THE VARIABILITY OF THE T TAURI STAR DI CEPHEI

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Abstract: It is demonstrated that the light variations of DI Cephei can be explained as due to the combined effect of variable completely grey circumstellar extinction and variable continuous and line emission.

Several attempts have been made to explain the light variability of T Tauri stars. The variations have been explanied as due to variable circumstellar extinction, variable physical properties in a stellar wind or accretion envelope, activity at the stellar surface (spots, plages, flares, convection cells) or geometrical changes in the stellar body (see e.g. Gahm, 1978 for a review).

The following is a brief summary of some of the results that we have obtained for DI Cephei, a T Tauri star with a fairly strong continuous and line emission spectrum superimposed on an absorption line spectrum of late spectral type. This study is based on spectrograms taken at the Crimean Astrophysical Observatory and covering the blue and visual spectral regions and on photometric UBV data kindly provided by Drs. E. Kolotilov and T.S. Beljakina. In addition we have made use of all published UBV data (Cohen and Schwartz, 1976; Gahm et al., 1977; Grinin et al., 1980).

Our spectrograms yield a spectral class of G8 IV for DI Cep. The relative contribution of light from the star and from the emission region was evaluated for three spectrogram taken simultaneouly with photometry. The details of this procedure will be published elsewhere. The results are given in Table 1.

Table 1. Spectroscopic results

Date (1980):	June 19	June 21	June 22
V	11.47	11.48	11.66
ΔB	0.12	0.12	0.43
E(B-V)	0.12	0.11	0.07

It is seen that the contribution from the emission region in B (ΔB) is variable and that the extinction is low. The contribution from emission in V is negligible. It is obvious that variable emission activity influences the brightness level of DI Cep in the B band.

In Figure 1 (top) we have indicated the number of observations when DI Cep was found within boxes of 0.1x0.1 mag. in the V/B plane (left) and V/U plane (right). The question mark refers to 2 uncertain observations which we ignore in the following discussion. Kholopov (1952) presented photographic magnitudes that indicate that the star on occasion can reach a minimum in B of around 13.0. It is seen that a gross pattern exists in the sense that increasing V is followed by increasing B and U. A con-

P. B. Byrne and M. Rodonò (eds.), Activity in Red-Dwarf Stars, 497–500.
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https://doi.org/10.1017/S0252921100096561 Published online by Cambridge University Press

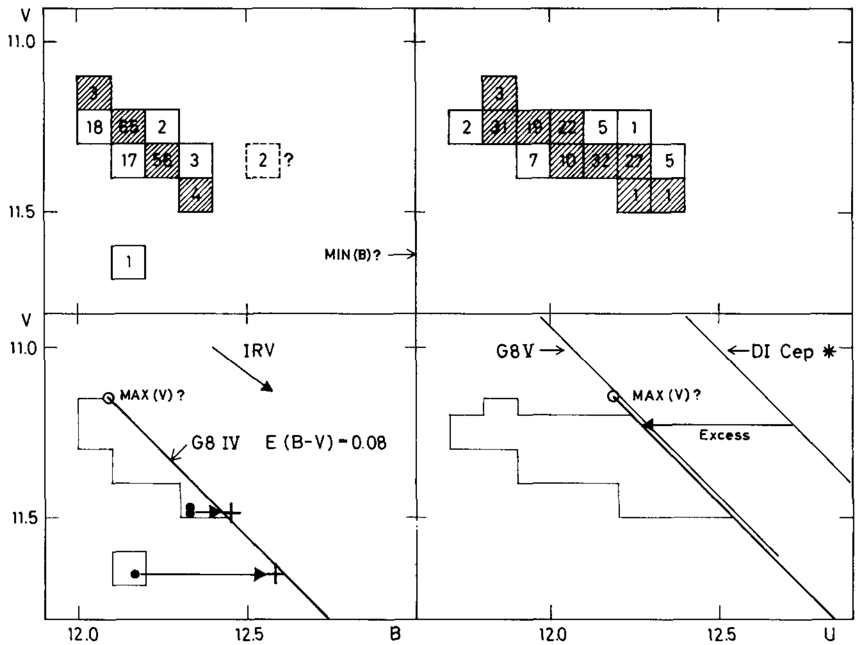

Fig. 1. Variability pattern of DI Cep in U, B and V. Top: Number of observations in squares of 0.1 mag. Preferred areas hatched. Bottom: The thick lines are loci for the most quiescent phase of the star under various amount of grey extinction. IRV = interstellar reddening vector. MAX(V)? = possible maximum in visual brightness under quiescent phase. Loci for a G8 V (unreddened) and G8 IV (present solution) are given and the remaining ultraviolet excess indicated (right).

siderable scatter is present, especially in U, that permits the star to become both redder and bluer with decreasing visual brightness.

The gross pattern is inconsistent with a model where variable emission activity is the only cause of the light variability. Instead, Fig. 1 indicates that there are two causes of the variations. One, producing the gross pattern and another causing the spread in this relation. We have attempted two models to explain the variations. 1. Changing spectral class producing the gross pattern and emission activity causing the spread. 2. Variable circumstellar extinction producing the gross pattern and emission activity causing the spread. On the assumption that the colours of the star is similar to those of normal stars we can exclude model 1.

If the variations follow model 2 we expect all observed points in Fig. 1 (top) to lie to the left of a reddening line which defines the most quiescent state of the emission activity. If the contribution of emission activity is $-\Delta B$ and $-\Delta U$ we expect a relation ΔB = const ΔU. Several laws of extinction by dust were tried. The best solution was obtained for a completely grey extinction law which yields (see Fig. 1, bottom):

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$B = V + 0.94 - \Delta B$

$U = V + 1.04 - \Delta U \qquad \Delta U = 2.0\ \Delta B$

From these relations we can express U in B and V as:

$U = - V + 2B - 0.91$

From all available information on UBV for DI Cep we conclude that with given values of V and B this formula predicts U to within a standard deviation of 0.08 mag.

In Fig. 1 (bottom, left) we can see that the corrections for blue emission as derived from the spectroscopic analysis are fully consistent with the photometric analysis. Furthermore the derived extinction E(B-V) is small even at V = 11.66. However, the locus of the quiescent state in the V/U plane (Fig. 1, bottom, right) is ~ 0.4 magnitudes in excess of the expected colours for a G8 IV star with E(B-V) = 0.08. A change in spectral type or luminosity class of one step in any direction leads to larger discrepancies. Hence, the present model implies that when the star is in its most quiescent phase there is a remaining ultraviolet excess but no, or very little, veiling.

References

Cohen, M., Schwartz, R.D.: 1976, Mon.Not.Roy.Astron.Soc. 174, 137.

Gahm, G.F.: 1978, Stockholm Obs. Report, No 14.

Gahm, G.F., Gehrsberg, R.E., Petrov, P.P., Shcherbakov, A.G., Kolotilov, E.A., Zaitseva, G.V., Shanin, G.I.: 1977, Variable Stars 20, 381.

Grinin, V.P., Efimov, Ju. S., Krasnobatsev, V.I., Shachovskaja, N.I., Shcherbakov, A.G., Zaitseva, G.V., Kolotilov, E.A., Shanin, G.I., Kiselev, N.N., Gjulaliev, Ch. G., Salmanov, I.R.: Variable Stars 21, 247.

Kholopov, P.N.: 1952, Variable Stars 9, 157.

DISCUSSION

Worden: I would like to caution people about making too much of changes in colour. A few years ago we made some high-speed photometry and especially in the U-band the T-Tauri stars appear to be continuously flaring, or at least they look as though they are flaring. One should be careful to ensure that colours are measured simultaneously. One can get spurious colour changes due to the fact that either the star was flaring in one colour or the other or the flare light is blue.

Gahm: You are saying that the colour will be different from flare to flare. I agree.

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Worden: I am saying that any observation of variable colour may be due to flaring (Part lost).

Gahm: Yes, but the changes I am discussing are slow. I can believe that there are flare-like peaks on a short timescale. Were your flares on a short timescale or were they on a timescale of hours?

Basri: I would just like to muck up the situation a little further. Models of T-Tauri chromospheres that Dr.Calvet and I have calculated indicate that it is relatively easy to produce changes in the visual continuum as well as the blue due to the chromospheric activity which takes place. So again one has to be careful in interpreting colour changes in these stars.

Gahm: Yes, that is true. But these colour changes are tied up with spectroscopic observations. Since the star varies so much, it goes down to B = 13, it is very difficult to imagine that when you leave out all the excess continuum and line emission you will find a normal star there. I believe it is impossible. So either you invoke a star completely covered in spots which will be completely black or it must be something circumstellar such as extinction.

Hartmann: If one looks with good resolution at the optical spectrum of this star the photospheric lines are seen to be filled-in with emission and the Mg I B line sticks up in emission.I don't see how you can make a simple veiling correction given the complicated nature of the filling-in.

Gahm: (First part of answer lost) ... over the red spectral region. What we have is a set of standard stars and for the red spectrogrammes you can find that the amount of veiling and emission is very low indeed. Of course you can find lines like the Na-D lines and the Mg lines and Hα, of course, but in the V band and in the red it is a typical G8IV star.

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