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AN APPLICATION OF WESSELINK'S MODIFIED METHOD TO THE DETERMINATION OF MEAN RADII OF RV TAURI STARS

The observational evidence favouring the existence of strong shock waves (SW) in the atmospheres of RV Tau stars is overwhelming. We have calculated the mean radii of AC Her ($P=75^{d}.46$) and V Vul ($P=75^{d}.72$) by Wesselink's modified method (Batyushkova, 1981, 1982) with shock radiation effect on light and colour curves being taken into account. It should be noted that the earlier attempts to apply the Wesselink's method to the determination of radii of RV Tau stars had failed (Du Puy, 1973).

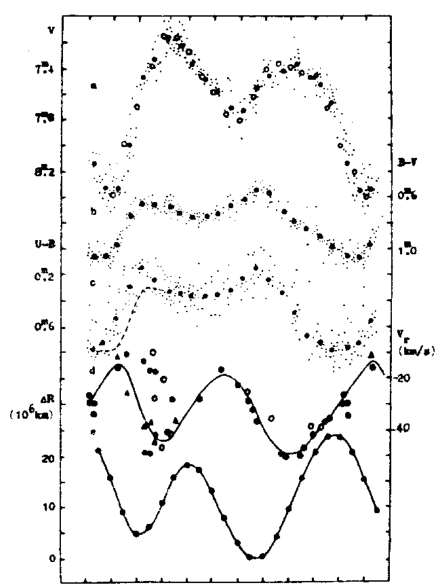

Figure 1

The mean normal V, B-V, U-B light and colour curves of AC Her, and the radial velocity and the radius displacement curves of AC Her (the explanation of the signs are given in the text).

For the first time the mean normal light and colour curves of AC Her (Figure 1 a,b,c) have been plotted with all accessible photoelectric UBV observations (Eggen, 1961, Preston et al., 1963, Du Puy, 1973, Dawson, 1979, Nakagiri and Jamashita, 1979, Zubarev, Kayumov, Rahimov, Chernova, to be published). The adequate stability of these curves and coincidence of different authors' photometric systems were deduced. The mean square errors of normal points (big dots), calculated through ≈ 0.05P interval are about $\bar{\sigma}_V = \pm 0^m.03$, $\bar{\sigma}_{B-V} = \pm 0^m.02$, $\bar{\sigma}_{U-B} = \pm 0^m.04$.

The radial velocity curve (Figure 1c) of AC Her was plotted on Sanford's (1955) and Du Puy's (1973) observations with dispersion of 10 Å/mm and 12 Å/mm (marked by dots and open circles, respectively). This is also in a full accord with Baird's data (1982). The Fe neutral lines have been used but the H emission lines (marked by triangles) as well as the violet absorption components at phases of spectral peculiarities have been preferred as being formed more closely to the stellar photosphere (Baker et al., 1971, Hill and Willson, 1979).

The mean radii of the stars were computed by our own program. The dashed line on the U-B colour curve (Figure 1c) shows $(U-B)'$ magnitudes, which are in accordance with the phases of equal B-V. The V band shock radiation excesses ΔV have been calculated and the V light curve has been corrected for the SW emission by using the relation

$$\Delta V = K\ \Delta(U-B)$$

Here the colour excess $\Delta(U-B) = (U-B) - (U-B)'$ is due to the SW emission and the value k is assumed to be 0.6 (Batyushkova, 1981, 1982).

The systemic velocity of the star $V_\gamma = -32{,}8$ km/s was determined. Then the radial velocity curve was integrated and the radius displacement curve has been obtained (Figure 1e). It is obvious that the star is compressed and extended twice during a pulsation period. The main minimum of the displacement curve occurs at phase 0.57P, the secondary one at phase 0.11P. The radius displacement reaches its maximum amplitudes $\Delta R = 24.19 \cdot 10^6$ km at phase 0.88 P, the secondary maximum occurs at phase 0.31P.

Then we calculated the mean radii of the star assuming that the phase shift between light and radial velocity curves was changed from $\Delta\varphi = -0.1P$ to $\Delta\varphi = +0.1P$ with 0.01 P interval. A well known formula

$$\bar{R} = \frac{\Delta R_2 - n\Delta R_1}{n - 1}$$

was used, where

$$n = 10^{0.2(m_1 - m_2)}$$

ΔR_1 and ΔR_2 are the displacements from the mean radius, m_1 and m_2 are the V corrected light magnitudes at phases of equal B-V.

It turned out that the minimum mean square error $\sigma = 1.7 \cdot 10^6$ km is corresponding to the mean radius $\bar{R} = 44.5 \cdot 10^6$ km with the phase shift $\Delta\varphi = -0.03P$ (28 phase pairs have been used). Such shift exists (Figure 1) between the minimum of the light curve and the maximum of the compression velocity. The problem of phase matching will be regarded in another paper.

The knowledge of the mean radius $\bar{R}$, the availability of the displacement curve ΔR and the colour curve B-V make it possible to calculate the relative amplitudes of the light changes at each phase by the formula:

$$\Delta m = -5 \lg \frac{R_2}{R_1} - 10 \lg \frac{T_2}{T_1} - \Delta BC$$

where R_1 and T_1 are the radius and the temperature at light minimum, R_2 and T_2 are the same ones at any other phase, ΔBC is the difference between bolometric corrections at phases in question. The effective temperature scale was derived by the averaged relations of Böhm-Vitense (1973), Kurucz (1979) and Traat and Malyuto (1981) for the stars with decreased metal content. The colour excess $E_{B-V} = 0\overset{m}{.}4$, which is caused by the interstellar and circumstellar absorption (Baird, 1981) was taken into account. The results of the calculations are shown in Figure 1a (open circles). The coincidence between the calculated amplitudes and the observed ones is quite satisfactory and it may justify our method.

The photoelectric UBV observations by Preston et al., (1963), Du Puy (1973), Zubarev, Kayumov, Chernova (Dushanbe, to be published) and the radial velocity curve by Sanford (1931) with the dispersion of 70 Å/mm are accessible for V Vul. Because of the absence of high dispersion observations for V Vul, a comparison between the radial velocity curves of AC Her and V Vul was made. It turned out that they are very close and this is not surprising, because the periods of both stars are nearly the same and their light curves have similar amplitudes. So the velocity curve of V Vul was plotted as that of AC Her at phase 0.0 + 0.2 P. The mean radius $\bar{R} = (45.9 \pm 2.2) \cdot 10^6$ km was determined by the above method, 19 phase pairs being used.

The mean absolute magnitudes $M_V = -4\overset{m}{.}34$ and $M_V = -3\overset{m}{.}98$ for AC Her and V Vul, respectively were calculated (E_{B-V} for V Vul was assumed to be equal to that for AC Her). This is in accordance with Du Puy's (1973) P-L relation and places these stars on the H-R diagram in the domain of RV Tau stars. A more detailed account of this work will be presented elsewhere.

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