Exploring the Long & Short-Term Rotation and Activity in Young Stars

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Introduction:

Young stars are newly formed stars that have not yet reached the main sequence phase of their evolution.

Young stars are typically surrounded by a protoplanetary disk, a rotating disk of dense gas and dust, and due to their large convective layers are very active. Material from this disk is often accreted onto the stellar surface of young stars resulting in the formation of active sites.

Due to the faster differential rotation of young stars, we expect their magnetic poles to flip more often than older stars. The duration between the flipping of the poles is known as a magnetic cycle.

The work and findings summarised in this poster was carried out as part of my final year BSc (Hons) project.

Aim:

To analyse the long and short-term rotation and activity in a group of young stars, including exploring any potential changes and correlations in their results.

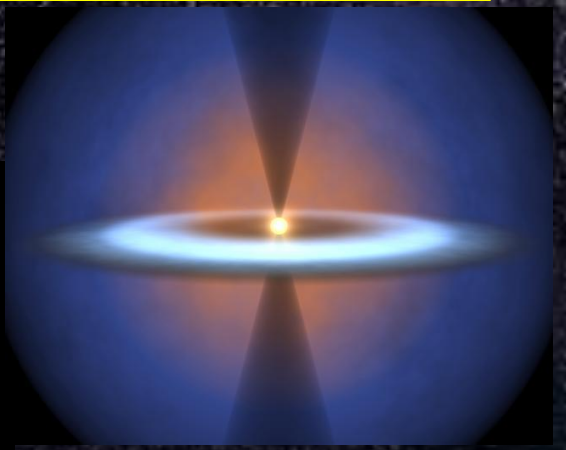

Figure 1: Illustration of a young star, with a surrounding protoplanetary disk .
[Image Credit: NASA/JPL-Caltech, Identifier*:* PIA09966*]*

Methodology:

- 32 Young Stars were selected from a base paper [*L.M. Rebull et al. (2018). The Astronomical Journal, 155(5):196.*] and data for each was taken from the Kepler 2 Space Mission [1], Catalina Survey [2] & All Sky Automated Survey (ASAS) [3].
- Light curves, periodograms, wavelet analysis diagrams and phase diagrams were plotted to analyse each star.
- Spearman's and Kolmogorov-Smirnov tests were carried out to determine any correlations and the significances of these correlations.
- Monte Carlo analysis of any potential long-term modulation candidates were carried out.

Kepler 2 Results:

- Multiple light curves had spikes or dips, indicating the presence of flares, hot spots, cold spots, protoplanetary disks or potential binaries.
- All periodograms showed distinct periods, with several periodograms containing secondary smaller period peaks (indictive of the presence of a spot).
- Wavelet analysis matched the periods obtained from the periodograms and phase analysis showed strong modulations for each young star, with a few containing moving stellar spots.

EPIC Name	Disk	Spectal Class	Flares	Dips	Possibly Binary	Period (Days)
203271901	no	M0	Yes	Yes	Yes	1.59
203476597	no	G8	No	Yes	Yes	3.21
203553934	no	M0	Yes	No	No	4.72
203640875	yes	M0	No	No	No	9.11

Figure 2: Summary of some of the information gathered for the young stars (identified by Epic Name) from the Kepler 2 results.

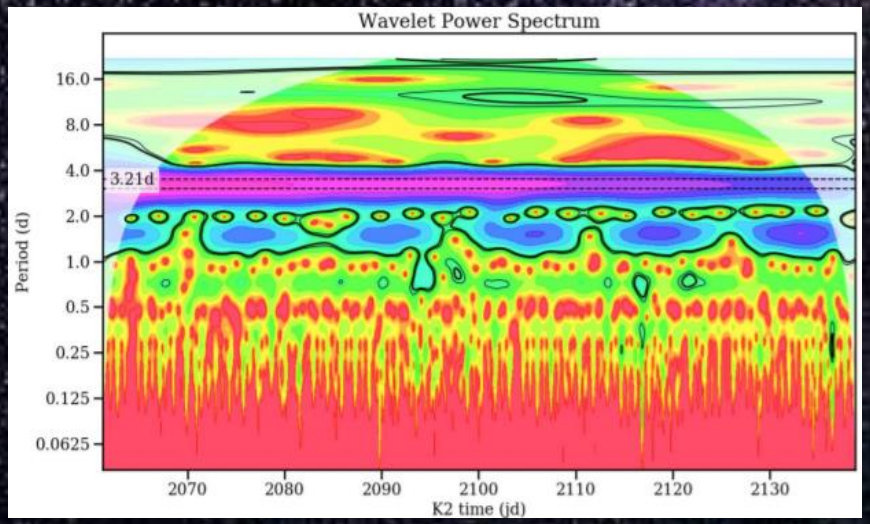

Figure 3: Wavelet analysis diagram for one of the selected young stars. The purple region indicates the strongest power (this is the young stars period).

Catalina Results:

- No flares present on the light curves due to the short lifetime of flares compared to the survey length.
- Periodograms contained many peaks and phase diagrams showed signs of order & little/no modulation. This suggested that any magnetic cycles were longer than the 1000 day observational period of the survey.
- False periods a result of ground sampling (caused by the uneven time intervals between observations).

ASAS Results:

- Similar to the Catalina Survey, no flares were present on the light curves from the ASAS data.
- Periodograms contained many peaks (false periods) and the phase diagrams showed signs of order & no modulation. No magnetic cycles were detected due to the lack of data points and ground sampling.

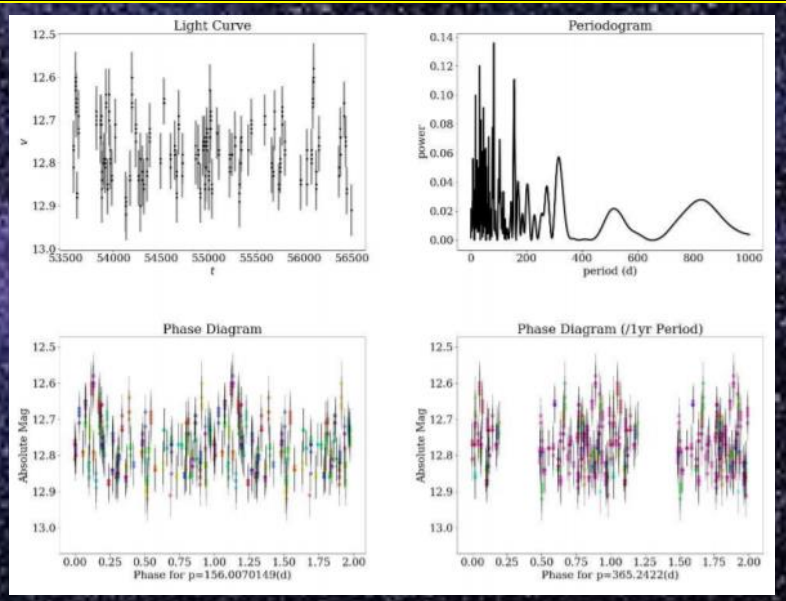

Figure 4: Light curve, periodogram and phase diagrams for one of the selected young stars using its respective Catalina data. The phase diagram showed some potential modulation for the long – term survey data and was the only young star that showed potential long-term modulation.

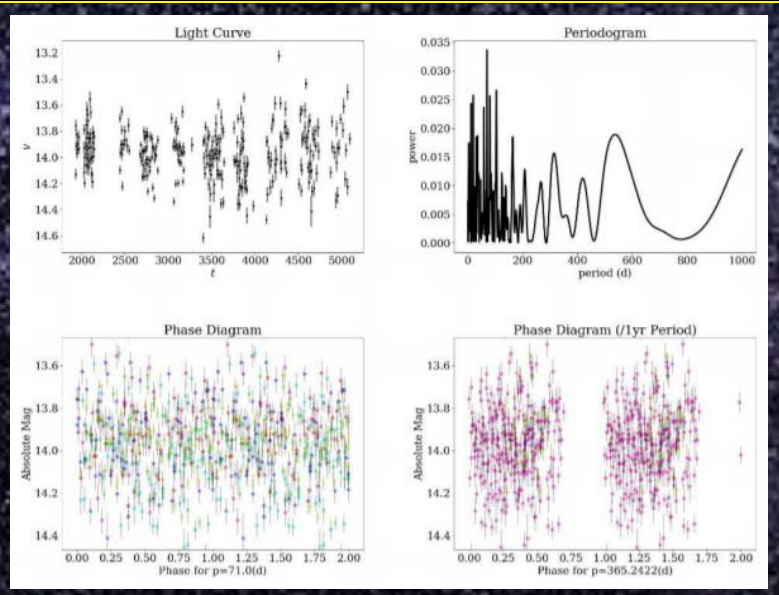

Figure 5: Light curve, periodogram and phase diagrams for one of the selected young stars using its respective ASAS data. The phase diagram showed no signs of modulation and the periodogram contained multiple peaks.

Statistical Test Results:

- Potential link between shorter periods and the presence of flares, suggesting more active young stars tend to rotate faster.
- No correlation between periods and presence of a disk.
- The long-term modulation candidate had several significant peaks but not all peaks were real, due to ground sampling.

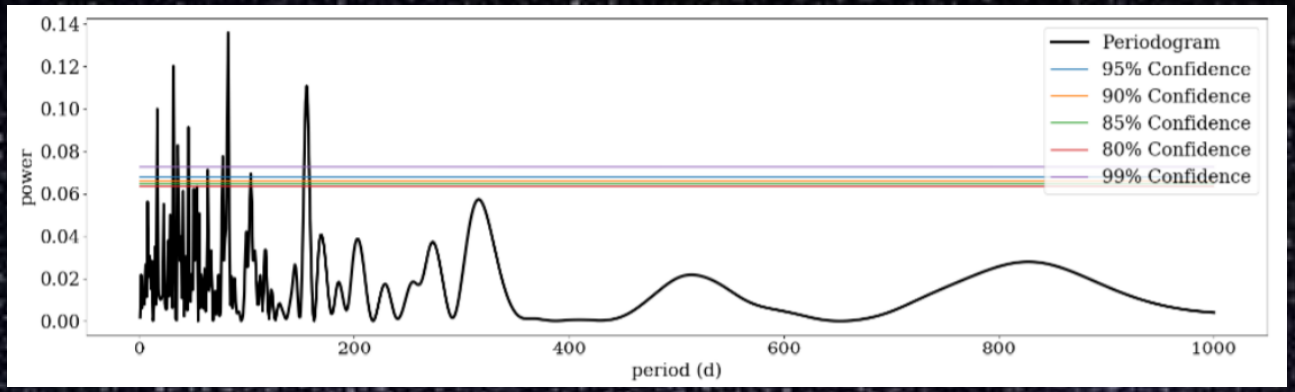

Figure 6: Periodogram for the long-term modulation cancidate (EPIC 204274993). The periodogram included the confidence intervals (significance values) for the peaks.

Conclusion:

- Strong modulation in short-term survey as expected.
- Little modulation in long-term survey.
- Period values, the existence of flares or dips, spot types and, binary status were successfully determined from the short-term results for 28 out of the 32 young stars.
- Magnetic field cycles likely longer than 1000 days.
- Potential correlation between shorter Kepler 2 periods and existence of flares.

Survey Acknowledgments & References:

[1] "D*ata collected by the K2 mission. Funding for the K2 mission is provided by the NASA Science Mission directorate". D*ata obtained from the Mikulski Archive for Space Telescopes (MAST). STScI is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555".

[2] "The CSS survey is funded by the National Aeronautics and Space Administration under Grant No. NNG05GF22G issued through the Science Mission Directorate Near-Earth Objects Observations Program. The CRTS survey is supported by the U.S. National Science Foundation under grants AST-0909182".

[3] *G. Pojmanski et al. Acta Astronomica, vol. 55, pp. 275–301, Sept. 2005.*