

From Bioengineering to the Sun: A Summer in Solar Spectroscopy

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From Bioengineering to the Sun: A Summer in Solar Spectroscopy

By Rebekah Swanson

Abstract

During my time as a Summer 2025 intern with the Montana Space Grant Consortium at the Montana Learning Center (MLC), I gained experience with both astronomy education and research. My primary project involved learning to operate the MLC’s spectroheliograph (SHG) to image the sun in the H-alpha wavelength. With no prior knowledge of solar photography, I studied observing methods, instrument focusing, and image processing using multiple types of software. I successfully captured and processed images throughout the summer, documenting prominences and other activity during the peak of Solar Cycle 25. To support the astronomical community, I compiled a series of guides, now published on the MLCastro website and available soon through the MLC, to help others approach solar imaging and spectroscopy with ease.

Introduction

Although I am a bioengineering major, astronomy, aerospace, and astrobiology—the study of the origin, evolution, and the future of life in our universe—have always been major interests and career goals of mine. Astrobiology often involves searching for key elements such as carbon, hydrogen, oxygen, nitrogen, and, in some cases, phosphorus, which are necessary to sustain life. One way to detect these elements without direct sampling is through spectroscopy, which identifies elements based on the specific wavelengths of light they emit or absorb.

I immersed myself in learning how to use the SHG: reading materials on solar observing, watching tutorials, and practicing setup, calibration, and image processing. Once I was prepared, I began imaging the sun in the H-alpha wavelength. Over the course of the summer, I captured images at various times and processed each set of images into one sharp photograph. This project allowed me to expand my technical skills as well as help future learners at the MLC and beyond.

Objectives

The primary goals of this project were to:

- Gain practical experience in solar imaging and spectroscopy.
- Learn and apply methods of calibration, data collection, and image processing in the H-alpha wavelength.

- Document solar phenomena during the solar maximum phase.
- Explore the connection between spectroscopy and astrobiology by observing how elemental signatures can be detected through light.
- Create user-friendly guides to support the astronomical community.

Methodology

Using the MLCastro SHG 700, I was able to image the sun in the H-alpha wavelength (656.28 nm). H-alpha corresponds to a specific transition in a hydrogen atom where the electron drops from the $n=3$ to the $n=2$ energy level. This transition emits a photon of light. H-alpha is visible near the red part of the electromagnetic spectrum (Spence, 2004).

For live capture of the spectra, I used Sharp-Cap. The recorded spectral scans were reconstructed into disk images using J’SolEx. Image alignment and fine-tuning exposure was completed in ImPPG. Auto-Stakkert was used for stacking images.

The process of achieving proper focus is as follows:

1. Adjust the slit with the micrometer collimator.
2. Focus the spectrum using the camera micrometer.
3. Refine the spectral lines using the telescope’s helical focus. (See Fig. 1.)

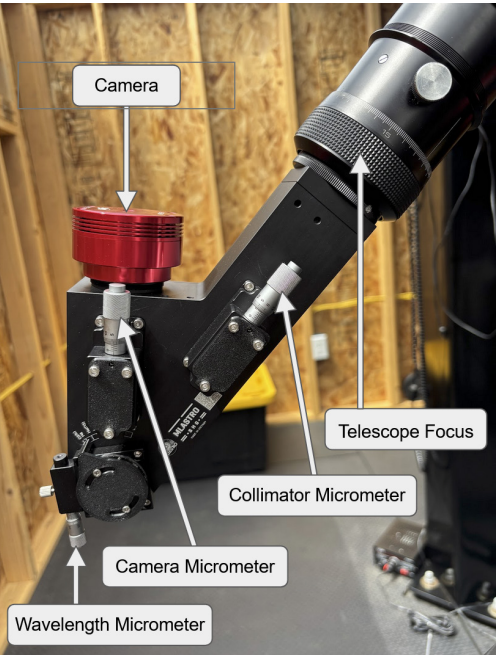


Figure 1. MLCastro SHG 700 with Labeled Key Components.

Results

Using this process, I obtained high-quality images of the solar disk in H-alpha. Imaging in H-alpha gave a good view of many solar phenomena such as filaments and solar flares erupting from the disk. As shown in Figure 4 and 5, several prominences were visible at the solar limb. Sunspots and surrounding energetic activity were evident (Figure 2 and 4).

Granulation—the textured pattern of convection cells on the sun’s surface—is quite visible on the surface as well. Figures 3 and 5 highlight activity, with bright regions near the edge of the disk corresponding to active prominences. Figures 3 and 5, being negative, are particularly helpful at emphasizing subtle plasma flows and fine filamentary structures.

Using some functions in J’SolEx allows you to collect quantitative data. The Redshift function in J’SolEx will pinpoint and report the velocities of some areas where plasma is moving the fastest (Figure 6). Flow direction on the disk can be determined via Doppler mapping (Figure 7) (blue indicates motion towards the observer, and red indicates motion away). J’SolEx can accurately measure distances on the solar disk or the diameter of sunspots.

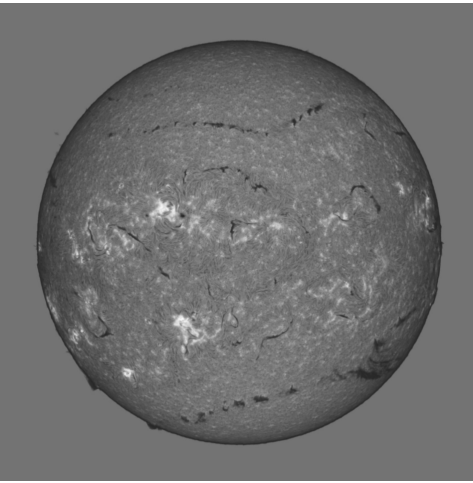


Figure 2. Positive, H-alpha Image of the Sun, July 24.

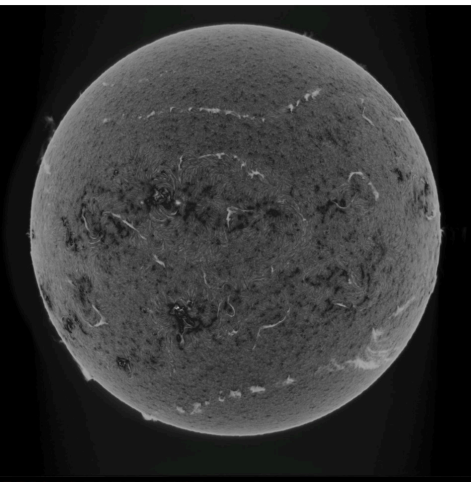


Figure 3. Negative, H-alpha Image of the Sun, July 24.

Discussion

Observations aligned with the solar maximum phase, as indicated by the abundance of prominences and active regions. I was able to achieve my goal of deepening my understanding of spectroscopy and learning to use the equipment and software for this process.

Beyond personal learning, I have used my new knowledge for educational purposes, delivering a demonstration on the spectroheliograph to our astronomy students. H-alpha images are valuable tools for tracking solar activity and can contribute to overall knowledge of the sun’s behavior. The instructional guides I wrote will support the astronomical community in developing their own skills.

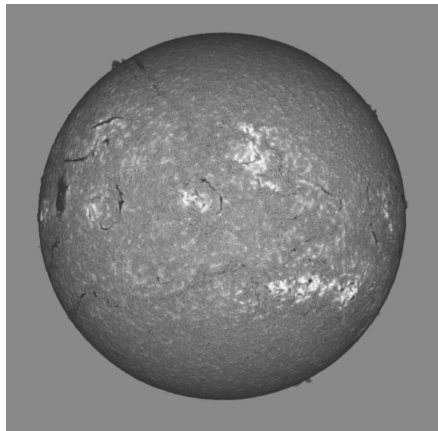


Figure 4. Positive, H-alpha Image of the Sun, July 19.

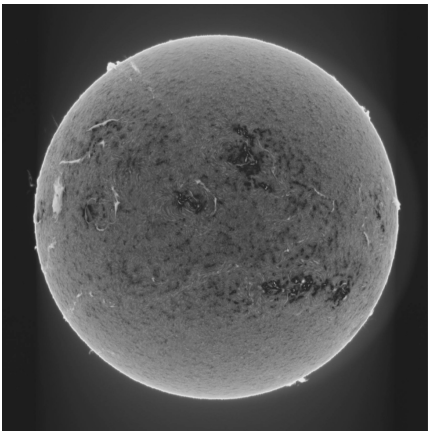


Figure 5. Negative, H-alpha Image of the Sun, July 19.

Conclusion

- Successfully captured and processed H-alpha images of the sun revealing filaments, flares, and granulation characteristics of the solar maximum phase.
- Applied and refined techniques such as focusing and multi-software image processing to produce high-quality images.
- Produced instructional guides on solar spectroscopy techniques, now available through MLAstro and the MLC.

Future work could expand beyond H-alpha imaging to include other wavelengths such as Ca-K (Calcium-K) for a detailed look at the chromosphere and white light for sunspot studies. In addition to this, exploring long-term monitoring of the solar cycle to track changes over time could be a significant project at the MLC.

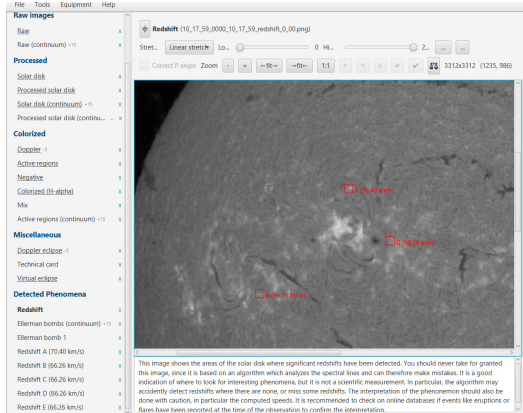


Figure 6. Redshift mapping in J'SolEx.

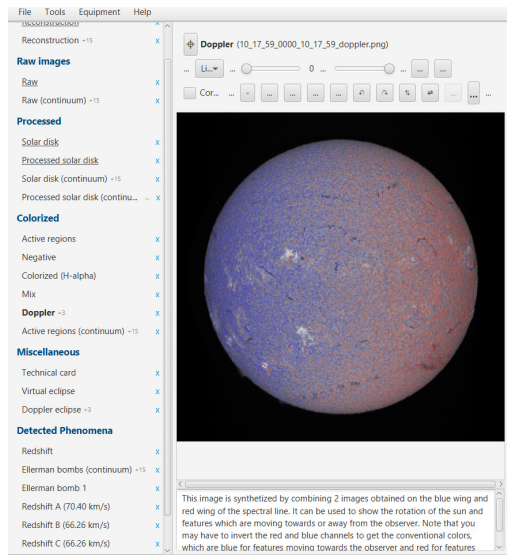


Figure 7. Doppler mapping in J'SolEx.

About the Author

Rebekah Swanson is a junior at Montana State University majoring in Bioengineering with a minor in Biomedical Engineering. Rebekah spent her summer of 2025 working with her mentor, Ryan Hannahoe, at the Montana Learning Center (MLC). She has worked with the MLC since 2021 and was involved in research opportunities with support from the Montana Space Grant Consortium. When not immersed in her studies, she likes to enjoy the natural scenery around Bozeman through hiking and snowboarding. When not outdoors, she enjoys making art in many forms such as painting, sewing, embroidery, and cake decorating.



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