



# Measuring Activity Metrics of Low-Mass Binaries

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## Why Measuring Low-Mass Binaries' Activity Metrics?

1. Precisely determine the properties (mass, radius, etc) of exoplanets helps astrophysicists answer critical problems (such as if there are habitable planets).
2. Planet properties are determined by their host stars.
3. Models can make predictions about host stars' overall properties, but how good are they?
4. Some earlier studies have claimed that strong magnetic fields (activity) can change the stellar properties. This is not included in the models.
5. Measuring the activity of stars where we know the properties very precisely (e.g., low-mass binaries) can confirm or invalidate the above claim.

### Standard Model

Active Star (Host)

Planet



### Hypothetical Claim

Active Star (Host)

Planet



Strong magnetic field affects host star's properties

Planet's properties change accordingly

Since magnetic field strengths often cannot be measured directly, this research measures the following 3 activity metrics as indications of the star's magnetic field strength.

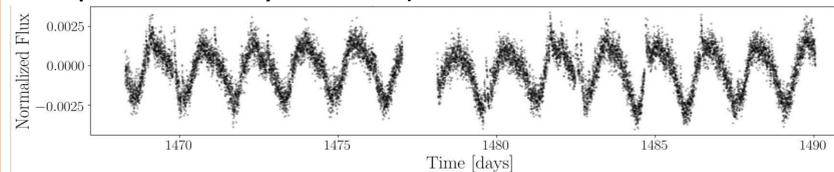
1. Star rotation period
2. H $\alpha$  emission line of the star's spectrum
3. Ca H & K emission line of the star's spectrum

The above metrics are then colored in the standard HR diagram (mass VS absolute magnitude) to see if strong magnetic fields have significant influence on stellar masses.

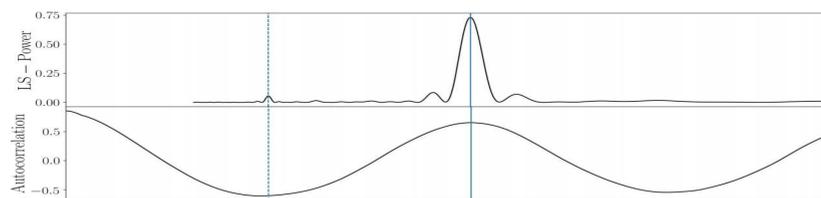
## Measuring Activity Metrics

### A. Rotation Period and Rossby Number

Target stars' spectra are obtained from TESS (Transiting Exoplanet Survey Satellite).



Starspot, an analyzing tool is used to extract stars' rotation periods from their spectra.



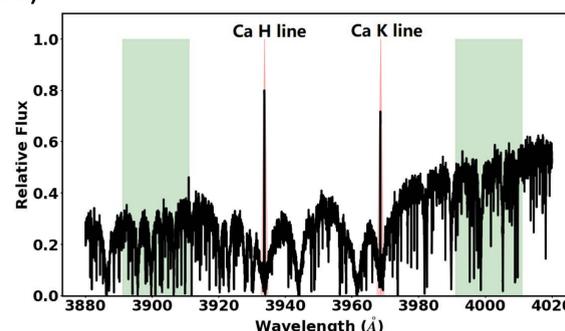
Rossby number is calculated based on the rotation period and convection turnover time to eliminate spectral type dependency.

### B. H $\alpha$ Emission Line and Its Correction

H $\alpha$  emission line measurement is obtained from spectra taken with SOAR (Southern Astrophysical Research Telescope). Correction is made by subtracting the measurement by a baseline to eliminate spectral type dependency.

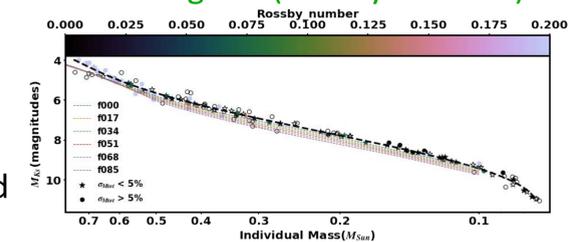
### C. Ca H & K Emission Line and S index

Target stars' spectra are obtained from ESO archive, SOPHIE archive, and KECK observatory archive. S index, an indicator of star's chromospheric activity, is then obtained by measuring the flux in the following 4 regions (indicated by red triangles and green rectangles).



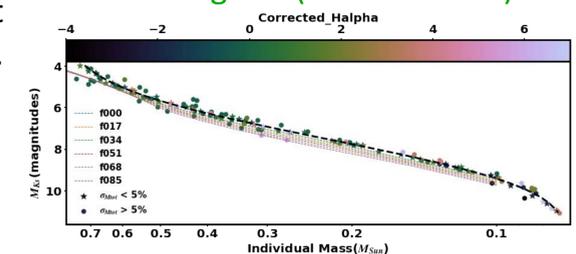
## Results on Stellar Activity Metrics VS Stellar Masses

### A. HR Diagram (Rossby Number)

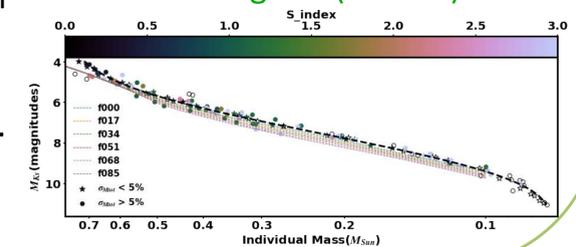


In the figures on the right are the HR diagrams colored by Rossby number, corrected H $\alpha$ , and S index. The black dashed line is the curve fit of the data points. The colored dashed lines are the hypothetic models indicating how stellar activities may alter the physical properties shown in the HR diagram.

### B. HR Diagram (Corrected H $\alpha$ )



### C. HR Diagram (S index)



## Summary and Future Work

1. This research successfully measures the Rossby numbers (using the rotation periods) and S indices (using the Ca H & K emission lines) and tests the validity of the hypothetical claim.
2. According to the plots above, the influence that strong magnetic fields have on stellar masses is insignificant.
3. Future work should focus on adding more activity metrics and enlarging the sample of target stars.

## References (Partial)

1. N. Astudillo-Defru et al. 2016, arXiv:1610.09007v2 [astro-ph.SR].
2. Sam Morrell & Tim Naylo 2019, DR2, MNRAS 000, 1–19.
3. Aurora Y. Kesseli et al. 2018, AJ 155:225 (14pp).