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Physical parameters of the Algol system VW Hydrae from simultaneous analysis of Geneva seven-colour light curves ☆,☆☆

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Abstract

The semi-detached eclipsing binary system VW Hydrae ($P = 2.70$ days) has been analysed using the Wilson–Devinney program, on the basis of light curves obtained in the Geneva seven-colour photometric system, and radial velocity curves for both components measured with the cross-correlation technique. The physical and orbital parameters have been determined through a self-consistent simultaneous solution of light curves in seven colours and of the radial velocity curves of both components. The effective temperature of the primary component is determined from the photometric analysis, $T_{\mathrm{eff}_1} = 10,650 \pm 200$ K. It is shown that this value can be very well determined, despite the fact the primary eclipse is partial, by the use of colour indexes, as e.g. $[B_2 - V_1]_0$.

The absolute elements of the components are for the primary (mass gainer), with the value of T_{eff_1} fixed, $M_1 = 3.10 \pm 0.07 M_{\odot}$, $R_1 = 2.60 \pm 0.01 R_{\odot}$, $M_{\mathrm{bol}_1} = 0.05 \pm 0.01$, and for the secondary (mass loser), $M_2 = 0.76 \pm 0.02 M_{\odot}$, $R_2 = 3.38 \pm 0.01 R_{\odot}$, $M_{\mathrm{bol}_2} = 2.90 \pm 0.01$, $T_{\mathrm{eff}_2} = 4848 \pm 6$ K. The semi-major axis A of the relative orbit is $12.771 \pm 0.090 R_{\odot}$. The estimated spectral types of the components are about B8/9 V (primary) and F9 III. The equatorial rotational velocity of the primary (54 km s^{-1}) shows that the system is synchronised. The distance to VW Hya is evaluated to 1122 ± 42 pc, and the colour excess $E[B_2 - V_1]$ to 0.046 ± 0.022.
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☆ Based on observations collected at the Swiss 70 cm and 120 cm telescopes at the European Southern Observatory (La Silla, Chile).
☆☆ Table 1 is only available in electronic form at the CDS via anonymous ftp to `cdsarc.u-strasbg.fr` (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

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1. Introduction

VW Hydrae is a semi-detached eclipsing binary of period $P = 2.696$ days, with an evolved secondary component. The total primary eclipse is 3.2 mag deep in the V band. The variability of VW Hya was discovered by Hoffmeister (1929), as an eclipsing binary with a very deep minimum and with a brightness outside minimum of 10.5 mag. According to Kviz and Rufener (1987) the general shape of the light curve is typical of a double star with red and blue components. They have also observed that the secondary eclipse in the U colour is unexpectedly too deep, and they have argued that an ultraviolet source of radiation must be eclipsed during the secondary eclipse.

Very few things are known on VW Hya. In particular, no complete radial velocity curve has been yet published. For that reason, this star was measured intensively in the seven-colour Geneva photometric system (Golay, 1980; Rufener, 1988; Burki et al., 2005) using the 0.70 m Swiss telescope at La Silla (European Southern Observatory, Chile) equipped with the two-channel aperture photometer P7 (Burnet and Rufener, 1979). Moreover, the radial velocity curve of each component has been determined with the spectrograph Coralie installed on the 1.20 m Swiss telescope at La Silla.

In this paper, the physical parameters of the two components of this eclipsing system will be determined from the simultaneous analysis of the light and radial velocity curves.

2. Period

The orbital period listed in the GCVS (Kholopov et al., 1985), is $P = 2.696423$ days. A slightly larger value, 2.6964378 days, was obtained by Kviz and Rufener (1987) in 1983–1987. A new determination of the ephemeris was made on the basis of our extended photometric survey (1983–1990)

$$\mathrm{HJD(Min\ I)} = (2446620.3589 \pm 0.0001) + (2.6964626 \pm 0.0000001) \times E. \quad (1)$$

The uncertainties depend on the precision of the measurements (times and photometric data), shape of the eclipse light curve, number of measurements during the primary eclipses and duration of the survey. In this case, the uncertainty on the period corresponds to an error of 0.00003 in phase over the 2355 days of the survey of the primary eclipse ($873P$).

However, it must be noted that the orbital period has varied, as shown by the times of minima registered over decades by amateur astronomers. The $O–C$ values so obtained, and published in the BSAG Bulletin (Locher, 2001) are shown in Fig. 1 together with the $O–C$ values derived from our survey in Geneva photometry, and the value calculated from our radial velocity measurement. The global mean trend of the $O–C$ variation has a parabolic shape given by

$$O–C = A \cdot (\mathrm{HJD} - t_0)^2, \quad (2)$$

where $A = 3.2262 \times 10^{-9} d$ and $t_0 = 2446620.3589$. The fit only represents a mean trend, upon which are superposed probable sudden period changes.

Although the period changes are interesting by themselves, they are rather a nuisance in our context, because the radial-velocity and photometric data have to be put in phase for the analysis with the Wilson–Devinney program (see Section 6). For this reason, the phases of the measurements have been corrected, according to the mean variation shown in Fig. 1.

The parabolic shape of the $O–C$ variation implies a linear variation of the period, $P_i = P_0 + i \cdot \Delta P$, where P_0 is the value of the period at t_0, P_i the value of the period at $t = i \cdot P$, and ΔP is the constant period increase, given by

$$\Delta P = 2 \cdot A \cdot P_0^2. \quad (3)$$

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