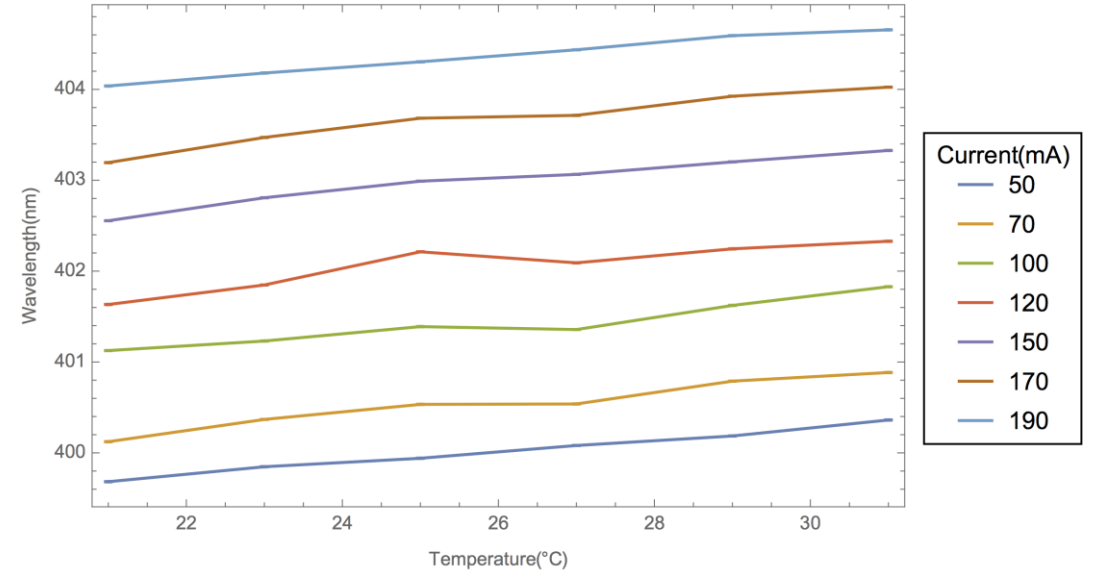
Single-mode

Injection Locking

Mode Matching & Wavelength Overlapping



Multi-mode laser diode



Single-mode laser diode

Results

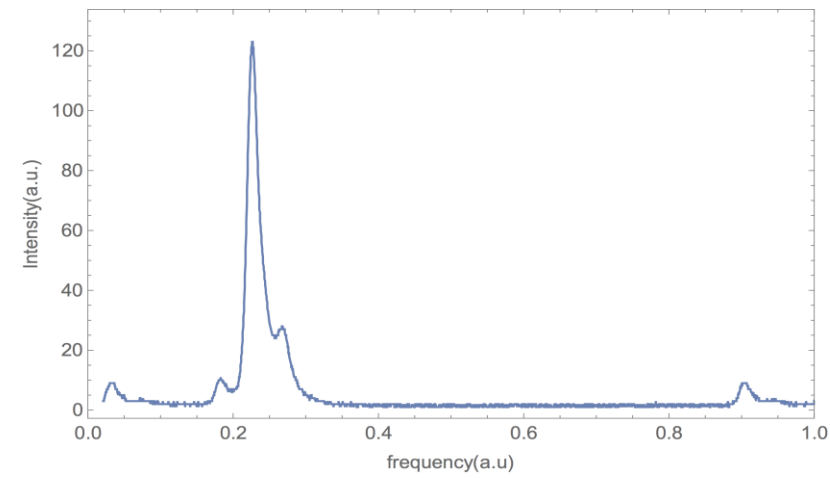
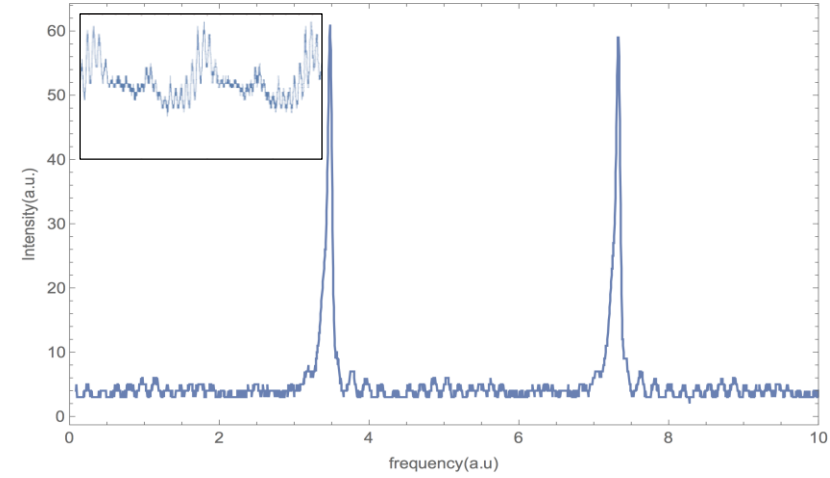
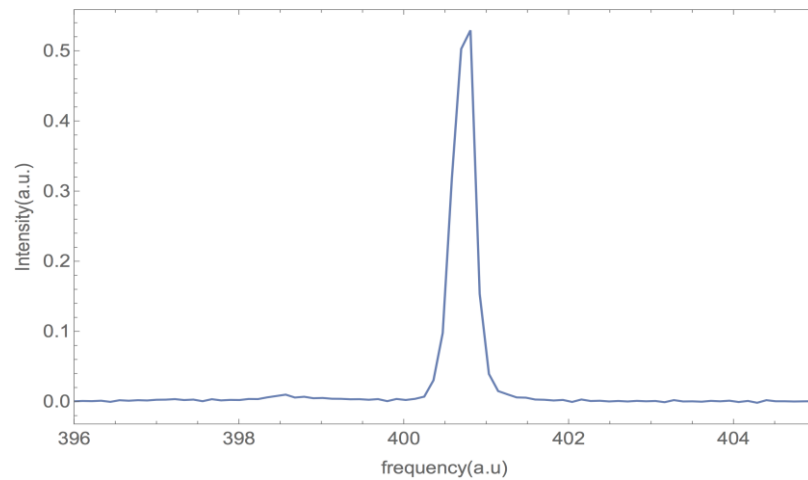
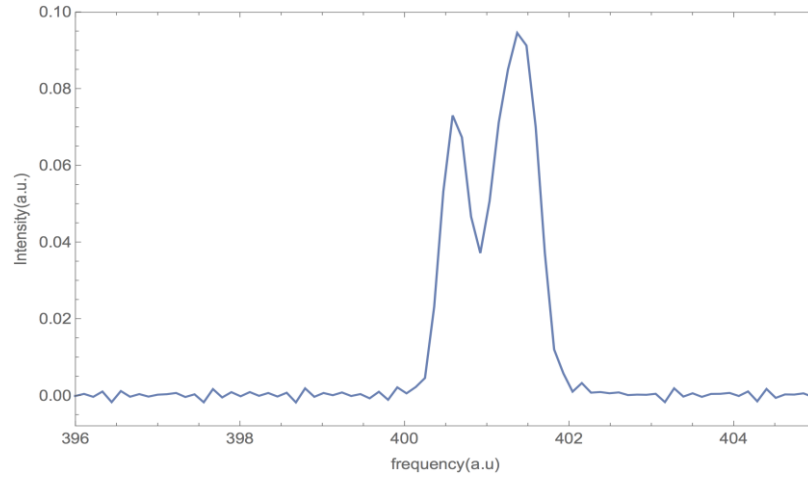
Efficiency

1. For multi-mode, get $\sim 80\text{mW}$ with $\sim 7\text{mW}$ injected
2. For single-mode, get $\sim 106\text{mW}$ with $\sim 1.6\text{mW}$ injected

Results

Wavelength & Frequency Spectrum (single-mode)

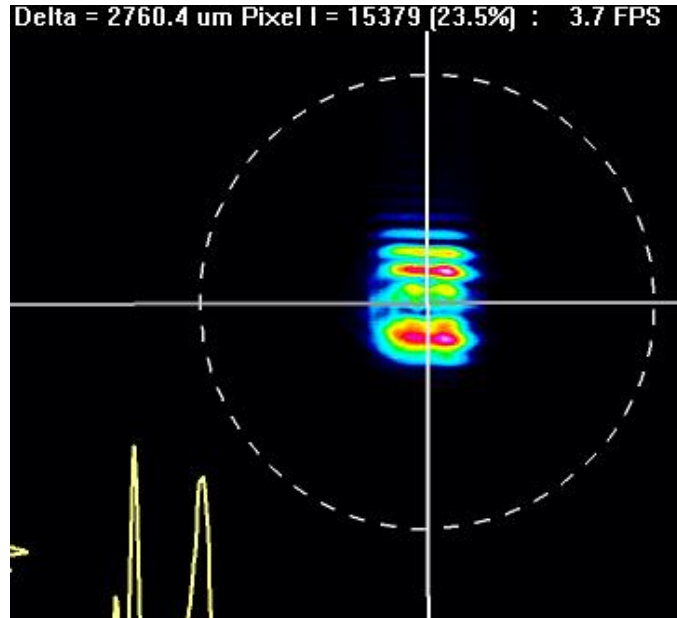
Optical Spectrum Analyzer



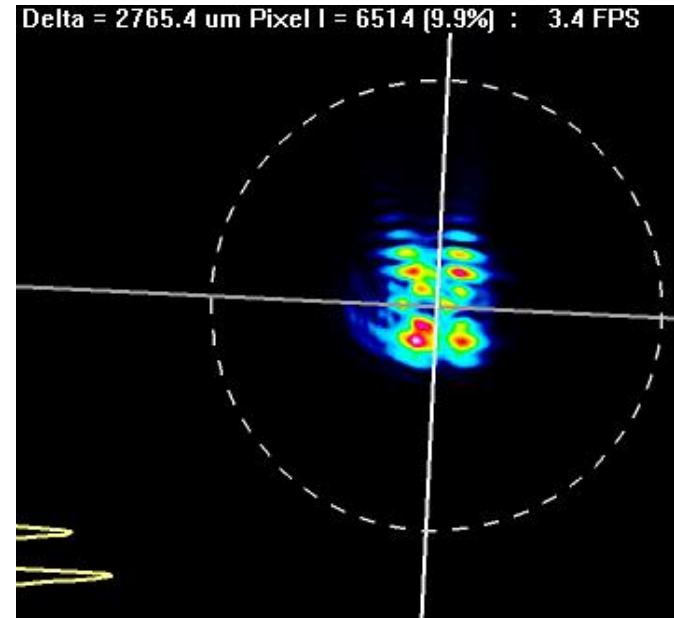
Fabry-Perot Cavity

Results

Beam Profile Change



Without injected beam

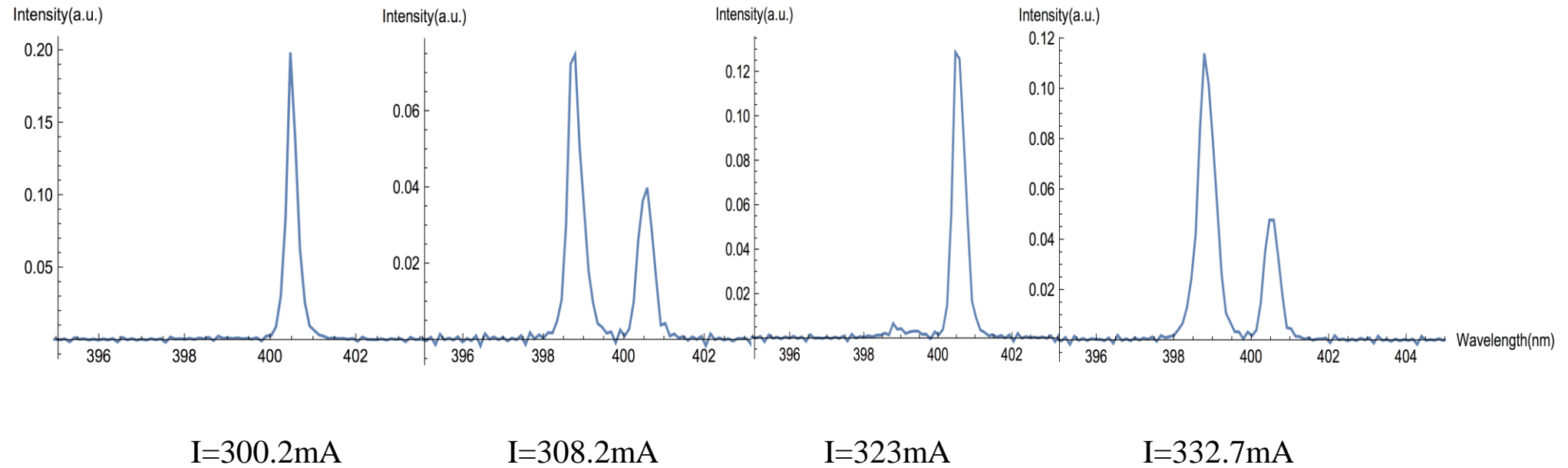


With injected beam

Results

Discrete Change

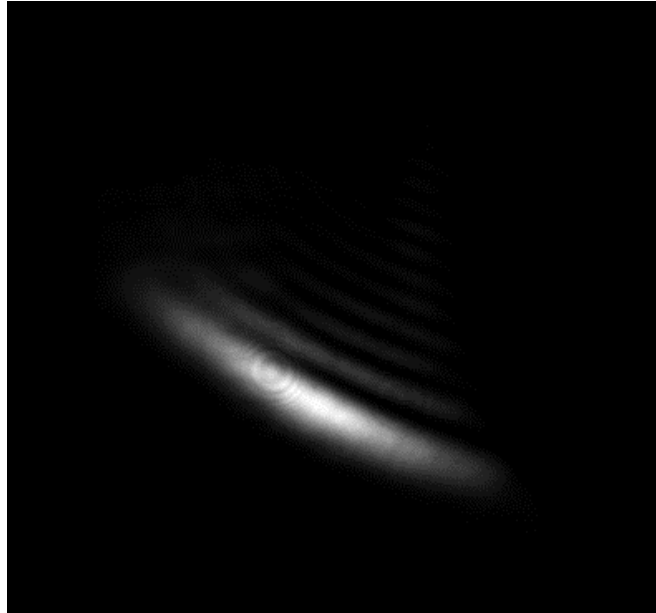
$T=30\text{ }^{\circ}\text{C}$



Future Work

Improvement of the project

1. Stabilization of the signal
2. Transferring of the laser beam



Beam profile of the single-mode
laser after injection-locked

Future Work

Cooling and Trapping of Erbium Atoms:
Optical Molasses & Zeeman Slower
Magneto-Optical Trap

Why Erbium?

1. Abundant bosonic and fermionic isotopes
2. Large magnetic moment

Acknowledge

- Helps provided by Prof. Chu and Prof. Wang
- Prof. Gadway and graduate students Jackson and Sia in UIUC
- Scholarships provided by Physics Department and S.H.Ho College
- Thorlabs snacks



Reference

1. Pagett, C., Moriya, P., Celistrino Teixeira, R., Shiozaki, R., Hemmerling, M. and Courteille, P. (2016). Injection locking of a low cost high power laser diode at 461 nm. *Review of Scientific Instruments*, 87(5), p.053105.
2. Hosoya, T., Miranda, M., Inoue, R. and Kozuma, M. (2015). Injection locking of a high power ultraviolet laser diode for laser cooling of ytterbium atoms. *Review of Scientific Instruments*, 86(7), p.073110.
3. Saxberg, B., Plotkin-Swing, B. and Gupta, S. (2016). Active stabilization of a diode laser injection lock. *Review of Scientific Instruments*, 87(6), p.063109.
4. Phillips, W. D. (1998). Nobel Lecture: Laser cooling and trapping of neutral atoms. *Reviews of Modern Physics*, 70(3), 721-741.