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High Precision In-Situ Raman Spectroscopy on a Novel Room-Temperature Superconductor, Carbonaceous Sulfur Hydride, Under Pressure and Cryogenic Temperatures

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NEXCL
Nevada Extreme Conditions Lab

UNLV Physics and Astronomy

In-situ Raman Spectroscopy on a novel Room-temperature Superconductor, Carbonaceous Sulfur Hydride, under Pressure and Cryogenic Temperatures

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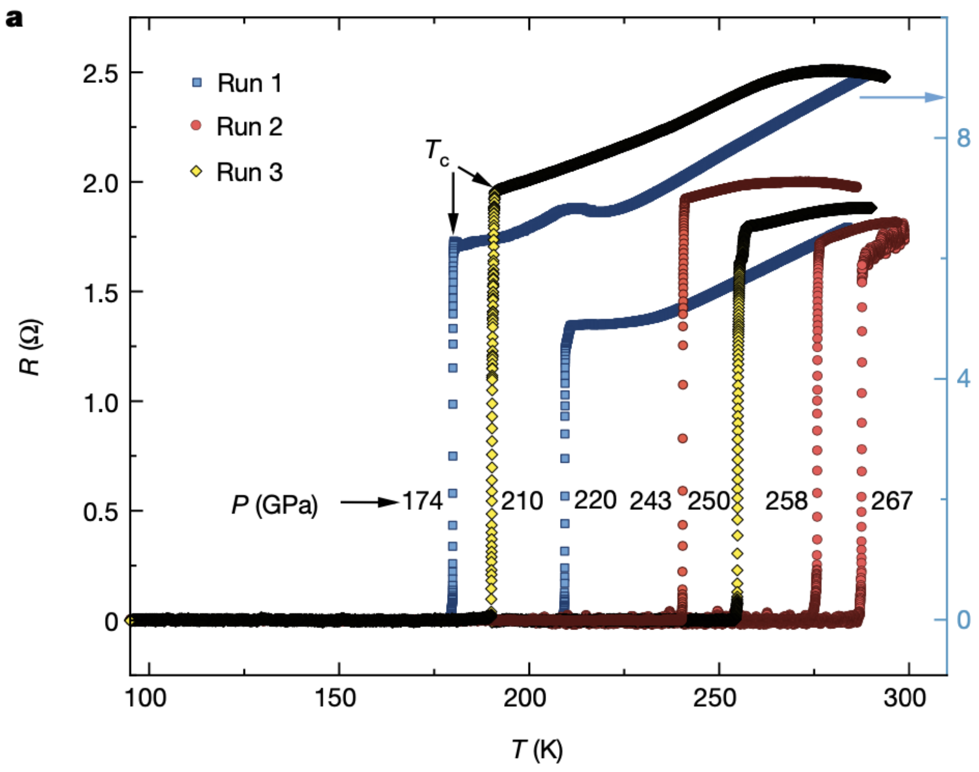
Overview

- Introduction
- Literature Review
    - Motivations
    - Background
- Methodology
- Results and Discussion
- Conclusions and Outlook
- References

Introduction

- Superconductivity
  - **E=0**
  - **B=0**
- CSH
  - T_c = 288 K (16ºC)
- Spectroscopy based on principles of Raman scattering



E. Snider *et al*, 2020.

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Motivations

- Energy Transmission and Distribution (T&D)
  - In 2019, electric power industry revenued $400 billion
  - In past 2 decades, **T&D lost 5-10% annually ($30,000,000,000)**
- Medical Imaging Devices
  - $25,000 annual energy cost for each MRI machine
  - 50% is operational costs alone
- Related sciences
  - Quantum Computing

Background

- In 1957, J. Bardeen, L. Cooper, and J. Schrieffer published the *Theory of Superconductivity* known as BCS theory
- N. Ashcroft publications for room-temperature superconductors Metallic hydrogen and Hydrogen-rich metallic hydrides
- A family of hydrides that was of particular interest to scientists was the sulfur hydride family
  - H_2S
  - $(H_2S)_2H_2$
  - CSH

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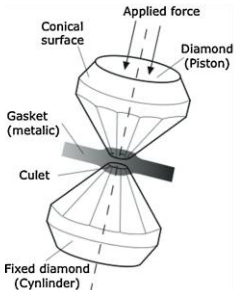
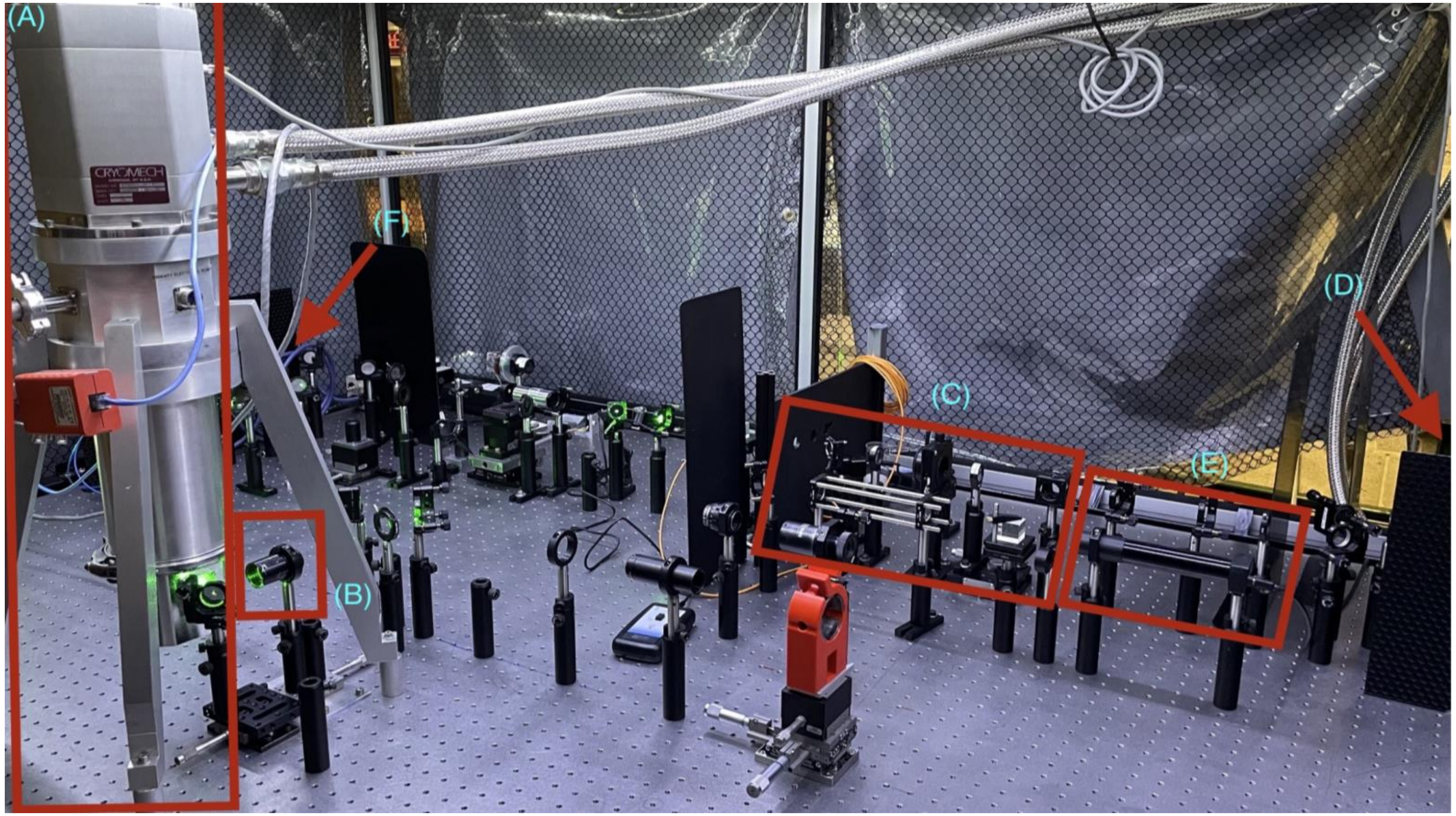
Methods and Experimental Considerations

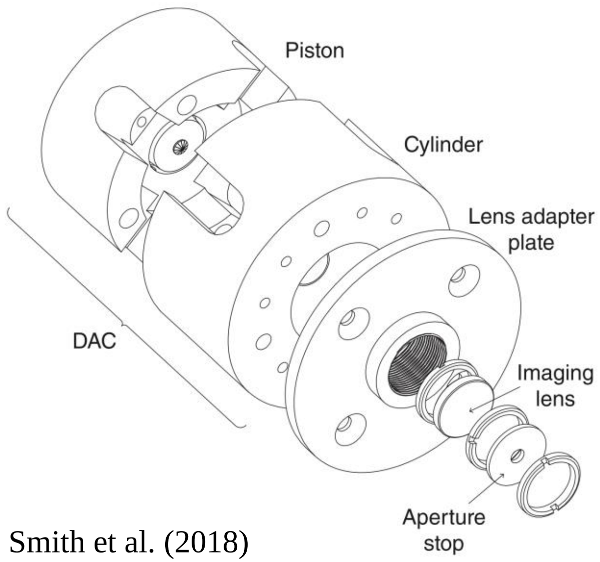
Experimental considerations:

- Temperature:
    - Helium cooled cryostat
- Pressure:
    - Diamond Anvil Cell (DAC)
- Optics

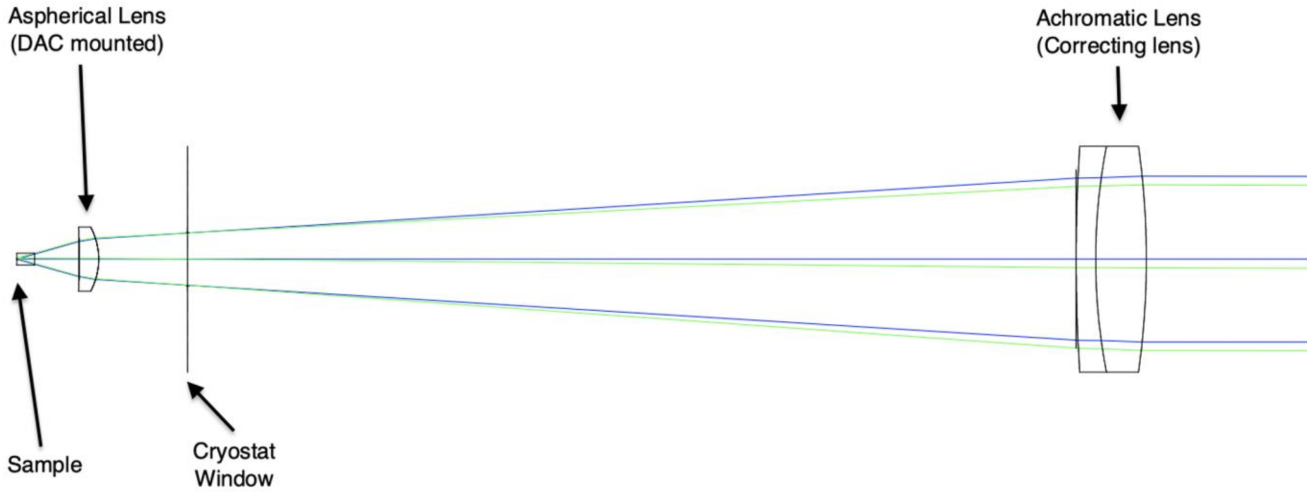


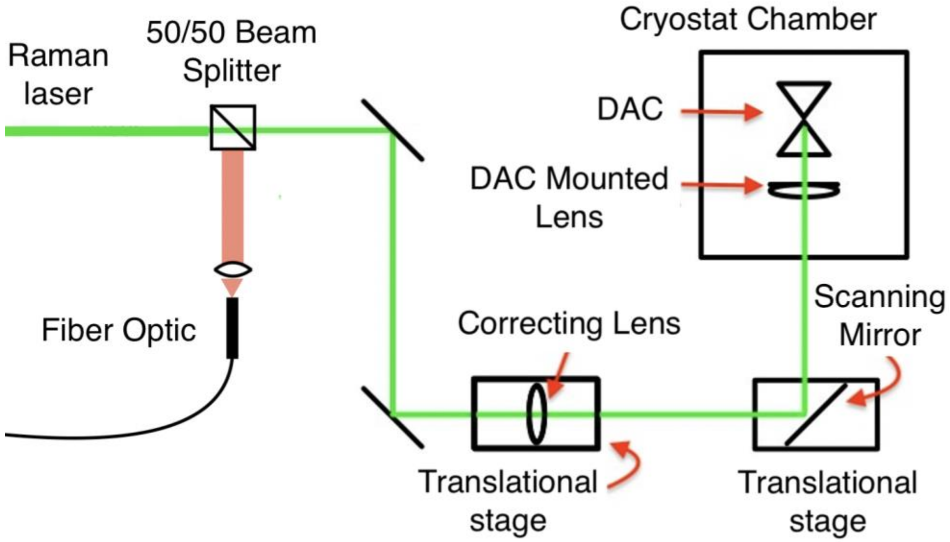


Optics



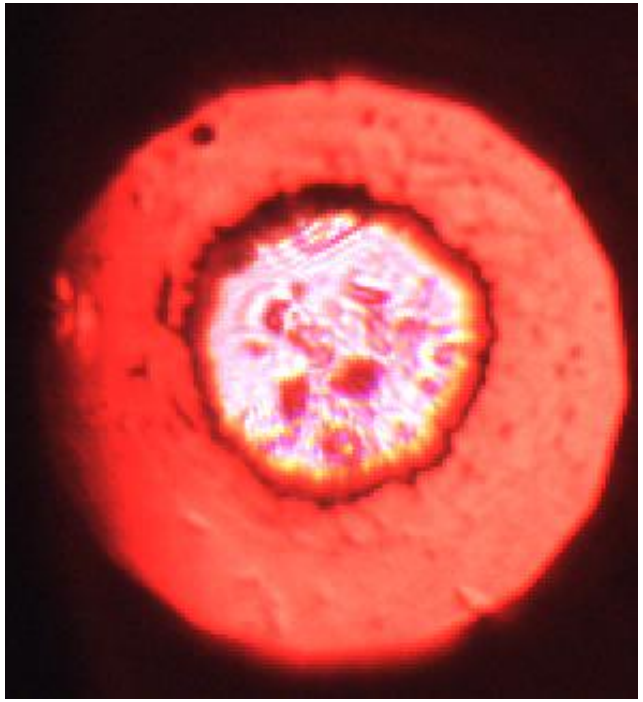
Smith et al. (2018)





Methods

- DAC was hydrogen-loaded with carbon and sulfur and CSH was photochemically synthesized
- The DAC was placed within the cryostat Raman system and was imaged.
- 35 mW power
- low temperatures of 10, 50, 80, 130, 170, and 293 kelvin at a measured pressure of 28 GPa.



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Results

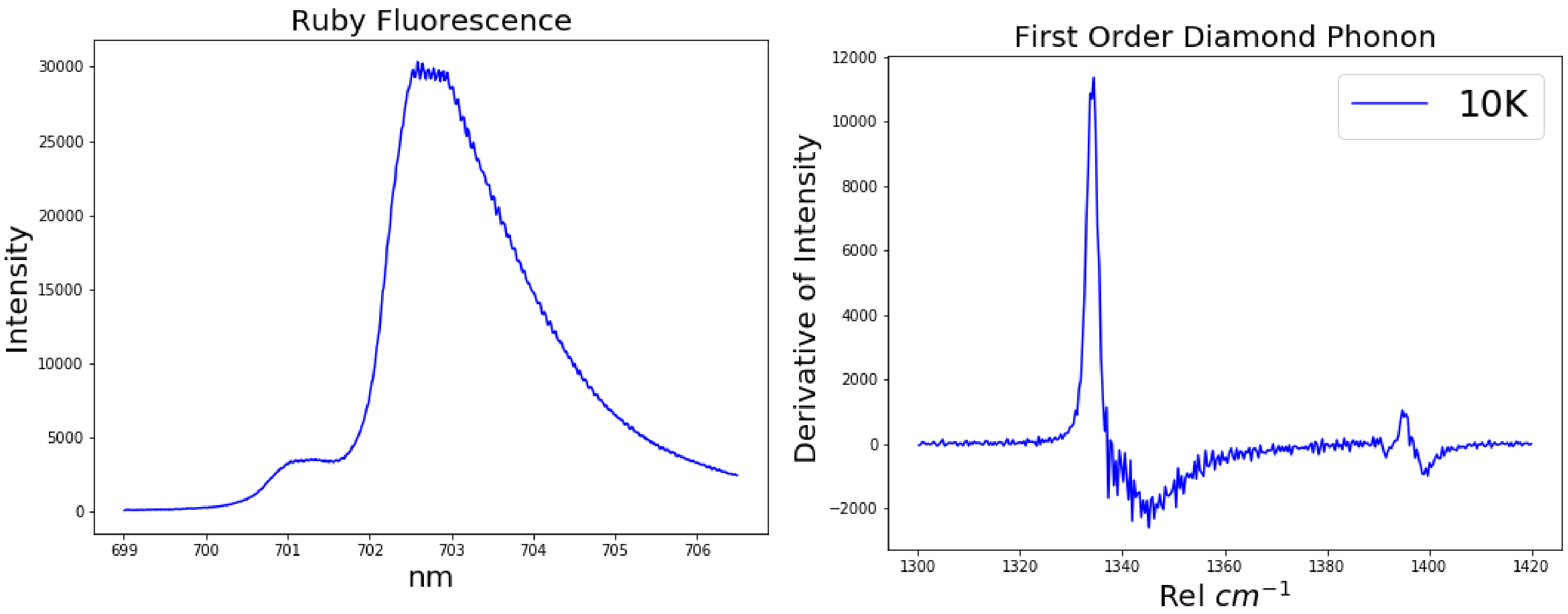


Figure 1. Ruby fluorescence and first-order diamond phonon spectra at 10 kelvin used to measure the pressure within the diamond anvil.

Results

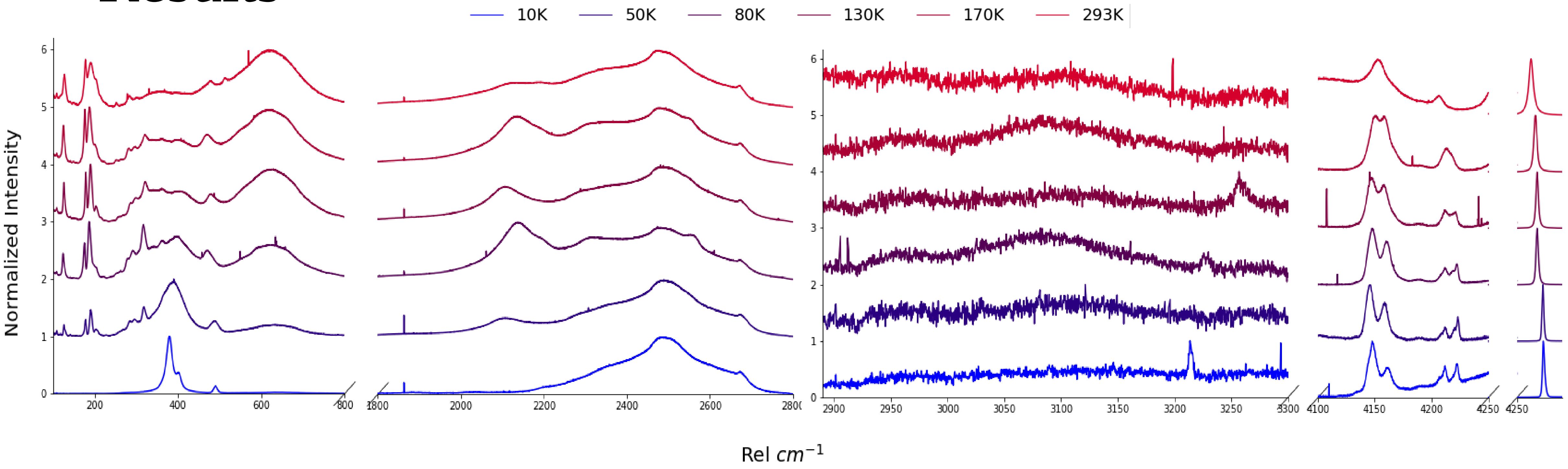


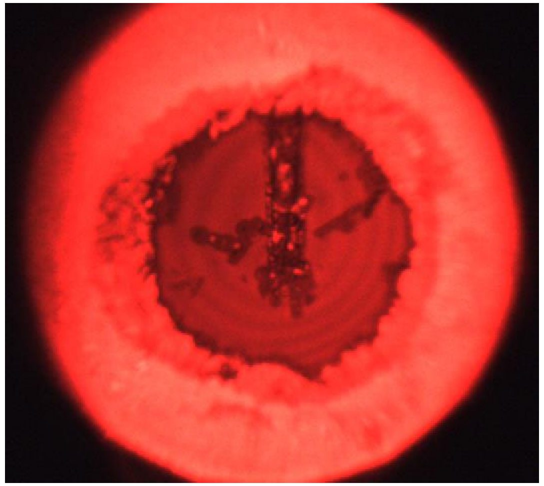
Figure 2. Overall Raman spectra of CSH under various cryogenic temperatures in regions of interest.

Overview

Conclusions and Outlook

- The vibrational spectra of CSH were explored via Raman scattering at 28 GPa from 10 to 293 kelvin.

- Work in progress: temperature runs on different pressures to map phase space



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Questions