COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4681

Konkoly Observatory
Budapest
10 March 1999

*HU ISSN 0374 – 0676*

# NEW TIMES OF MINIMA AND UPDATED EPHEMERIDES OF SELECTED CONTACT BINARIES

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The period variation of contact binary systems of the W UMa-type is a controversial issue of binary star astrophysics. It is known that W UMa-stars show a wide variety of period change (Kreiner, 1977), but the cause of the long- as well as short-term variations is still a mystery (see e.g. Kalimeris *et al.*, 1994 for a discussion of possible physical mechanisms). There are pieces of evidence that the observed period variations of contact binaries are basically random phenomena (van't Veer, 1991; Rucinski, 1993), besides the occasional light-time effect caused by a third component. On the other hand, it was pointed out very recently by Kaszás *et al.* (1998) that the period variation of VW Cep seems to be also affected by the magnetic activity cycle.

The aim of this paper is twofold: first, to present new times of minima of bright W UMa-systems in order to contribute to the period variation studies, and second, to provide up-to-date accurate ephemerides of a sample of W UMas that can be used to predict orbital phases in the present and the next few observing seasons. Such ephemerides are essential to perform high-resolution spectroscopic studies, where the accurate phase of the system that can be assigned to the observed spectrum must be precisely known.

We obtained Johnson BV photometric measurements of the W UMa-stars listed in the first column of Table 1, with the 40 cm Cassegrain telescope at Szeged Observatory between 1995 and 1998. A sample light- and colour curve of SW Lac illustrating the photometric accuracy is plotted in Fig. 1 as a function of phase. The times of minima calculated by low-order polynomial fitting to the data points close to the particular minimum are collected in the second column of Table 1. The typical uncertainty of these moments is ±0.0005 day.

We have also collected recently published times of minima for a sample of bright W UMa-stars that were selected for targets of our spectroscopic observing program. The spectroscopic results will be published elsewhere. Here we present the updated ephemerides of these program stars that can be used for calculating phases accurate to ±0.01 during the next observing season (provided the systems do not exhibit sudden and violent period changes in the meantime).

W UMa-stars usually change their period slowly but continuously over time, and it can seldom be described as a linear period variation. Since the purpose of our study was to find approximate periods for a limited duration, we restricted the time base of our study only to the past five years. $O-C$ diagrams were computed for all program stars

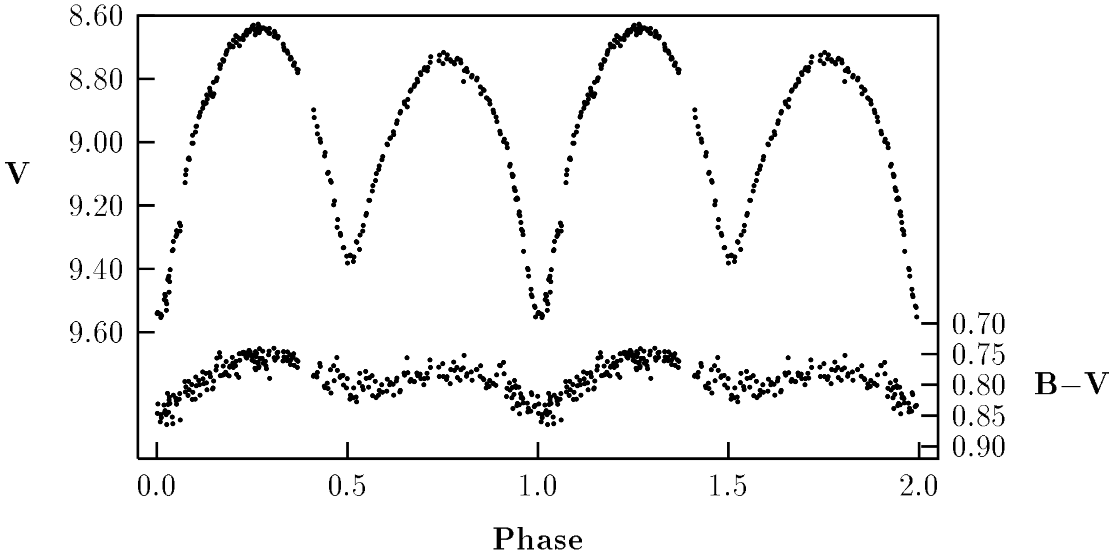

**Figure 1.** Light- and colour curve of SW Lac

Table 1: New times of minima of W UMa systems

| Star | Min (Hel.JD) 2 400 000+ | type | Star | Min (Hel.JD) 2 400 000+ | type |
|---|---|---|---|---|---|
| 44i Boo | 49828.5515 | II | U Peg | 50728.3701 | II |
| | 49830.5611 | I | | 50728.5567 | I |
| | 49841.4052 | II | | 50750.2953 | I |
| | 49841.5414 | I | | | |
| | 50180.4658 | II | VW Cep | 50707.2843 | II |
| | 50182.4747 | I | | 50707.4248 | I |
| | 50941.3394 | II | | | |
| | 50942.4089 | II | XY Leo | 49828.3876 | II |
| | 50942.5450 | I | | 50195.3114 | I |
| | | | | 50196.3080 | II |
| AB And | 50702.3634 | II | | 50508.3982 | I |
| | 50702.5283 | I | | 50513.3698 | II |
| | | | | 50519.3377 | II |
| SW Lac | 50694.3642 | II | | 50547.3229 | I |
| | 50700.2965 | I | | 50862.3933 | I |
| | 51035.4430 | I | | 50862.5359 | II |

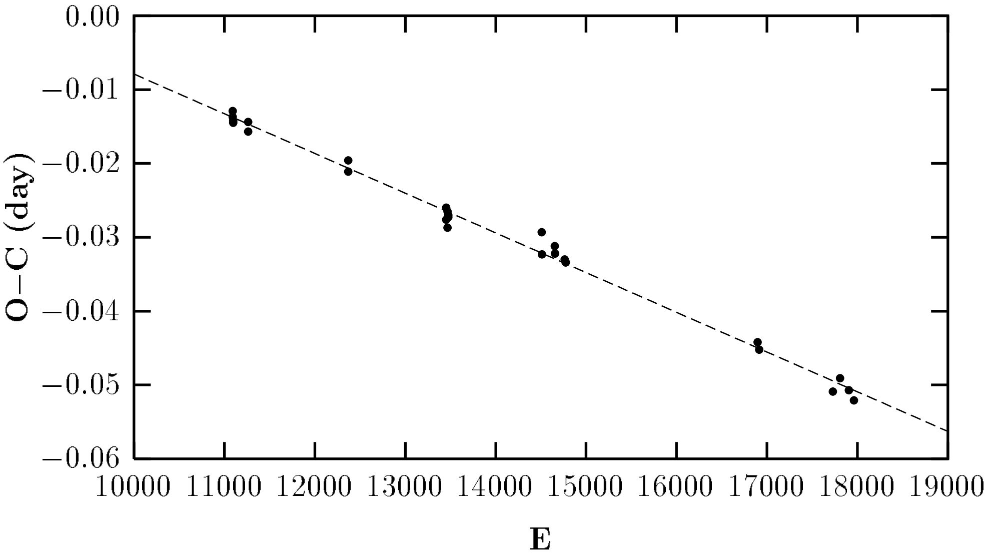

**Figure 2.** The *O–C* diagram of SW Lac as a function of the cycle number *E*

Table 2: New ephemerides of selected W UMa-stars.

| Star | T Min I<br>(HJD 2 400 000+) | Period<br>(days) | $\Delta P$<br>($10^{-6}$ day) | $\Delta P/\Delta T$<br>($10^{-10}$) |
|---|---|---|---|---|
| AB And | 51000.2368 | 0.33189103 | −1.11784 | −0.752 |
| OO Aql | 51000.1473 | 0.50678964 | +1.16731 | +0.936 |
| VW Cep | 51000.2054 | 0.27830821 | −6.38711 | −9.339 |
| DK Cyg | 51000.0999 | 0.47069290 | +2.35766 | +1.808 |
| V1073 Cyg | 51000.2912 | 0.78585079 | −8.90802 | −7.228 |
| LS Del | 51000.2257 | 0.36384021 | +3.41065 | +5.826 |
| SW Lac | 51000.1656 | 0.32071552 | −5.37688 | −9.398 |
| U Peg | 51000.2713 | 0.37477746 | −3.97695 | −2.740 |

using the data published recently in *IBVS* and the ephemerides in *GCVS*. In all cases the *O–C* diagrams could be well approximated with a straight line, and linear least-squares fit provided the correction of the period and the epoch as the fitted slope and the zero-point, respectively. An example of the computed *O–C* diagrams and the fitted line is plotted in Fig 2 in order to illustrate the validity of the linear approximation of the *O–C* diagram over the studied time interval. The list of individual moments of minima and their references for all stars can be requested from the first author of this paper via e-mail.

Table 2 presents the newly inferred ephemerides together with the $\Delta P$ differences (in $10^{-6}$ day) between the periods presented in this paper and those listed in *GCVS*, and the approximate rate of the period change $\Delta P/\Delta T$ (in $10^{-10}$ day/day) where $\Delta T$ is the difference between the current epochs and those in *GCVS*. $\Delta P$ may give some hints about usefulness of older periods in calculating orbital phases, while the other parameter is a rough measure of the stability of the period over a few thousand days, although this is obviously not a proper representation of the actual period variation, which would require much longer samples and correct treatment of non-linear terms in the fitting.

It is apparent from Table 2 that both the increase and the decrease of the period can be observed among the W UMa-stars analyzed here. This is a well-known property of contact binaries and it can be confirmed by larger statistical samples (e.g. Kreiner, 1977). If one assumes that these systems remain in stable contact configuration and the total mass of the system is constant then the increase of the period corresponds to a mass transfer from the less massive to the more massive component (thus, decreasing the mass ratio), while in the case of period decrease the direction of the mass transfer is reversed (i.e. the mass ratio is increasing). The thermal-relaxation oscillation theory of contact binaries (Lucy & Wilson, 1979) proposes such kind of mass transfers as the system is oscillating around the marginal contact state being temporarily in contact and non-contact phases. In this picture the systems with increasing period (OO Aql, DK Cyg, LS Del) are before the broken-contact phase, while the systems with decreasing period (AB And, VW Cep, U Peg, SW Lac, V1073 Cyg) are after that.

Concerning the speed of the observed period variations, it can be seen in Table 2 that the period variation rates are about the same order of magnitude, $10^{-9}$–$10^{-10}$ day/day for all systems studied in this paper. Model calculations by Mochnacki (1981) give about $\tau \approx 10^9$ years as the lifetime of contact binaries due to magnetic braking. A rough estimate of the theoretical period variation rate of the contact binary is $1/\tau$ day/day, therefore, the period variation rates in Table 2 are at least an order of magnitude higher than the prediction by the magnetic braking mechanism. However, more precise treatment of much more extensive observational data are necessary to address these questions in a satisfactory and more detailed way.

This research has been supported by OTKA Grants F022249, T022259, Soros Foundation Grant 222/2/3624, Szeged Observatory Foundation and Foundation for Hungarian Education and Science (AMFK). Useful discussions with Dr. K. Szatmáry are gratefully acknowledged.

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