Gathering new data to understand the dynamo in Sun-like Stars.

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Previous observations have shown a strong relationship between a star's rotation period and magnetic cycle period. As stars age, their rotation period grows due to magnetic braking, this causes an increase in the magnetic cycle period as well. Recent analysis of Kepler data found older stars were rotating too quickly according to the current model of a star's aging process. This data, along with other studies, suggests that at a certain point in a star's life, magnetic braking shuts down(fig. 6). It is believed that the Sun is in this transitional phase now. More data from Sun-like stars, at various stages of the Sun's life, are critical to understanding the possible breakdown of the Sun's dynamo.

The Las Cumbres Observatory NRES is an automated global network of 6 telescopes and spectrographs which launched in 2017 to study exoplanets. We have created an open source Python pipeline to take raw data from NRES and produce a stellar magnetic activity proxy. The S-Index is a traditional indicator for magnetic activity developed by the Mt. Wilson HK Project. It utilizes the fact that star spots induce magnetic heating in the chromosphere which produces an emission reversal in the Calcium II H&K lines(fig. 1). Our pipeline seeks out this magnetic indicator in spectra from NRES and produces a time series of activity for stars.

Open Source Python Pipeline Steps

1. Divide flat field from spectrum to remove instrumental error.
2. Cross correlate to place stellar spectrum in lab frame.
3. Calculate S-Index from Ca HK emission reversal features.
4. Detect and log bad data, then remove from time series.
5. Repeat process for each night's spectra for any desired stars.
6. Create SHK time series of each star for analysis.

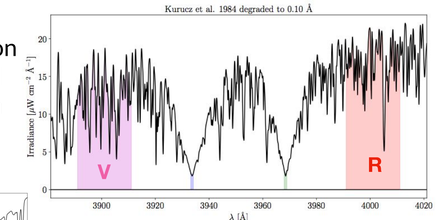
Our pipeline and initial study of short cycle stars is a proving ground for detecting magnetic activity using NRES. However, the accuracy of our results are limited by the exclusion of the V-band(fig. 1) from NRES data. We have shown that using a Planck scaled R-band as a pseudo V-band introduces 20-30% error in calculations(fig. 2). We are confident LCO will later include the V-band data and our pipeline will then be used as the standard method for extracting magnetic activity from NRES.

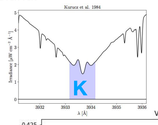
Do Sun-like stars experience a magnetic mid-life crisis?

Investigation from a new Ca HK activity survey using LCO NRES.

Take a picture for link to github project and more information.

Fig 1. right S-index calculation highlighting need for real V-band in calculation.
Used w/ permission from Ricky Egeland.





$$S = \alpha \frac{N_H + N_K}{N_V + N_R}$$

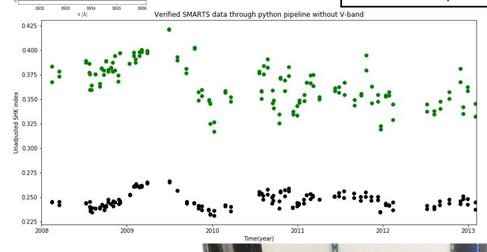


Fig 2. above- Verified data through pipeline with(black) and without(green) real V-band.

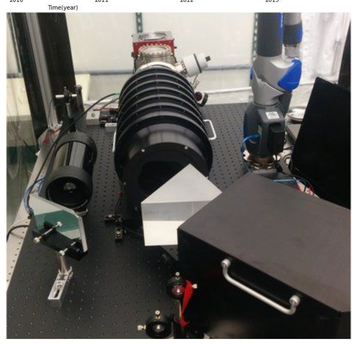


Fig 3. right - NRES in a clean room. https://lco.global/observatory/instruments/nres/

Fig 4. below - Our pipeline's nightly observation report showing real data and steps of SHK calculation.

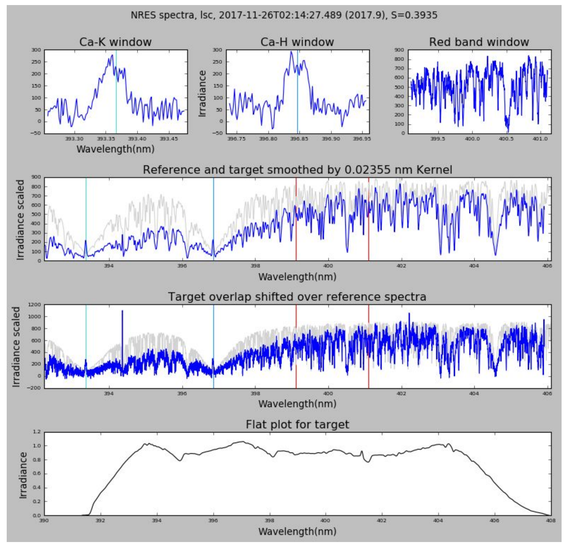


Fig 5. below - Time series of Epsilon Eridani's roughly 3 year magnetic activity combining published data(teal) with new data(blue/green) from our python pipeline.

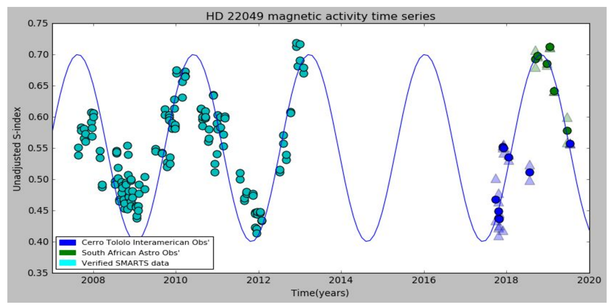
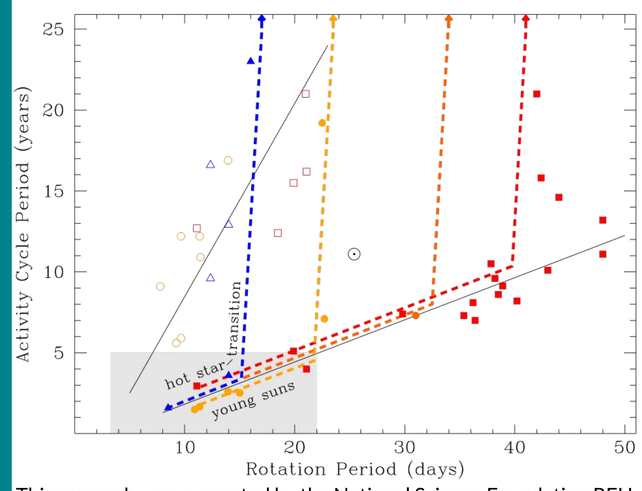


Fig 6. below - Dotted lines represent evolution paths stars may take due to shutdown of magnetic braking. Updated from Metcalfe & van Saders (2017)



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