Identifying Magnetically Sensitive and Insensitive Spectral Lines to Improve Radial Velocity Detections of Exoplanets

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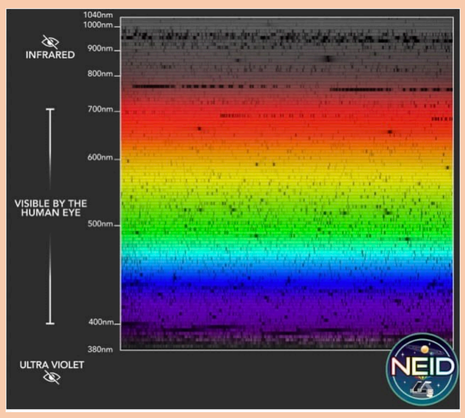
Introduction

Knowing which lines can be distorted by magnetic activity can help us distinguish stellar activity from mistaken planetary signals, as distortions in lines from magnetic activity can masquerade as radial velocity (RV) signals from planets. **A potential pathway forward is to flag and remove the stellar absorption lines most responsive to stellar variability from consideration when measuring the star's RV.** To identify these lines, we took stellar spectra from the NEID spectrograph, matched each observed absorption line to a theoretical photospheric line list, and measured the observed line parameters over time. **We then looked for correlations between change in these observed line parameters and a known stellar activity indicator.**

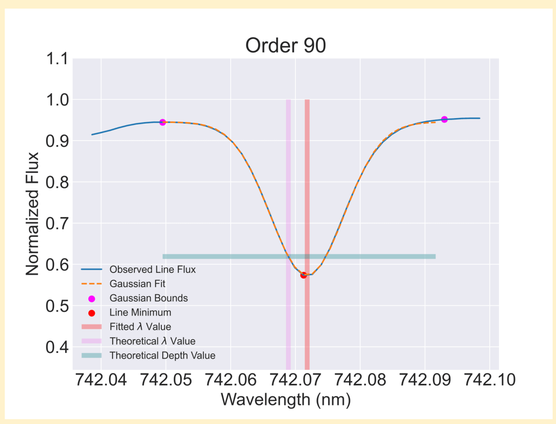
NEID Spectra

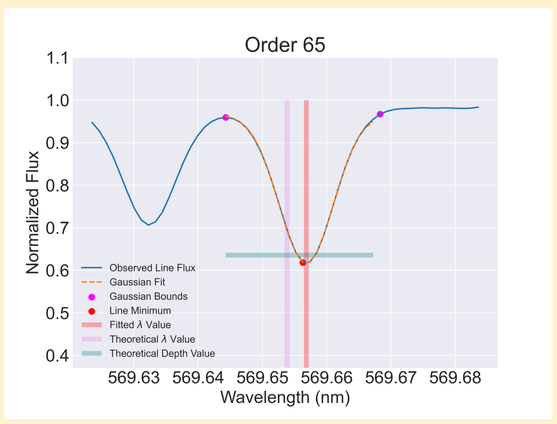
We analyzed high resolution spectra from the NEID spectrograph (Lin et al. 2022). **Of the many NEID data products, we are utilizing the 1D reduced spectra and their corresponding Ca II H & K S-index measurements, a well-known chromospheric activity indicator (Wilson 1968; Duncan et al. 1991).** We examined NEID spectra for the Sun to build our framework, and then focused our efforts on the highly active Epsilon Eridani, which is a K dwarf.



Line-by-Line RV Pipeline

To determine which lines are magnetically sensitive, we first matched each observed spectral line to the VALD theoretical line list. This allows us to determine its species, along with other characteristics of the spectral line. We began with a line list of 7849 modeled photospheric lines for K-type stars from the VALD database, which contains information on the lines' wavelength, species, and line depth, along with other parameters such as Lande G factor. **Our pipeline identifies peaks and minima in the NEID data as a way to locate absorption features, and then matches each line minimum to an entry from the VALD line list.** We apply a depth minimum of 0.2 (20% below the continuum) to ensure the line is distinguishable from noise and continuum normalization artifacts. **Once the line is identified, a modified Gaussian is fit to the line, FWHM and depth are measured and recorded.**

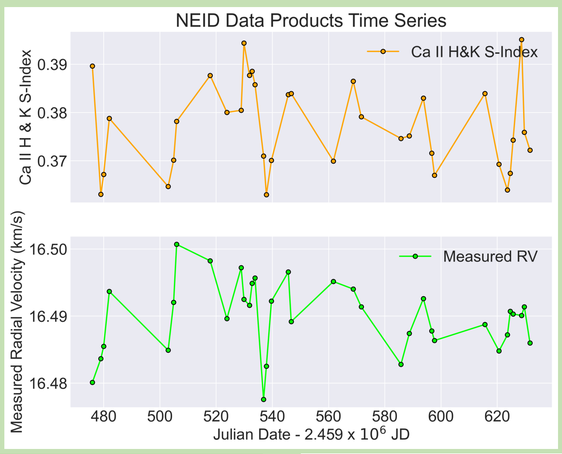


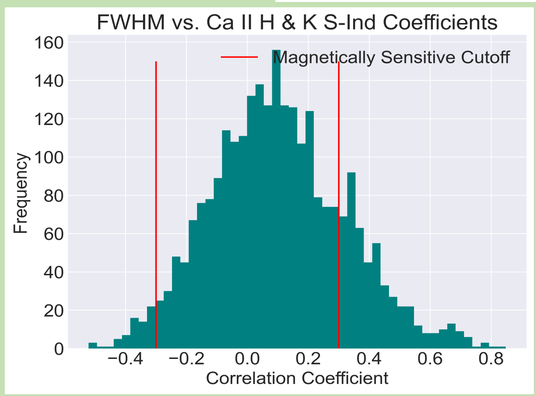


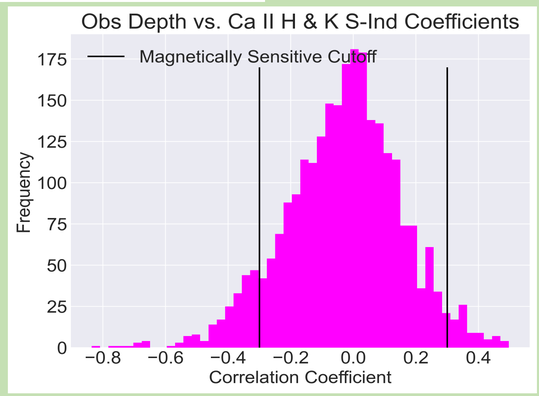
2 examples of absorption lines matched based on similarity to theoretical wavelength and depth, then fit with a modified Gaussian.

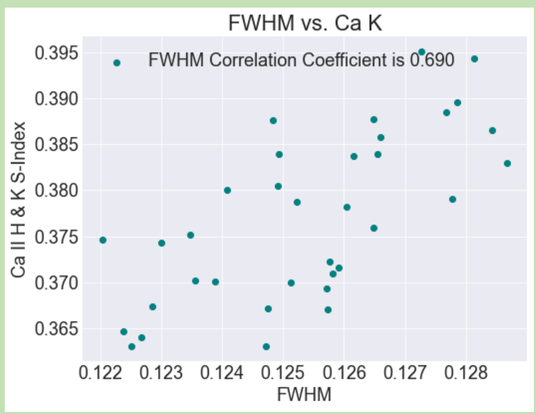
Correlation Analysis and Results

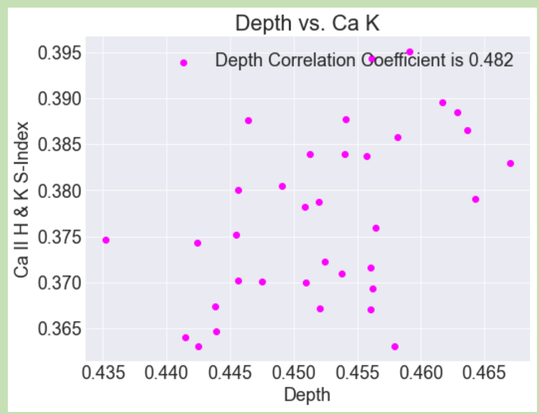
Of the initial 7849 lines from the VALD list, 2624 were successfully matched and fitted by the pipeline. We then focused on the Ca II H & K S-Index, a well-known activity indicator which is also a widely available NEID data product. We calculated the Pearson R correlation coefficient between the S-Index and both FWHM and depth for each of the 2624 lines. If both the FWHM and depth correlation coefficients had a magnitude greater than 0.3, we considered them to be magnetically sensitive lines. **This study yielded 104 magnetically sensitive lines for Epsilon Eridani.**









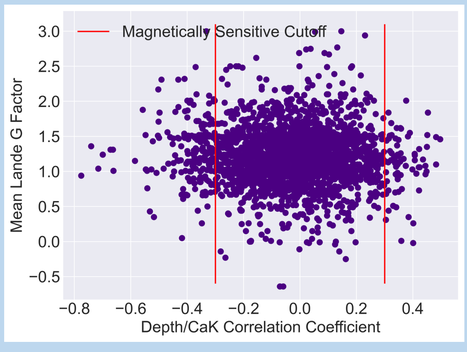


Example of magnetically sensitive line at 5108.839 Angstroms

Moving Forward

We hope to:

- Expand our study to factor in additional line characteristics, such as line transition parameters.
- Improve our continuum normalization to successfully measure and analyze shallower lines.
- Expand our study to additional stars with new line lists curated specifically for the star's spectral type.
- Use these sensitive lines to model stellar activity.



Acknowledgements and References

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