Detecting Stellar Magnetic Cycles and Rotation Period Using UF's Dharma Planet Survey

F. Mendez[1], Y. Zhao[1], K. Willis[1], B. Kimock[1], N. Grieves[1,2], D. Deng[3], S. Yan[3], D. Deal[1], and J. Ge[1]

[1]Department of Astronomy, University of Florida. Bryant Space Science Center, Museum Rd, Gainesville, Florida, 32611.
[2]Department of Astronomy, University of Geneva. 24 rue du Général-Dufour, 1211 Geneva 4.
[3]Department of Astronomy, Beijing Normal University. Beijing 100875, China

Introduction

The detection of Earth-like exoplanets has now become a reality thanks to the new high-resolution instruments used to detect Radial Velocity (RV) variations. The RV signal is caused by the Star-Planet gravitational interactions. As we start detecting sub ms^{-1} variations, the RV signals are being contaminated by stellar periodic variations; such as magnetic cycles or stellar rotation. These external signals make the exoplanet detection a challenge, since now we have to consider the analysis of stellar activity separately. Then, we should be able to subtract these contributions from the RV signals and confirm the existence of low-mass exoplanets.

Hypothesis

Using two well-known stellar activity indicators, we should be able to detect both magnetic cycles and stellar rotation for stars of different spectral types (FGK).

Methods

- Analyzed a sample of 23 stars taken from the UF's Dharma Planet Survey using TOU, a high-resolution spectrograph.
- Measured the flux from the Hα line (656.3 nm) and Ca IRT lines (849.8 nm, 854.2 nm, and 866.2 nm) to detect stellar activity.
- Magnetic cycles were detected by removing short-term mitigations on the data. We binned the nightly observations every 150 days so the magnetic cycle can be seen.
- Rotation periods were measured by computing a Lomb-Scargle Periodogram. Those signals above a 5% False Alarm Probability (FAP) significance level were considered to be the actual rotation period of the star.

Results

- Because of the short observation time span of our stellar sample, we were only able to detect a phase of the magnetic cycle. We detected three different phases in our result based on the best second-order polynomial fit to the binned data: Active, Quiet, or Transition.
- The Lomb-Scargle Periodograms show four different rotation phases based on the peak significance level: Significant, Not Significant, Stable, or Immeasurable.

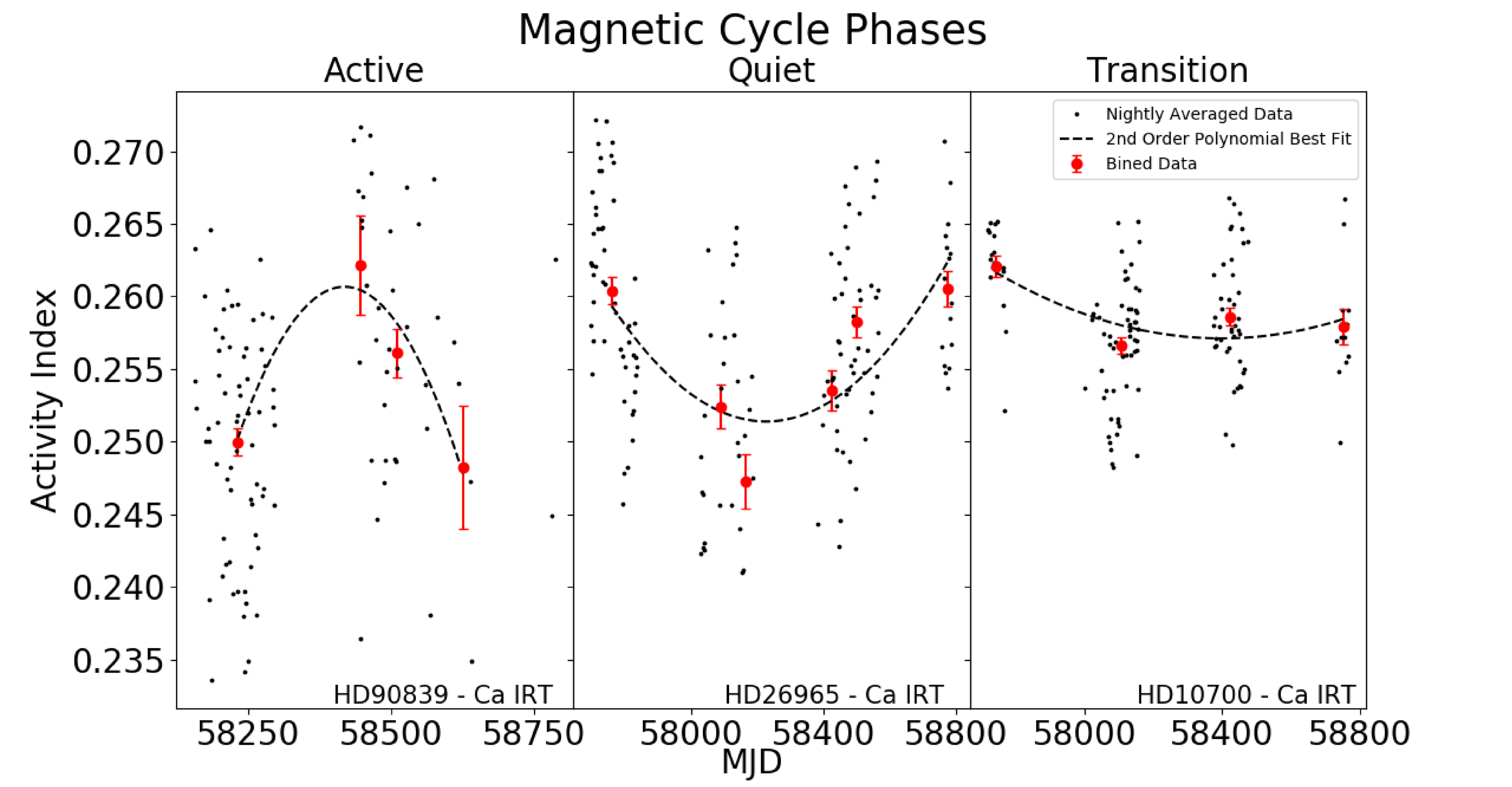

Figure 1. Shows the three different magnetic cycle phases. (Active (left), Quiet (center), and Transition (right). The black dots represent the nightly observations. The red dots are the binned data. The dash curve represents the best send-order polynomial fit to the binned data.

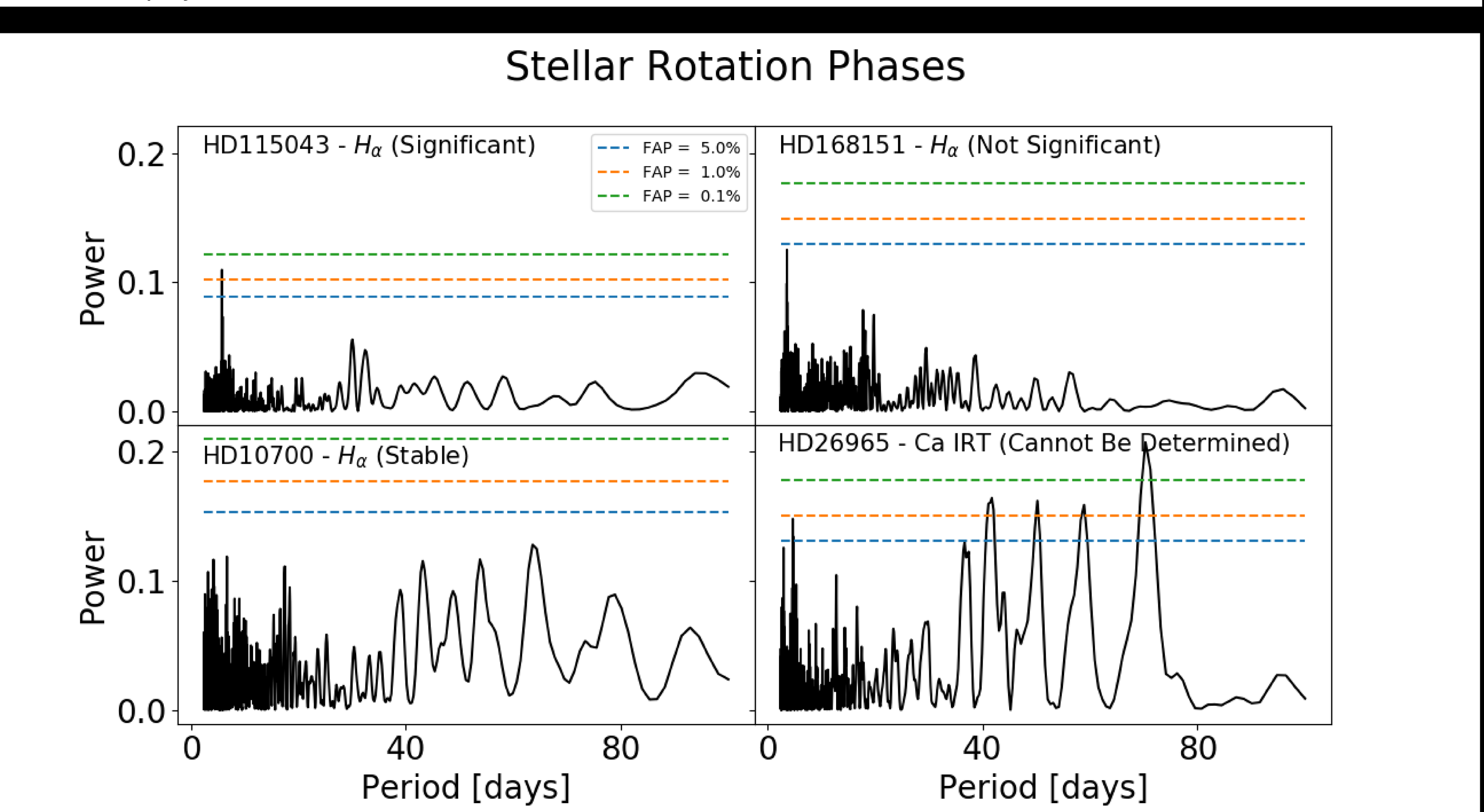

Figure 2. Shows the four different stellar rotation phases. Significant (top left), Not Significant (top right), Stable (bottom left, and Immeasurable (bottom right). We used different False Alarm Probabilities (FAP) to determine the peak significance, which are plotted as the colored dash lines. The blue line represents a FAP at 5% significance level. The orange line is for a FAP at 1% significance level. And the green line represents the FAP at 0.1% of significance level.

Discussion

- Because each activity indicator is sensitive to different types of activity (Hα to filaments and Ca IRT to plages), we see a different magnetic cycle phases for an individual star at each activity indicator.
- The Ca IRT lines are well-known indicators for magnetic activity. However, they are less sensitive when it comes to rotation period measurements in comparison with the Hα lines.
- We calculated the rotation period for the star HD115043, which has a well-known rotation period of ~6 days. We were able to detect this same value using both activity indicators.

Conclusions

- Using the Hα and Ca IRT lines as activity indicators, we were able to detect three different magnetic cycle phases and four different rotation period phases).
- Activity indices can be sensitive to different types of stellar activity. For instance, filaments or plages.
- The Ca IRT lines are less sensitive to rotation period measurements. However, we were able to measure the rotation period of the star HD115043. Our measurements are supported by the literature.

Future Work

- Use the Ca H&K lines, another well-known activity indicator to measure magnetic cycles and stellar rotation periods.
- Apply the stellar activity results to RV measurements and confirm the existence of several low-mass exoplanets.

References

- Fuhrmeister, Czesla, and Schmitt et al. "The CARMENES search for exoplanets around M dwarfs." A&A. 623, (2019).
- Nava, et al. "Exoplanet Imitators: A Test of Stellar Activity Behavior in Radial Velocity Signals." AJ. 159, (2019).
- Silva, Santos, and Bonfils et al. "Long-term magnetic activity of a sample of M-dwarf stars from the HARPS program." A&A. 534, (2011).