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VG09-227

Spectroscopic and Kinetic Measurements of Alkali Atom-Rare Gas Excimers

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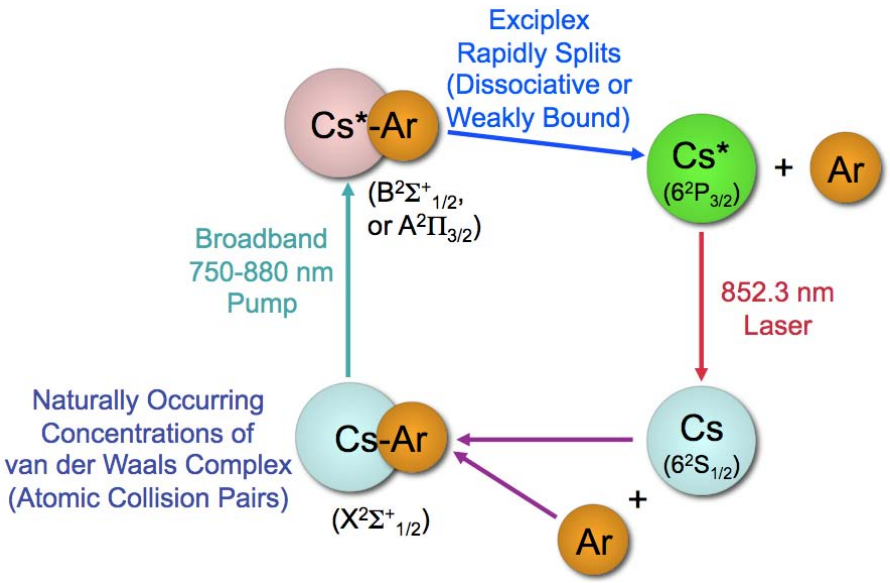
Goals

- **Novel use of alkali/rare-gas molecules to efficiently couple high power diode arrays into alkali vapors**
  - Exciplex molecules absorb over much greater bandwidth
- **Control of inherent high optical gain to minimize ASE and optimize laser oscillation**
- **Development of large volume resonators that allow efficient power extraction**
- **Demonstration of high electrical-to-optical efficiency/power Exciplex assisted diode Pumped Alkali Laser (XPAL)**
- **Education of a future generation of laser scientists**

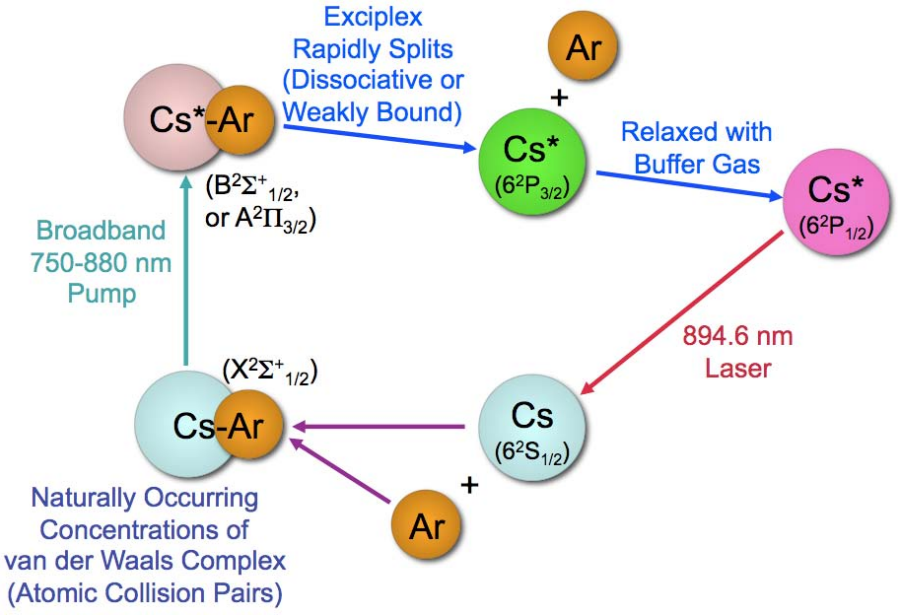
Novel Approach

- **This new laser exploits the optical properties of weakly-bound alkali/rare-gas exciplexes for pumping the $^2P_{1/2, 3/2}$ alkali atomic excited states**

4-level variant



5-level variant



Cs-Ar Energy Level Diagram

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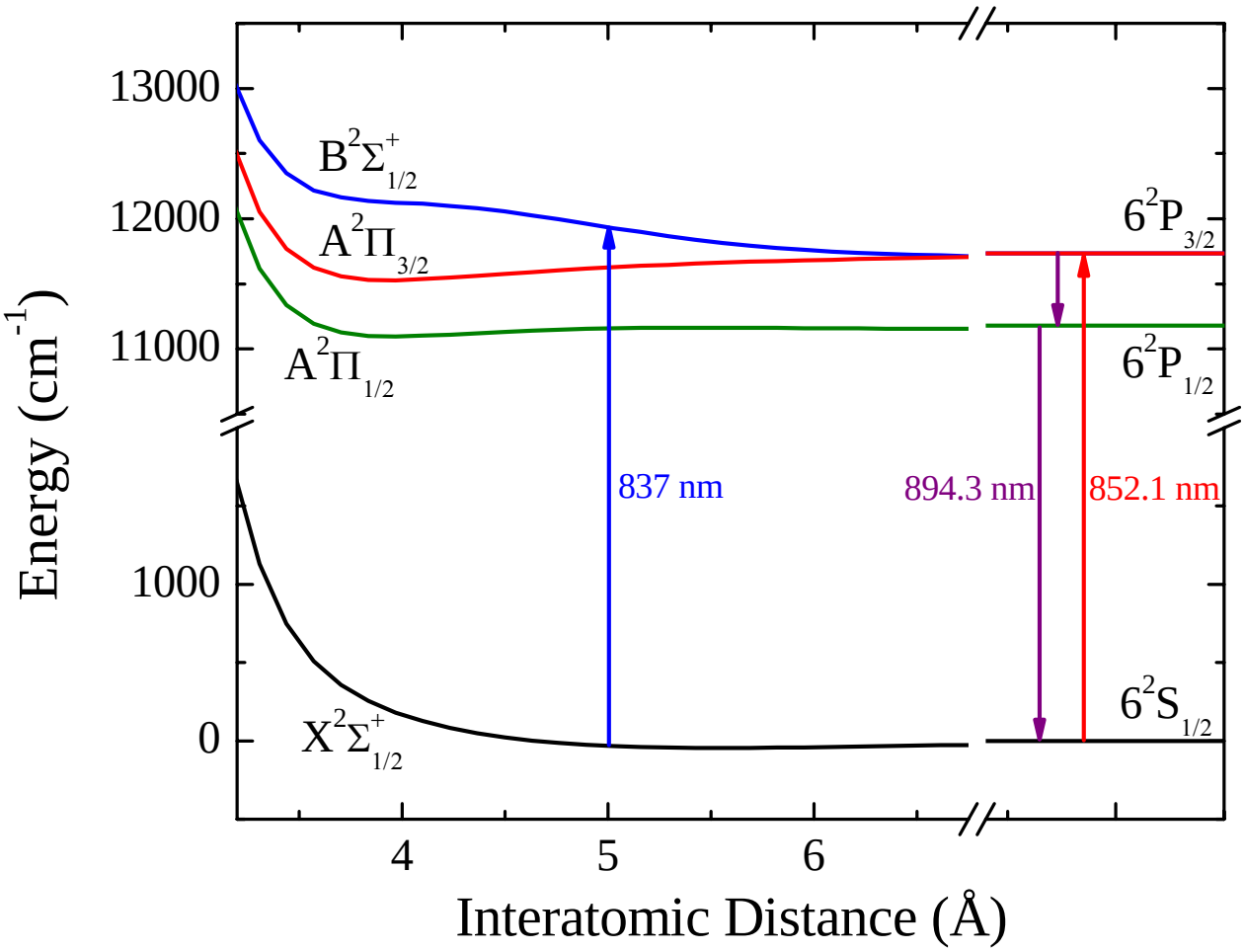

Alkali Cell Oven Design

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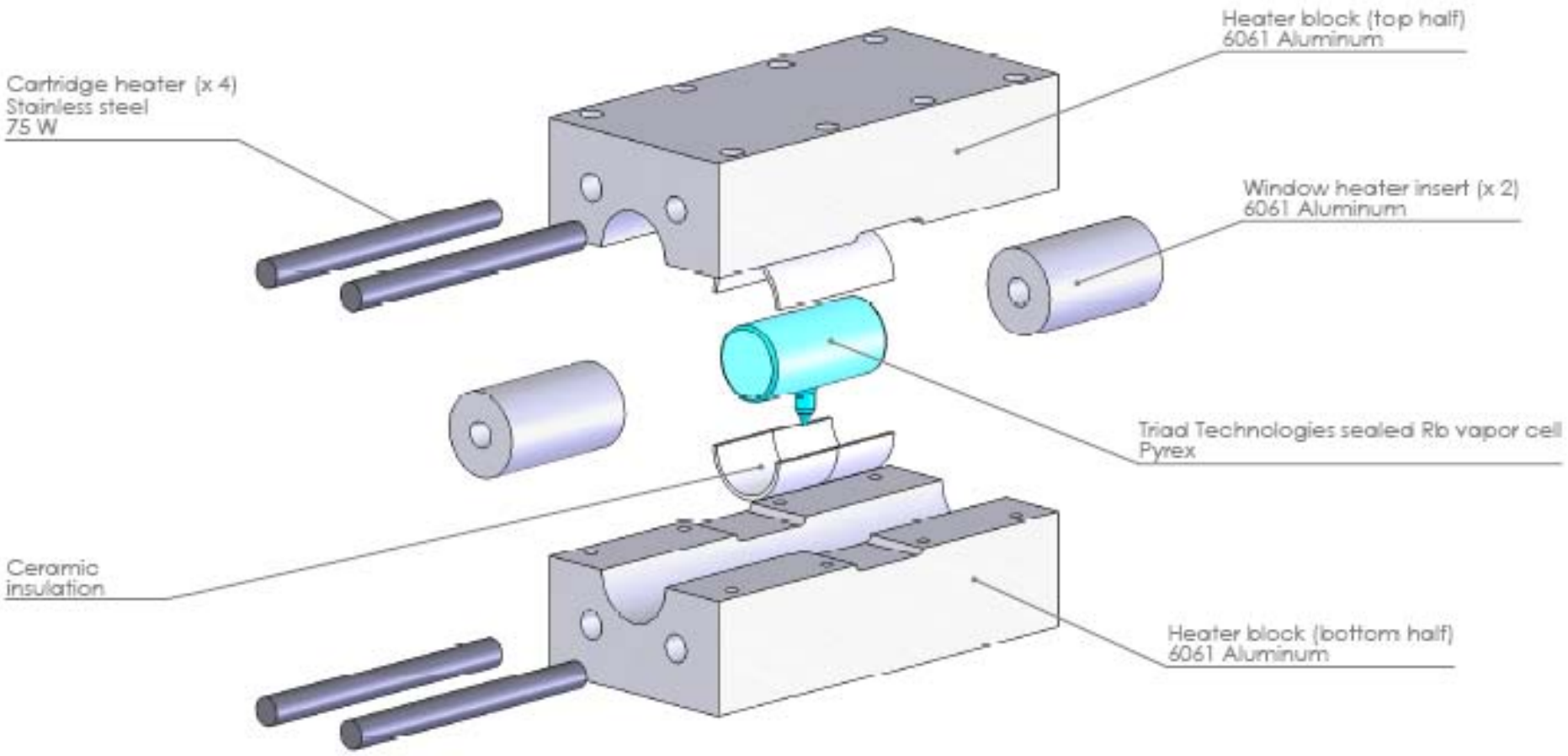

Assembled Alkali Cell Oven: Exterior

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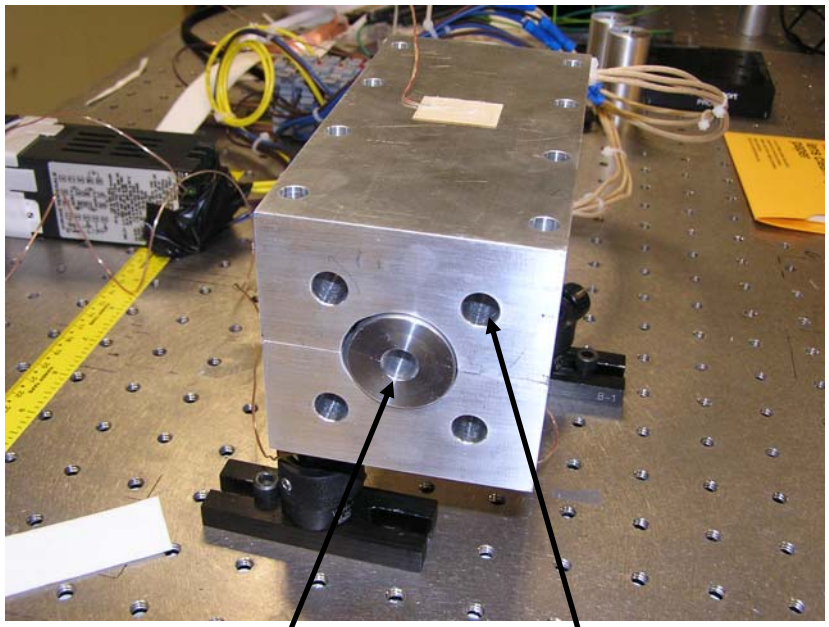
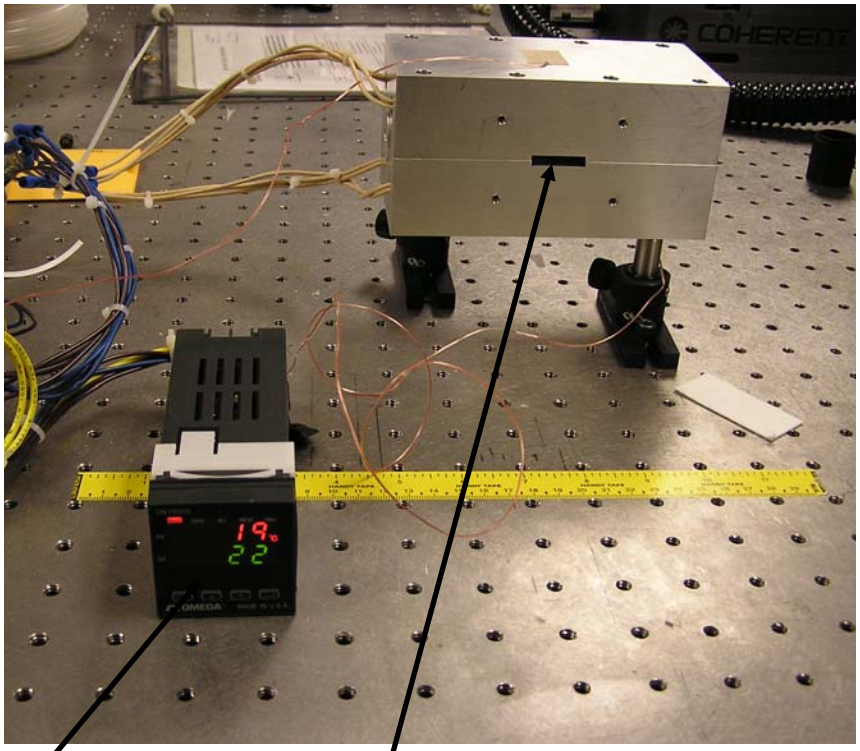


End View Optical Access Through Heated Inserts

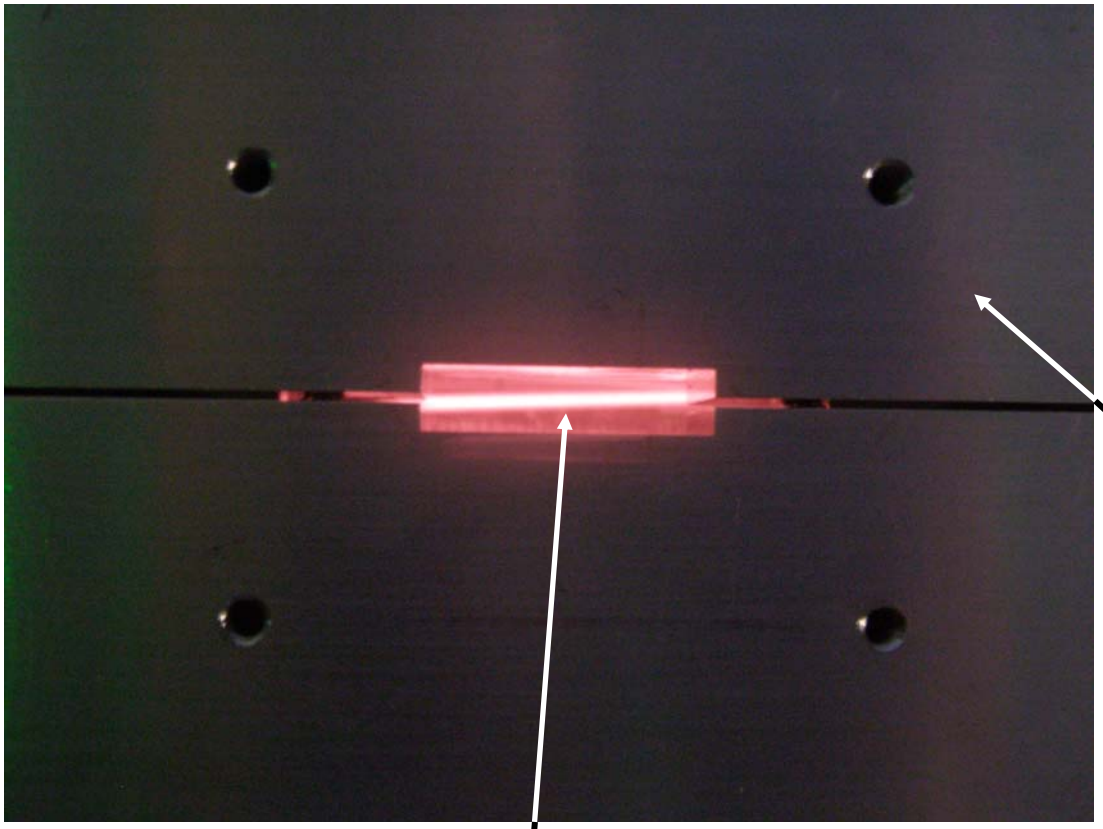
Cartridge Heater Ports (x 4)



Temperature Controller

Side Port for OMA Spectrometer Diagnostic Access and Side Pumping

Photograph of Rb Atom Fluorescence Viewed Through the Alkali Atom Oven Side Port: $\lambda_{excitation}$: 780 nm



Absorption Spectra of Cs Buffered with 500 Torr of Ar

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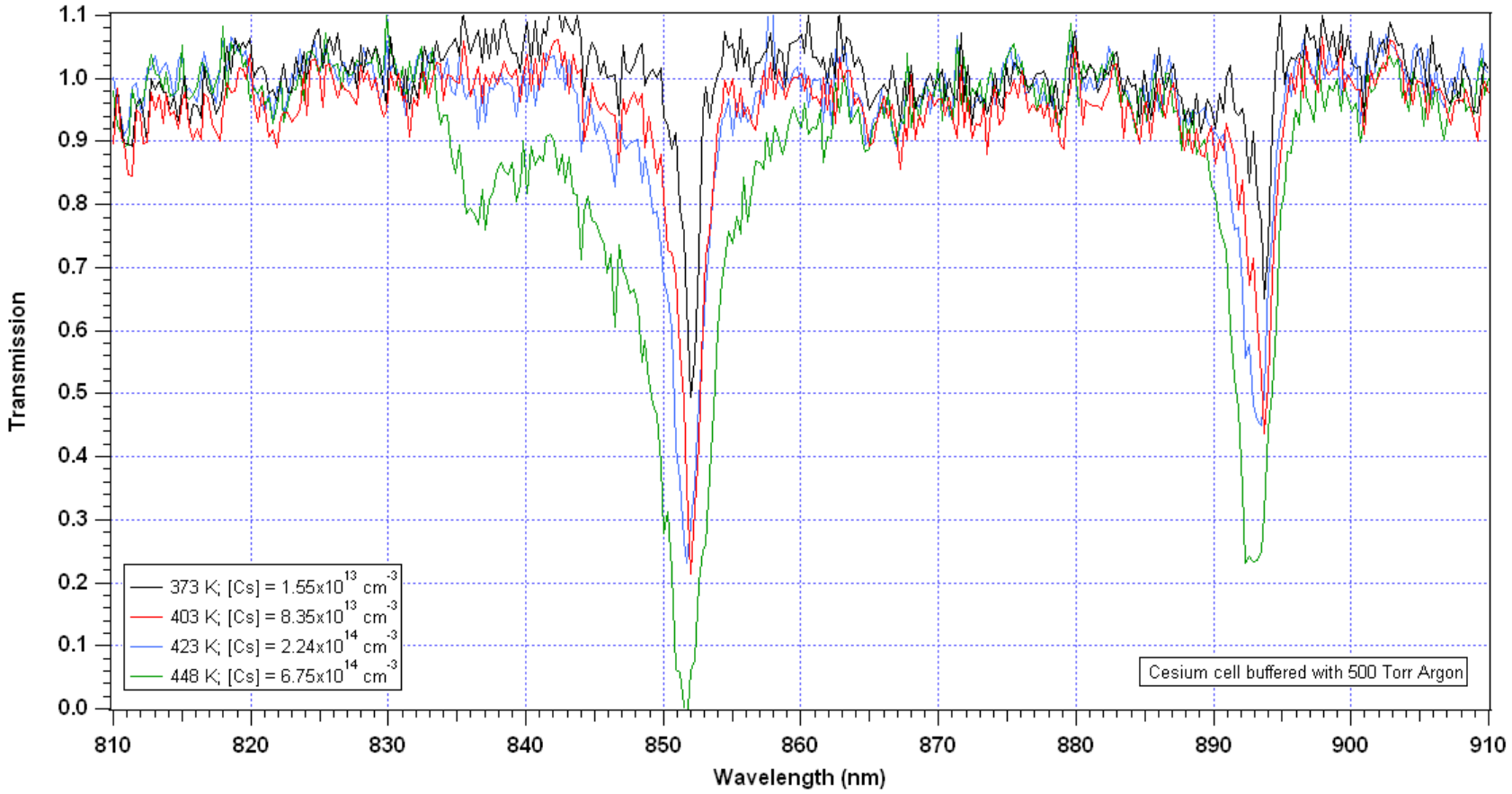

Absorption Spectra of Cs Buffered with 500 Torr of Ar and 75 Torr of Ethane

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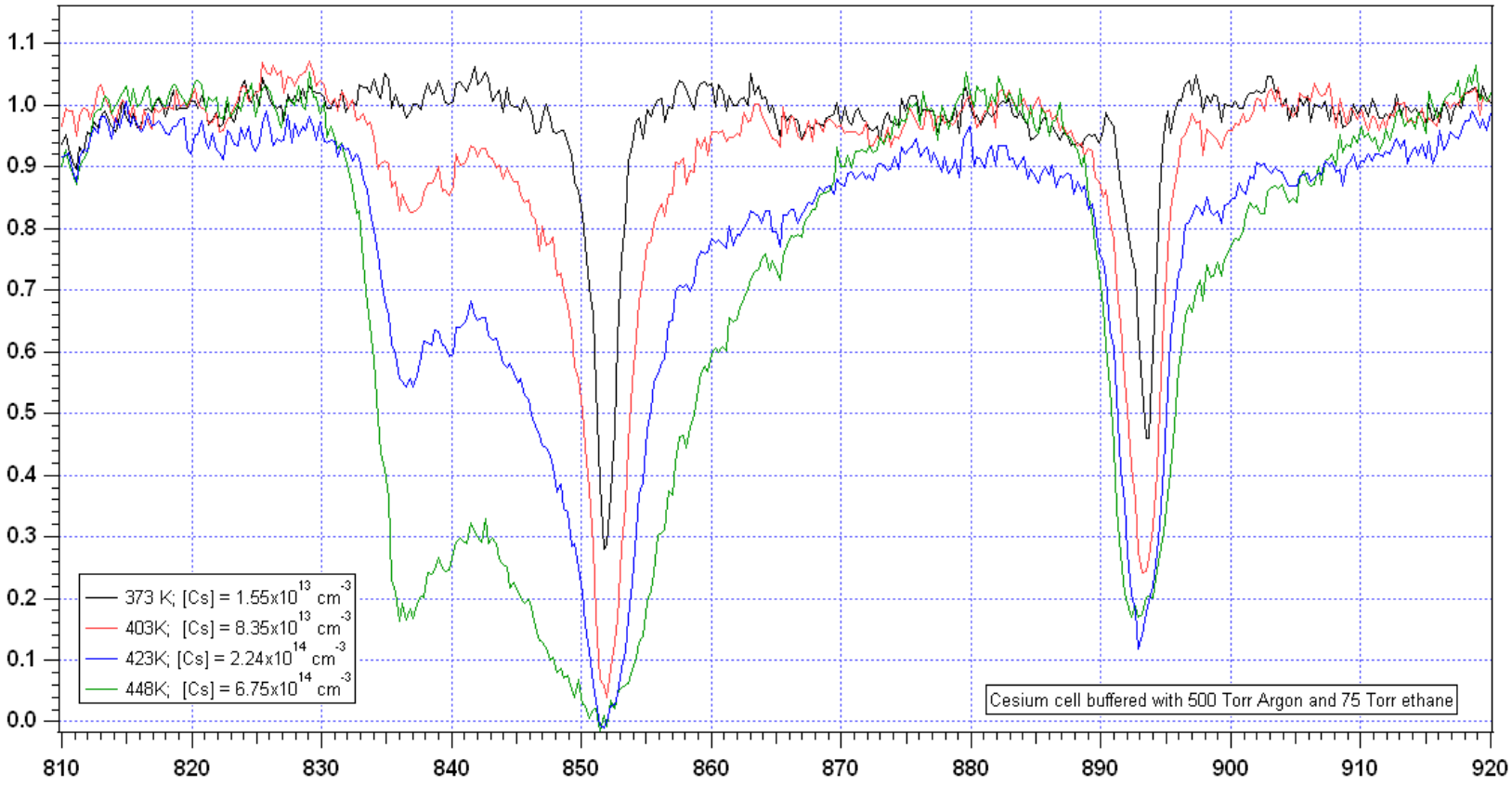

Absorption Spectra of Cs Buffered with 500 Torr of Xe

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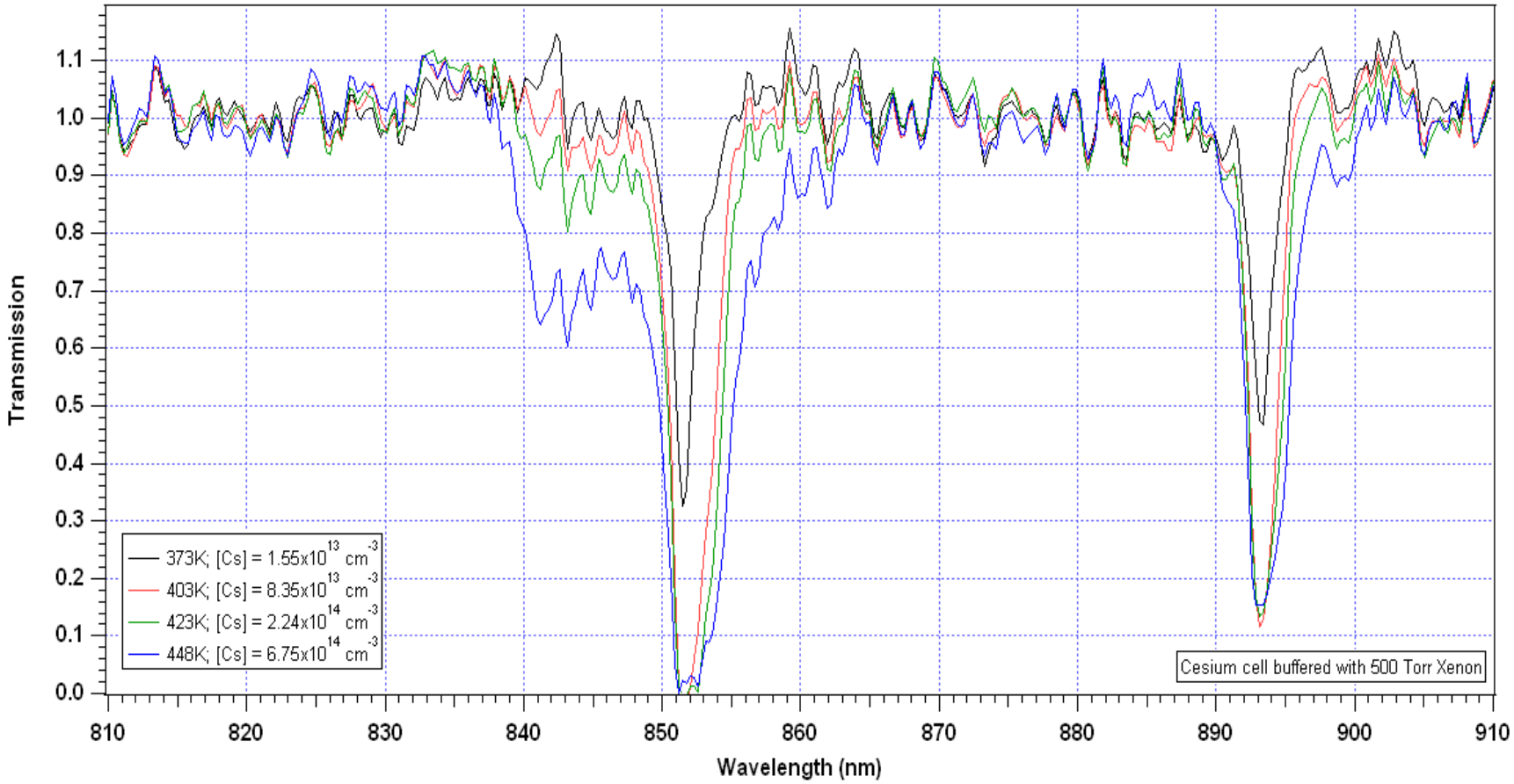

Temperature Dependant Absorption of Rb (Rb-He-Ethane Cell)

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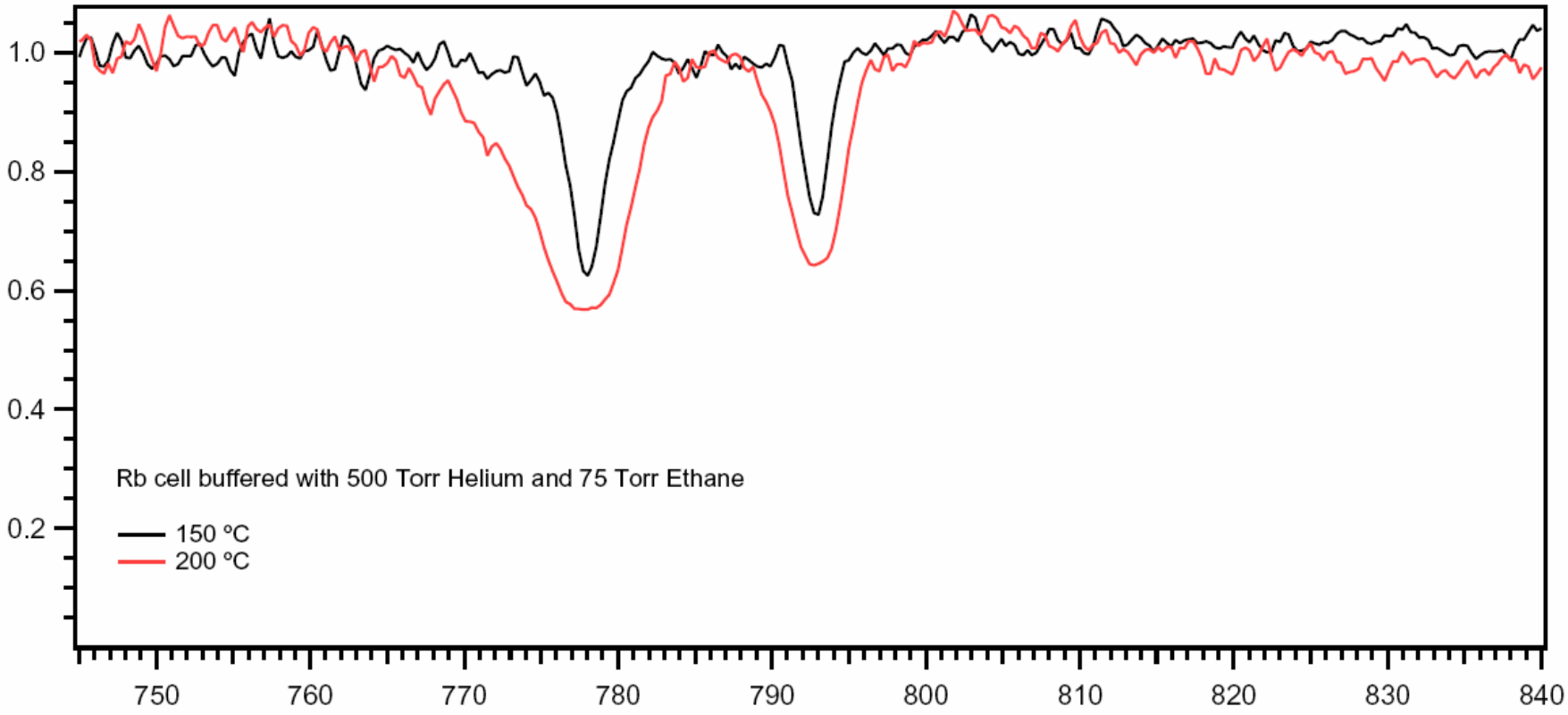

Temperature Dependent Rb–Kr and Cs–Kr Absorption Spectra

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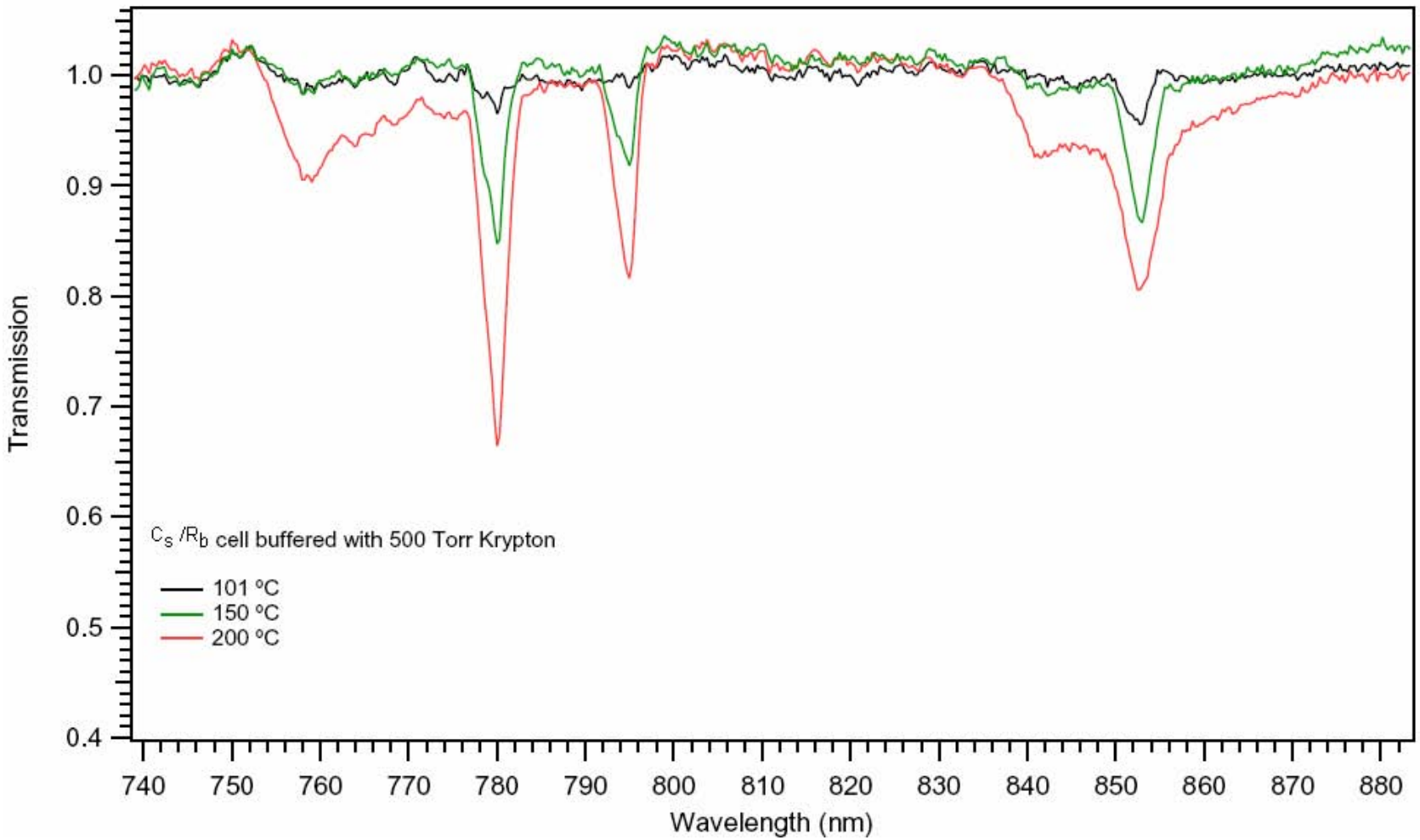

Cs Atom Fluorescence Spectra as a Function of Excitation Wavelength

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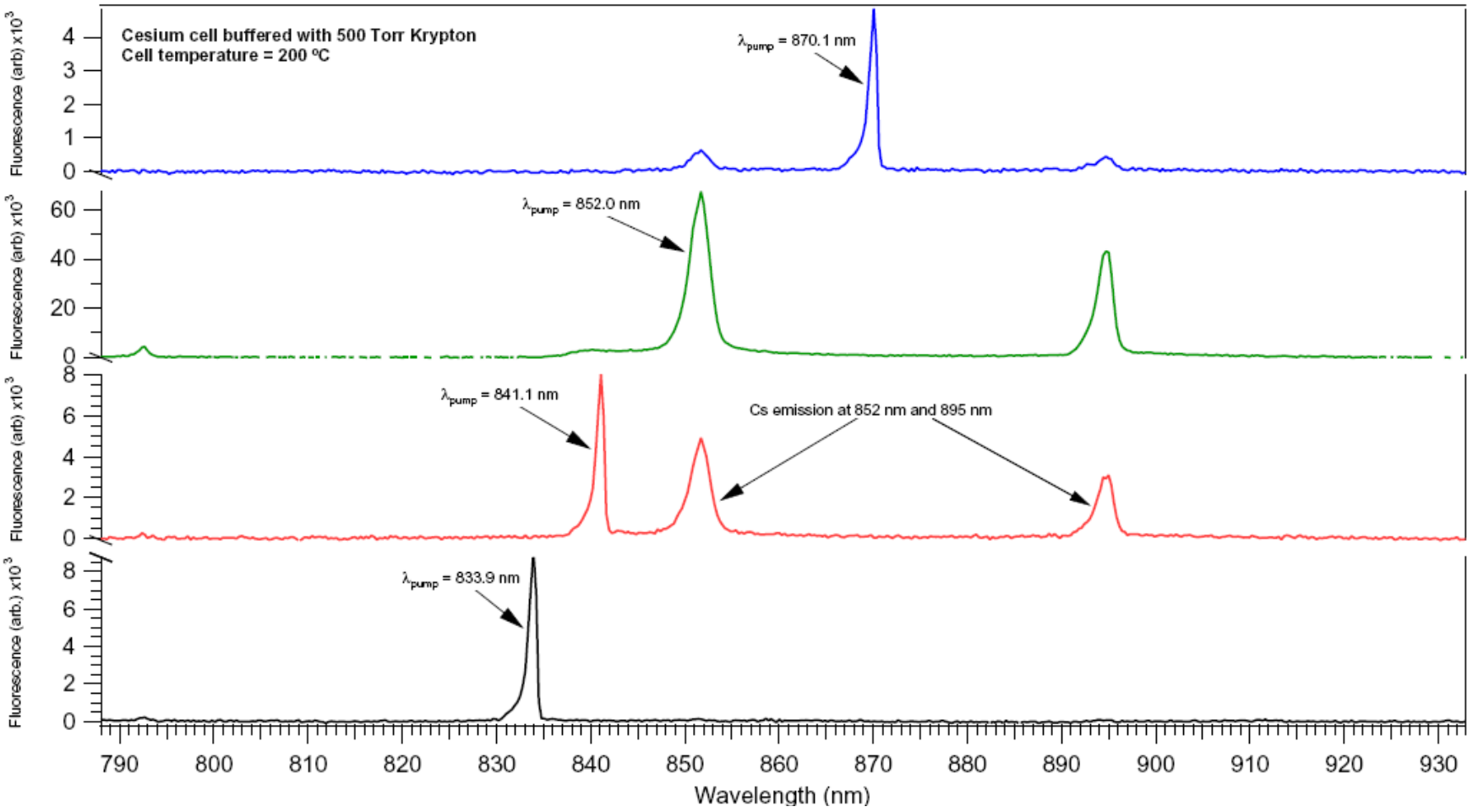

Experiments to Develop Kinetics Data for XPAL Based on Optical Gain

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- **Measurements will provide a key parameter concerning efficiency of XPAL process**
  - **Probe gain medium directly in absence of optical resonator**
    - **Provides information on population inversion and its sensitivity to pump laser intensity and wavelength, cell temperature, bath gas type and pressure**
- **Will enable design of optical resonators for optimal output coupling**
- **Portable system will be transportable to MRI partners' facilities for collaborative experiments**
- **Applicable to both CW and pulsed laser excitation configurations**

Experimental Setup for Gain Measurements in Optically Pumped Lasers

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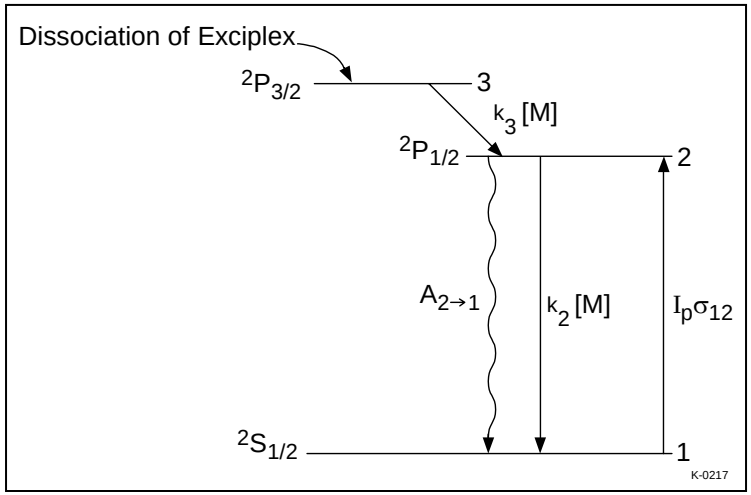

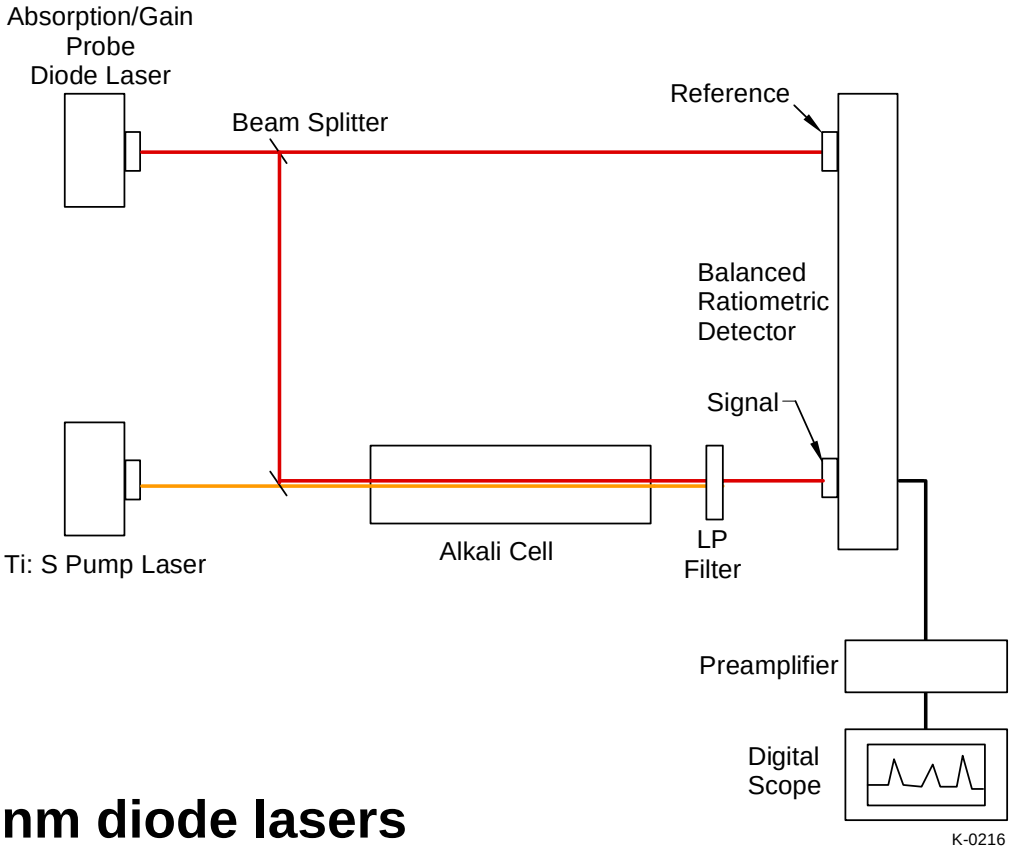

- **For XPAL studies**
  - **Pump: Ti:S laser**
  - **Probe: 794 nm and 895 nm diode lasers**
  - **Portable systems; will be used at PSI and UIUC**

Strategy for XPAL Gain Measurements

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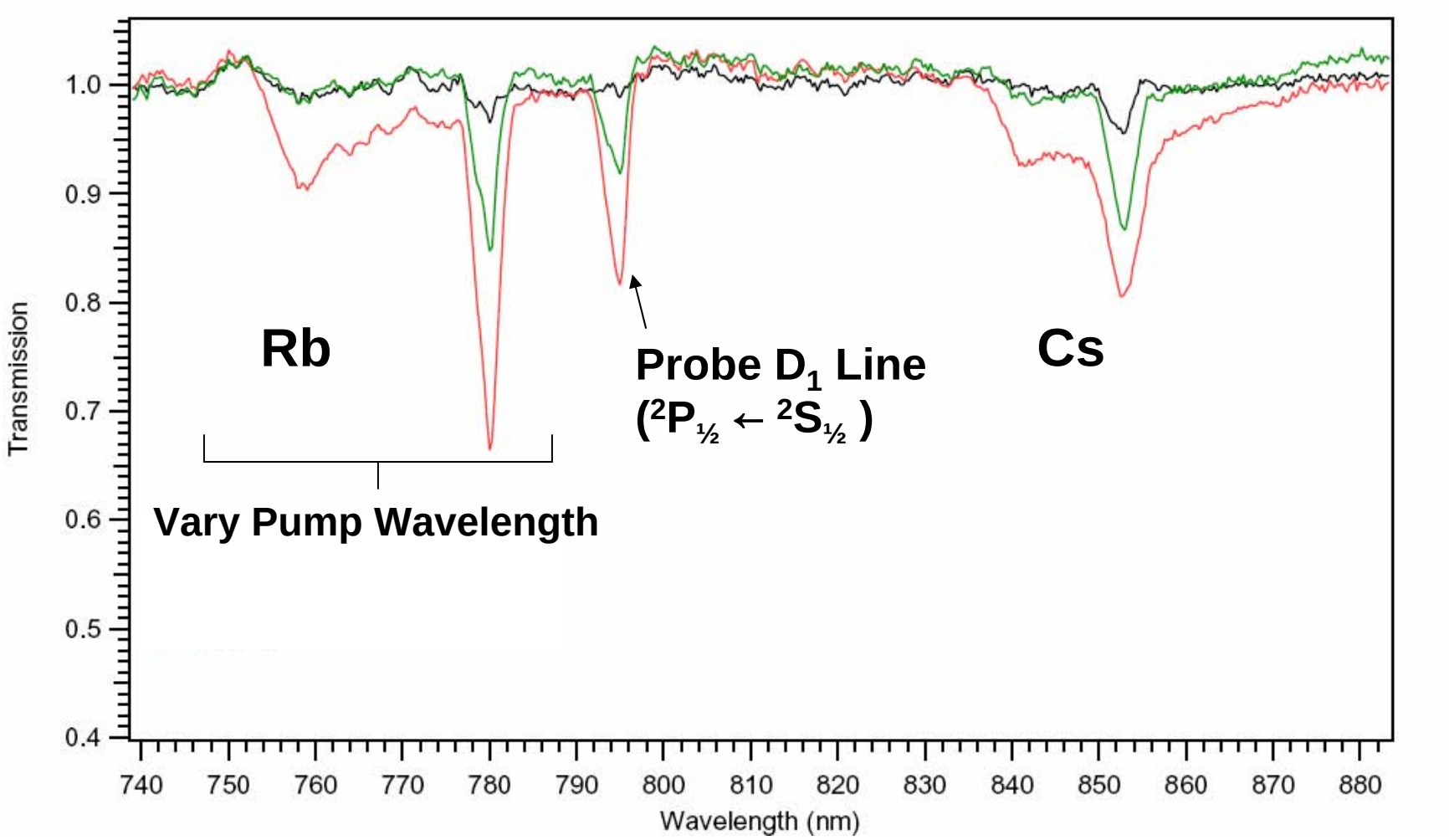

Experimental Setup for Initial Gain Probe Measurements

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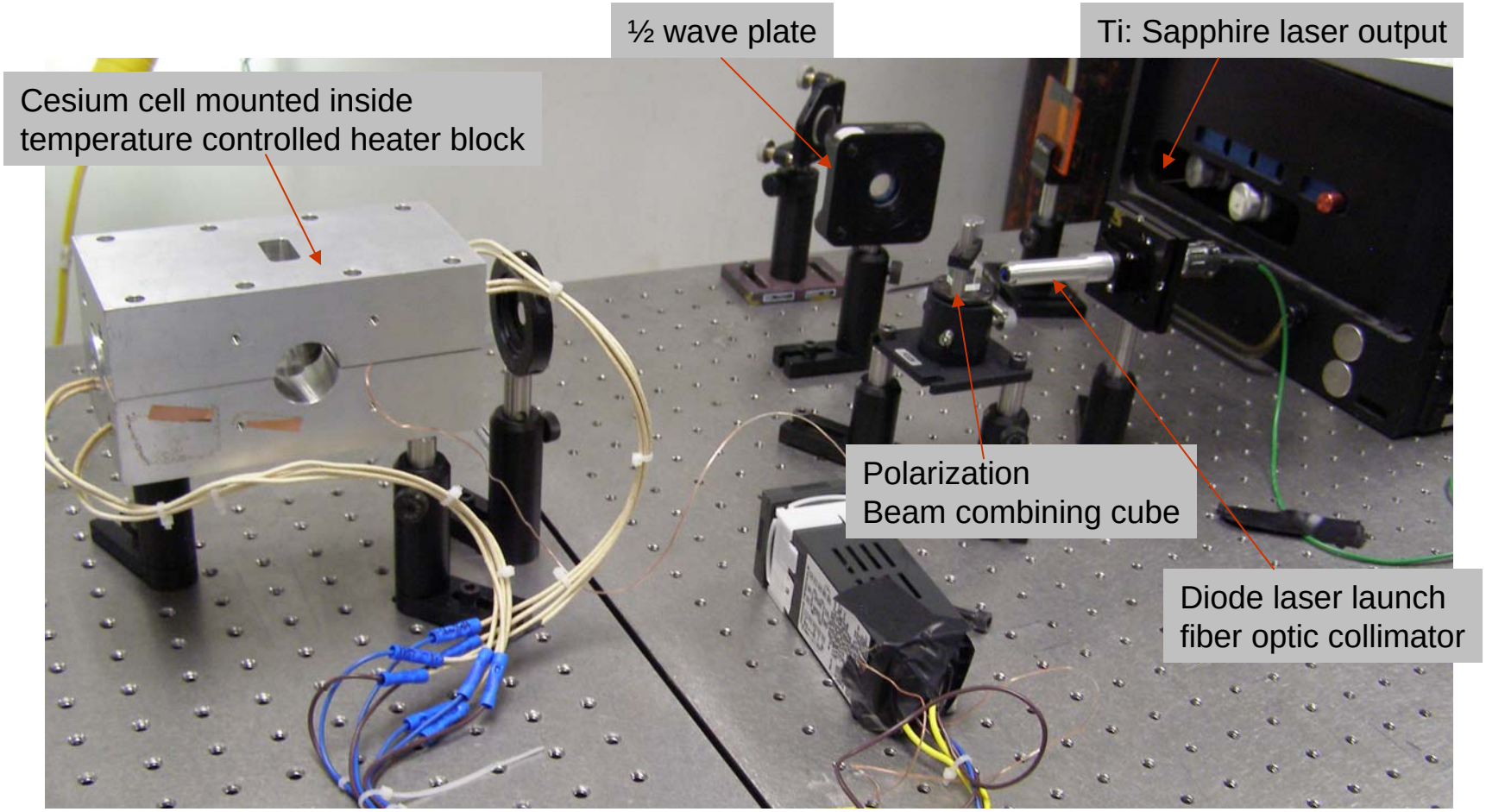

Absorption Spectrum of Cs D_1 line in CsKr Cell (no optical excitation by Ti:S laser)

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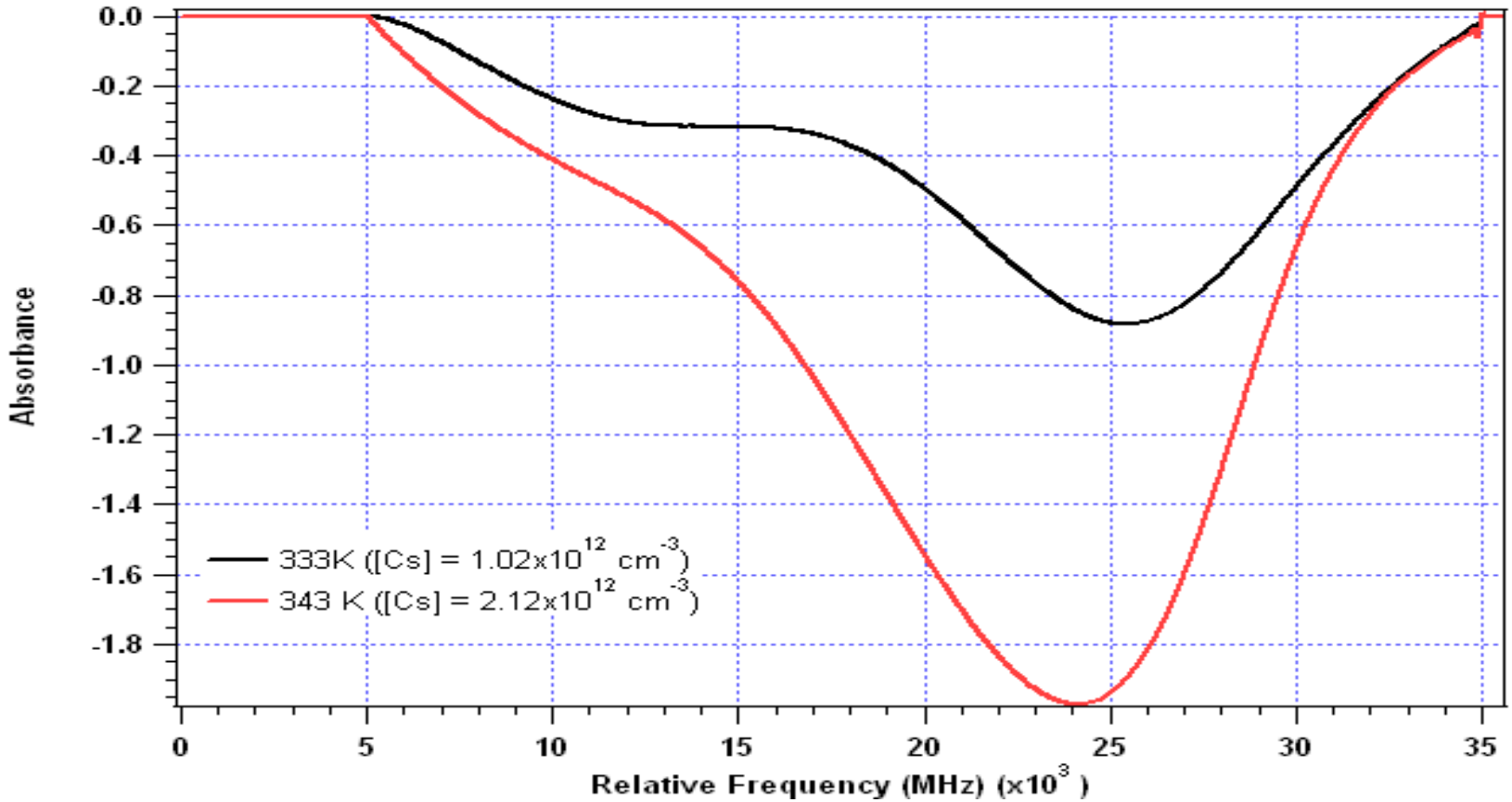

Absorption and Gain Spectra for CsKr Cell

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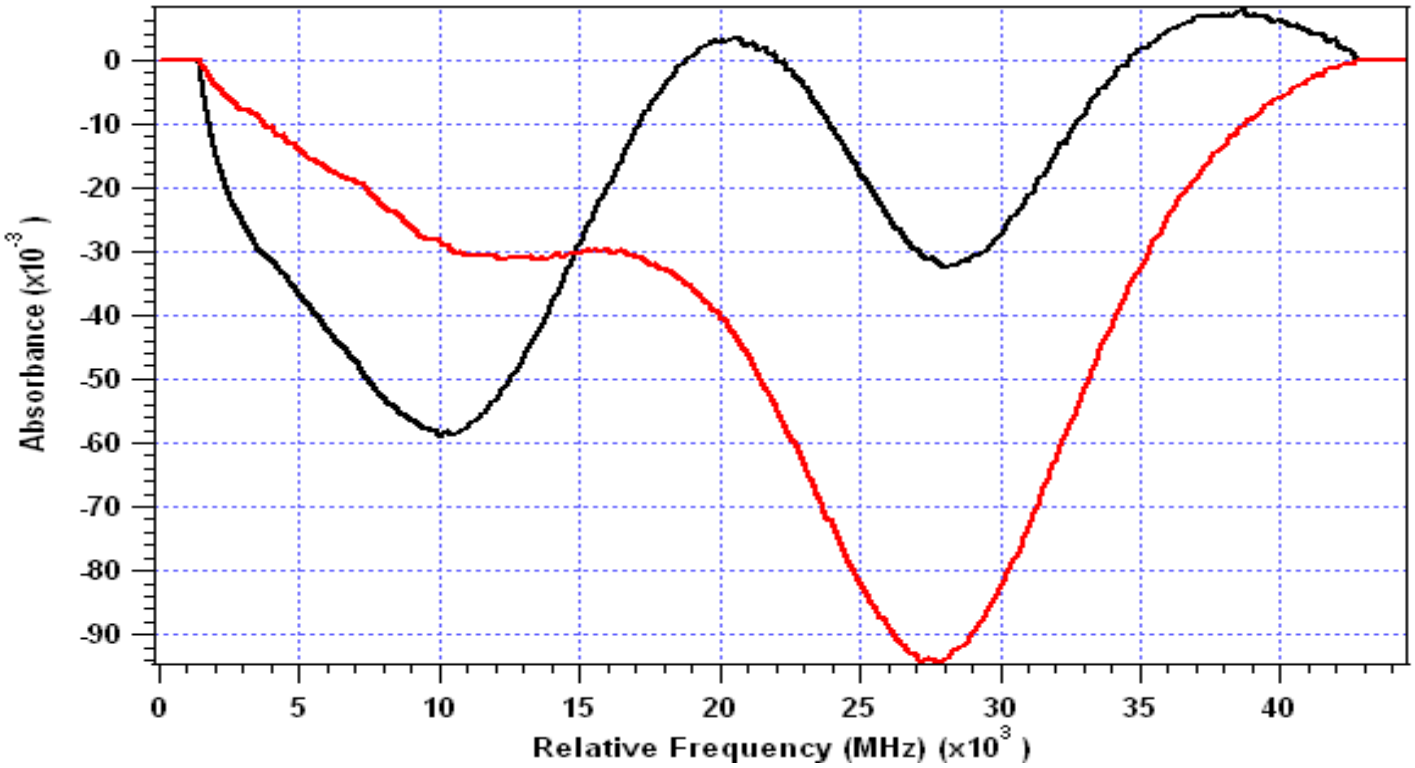

- Black Trace: Ti:S tuned to Cs D_2 line
- Red Trace: Ti:S laser tuned off the D_2 resonance

- **These data confirm the approach**
- **Will develop key data base for both DPAL and XPAL pumping schemes**

"Blue" Cs Doublet Emission at $\lambda_{excitation}$: 852 nm

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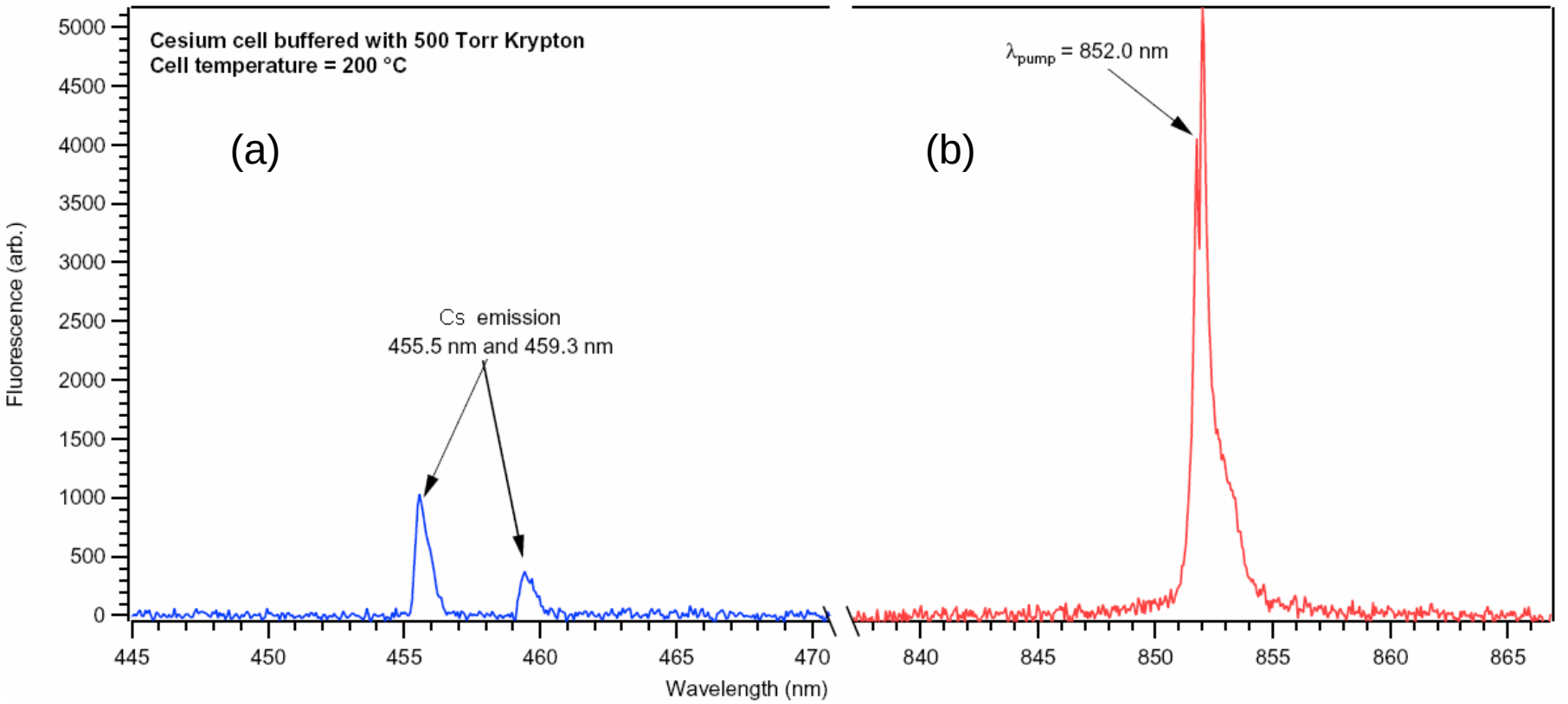

Energy Level Diagrams for Cs and Rb Showing the Ground $^2S_{1/2}$ State and Several Excited States Relevant to Alkali Atom Lasers

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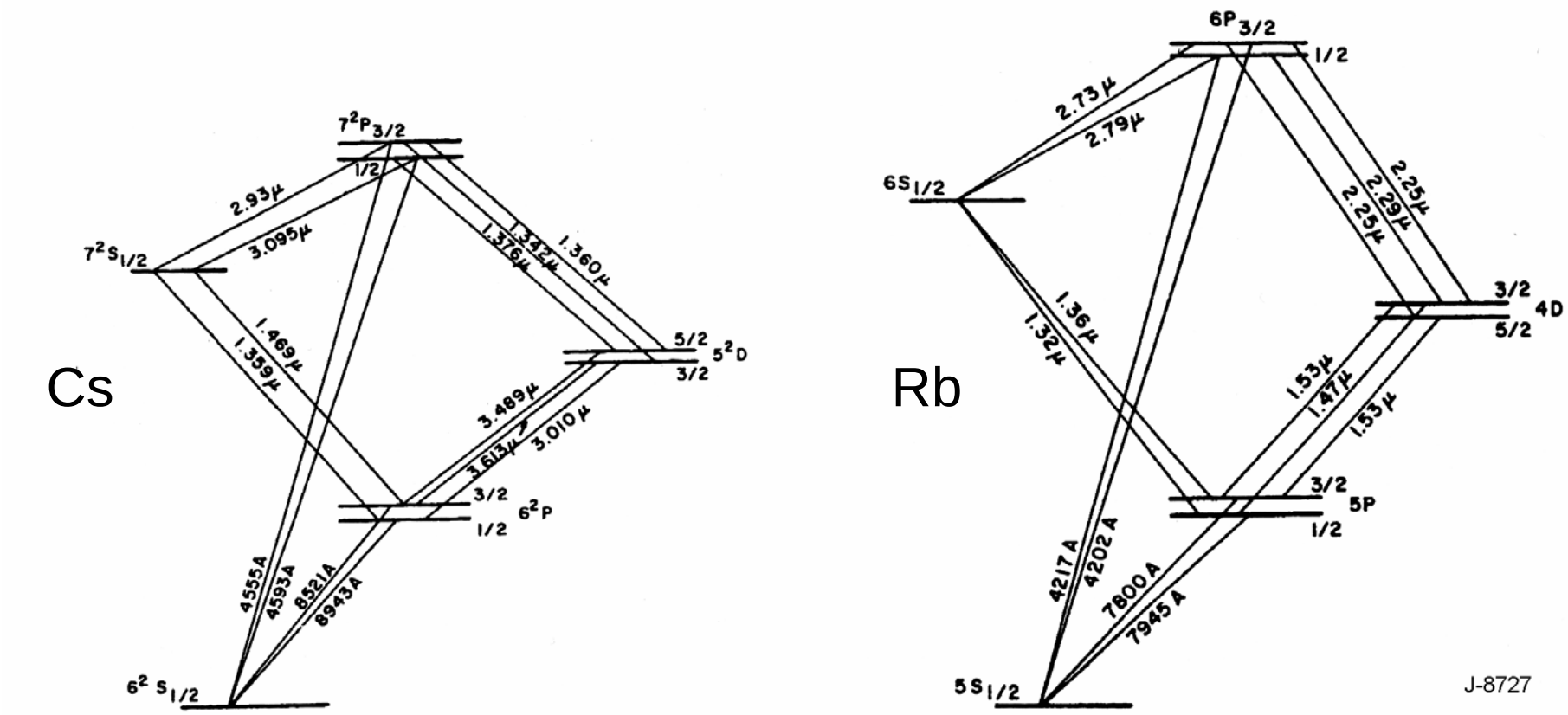

From: Sharma *et al.* APL 39, 209 (1981)

Cs Near-IR Emission Line ($7\ S_{1/2} \rightarrow 6\ P_{3/2}$) ($\lambda_{pump}$ ~ 780 nm)

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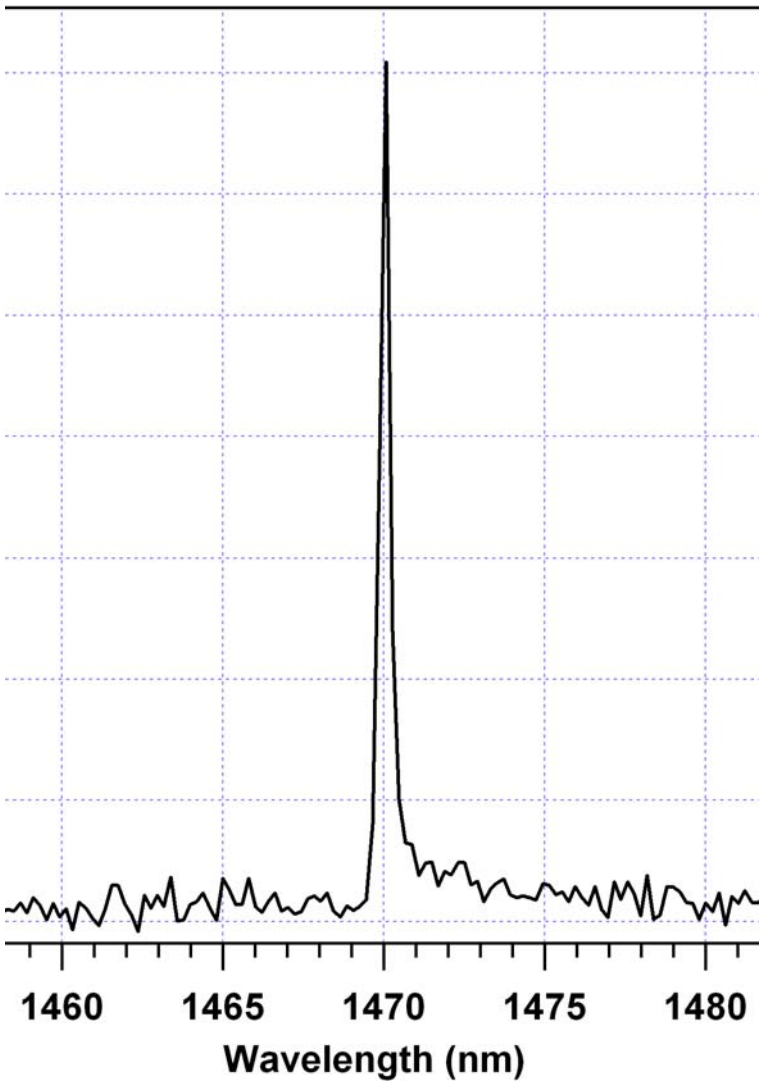

Summary and Future Work

- **Demonstrated fluorescence at 852 and 894 nm when pumping in blue-wing of exciplex in Cs-Kr cell**
- **Measured absorption spectra in Cs-Kr and Rb-Kr cells**
  - Blue wings significant
- **Have observed blue fluorescence and IR fluorescence from higher lying states in both Rb and Cs excited at or near D_2 lines**
- **Developed gain diagnostic for alkali systems**
- **Continue work on side pumping and unstable resonator configurations**
- **Utilize high power Q-Peak diode laser system for Rb XPAL experiments**

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