THE AGE OF THE TRIPLE SYSTEM HD 165590

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ABSTRACT

It has been found that the close spectroscopic pair of this system consists of a G type primary and a late type secondary, which most likely is a T Tauri star. As such, the system is semidetached and a mass transfer takes place between the components.

1. INTRODUCTION

The spectroscopic orbit of the triple system HD 165590 has been discussed by Batten et al. (1979). They found that the A component of the visual pair is a spectroscopic binary with a period of 0.88 days. The mass function indicates that the secondary is a star of spectral type M and the visual companion of spectral type G5. At the time of periastron passage the visual pair has a separation of 0.4 A.U. while the separation of the spectroscopic pair is only 3.2×10^6 km. The authors have discussed the stability of this system and have concluded that despite the closeness of the stars the system appears to be stable. A sensitive indicator of an instability would be a change of the period of the close pair.

Another point raised by the authors was the age of the system. Since the strength of the lithium lines is considered to be a good indicator of the age of a star, they measured the equivalent width of the lithium lines and by comparing the abundance of lithium with that in the Hyades and Pleiades they concluded that the age of HD 165590 is about 5×10^7 years.

In this presentation we shall address ourselves to the two points raised by Batten et al., namely to find other indicators for the stability and the age of this system.

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2. OBSERVATIONS

Since 1977 we have made observations of this system by means of a photoelectric photometer in the visual and the blue region of the spectrum. The internal accuracy of our observations is about ±0.005 mag. As already found by Scarfe (1977) the spectroscopic pair is variable and it shows a shallow (0.06 mag) minimum. Our light curve appears to be variable at other phases as well and the most remarkable phenomenon is the rare appearance of the secondary minimum. A representative light curve exhibiting both minima is shown in Fig. 1a, while the two minima are plotted separately in Fig. 1b. The duration of

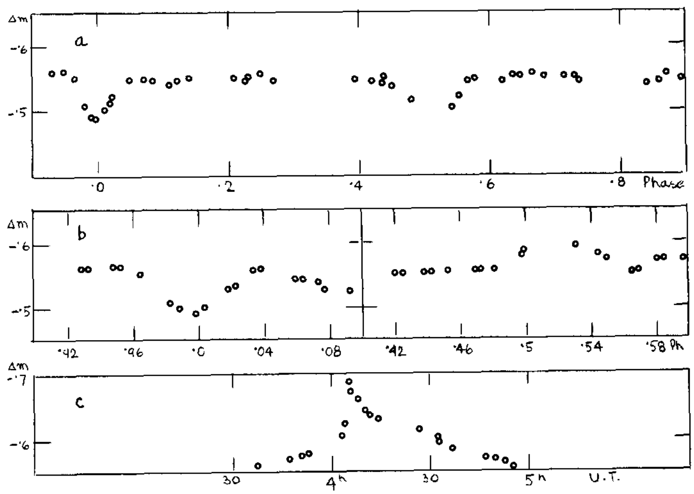

Fig. 1a: The light curve of HD 165590.
Fig. 1b: The light curve near a primary and a secondary minimum.
Fig. 1c: A flare observed on June 16, 1979.

the primary eclipse is about two hours. Between the minima the light curve is subject to variations over short and long time intervals.

From observations made between 1978 and 1981 we derived six epochs of primary minima. These are listed in Table I. For the period of the spectroscopic orbit a value satisfying all observations is P = 0.8794998 days. The O-C diagram indicates the tendency for the residuals to be slightly positive. However, it would be wrong to conclude that a change

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TABLE I.

Photoelectric Epochs of Primary minima of HD 165590.

J.D. hel.	E	O-C
244 3656.6635	0	$0^d.0000$
3998.7889	389	0.0000
4050.6792	448	-0.0002
4459.6474	913	+0.0006
4467.5623	922	0.0000
4816.7249	1319	+0.0012

of the period is present. The time interval is still too short to be able to detect a change as small as 10^{-10} days/cycle, a typical value that would indicate a transfer of one solar mass in 5×10^7 years. Therefore, from this point of view we are unable to conclude whether the system has remained stable for the duration of its lifetime.

3. ANALYSIS OF THE LIGHT CURVE

3.1. The Primary Minimum

The primary minimum appears to be well defined as far as its depth and duration is concerned. However, a closer inspection indicates that the ascending branch shows a definite brightening at phase 0.02, up to 0.025 mag and duration of about 20 minutes. This is not necessarily a permanent feature of the primary minimum since in a few cases the brightening is hardly observable. It appears that the primary minimum is an occultation and a presence of a hot spot on the surface of the G star facing the M star would explain the brightening at this phase. A symmetrically opposite increase of brightness at phase 0.98 is not obvious.

We have plotted the apparent magnitude of the minimum and the maxima on each side of the minimum (phase 0.9 and 0.1) as a function of time. We have found that the brightness varies by 0.05 mag, being lowest in 1978 and again in 1981, while it reached a maximum in 1980, a variation on a time scale of three years. For the visual pair the periastron passage happened in June 1978. Thus the maximum light of the system does not correspond to the periastron passage of the G5 star.

From the geometry of the system and the constant depth of the minima it follows that the G0 component is not responsible for the changes of brightness. Otherwise the depth of the minima would be variable. Thus, either the M component is intrinsically variable or it might be the G5 star.

3.2. The Secondary Minimum

Since the M star represents about 3 per cent of the total luminosity of the system one would expect to see at the time of the secondary minimum a drop of brightness by 0.03 mag. In our composite light curve such a drop is indicated, however, a complete secondary minimum has not been observed. Instead a brightening sets in at phase 0.5 reaching a maximum at phase 0.52. In fact the largest light variations occur near the secondary minimum. This is also confirmed by a very large scatter of the B-V colour around the secondary minima. There is no obvious mechanism that could explain this anomaly.

3.3. The Light Curve Outside Eclipses

Assuming the mass ratio of 0.6 for the spectroscopic pair, as derived by Batten et al., this system is definitely detached. Therefore we would expect to find a constant brightness of the light curve outside eclipses. However, the light curve indicates considerable variations. We would like to call attention to the drop of brightness by 0.03 mag following the primary minimum, near phase 0.10. At other phases we find variations of a similar magnitude. The time scale is relatively short.

3.4. Flaring

A remarkable change in the light curve happened on June 16, 1979 when the star increased its brightness by 0.125 mag during a time interval of 20 minutes. The shape of the light curve showed a steep increase followed by a slower decline for about 50 minutes. At the end of the flare the brightness reached the same level (Fig. 1c) as at the start of the flaring. In the blue light the amplitude was 0.2 mag. The flare occured shortly after a secondary minimum. Since the eclipsing pair was approaching a quadrature it is not obvious which star was responsible for the flare. By its appearance the flare resembles closely the brightness variations of UV Cet type stars.

4. Discussion

If indeed the flare represents a UV Cet type activity then, it is associated with the red star and it would represent an increase of brightness by 2.8 mag. There exists a relation, derived by Parsamian (1977) between the age, absolute magnitude and the amplitude of a flare. With the given amplitude and the known absolute magnitude of the star Parsamian's relation gives the upper limit of the age of the system, at 2×10^9 years. Since such an age would be at variance with the observed abundance of lithium it became obvious that the observed flux was not the maximum flux to be expected for this type of star or, alternatively, we have not observed a UV Cet phenomenon. There is another reason why we should not consider this flare of a UV Cet type.

The total amount of energy released during the flare amounted to 10^{37} ergs, which is a much higher energy than the one produced in UV Cet flares. Thus we are lead to conclude that the red star in this system is, most likely, a T Tau star. The types of flares in the considered range of energies are typical for T Tau itself. A frequency of flares in T Tau was found to be one in 30 to 40 hours. Although we do not know the radius of the M Star, radii of T Tau stars are about one to two solar radii. If this were the case for HD 165590 then we would have a semidetached system and a mass transfer mechanism capable of moving mass from one star to another through its inner Lagrangian point. We suggest that the hot spot, observed on the G star might indicate an infall of mass from the M star.

5. Conclusion

Since there are good reasons to believe that the red star is a T Tau star having a radius of about two solar radii then we have to assume that the star is a young object. This indirectly confirms the findings of Batten et al. If the star overflows its Roche lobe the system is semidetached and a lengthening of the orbital period is to be expected. Finally, the orbital elements derived by Batten et al., especially that of the orbital inclination may have to be revised in order to conform with the changed dimensions of the system.

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