NEW MINIMA OF V566 OPH AND THE PERIOD BEHAVIOUR

Summary: about 2800 visual estimates and 44 minima times of the eclipsing binary V566 Oph remark the period is continuing to increase because the O-C diagram shows a parabolic arc. Instead, the shapes of the composite light curves, year by year, is very similar with well-defined primary and secondary minima.

Introduction

V566 Oph is an eclipsing binary of EW/KW type, well studied in the past by both astronomers and amateurs, mainly to detect differences in the light curve shape and to follow minima in order to determine the trend of the period. The GCVS 1985 catalogue gives the following light elements: V566 Oph has a light variation in the range 7.46-7.96 V, the secondary minimum has almost the same depth than the primary one, spectrum F4V and ephemeris for the primary minimum as below[1]:

$$\text{Min I (JD)} = 41835.8617 + 0.40964569 * E \qquad (1)$$

In the recent past many observers have published their results showing the increase of the O-C and have proposed various physical explanations to check the trend. In 1989 Hill and coworkers[2] remarked the star is an A-type W UMa, the deeper minimum corresponding to a transit eclipse of the larger component by the smaller and less massive component of the system. The A-type W UMa systems are in deep thermal contact and cannot exist in a static equilibrium, so that they undergo periodic thermal relaxation oscillation by the energy transfer through their common convective envelope. It was shown by Wang Jianmin[3] that in W UMa systems the secondary fills its Roche lobe, slowly transfering its mass to the primary. This causes an expansion of the system until the contact is broken and the two stars are separated. Now the primary, having a smaller radius than a zero-age main sequence radius, grows and fills its Roche lobe until the mass transfer starts in the opposite direction and the contact is re-estabilished again, beginning a new cycle. The system expansion and the following system contraction are related respectively as A-type and W-type system. Wang Jianmin[4] found V566 Oph expanding at a rate of about 28 m y^{-1}, and obviously, this fact could explain an observed trend of the period in a large scale of time. In 1991 van t'Veer considered the correlation between magnetic activity and the positive or negative period jumps in contact binaries[5]. His theoretical discussion about possible changes of the inertial and the quadrupole moment of the components connected to period variations was studied and rejected by himself. In 1993 Niarchos and Rovithis[6,7] photoelectrically observed V566 Oph determining additional minima which agreed with the Seeds & Dawson's ephemeris:

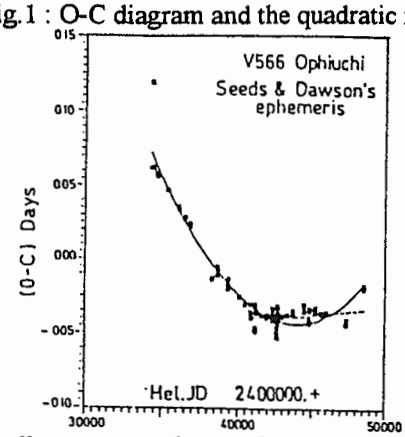
$$\text{Min I (JD)} = 40047.3478 + 0.40964600 * E \qquad (2)$$

Moreover, they proposed a quadratic least squares fitting to analize all minima times found in the literature:

$$\text{Min I (JD)} = 40049.0395 + 0.40956939 * E + 8.65 \cdot 10^{-10} * E^2 \qquad (3)$$

In this way the O-C diagram can be shown by a parabolic curve:

Fig.1 : O-C diagram and the quadratic fitting



The authors remarked that the eclipses were becoming more and more late, due to the continuous increase of the period. In 1992 Acerbi and Barani[8] visually observed V566 Oph determining four minima times which were in agreement with the SAC 62 light elements:

$$\text{Min I (JD)} = 43281.5034 + 0.4096466 * E \qquad (4)$$

In 1994 Kalimeris and his coworkers[9], studied several W UMa eclipsing binaries, mathematically describing their O-C diagrams by a system of four differential equations. The solutions showed V566 Oph had an oscillating period in a time of about 42 years. Instead, by this analysis was evident that no period jumps occurred in the system since 1952:

Fig.2 : the O-C diagram of V566 Oph

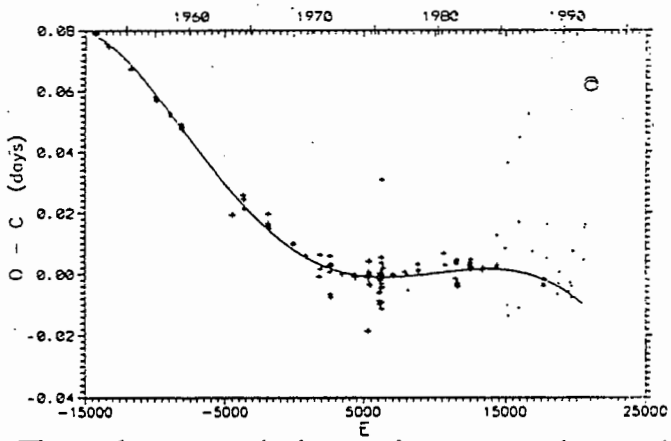
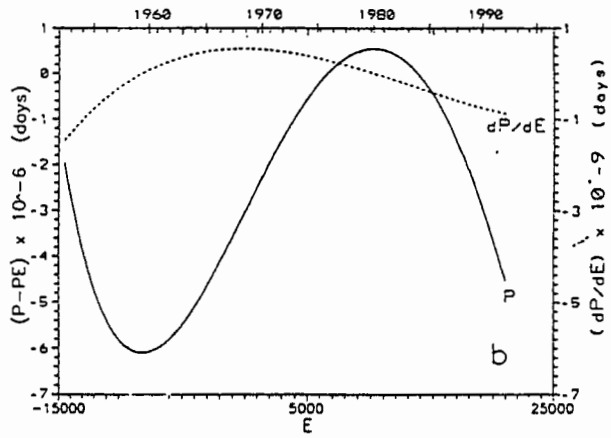


Fig.3 : the period (P) and its rate of change (dP/dE)



The authors remarked some important rules can be defined to analyse an O-C diagram in order to check the period behaviour:

1) Whenever an O-C diagram shows linear sections, the period is remaining constant.
2) Whenever an O-C diagram shows parabolic arcs, the period is changing at a constant rate.

Results and discussion

Since 1982 three GEOS members carried out 2832 visual estimates of V566 Oph using the finding chart C18. Observations and minima per year and per observer are reported below:

Tab.1 : arrangement of visual estimates and minima

Observer	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Dalmazio	-	-	-	-	-	-	-	-	-	-	-	-	-	297	146
Dumont	184	195	86	187	219	141	194	214	177	144	44	88	129	103	175
Fernandez	-	-	-	-	-	-	-	-	-	-	-	-	-	-	109

Minima	3	1	1	3	3	0	2	1	1	1	0	1	1	13	13

A total of 44 visual minima have been observed and calculated by SOP program[10] which are reported below:

Tab.2 : new times of minima of V566 Oph

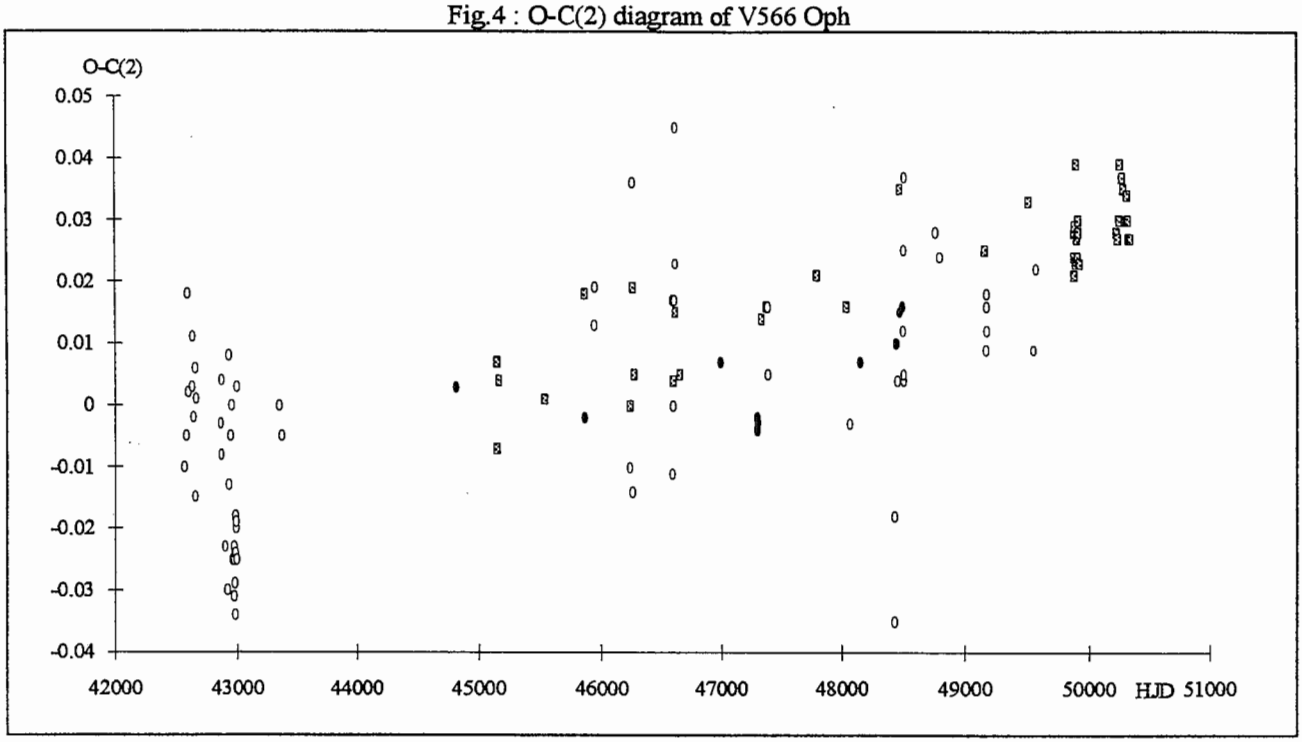
Observer	HJD	O-C(1)	O-C(2)	O-C(4)	Type
DMT	45142.537 ± 0.018	0.015	0.012	0,009	I
DMT	45143.547 ± 0.006	0.001	-0.002	-0.005	II
DMT	45158.510 ± 0.003	0.012	0.009	0.006	I
DMT	45531.489 ± 0.014	0.009	0.005	0.002	II
DMT	45861.476 ± 0.016	0.026	0.023	0.018	I
DMT	46236.489 ± 0.004	0.008	0.005	0.000	II
DMT	46259.448 ± 0.037	0.027	0.023	0.019	II
DMT	46271.518 ± 0.010	0.013	0.009	0.004	I
DMT	46591.452 ± 0.008	0.013	0.009	0.004	I
DMT	46610.511 ± 0.017	0.024	0.020	0.015	II
DMT	46645.524 ± 0.016	0.012	0.008	0.003	I
DMT	47332.511 ± 0.009	0.023	0.019	0.012	I
DMT	47373.476 ± 0.011	0.024	0.019	0.013	I
DMT	47793.367 ± 0.013	0.028	0.023	0.016	I
DMT	48036.490 ± 0.015	0.026	0.021	0.014	II
DMT	48475.443 ± 0.015	0.044	0.038	0.030	I
DMT	49156.471 ± 0.014	0.036	0.030	0.021	II
DMT	49503.449 ± 0.027	0.044	0.038	0.028	II
DDL	49874.374 ± 0.005	0.035	0.028	0.018	I
DDL	49875.391 ± 0.014	0.028	0.021	0.011	II
DDL	49876.415 ± 0.002	0.028	0.021	0.011	I
DDL	49877.442 ± 0.010	0.031	0.024	0.014	II
DDL	49882.363 ± 0.017	0.036	0.029	0.019	II
DDL	49883.387 ± 0.005	0.036	0.029	0.019	I
DDL	49885.429 ± 0.005	0.029	0.023	0.013	I
DMT	49894.462 ± 0.012	0.050	0.044	0.034	I
DDL	49895.469 ± 0.006	0.033	0.027	0.016	II
DDL	49903.455 ± 0.015	0.031	0.024	0.014	I
DDL	49908.374 ± 0.013	0.034	0.028	0.018	I
DDL	49910.425 ± 0.006	0.037	0.030	0.020	I
DDL	49916.357 ± 0.024	0.029	0.023	0.012	II
DDL	50224.416 ± 0.013	0.035	0.028	0.017	II
DDL	50233.427 ± 0.009	0.033	0.027	0.016	II
DMT	50242.448 ± 0.019	0.042	0.035	0.025	II
DMT	50250.445 ± 0.010	0.051	0.044	0.034	I
DDL	50266.414 ± 0.007	0.044	0.037	0.026	I
DDL	50274.400 ± 0.010	0.042	0.035	0.024	II
DDL	50299.387 ± 0.012	0.041	0.034	0.023	II
FDZ	50301.441 ± 0.009	0.046	0.039	0.029	II
FDZ	50303.485 ± 0.024	0.042	0.035	0.024	II
FDZ	50304.513 ± 0.015	0.046	0.039	0.028	I

Tab.2 (continued)

Observer	HJD	O-C(1)	O-C(2)	O-C(4)	Type
DDL	50309.420 ± 0.008	0.037	0.030	0.020	I
DDL	50316.381 ± 0.011	0.034	0.027	0.017	I
DDL	50333.381 ± 0.008	0.034	0.027	0.016	II

As stated by Acerbi and Barani, nowadays the best ephemeris remains the SAC 62's one. Collecting all minima times of V566 Oph published in the BBSAG, the ones of the present paper, and some photoelectric minima times from literature[6], we can plot the O-C(2) diagram according to Seeds and Dawson's ephemeris, as done in fig.1 and fig.2. In fig.4 photoelectric minima times (filled circles), visual minima from BBSAG (blank circles) and from GEOS (gray squares) are reported:

Fig.4 : O-C(2) diagram of V566 Oph

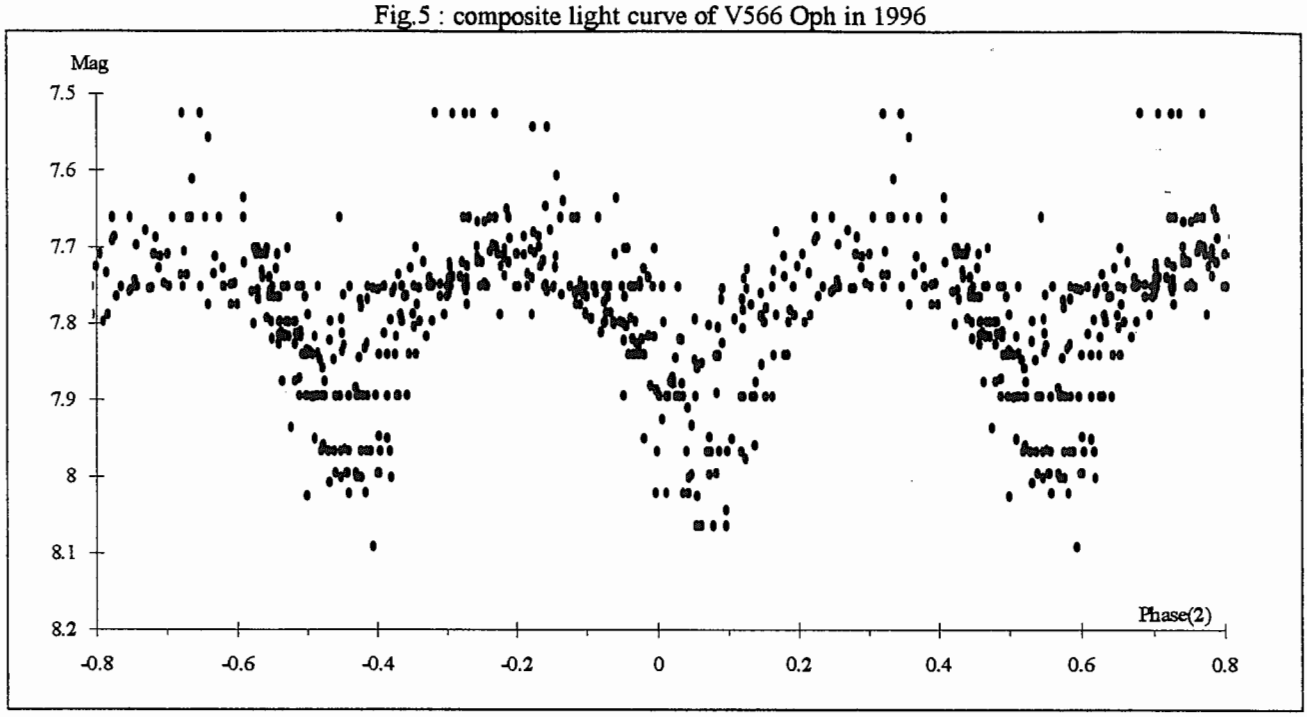


It is evident that the O-C(2) trend is positive and its shape is like a parabolic arc, that is the period is slowly increasing with a constant rate. Nevertheless it is important to note that the hypothesis of Kalimeris and coworkers fails to explain the O-C trend on a large time of scale. Infact they expected in 1996 the period was slowly oscillating, and the O-C value was decreasing, with a value about -0.02 day. On the contrary the O-C diagram totally agrees with the analysis of Rovithis and Niarchos: it fits very well on a parabolic arc as the continuation of their quadratic fitting showed in fig.1. They expected the O-C value in 1996 was about 0.02-0.03 day, almost the same obtained by GEOS. Therefore we can confirm the period of V566 Oph is continuing to increase at a constant rate.

The composite light curves

Light curves, composite every year from 1982 to 1996, mainly by DMT, are very similar to each other, indicating the profile of such curves was very stable in this range of time. All composite light curves exhibit the same height of both maxima and only a small difference in the depth of minima. Infact the primary minimum is 0.05 mag deeper than secondary minimum in almost all curves. As an example the composite light curve (according to ephemeris(2)) of V566 Oph in 1996, obtained by 430 visual estimates, is reported in the next page:

Fig.5 : composite light curve of V566 Oph in 1996



Conclusions

About 2800 visual estimates of V566 Oph, carried out by 3 members of GEOS since 1982, confirm the best ephemeris for the calculated minima is that one of SAC 62. The O-C diagram, analysed in the paper, exhibits a parabolic trend meaning the period of light variation is increasing at a constant rate, as reported by Rovithis and Niarchos in 1993. There are no reasons to think that the period is oscillating in 42 years cycles as stated by Kalimeris and coworkers in 1994. The comparison of composite light curves every year since 1982 remarks the stability of the profile and the features of the light curve. Even if this result is rather clear, V566 Oph needs other observations to check, year by year, the O-C trend on a large time scale and the real stability of its light curve.

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