Using spectroscopic observations and photometric light curves of 298 nearby M dwarfs from the MEarth transit survey, we examine the relationships between magnetic activity (quantified by Hα emission), rotation period, and stellar age (derived from three-dimensional space velocities). Although we have known for decades that a large fraction of mid-late-type M dwarfs are magnetically active, it was not clear what role rotation played in the magnetic field generation (and subsequent chromospheric heating). Previous attempts to investigate the relationship between magnetic activity and rotation in mid-late-type M dwarfs were hampered by the limited number of M dwarfs with measured rotation periods (and the fact that v sin i measurements only probe rapid rotation). However, the photometric data from the MEarth survey allows us to probe a wide range of rotation periods for M dwarf stars (<1-150 days). Over all M spectral types we find that magnetic activity decreases with longer rotation periods. We note the most magnetically active (and hence, most rapidly rotating) stars are consistent with a kinematically young population, while slow-rotators are less active or inactive and belong to an older, dynamically heated stellar population.

Why M dwarfs?
- Most populous type of star in the Milky Way (~70%; Bochanski et al. 2012)
- Cooler, dimmer and less massive than the Sun
- Lifetimes longer than the current age of the Universe
- Coolest M dwarfs have fully convective interiors
- Host strong magnetic fields (kG), which heat stellar atmosphere, causing “magnetic activity”
- Properties of the star (including magnetic activity) probe the true habitability of attending planets
- Studying magnetic activity in M dwarfs is critical to understanding magnetic field generation in low-mass stars

Our sample
- 298 stars cataloged, 218 with measured rotation periods
- Low-resolution spectra from the FAST spectrograph at Fred L. Whipple Observatory, Mt.Hopkins, AZ
- Photometric data from the MEarth transit survey
- Measured rotation periods (shaded, 218 total).

Fast-rotators are more likely to be active

![Figure 2. The fraction of active stars as a function of period in 30 day bins. Symbols are plotted at the median period of each bin. Error bars were calculated from the binomial distribution, with total stars per bin labeled above.](Image)

We find the most magnetically active stars to be rapidly rotating, while slower rotators show decreased likelihood of being active.

Inactive stars are kinematically older

![Figure 3. Average (V) space velocity (the star’s velocity in the direction of Galactic rotation) as a function of period, in 50 day bins with symbols at the median of each bin size. Both active stars (gray crosses) and all stars (diamonds) are shown. The complete sample shows evidence of a slight asymmetric drift for the slow rotators, indicating a clear connection between stellar rotation and age.](Image)

![Figure 4. The fraction of active stars as a function of spectral type.](Image)

In 50 day bins with symbols at the median of each bin size. Both active stars (gray crosses) and all stars (diamonds) are shown. The increasing dispersion (due to dynamical heating) for slow rotators confirms a strong correlation with age. The small dispersions for fast-rotators is a strong indicator of youth.

Activity decreases with rotation period

![Figure 5. Log L_Hα/L_Bol as a function of period for active M3 and M4 dwarfs (left), in 8 day period bins and M5-M8 dwarfs (right) in period bins of 20 days. All of the data are shown at the median values of the bins (in both period and activity). Narrow error bars indicate the standard deviation while wide error bars show the uncertainty in the mean. The total stars per bin are listed above each symbol. Fast-rotators show increased magnetic activity.](Image)

We find...
- Magnetic activity increases with stellar rotation
- Magnetic activity is more likely in fast-rotators
- Slow-rotators, specifically inactive stars, are kinematically older

More stars needed!
- Expand current stellar catalog to include more M0-M2 and M7-M8 type stars
- Measure more rotation periods for nearby M dwarfs

References:

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