Characterizing The Accretion Behavior Of AB Aurigae, A Potential Young Planet Host Star

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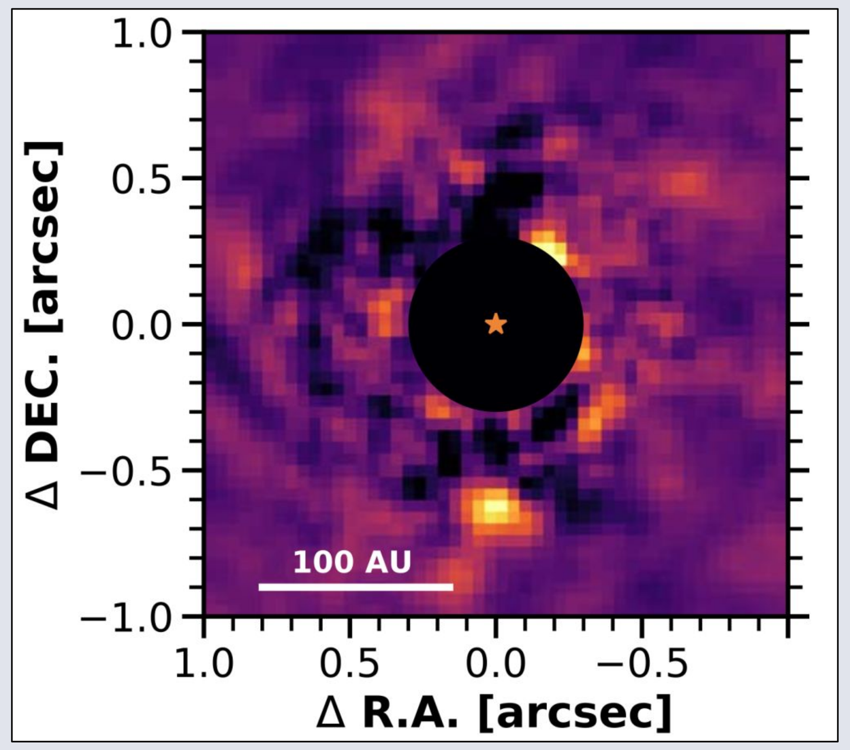
Introduction

- AB Aurigae (AB Aur) is a young Herbig Ae star (~ 4.4 Myr).
- AB Aur hosts a candidate accreting planet.
- Follow-up experiment from our team seeks to confirm or refute planet by determining whether AB Aur b is scattered starlight (Bowler et. al in prep).



- **This research characterizes AB Aur accretion variability to support the interpretation of this experiment.**

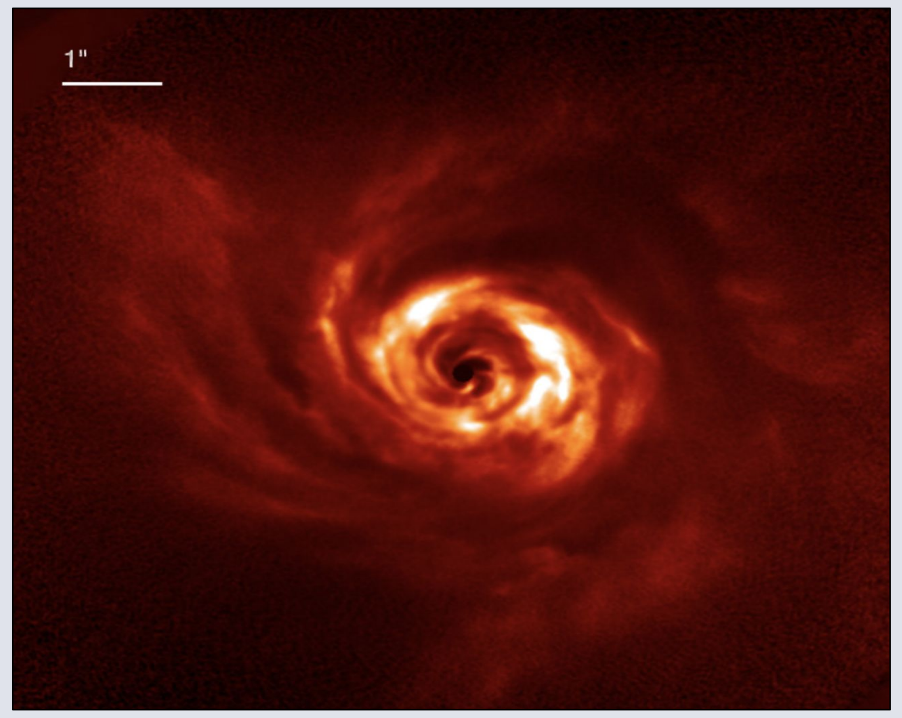
Research Goal

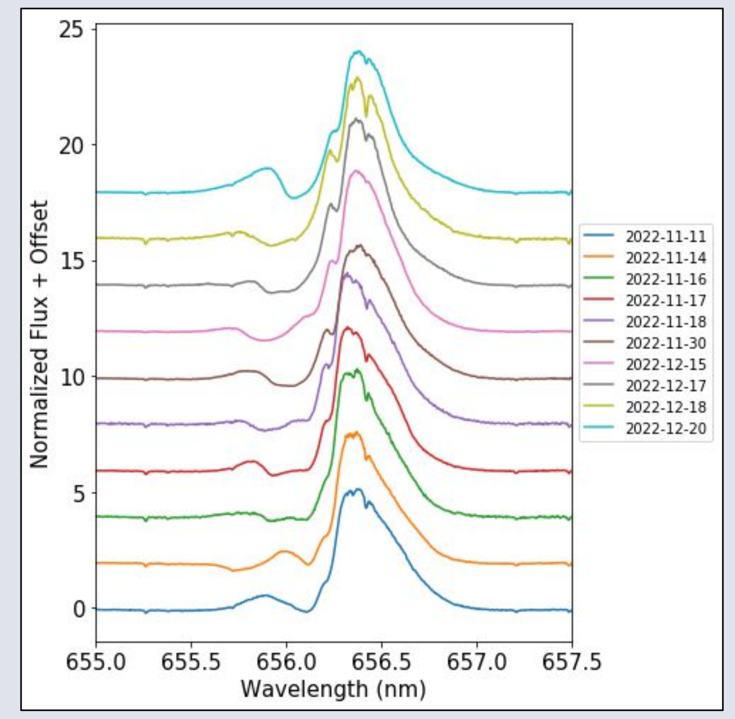
- Analyzing the fluctuations of the **H-alpha emission** line profile over a range of timescales:
  - This can help us trace the **geometry of the mass flow** in the star's immediate environment, such as accretion streams (inflows) and winds (outflows).
  - This can also help us better understand **accretion processes** onto Herbig stars.
- Understanding the characteristic timescales of the rate of accretion onto the star, which has a significant impact on the star's **brightness**:
  - Our follow-up experiment relies on accretion emission from the star, so we need to understand well what it's doing, and this project accomplishes just that.

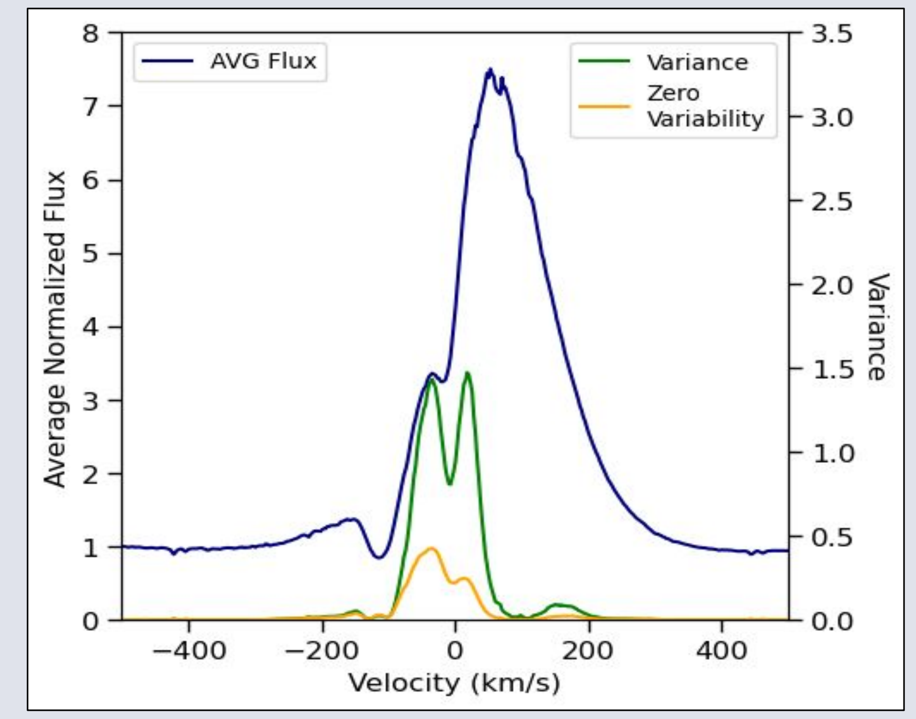
Methods

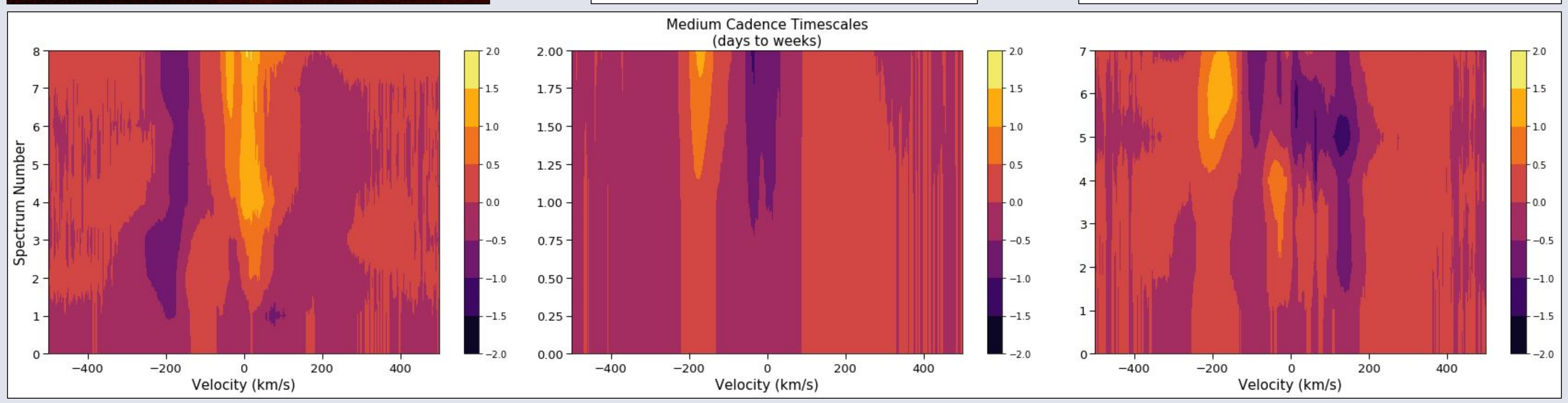
- The data consists of high-resolution time series **optical spectra** obtained with the Tull spectrograph on the 2.7-meter Harlan J. Smith Telescope, located at the McDonald Observatory. The night observations were obtained during the months of 2022 October, November, and December. In a few instances, AB Aur was observed in multiple blocks in a single night.
- Here, we present a study of H-alpha variability in AB Aur over a wide range of time windows, from minutes, to hours, to days, to weeks. We evaluate the variability using time series of line profiles and linewidth measurements. Strictly speaking, we investigated the behavior of over 250 spectra in this analysis.

Figures

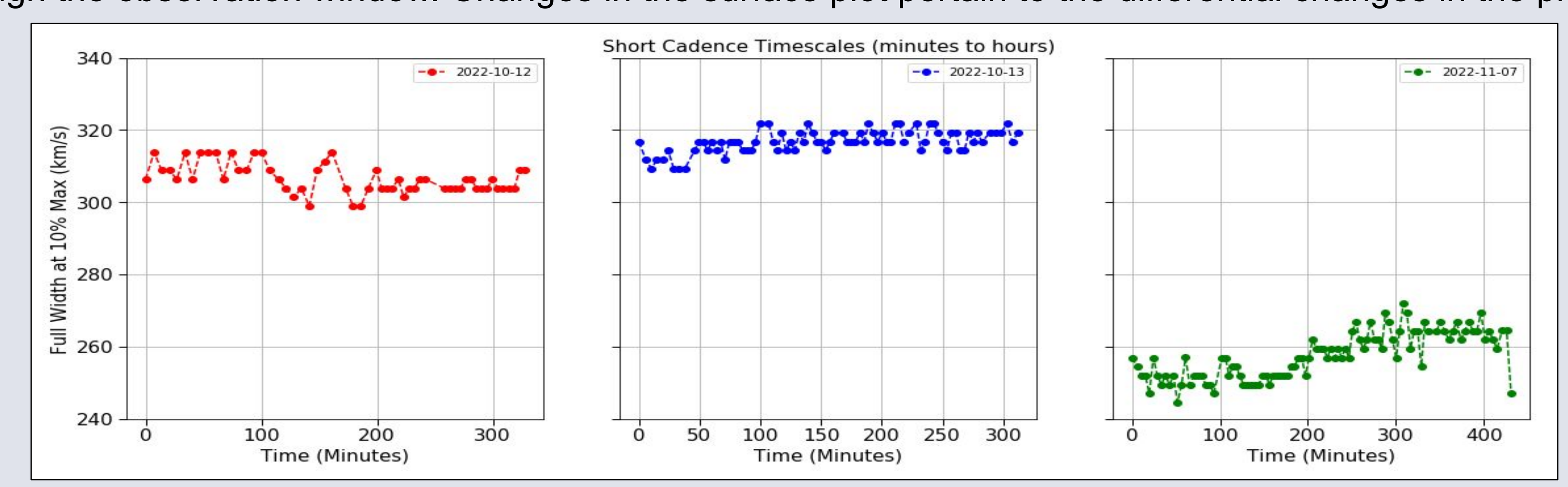


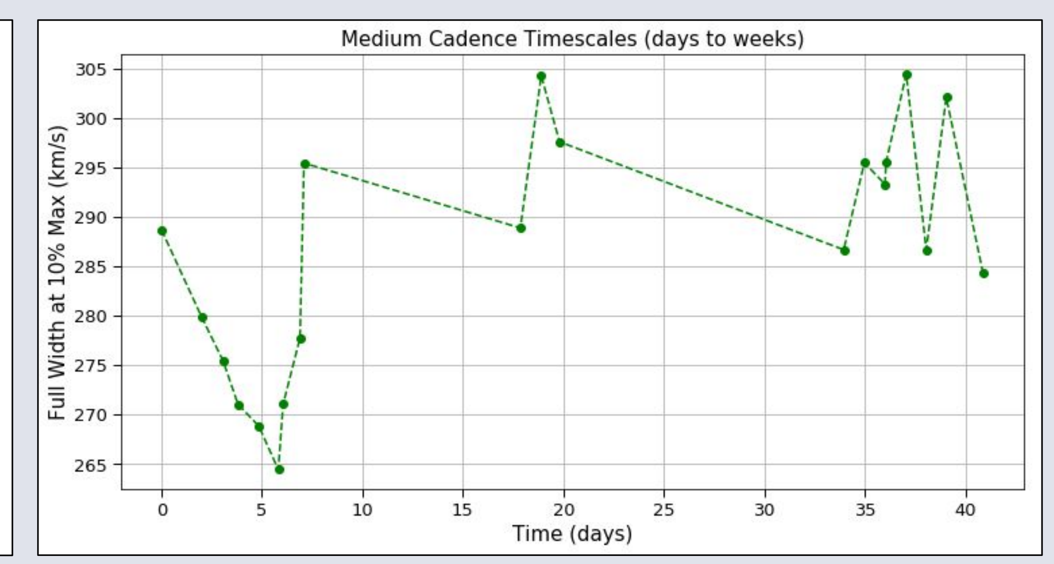


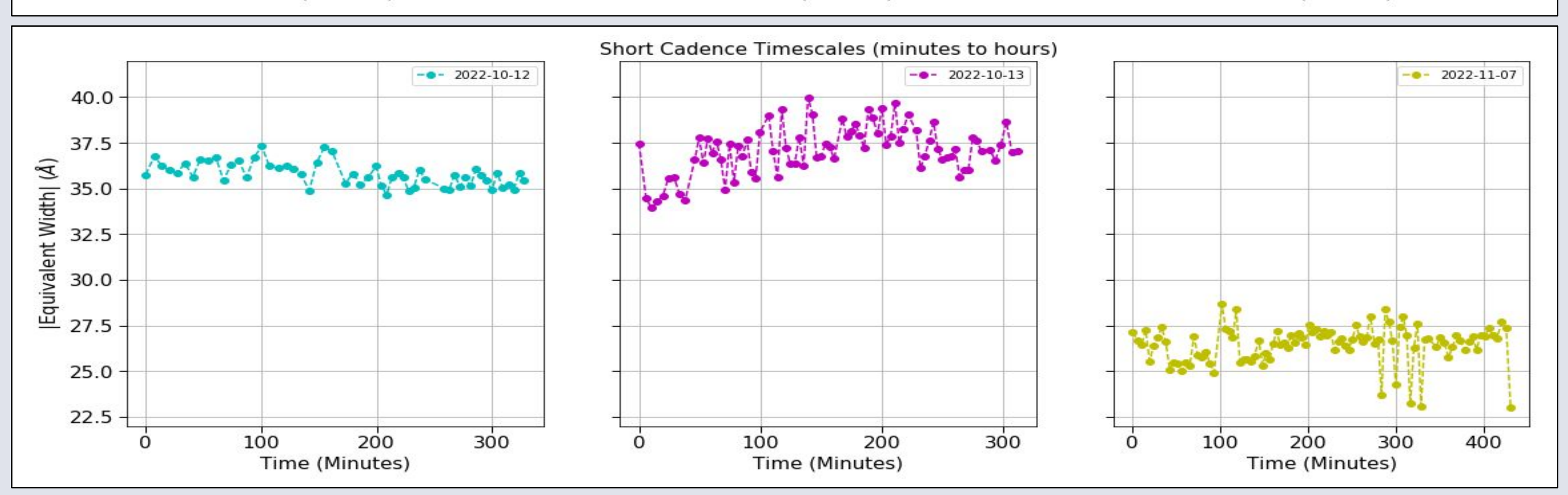


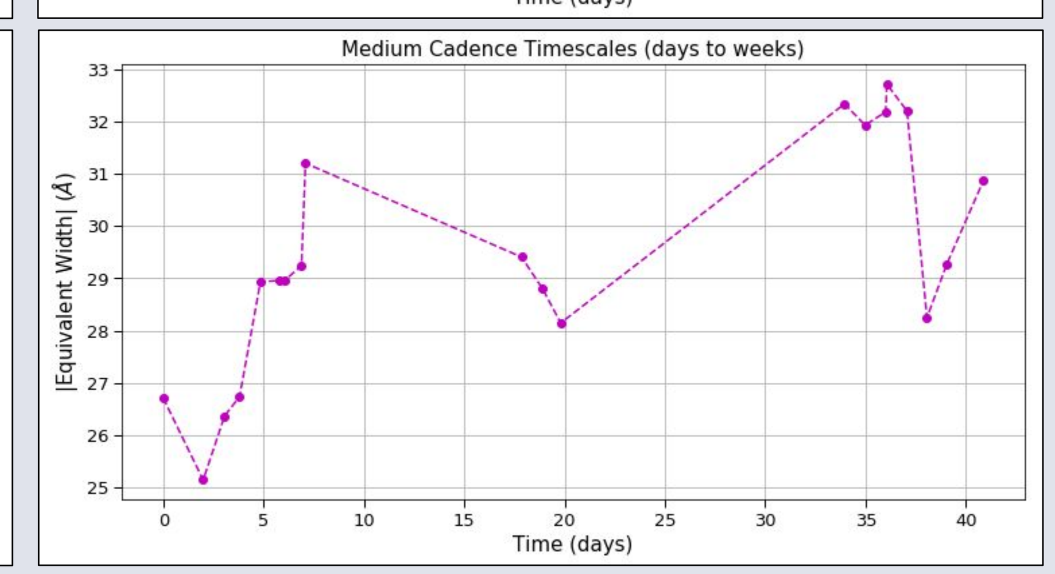


Row 1, 1st figure: a high-contrast H-alpha image of AB Aur, Boccaletti et. al (2020). **Row 1, 2nd figure:** a sequence of ten time series optical spectra. This plot depicts the small variations in the H-alpha peak and the adjacent absorption feature. Time stamps are given to the right of the plot, and it takes the form of the month and day of the observation. **Row 1, 3rd figure:** an average and variance profile. **Row 2:** a series of differential surface plots. These plots show the color-coded difference between the first spectra of that time window and the preceding spectra. As you move from the bottom of the plot to the top, you are moving through the observation window. Changes in the surface plot pertain to the differential changes in the profiles over time.





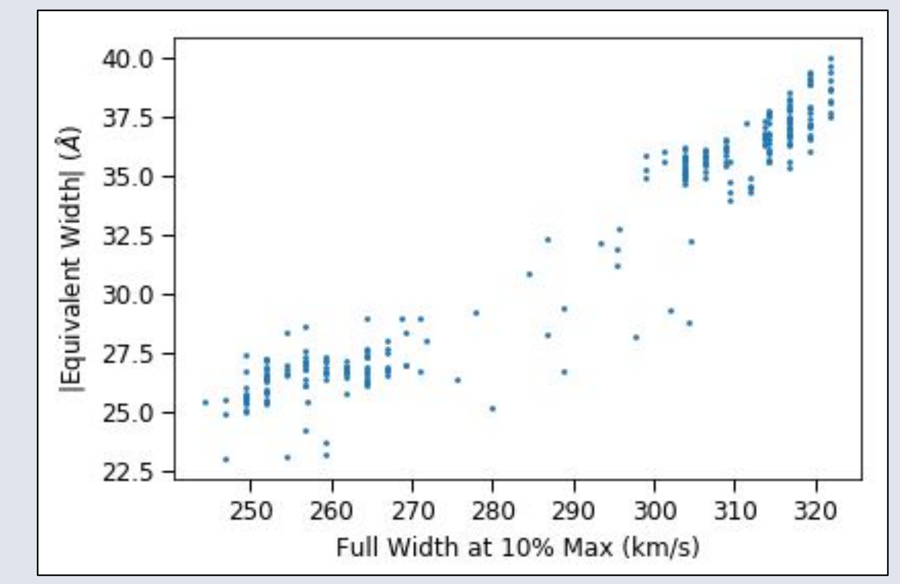




Row 3, 1st figure: a subplot displaying the full width of the H-alpha line at 10 percent of the peak height (10 μ) over a range of minutes to hours. Units are in kilometers per second. **Row 3, 2nd figure:** a plot showing the 10 μ over a range of days and weeks. **Row 4, 1st figure:** a subplot displaying the H-alpha equivalent width (EW) over a range of minutes to hours. Units are in angstroms. **Row 4, 2nd figure:** a plot showing the EW over a range of days to weeks. These measurements allow us to quantify changes in the H-alpha line. We can see that the 10 μ and EW deviations are more significant in medium cadence timescales.

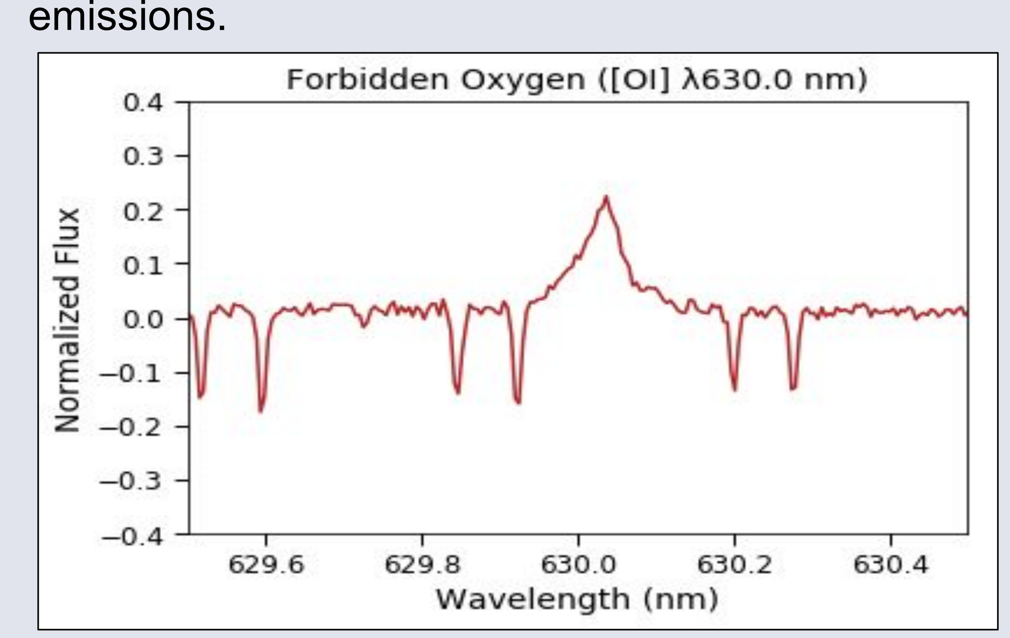
Discussion

- The 10 μ provides a means to measure the **broadening of the H-alpha line**. As the material accretes onto the star, it can reach velocities of 100s of km/s. These **high velocities** are then reflected in the broadening of the emission line.
- The EW gives a measure of the **strength** of the emission line. It can help gauge the number of emitting, or absorbing, atoms.
  - The 10 μ and EW exhibit a positive correlation with a correlation coefficient of 0.966 and a p-value of 4.001×10^{-148}.



Future Endeavors

- Conducting a **period search** using the Lomb-Scargle periodogram will help detect periodic signatures of the H-alpha line and its strength.
- Calculating **accretion luminosity** and **mass-accretion rates** will further aid our characterization of the accretion variability.
  - These computations could also inform us about the nature of the star's magnetic field lines and their ability to influence mass flows.
- Studying other kinds of emission lines such as **forbidden oxygen** can tell us more about wind emissions.



Acknowledgements

We recognize support from the National Science Foundation Research Experience for Undergraduates (NSF REU) grant AST-2244278 (PI: Dr. Shardha Jogee) and Dept. of Defense. I also want to thank Taco Joint for providing us with the best tacos and the relentless Austin heat for keeping us indoors to continue our work.