Characterizing the UV Emission of M dwarf Stars

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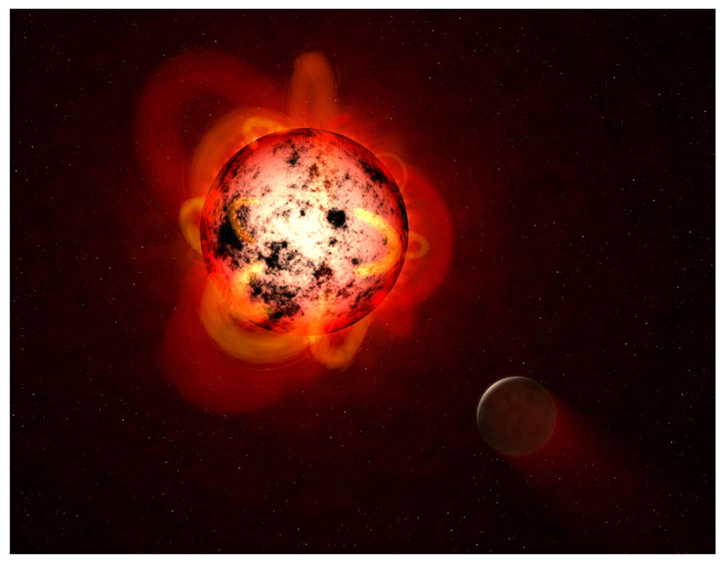
Objective

We seek to identify a relationship between the strength of optical and ultraviolet spectral lines of M dwarf stars. This will support future photochemical analyses of exoplanet atmospheres in similar stellar systems.

Why M dwarfs?



- Most abundant stellar neighbors
- Large populations of terrestrial exoplanets
- Easier to observe potentially close-orbiting planets
- Highly active in radiation emission

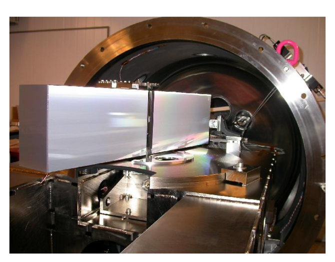
To determine the potential habitability of exoplanets orbiting M dwarfs, it is essential to quantify the UV emission of these stars.

Challenges with UV Spectra

Observations in the UV wavelength range require a space-based telescope, as the ozone layer blocks most UV photons from entering Earth's atmosphere. Time on these instruments is limited, so relating UV to optical spectra would provide a method of estimating the UV activity of M dwarfs from ground-based telescopes.

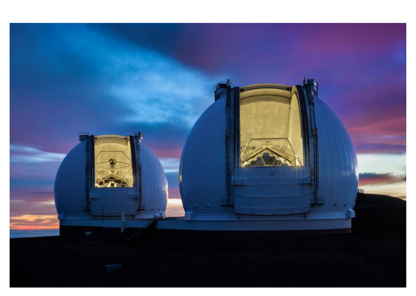
Archival Data Sources

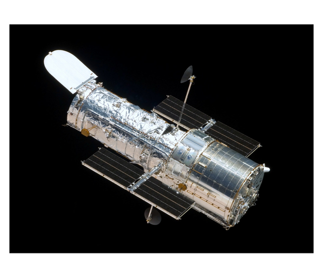
High Accuracy Radial-velocity Planet Searcher (HARPS)



Ultraviolet and Visual Echelle Spectrograph (UVES)

High Resolution Echelle Spectrometer (HIRES)



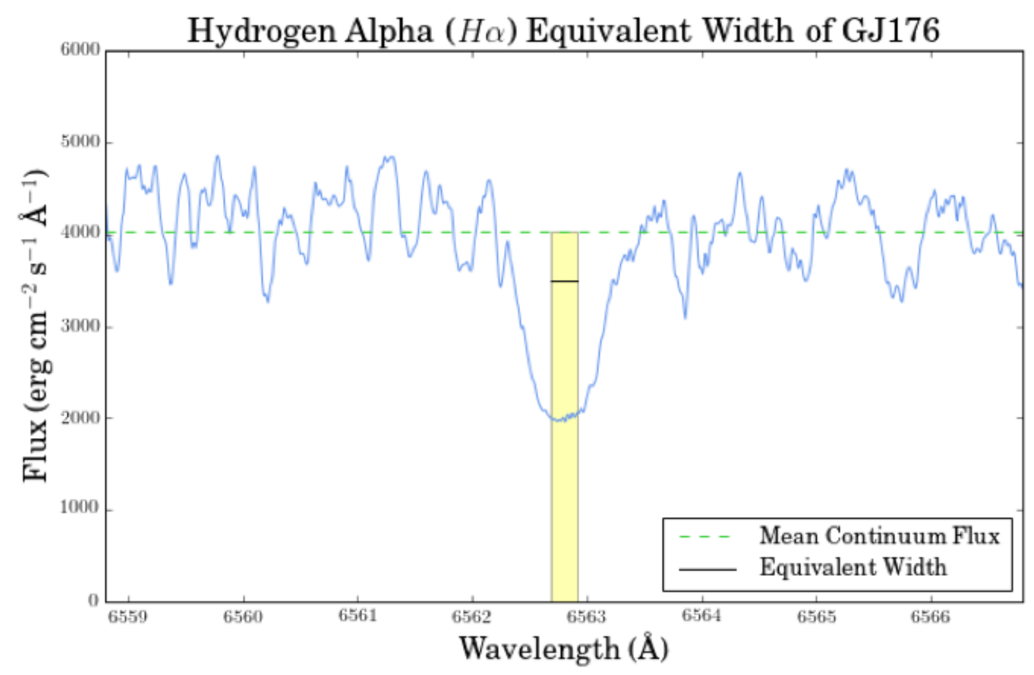


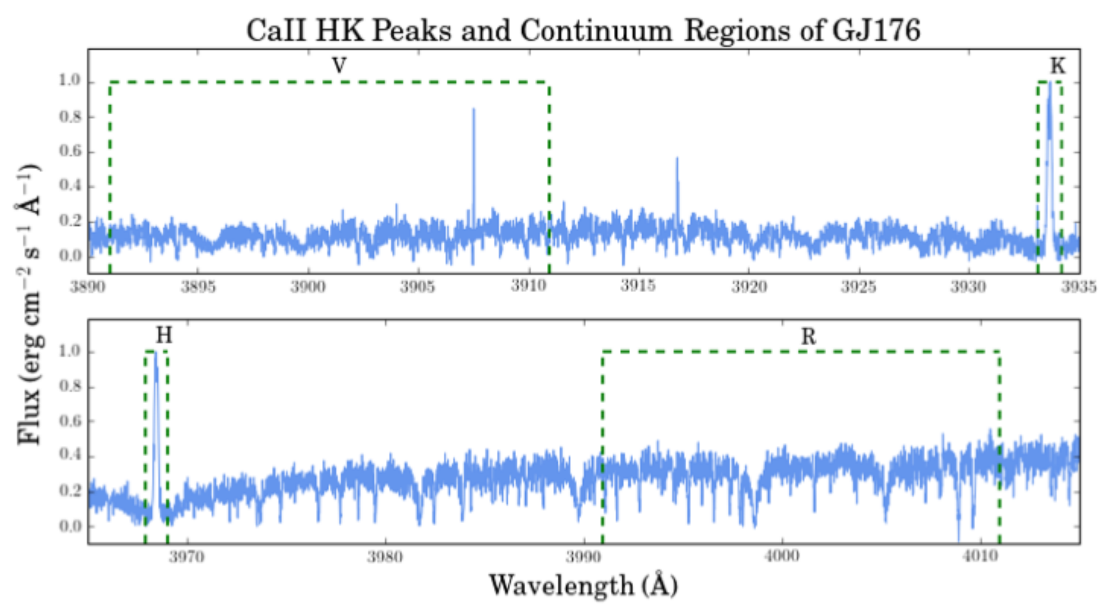
Hubble Space Telescope Spectrographs (STIS and COS)

Measuring Optical Emission

UV spectral lines originate in the stellar chromosphere, so we elected to use Hα (6562.8 Å) and CaII H and K (3969 and 3934 Å) in our optical spectral analysis, both of which have significant chromospheric contributions compared to other optical lines. Prioritizing methods that have been well-parametrized in past research, we calculated Hα equivalent widths and CaII H and K S-index and R'HK as described below.

Right: An equivalent width describes the hypothetical width of the spectral line if it was a rectangle extending from the mean continuum flux to a flux of zero, with a total area equal to the integrated flux of the line. Emission lines have negative equivalent widths.

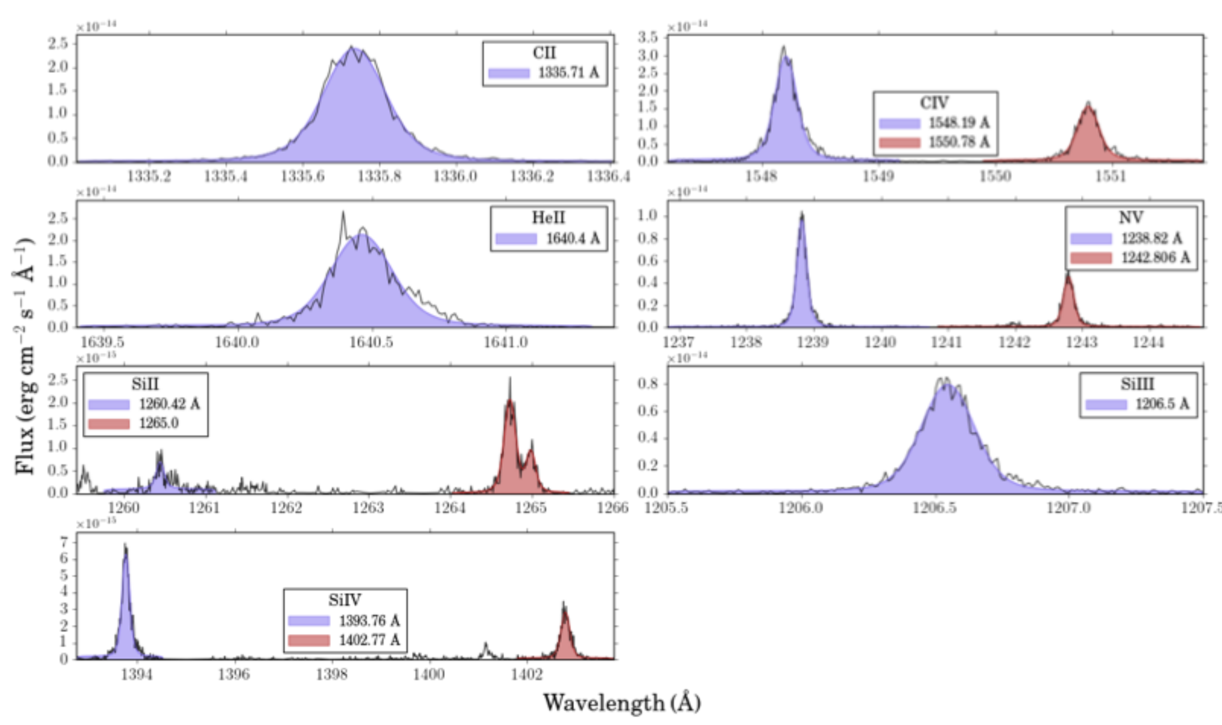




Left: The S-index is a ratio of the sum of the CaII line fluxes (K and H) over two continuum regions (V and R), and includes both chromospheric and photospheric activity. The S-index can be transformed into R'HK, which only includes the activity contribution from the stellar chromosphere.

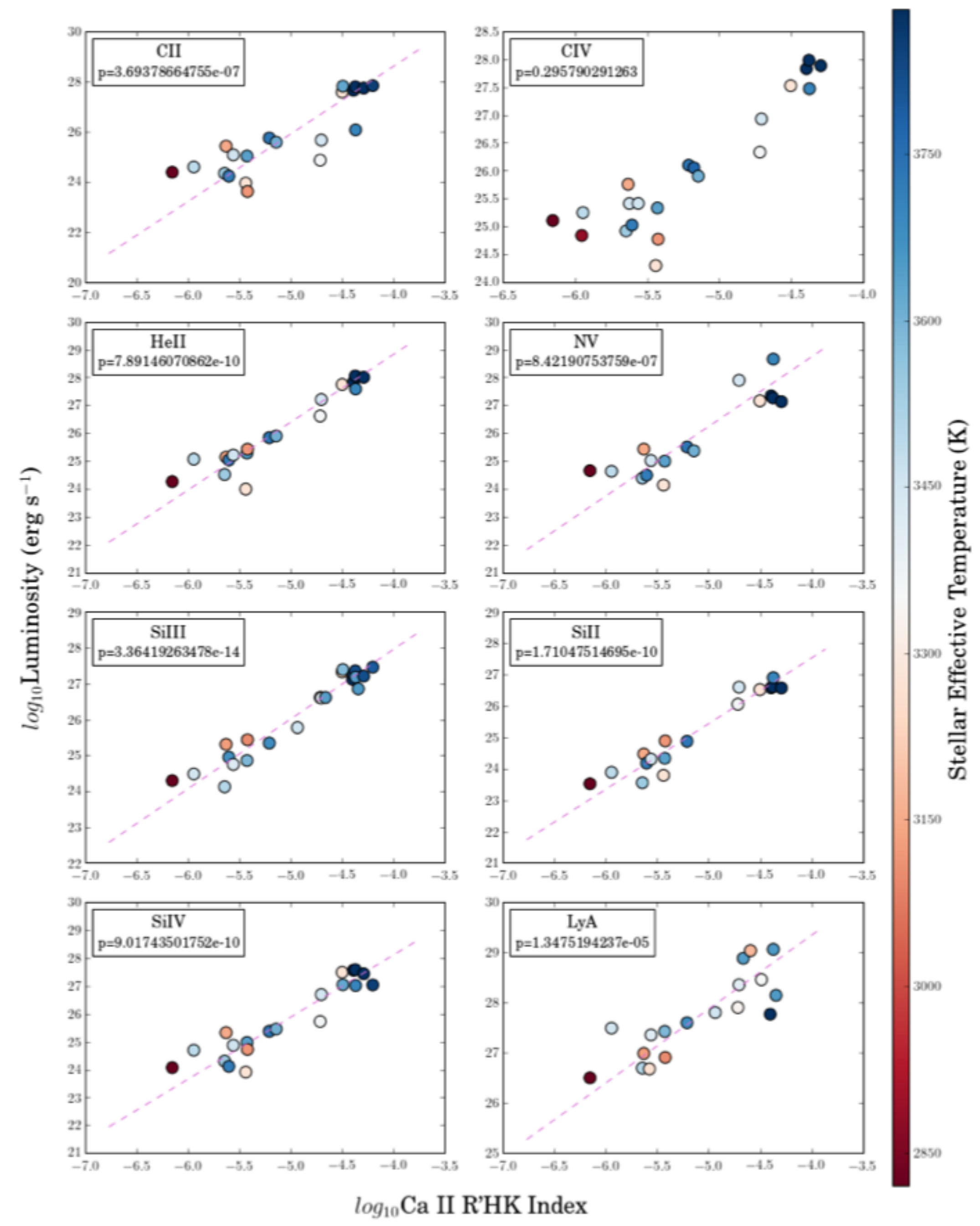
Calculating UV Fluxes

UV fluxes are calculated for 7 different lines shown below ranging from 1200 to 1600 angstroms. Each spectral line is fit with a Gaussian then integrated to find the total flux. This flux is converted into luminosity and surface flux for each target star.



Current Results

Although analysis is still in progress, we have preliminary results for 20 targets out of 107 total stars. Below are log-log linear regressions for each target's CaII R'HK and UV line luminosity.



Next Steps and Discussion

We will continue to analyze UV and optical data, including additional data points as more stars are observed and measured. Based on past research, we expect to find a correlation between the observed UV fluxes and their corresponding optical parameters. This would allow for efficient and accurate estimation of the UV emission from M dwarfs when UV data is not available. If the relationship between optical and UV emission is not as well characterized as anticipated, this work will underwrite the importance of the Hubble Space Telescope and emphasize the need for future UV space-based observatories in the continued search for potentially habitable exoplanets.

References

1. Astudillo-Defru et al. *Magnetic Activity in the HARPS M Dwarf Sample.* A&A, Vol. 600, id.A13. April 2017.
2. Newton et al. *The H alpha Emission of M Dwarfs and its Relation to Stellar Rotation.* ApJ, Vol. 834, Issue 1, id.A85. January 2017.
3. Youngblood et al. *The MUSCLES Treasury Survey IV.* ApJ, Vol. 843, Issue 1, id.A31. July 2017.

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