OPTICAL MONITORING OF T TAURI STARS

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At the Van Vleck Observatory of Wesleyan University, Middletown, Connecticut, we have initiated a program of monitoring T Tauri stars with the 24-inch reflector (Perkin Telescope). During the first observing season, we have obtained UBVRI and Hα (30Å and 150Å) data for five stars: T Tau, RY Tau, SU Aur, RW Aur, and CO Ori. The data will be presented elsewhere (Herbst, Holtzman and Phelps, 1982). Here we report some of our conclusions.

1. Many T Tauri stars exhibit "flare-like" activity which manifests itself as short time scale variations in Hα flux correlated with variations in the U bandpass (and, in extreme cases, B bandpass). This activity was seen in all the stars observed except SU Aur, which has the weakest Hα emission. The flare-like activity appears to be independent of the variations at longer wavelengths and, in fact, is easiest to see in those stars (e.g. T Tau and RY Tau) which did not change brightness in B, V, R, or I. The time behaviour of this component is discussed by Kuan (1976) and Worden et al. (1981) who monitored T Tauri Stars in U.

2. At longer wavelengths (V, R and I), all T Tauri stars studied behave in the same manner; they get redder when fainter. The stars with weaker emission lines also get redder in (B-V) and (U-B) when fainter. Stronger emission line stars tend to mask this behaviour with the independent "flaring activity" discussed in point 1. If such stars are studied only in U, B and V, or (worse yet) only in m_{pg}, the combination of two components of variation can result in very complex and confusing behaviour. Future monitoring of T Tauri stars should always include bandpasses redward of V.

3. Stars with moderate or small Hα equivalent widths and absorption line spectra in the optical region (SU Aur, CO Ori, BM And) show an increase of EW(Hα) as the star fades, while the flux in the Hα line remains constant or increases slightly. This shows that, if circumstellar dust is responsible for the variations at longer wavelengths, it must be located closer to the photosphere of the star than is the region responsible for the Hα emission. If the Hα emission originates

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in a chromosphere-like region of higher temperature above the photosphere, this means that the dust would have to be between the photosphere and chromosphere - an unlikely circumstance! At present, the more appealing alternative is that the variations of these stars come primarily from photospheric changes - presumably changes in the global effective temperature, perhaps related to magnetic activity such as that which produces sunspots.

4. In one star, RW Aur, a strong emission line object, the variations at all wavelengths from U to I are well correlated with Hα flux. The magnitude-color relations, however, show that in U (and to a lesser extent B), there are two components to the variability - one coming from the flare-like activity described in point 1, and one associated with the variations at longer wavelengths. The spectrum of RW Aur is dominated by emission lines and a largely featureless continuum over the entire optical range from U to I; however, high signal-to-noise data do show the presence of photospheric absorption lines at least occasionally (Mundt and Giampapa, 1982). Hence, it is not clear from the spectrum alone whether the variations at longer wavelengths could be "photospheric" or "chromospheric" in nature, although excellent correlation with Hα flux argues that they are chromospheric.

5. Since virtually all T Tauri stars, a class defined solely by spectroscopic criteria, are irregular variable stars (Herbig 1962), it is reasonable to suppose that there is a single underlying cause of that variability, however complex its manifestations may be. This statement is in contrast to some discussions in the literature which attempt to attribute variations in one star to one cause and others to other causes. If there were really several variability mechanisms that selectively operated in some stars and not in others, then one might expect to find a group of stars in which none of the mechanisms operated. Yet, nonvariable T Tauri stars do not appear to exist (although the author is admittedly unaware of a systematic study which firmly establishes this statement as a fact). Our impression from this study and the literature is that, if a single underlying cause of the irregular variability of T Tauri stars does exist, it is related to surface changes (e.g. localized flare events and perhaps spotting activity) presumably associated with magnetic fields, in the photosphere and/or chromosphere, and not to circulating protoplanets or other forms of dust. A test of the "photospheric" hypothesis should be whether or not stars like CO Ori change their spectral type when undergoing large changes in brightness. We intend to monitor that star as well as SU Aur both photometrically and spectroscopically during the next observing season to this hypothesis.
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