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Periodic activity in the T Tauri star TW Hya*

M. V. Mekkaden
Indian Institute of Astrophysics, Bangalore 560 034

Abstract. UBVRI photometry of the isolated T Tauri star TW Hya, obtained during 1987 April from ESO, is presented. The data analysis shows a periodicity of 2.195 d in light variation. The steep increase of amplitude towards shorter wavelengths is interpreted as due to the rotational modulation of hot plage region on the stellar surface.

Key words : T Tauri star TW Hya--UBVRI

1. Introduction

The T Tauri stars are variables usually with irregular light changes, but a few exhibit regular photometric variations with periodicities comparable to their anticipated rotation periods. Chugainov *et al.* (1986) have shown that most of the T Tauri variability is caused by hot plage regions on the stellar surface.

TW Hya is an isolated T Tauri star with very strong and variable H_α emission. Rucinski & Krautter (1983) have found that the star is not associated with any dark clouds or star forming regions. From a detailed investigation they have reported that TW Hya showed irregular light variability superposed on a possible short time scale periodic variation of a few hours' duration. Further observation and analysis by Rucinski (1988) have indicated that the light variability of TW Hya may have a periodicity of 2d.

2. Observations and discussion

UBVRI photometric observations of TW Hya were carried out during nine consecutive nights in 1987 April using the 50 cm telescope of the European Southern Observatory (ESO) La Silla. A cooled RCA 31034 photomultiplier tube and a photon counting system were used. All observations were made differentially with respect to the comparison star HD 95470. Sufficient number of Cousins' photometric standards were measured for the conversion of the instrumental magnitudes to the standard photometric system. TW Hya was observed several times every night to search for short time scale variability. The trend of the light variability indicated a periodicity around 2d. To determine the period of light variation more accurately, the method adopted by Raveendran, Mekkaden &

*Based on observations collected at the European Southern Observatory, La Silla, Chile.

Mohin (1982) was used. The best fit period was found to be 2.195 days. Figure 1 shows UBVRI light curves of TW Hya. The phases were calculated using the ephemeris (with an arbitrary initial epoch) given below:

$$JD_{\mathrm{hel}} = 2446897.575 + 2.^{\mathrm{d}}195\,E.$$

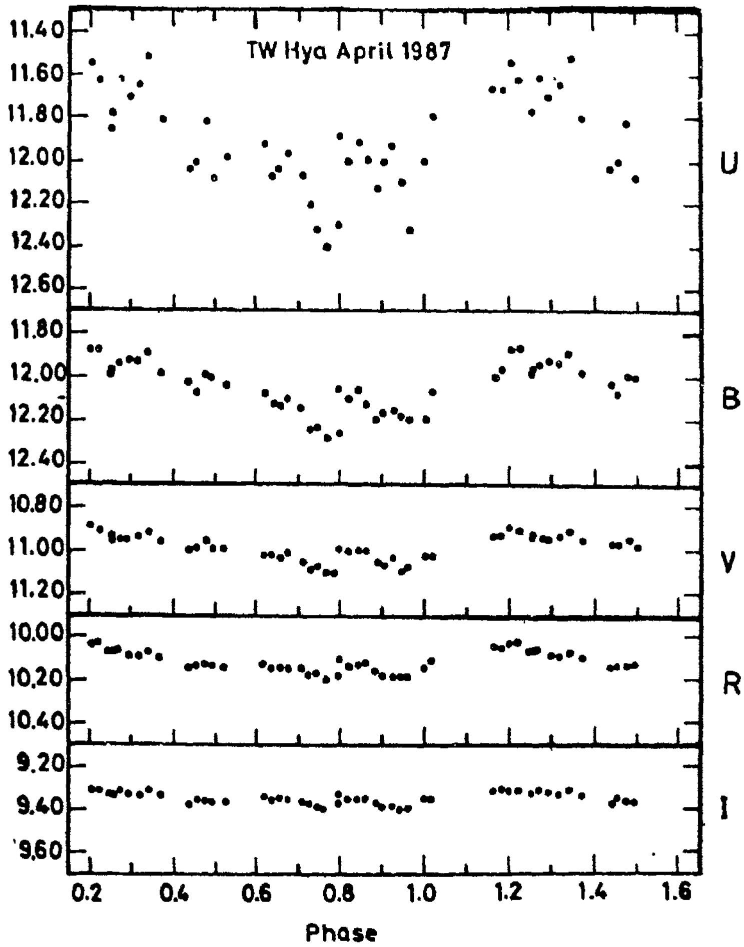

Figure 1. UBVRI light curves of TW Hya.

Analysis of the photometry obtained by Rucinski & Krautter (1983) during 1982 January also showed the 2.195d periodicity, though the amplitude and the shape of the light curve were entirely different. But the observations by Rucinski in 1987 March showed irregular light variation.

Figure 2 shows the V light curves of TW Hya obtained during 1982 January (Rucinski & Krautter 1983) 1987 March (Rucinski 1988) and 1987 April (the present work) using the ephemeris given above. It is evident from figure 1 that the amplitude of light variation increases towards shorter wavelengths. The steep amplitude increase towards shorter wavelengths observed in TW Hya can be produced only by hot plage

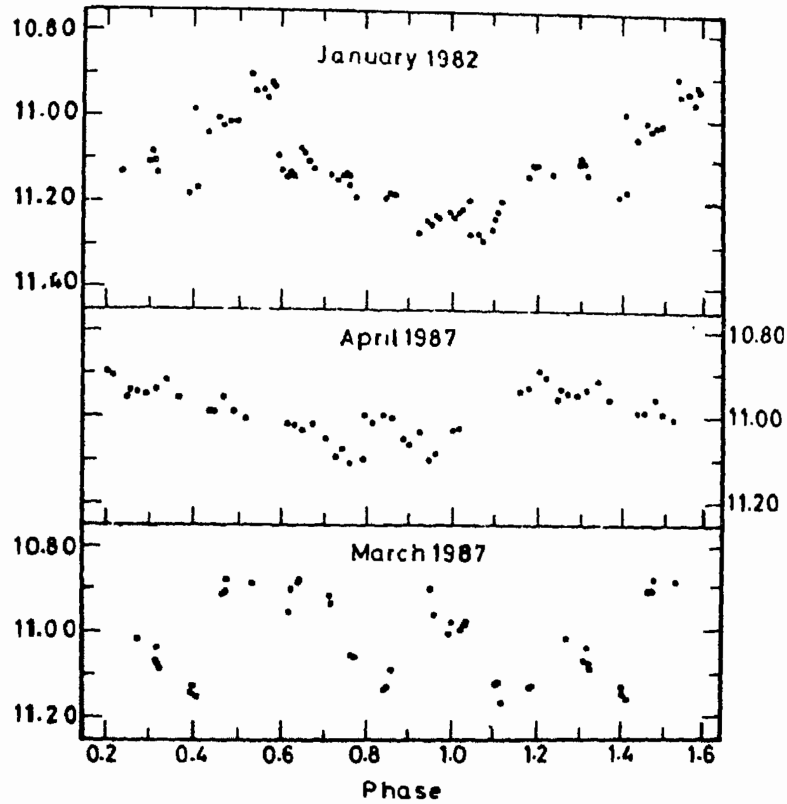

Figure 2. V light curves of TW Hya at different epochs

regions; however, in a few T Tauri stars there is photometric evidence that both plage regions and cool spots coexist (Chugainov 1986).

The expression

$$m_\lambda = -2.5 \log \{1 - f[1 - B_\lambda(T_{pl})/B_\lambda(T_*)]\}$$

has been used to derive the fractional area and the temperature of the hot plage regions on TW Hya. In the above equation m_λ is the amplitude of light variation at wavelength λ; T_{pl} and T_* are the plage and photospheric temperatures; f is the maximum fraction of the stellar disc covered by plages; and B_λ is the Plank function. This expression does not take into account the effects of the inclination of the rotational axis and the limb darkening. Assuming a photospheric temperature of 4000 K for TW Hya the values of f and T_{pl} were determined by fitting the above expression to the amplitudes in UBVRI bands by least square technique. The best-fit values are $f = 0.77\%$ and $T_{pl} = 8155$ K. Figure 3 is a plot of amplitude versus wavelength. The closed circles represent the observed values and the open circles the computed values.

The 1982 observations of Rucinski & Krautter (1983) were also analysed to determine the plage area and its temperature. The best-fit values are $f = 3.08\%$ and $T_{pl} = 6926$ K. In figure 4 the observed amplitudes (closed circles) and the computed

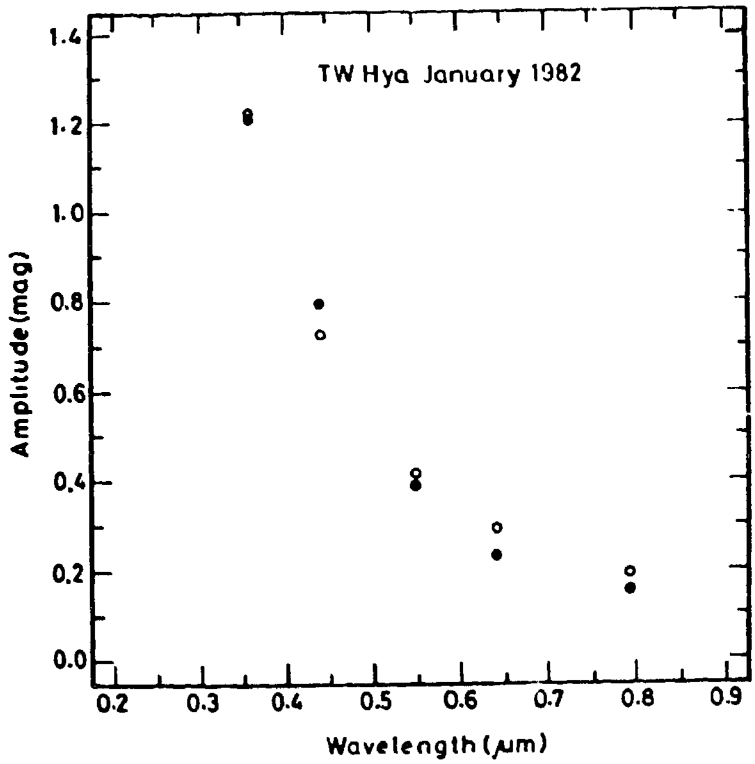

Figure 3. Amplitude vs wavelength (1987 April) The filled circles refer to observed amplitudes and the open circles the computed.

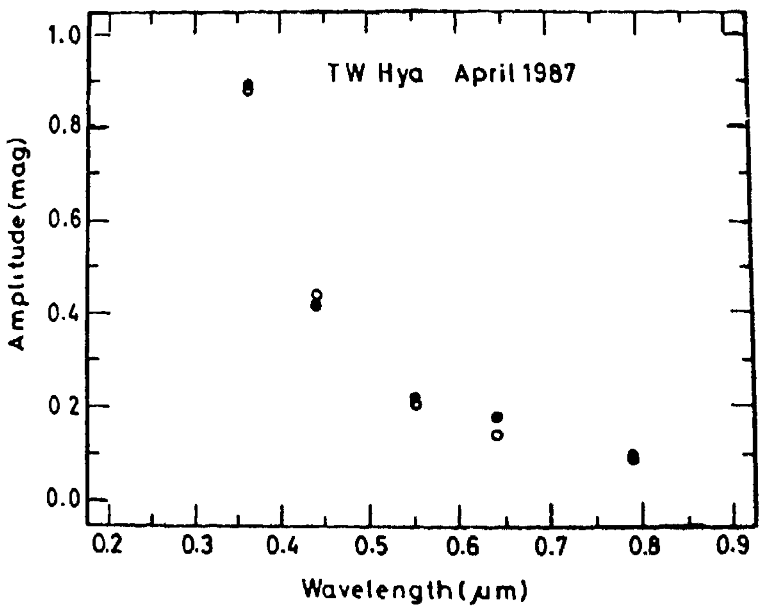

Figure 4. Amplitude vs wavelength (1982 January). Symbols are as in figure 3.

amplitude (open circles) are plotted against the wavelength. Though the 1987 April observations showed well defined periodicity, photometry by Rucinski (1988) during 1987 March did not indicate any periodic variation. Hence the formation and the disintegration of hot plage regions on TW Hya is a very fast process. Furthermore, photometry of TW Hya also shows short time scale variations probably due to flare type activity.

3. Conclusions

Analysis of the photometry of TW Hya during 1987 April shows that the star exhibits light variation with a 2.195d period. This period is found to satisfy the observations of Rucinski & Krautter (1983). The steep increase in amplitude towards shorter wavelengths can be explained in terms of the rotational modulation of plage like hot regions on the stellar surface. Rapid changes take place in the structure and formation of these plages.

The evidence that hot plage regions exist in T Tauri stars seems to point to the presence of strong magnetic fields on the stellar surface. These strong magnetic fields might cause extreme chromospheric activity. Another alternative hypothesis to the strong chromospheric activity in T Tauri stars is given by Bertout & Basri (1988). They assume a typical T Tauri star to consist of a late type star surrounded by an extended active thin accretion disc that reaches down to the stellar photosphere and a boundary layer where the matter from the disc finally encounters the star. Magnetically controlled accretion through the boundary layer could result in hot spots on the stellar surface.

An accretion disc around TW Hya is a remote possibility since the star is not associated with any dark clouds. So the extreme chromospheric activity due to the strong magnetic fields could explain most of the phenomena observed in TW Hya.

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