# PERIODIC LIGHT VARIABILITY IN FOUR LATE-TYPE PRE-MAIN-SEQUENCE STARS

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While the T Tauri stars are the best known of the late-type pre-main-sequence (PMS) stars, there are also some late-type PMS stars with only weak line emission in their visible spectra. Several years ago we noted that the weak-emission PMS stars have B-V colors too blue for their V-I colors and suggested that their surfaces might have regions of differing temperature. During October 1981 we used the USNO 40-inch and Kitt Peak National Observatory No. 4 16-inch telescopes to monitor, over a 7 night interval with UBVRI photometry, four of these weak-emission PMS stars: HD 283447, V410 Tau, and X-ray stars 1 and 2 of Feigelson and Kriss (1981). The PMS nature of these stars is established from (1) their membership in the Taurus dark cloud T-association and (2) their location within the T Tauri band region of the H-R diagram.

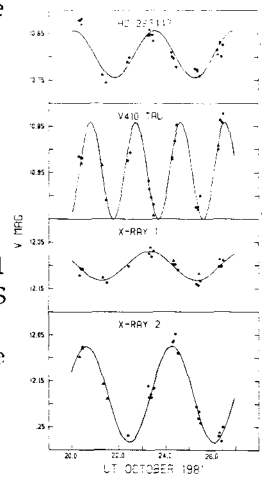


Figure 1

Figure 1 shows the V magnitudes of these stars as a function of time along with the best-fit sine curves to the data. All four stars show quasi-sinusoidal light variations with timescales ranging from 1.9 to 4.0 days. In Figure 2 we show the amplitude of the light curves as a function of wavelength for the three stars with largest amplitude along with the best fits to the data of a simple, geometrical starspot model. This over-simplified model indicates starspots with temperatures typically 600$^\circ$ K cooler than the photosphere and with fractional disk areas covering from 0.17 to 0.27 of the visible hemisphere.

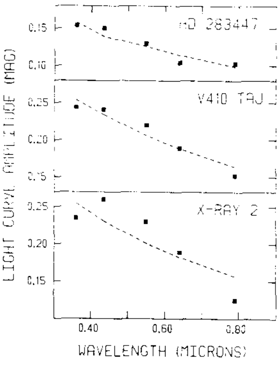


Figure 2

During the course of our monitoring we detected two U flares in X-ray 2 and one in V410 Tau. The apparent peak of one of the X-ray 2 flares



*P. B. Byrne and M. Rodonò (eds.), Activity in Red-Dwarf Stars, 503–504.*


https://doi.org/10.1017/S0252921100096585 Published online by Cambridge University Press

was observed for which we estimate total amplitudes of about 0.54 mag in U and 0.07 mag in B.

Our observations of the weak-emission PMS stars have shown: (1) periodic light variations which are approximately sinusoidal in form, (2) decreased light-curve amplitudes toward longer wavelength which are compatible with reasonable starspot parameters, and (3) UV flares in half of our sample of stars during a limited span of observation. From these results, along with the previously known weak line emission, we conclude that the program stars exhibit magnetic surface activity similar to that which is seen in BY Dra and RS CVn stars.

How do the weak-emission PMS stars relate to the T Tauri stars? Using the computed positions of our program stars in the log $(L/L_{\odot})$, $\log(T_{eff})$ plane along with conventional evolutionary tracks we derive masses (0.8-2.0 $M_{\odot}$) and ages ($\simeq 10^6$yrs) which are comparable to those of the T Tauri stars. *These ages do not clearly indicate that these* stars should be considered "post-T Tauri" stars.

The program stars' rotational velocities have been calculated from their light curve periods and from radii deduced from the observed luminosities and effective temperatures. The computed values range from about 20 km/s for X-ray 1 to 75 km/s for V 410 Tau. V sin i measurements of T Tauri stars by Vogel and Kuhi (1981) indicate rotational velocities of 50-100 km/s for stars of several $M_{\odot}$ to upper limits of 25-35 km/s for stars of 1 $M_{\odot}$ or less. Their measurement of V sin i $\simeq$ 76 km/s for one of our program stars, V 410 Tau, is in excellent agreement with our calculated results. We thus conclude that our weak-emission line program stars rotate at least as rapidly as typical T Tauri stars of similar mass.

In summary, the fundamental distinction between the weak-emission line PMS stars, such as we have observed, and the true T Tauri stars does not appear to be due to age, mass, or rotational velocity differences. Thus, it is by no means obvious that the weak-emission PMS stars are in a "post-T Tauri" phase of evolution. Additionally, the combination of relatively rapid rotation and weak line emission in these stars raises doubts that rapid rotation in a deeply convective PMS star is the fundamental cause of the T Tauri phenomenon via dynamo-generated intense magnetic fields.

A full report of our investigation has been submitted to The Astrophysical Journal for publication. Part of our observations were obtained at Kitt Peak National Observatory, operated by AURA, Inc. This work is partially supported by NSF grant AST80-18229.

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