Is M Dwarf Rotation Rate a Clue to Planetary Presence?

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Abstract: Rotational angular momentum may be transferred from stellar rotation to planetary orbits. As such, slower stellar rotation may **indicate planetary presence.** To find the correlation between planetary presence and stellar host rotation within the solar neighborhood, we must **determine the rotation periods** of predicted stellar hosts. We conducted **a multi-sector analysis of TESS data for 526 M dwarfs** with a mean of four TESS observation sectors per target and analyzed the distribution of planetary detections for these stars as a probe for understanding angular momentum evolution in stellar and planetary systems.

Question #1:
For M dwarfs in rotation classes of superfast (<1 day), fast (1-10 days), and slow (>10 days), which class hosts the most exoplanets?

Question #2:
Can angular momentum transfer be used as a new detection method for finding exoplanets around M dwarfs?

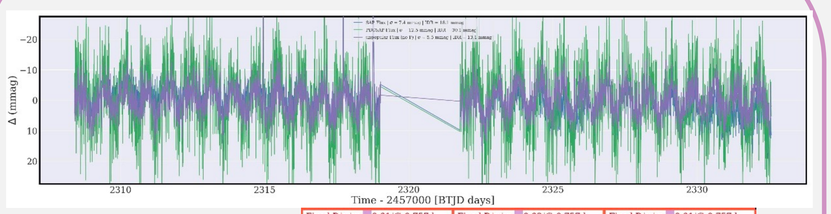
Methodology

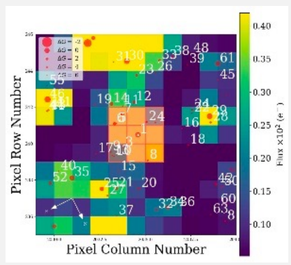
`unpopular`
A cumulative span of six years of TESS photometric, multi-sector observations were reduced using the `unpopular` Python package to produce light curves for each target in the volume-complete sample of 526 M-type dwarfs within 15pc.

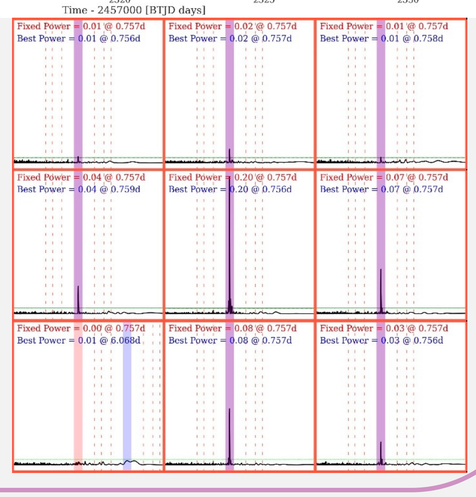
Periodogram Fitting
The rotation period of each light curve was determined by Lomb-Scargle periodogram fitting. This technique fits sinusoidal functions of varying periods to a given light curve. Each function is assigned a value of power to indicate the wellness of fit. The period of the function with the highest power for a given light curve is determined to be the period of the light curve.

Crossmatch with the NEA
To find the host candidates in our sample of M dwarfs with confirmed rotation periods, we conducted a crossmatch with the NASA Exoplanet Archive (NEA). The results of this crossmatch are current as of July 2025.

Pixel-by-Pixel Analysis







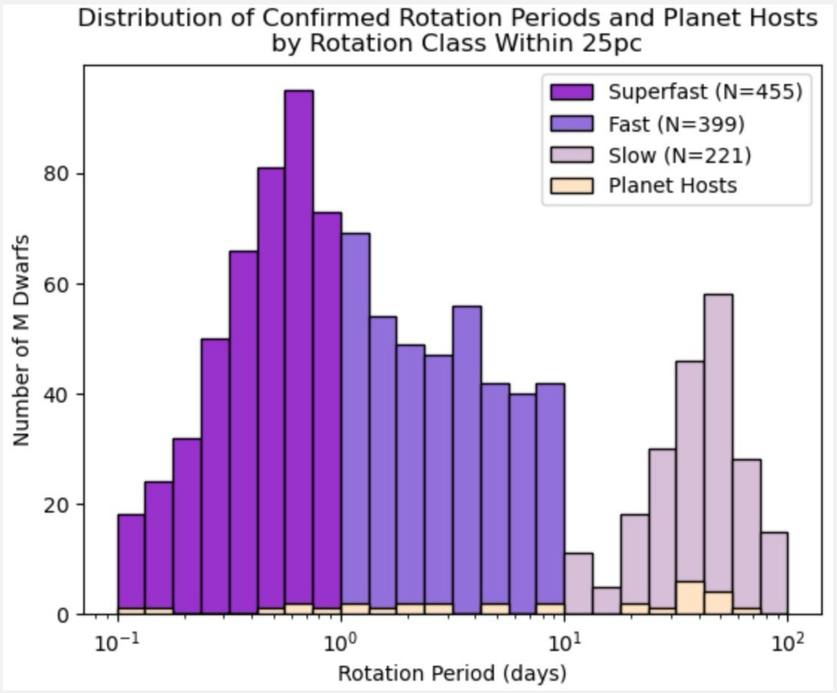
Rotation Classes

Superfast → rotation period < 1.0 day

Fast → 1.0 day < rotation period < 10.0 days

Slow → rotation period > 10.0 days

The subdivision of the superfast class was chosen to be less than one day rotation since targets with rotation rates within this regime approach velocities that risk structural instability. The subdivision of the slow class was chosen to be greater than 10 days since there is a drastic decrease in targets within this regime due to the rapid slowing of the rotation rate as a result of magnetic braking.

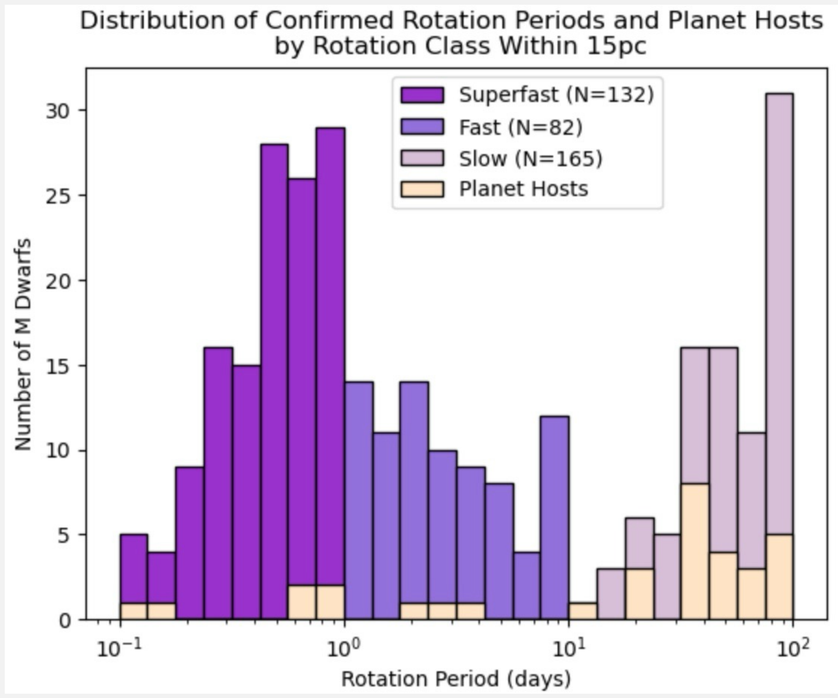


Superfast hosts 1.7%

Fast hosts 2.7%

Slow hosts 6.0%

Limit to 15pc



Superfast hosts 4.5%

Fast hosts 3.7%

Slow hosts 20.0%

Answer #1:
M dwarfs with long rotation periods tend to host planets more often

Answer #2:
AHA! Stay tuned as we determine more rotation periods...

Biases

Bias #1: Brighter stars are observed more than faint stars
Bias #2: More active stars tend to be underreported as hosts
Bias #3: Shorter rotation periods are more likely to be confirmed than longer rotation periods

For more details about this work and future efforts, please contact kkimanistewart1@gsu.edu