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Research Note

The Unusual Variability of the Bright Supergiant Companion of the Eclipsing Binary BL Tel

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Summary. A discussion is presented of the variability of the binary BL Tel outside the eclipse with the aid of published radial velocity and photometric observations. The average period for this oscillation, which is caused by the F type supergiant companion is $65^d.1$. However, this variability is not strictly periodic. The shape of the light-curve is subject to strong variations. Radial velocity and light-curves are in phase with each other, making the star rather exceptional. It is probably not a small-range Cepheid of population I as sometimes suggested.

Key words: variable supergiant — binary

1. Introduction

The high-latitude eclipsing binary BL Tel consists of a bright F type supergiant and a dark M type secondary, which eclipses it once in 778^d (Cousins and Feast, 1954). Wing (1962) suggested the presence of an oscillation outside the eclipse with a period of about 67^d . This conclusion was based on the residuals of the orbital velocity curve. Confirmation came from photometric observations by Cousins (1966) and Walraven and Walraven (1970), both of whom found a variability of about 0.1 mag. It was clear from the latter reference (describing five-colour photometry) that the variable F companion is indeed of a high luminosity. The important question whether the star belongs to the Cepheids of population I had to be left open. The system was extensively discussed by Feast (1967). Recently BL Tel was discussed together with the high latitude eclipsing binary V748 Cen by van Genderen et al. (1974). We present here a revised period for the variation outside the eclipse, based on the residuals of Wing's orbital velocity curve and the published photometry. The revised radial velocity curve of the oscillation is discussed together with the light and colour variations.

2. Reductions and Discussion

In order to compare the B and V observations of the UBV system (Cousins, 1966; Cousins and Lagerwey, 1966, 1969, 1971) with the B and V observations of the five-colour system of Walraven (Walraven and Walraven, 1970), the first were transformed into the Walraven system. The formula to transform the V of the UBV system (called V_J) into the V of the Walraven system is given by Pel (1976). The $B-V$ of the UBV system [called $(B-V)_J$] is transformed into the $V-B$ of the Walraven system with the aid of Table 7 in Walraven et al. (1964), but a correction was applied for the change in response curve of the V band (Lub and Pel, 1977). Consequently the V and $V-B$ values used here are in the present system of the Walraven V band. Moreover we give the brightness and colour of BL Tel relative to the comparison star ρ Tel, which was used by the Walravens [ΔV and $\Delta(V-B)$ respectively, all given in log intensity scale]. The transformation errors are likely to be much smaller than 0.01 mag.

It was not possible using the proposed period of 67^d , to match photometric and radial velocity measurements made in the same years (1953–1955). [All photometric observations within 52^d of the mid eclipse were omitted (Feast, 1967).] It appeared that a period of $65^d.1$ fitted better; using this, the scatter in the radial velocity curve decreased somewhat. In the first two panels of Figure 1, phases were computed with the formula:

$$\phi = (\text{JD} - 2434983.47) / 65^d.1.$$

The dispersion in the radial velocity curve is still considerable, which is caused largely by scatter: according to Wing the probable errors in the velocities range from 1.5 to 2.1 km/s. It may also be partly intrinsic. This conclusion is based on a plot of the radial velocity (the residuals of the orbital velocity curve)

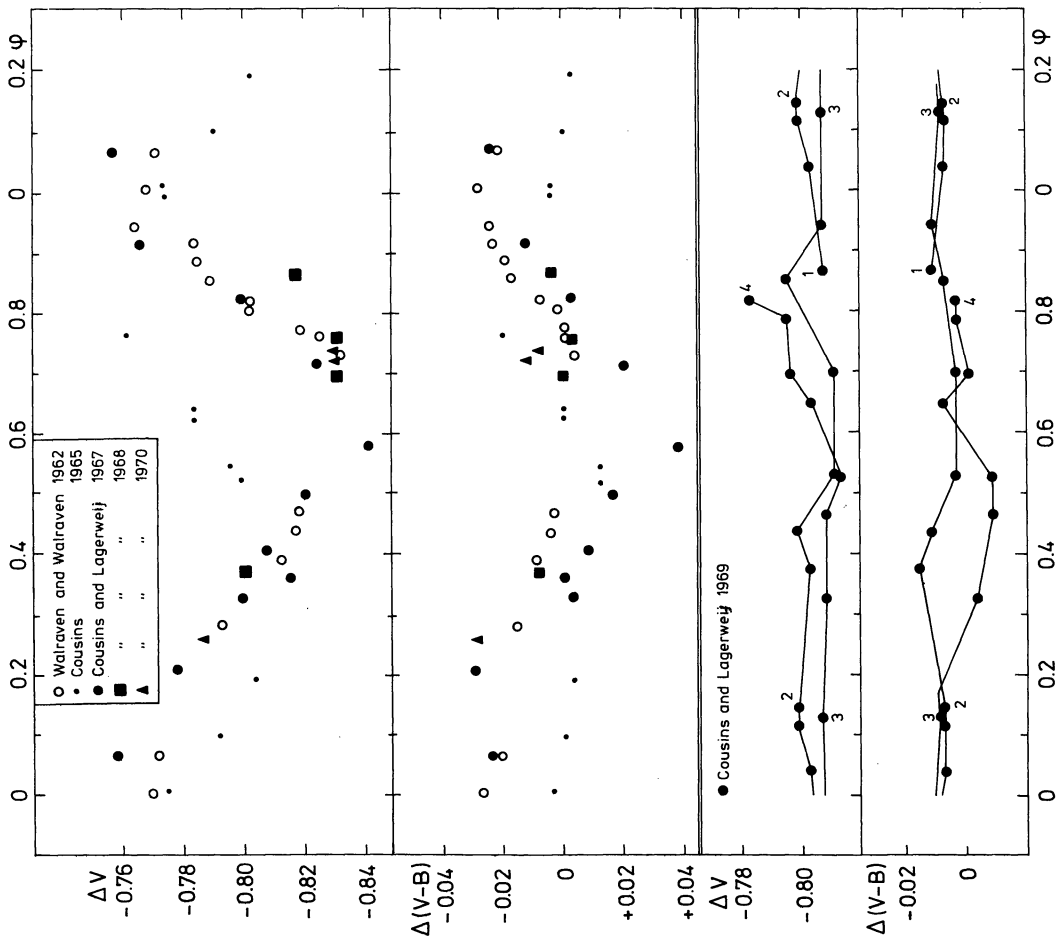
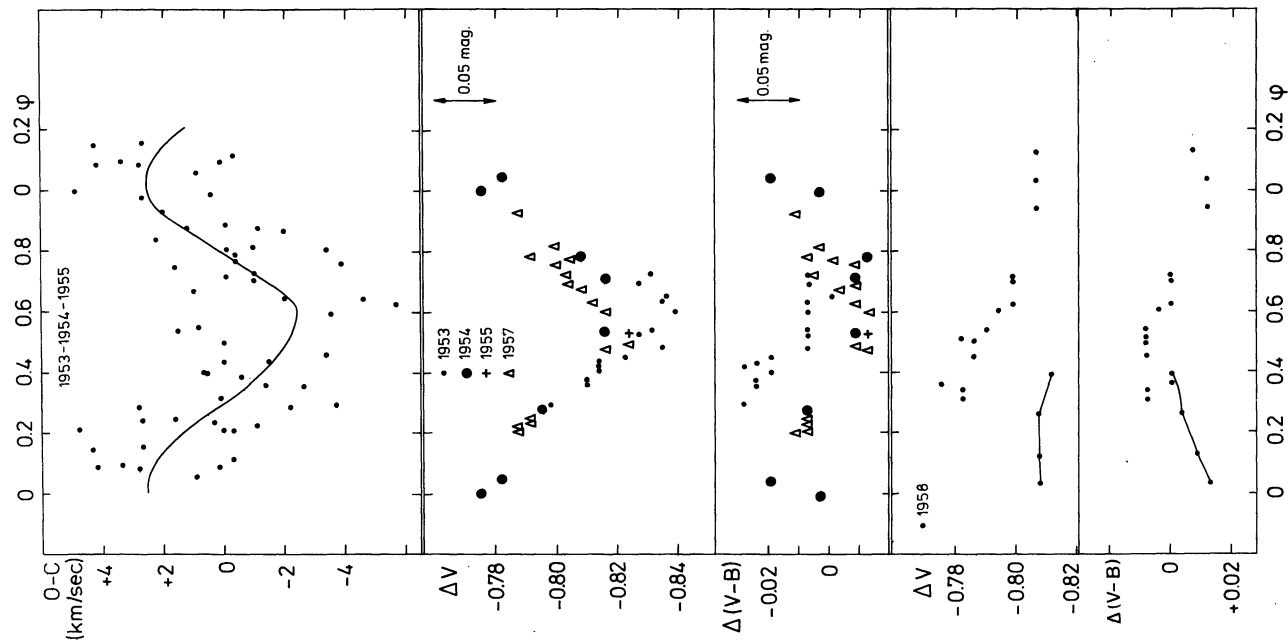


Fig. 1. Radial velocity curve for the oscillation and the light- and colour-curves for several seasons. ΔV and $\Delta(V-B)$ are given in log intensity scale. [For $\Delta(V-B)$ blue is at top.] The magnitude scale is indicated

Fig. 2. Light- and colour-curves for the years 1962-1969. The lines connecting the observations and the numbering 1-4 were necessary to indicate how the sequential order was (third and fourth panel)



against the date, which shows an important variation in the shape of each cycle.

The observations of 1957 also fit the mean light-curve in the second panel rather well; this is in contrast with those of 1958 (fourth panel of Fig. 1). The third and fifth panels, showing the colour behaviour, will be discussed later. Figure 2 shows in several panels the observations of 1962–1969. The period of $65^d.1$ is also used, but another zero point had to be taken to position most maxima at $\phi=0$, vis. JD 2437881. Also the shape and amplitude of the mean curve in the first panel is quite different from that of Figure 1 (1965 excluded). In 1969 the star did not show much variation in brightness.

The following facts are also interesting:

a) Figure 1 shows that the radial velocity curve is *in phase* with the photometric observations made in the same seasons. This behaviour is completely unlike that of a Cepheid, for which the radial velocity curve is in anti-phase. The star is faintest when the expansion velocity is highest. Moreover the brightness is about equal at the times of smallest and largest diameter. So far no other variable star is known showing such a behaviour.

b) Also remarkable is the fact that although the light-curves sometimes repeat very well, the colour-curves show much more systematic deviations, which are of such a size, that they cannot be attributed to errors in the observations or the transformations.

3. Conclusions

The bright F companion is unique in that the radial velocity- and light-curves are in phase. At present no other variable star is known showing such a behaviour. The average period seems to be $65^d.1 \pm 0^d.1$ (estimated error), although one cannot speak of a periodicity. At most there is a periodicity for a number of successive cycles. The shape of the light- and colour-curves is subject to appreciable variations. It is unlikely that the star is a small-range Cepheid of population I.

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