OBSERVATIONS OF FOUR SUMMER ECLIPSING BINARIES

Summary: the analysis of 33 timings of visual minima confirms the light elements of V477 Cyg, TX Her, FL Lyr and U Oph given in the GCVS 1985. Light curves of these EA/DM type variable stars are presented, confirming again the typical light shape and the duration of eclipses.

Introduction

Four interesting variable stars of EA/DM type have been observed from 1990 to 1995 in order to confirm their light elements and to show the light curve shape. The GCVS 1985 catalogue indicates the data for the observed stars, reported below:

Tab.1 : GCVS elements of observed stars

Star	Type	RA_{1950}	Dec_{1950}	Range (V)	Light elements	D
V477 Cyg	EA/DM	20h 03m 29s	+31° 49.7'	8.50-9.34	44189.2639 + 2.3469906 * E	0.07
TX Her	EA/DM	17h 17m 02s	+41° 56.3'	8.54-9.31	40008.3643 + 2.05980944 * E	0.08
FL Lyr	EA/DM	19h 10m 38s	+46° 14.3'	9.27-9.89	38221.5525 + 2.1781544 * E	0.08
U Oph	EA/DM	17h 13m 59s	+1° 15.9'	5.84-6.56	44416.3864 + 1.67734617 * E	0.16

All these variable stars are EA/DM or Algol (Beta Persei)-type eclipsing systems. "Binaries with spherical or slightly ellipsoidal components. It is possible to specify for their light curves the moments of the beginning and end of the eclipses (D), and between eclipses the light remains almost constant or varies insignificantly because of reflection effects, slight ellipsoidality of components, or physical variations. Moreover, both components are main-sequence stars and do not fill their inner Roche lobes."(1)

Observations

From 1990 to 1995 I collected about 1300 visual estimates of the previous variable stars. The tab. 2 shows the number of estimates per star, the number of used GEOS finding chart and minima observed in different years:

Tab.2 : results of visual observations

Star	Estimates	Chart nr	1990	1991	1994	1995
V 477 Cyg	297	14	2	1	-	5
TX Her	358	13	-	-	4	4
FL Lyr	356	19	1	1	1	5
U Oph	316	474	-	-	3	6

Now I will analyse data of each eclipsing binary one at once.

V 477 Cyg: results and discussion

The 8 timings of observed minimum are reported in tab. 3, calculated processing data by SOP program(2), together with the O-C according GCVS light elements and the type of observed minimum, primary or secondary. It is important to remark that no further ephemeris have to be given for this variable star because the mean O-C indicates the complete validity of the elements provided by GCVS 1985:

$$O\text{-}C_{mean} = -0.001 \pm 0.008 \text{ day}$$

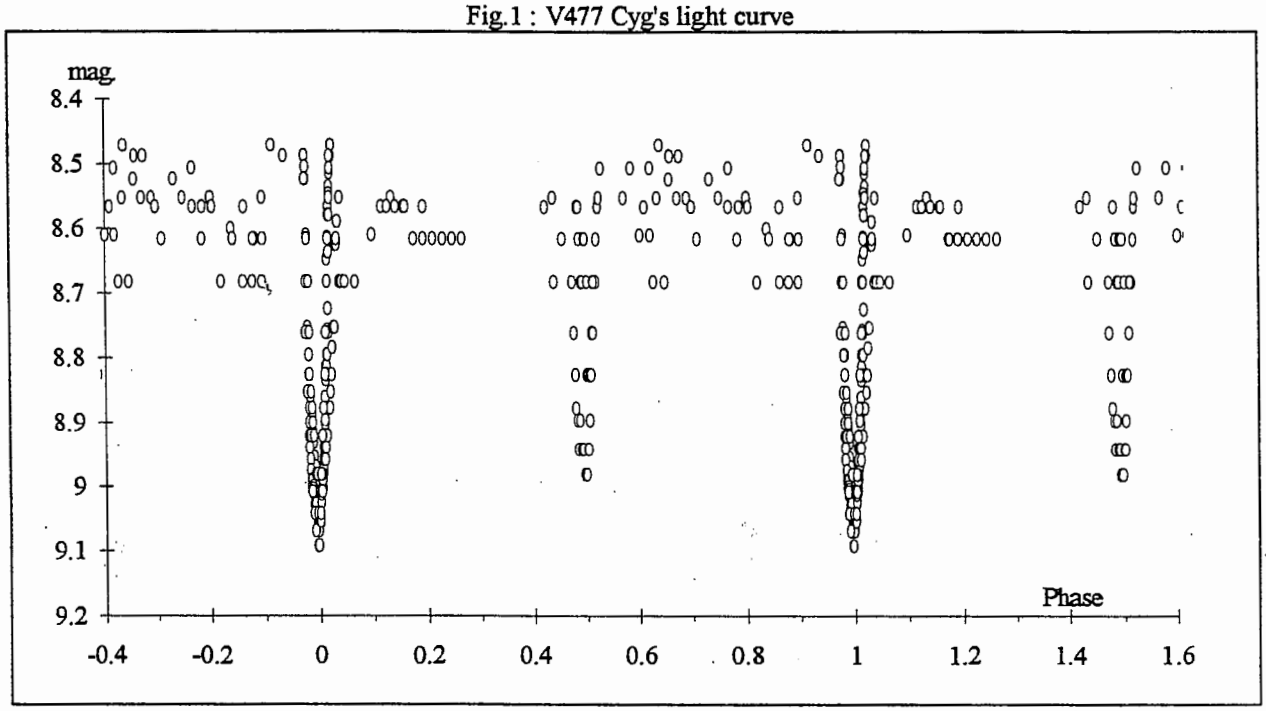
This fact confirms the eclipses' regularity and the period's stability.

Tab.3 : V477 Cyg's timings of minimum

HJD	O-C	TYPE OF MINIMUM
48099.354	0.004	I
48120.472	-0.001	I
48458.434	-0.006	I
49885.413	0.003	I
49905.372	0.012	II
49919.431	-0.010	II
49946.421	-0.011	I
49953.469	-0.004	I

The light curve, obtained phasing all data by GCVS elements, is reported below:

Fig.1 : V477 Cyg's light curve



The primary eclipse is deeper than secondary one of about 0.1 magnitude, and the value of the duration of whole eclipse (D) is clearly minor than 0.1 P, like indicated in the GCVS catalogue too.

TX Her: results and discussion

The next tab.4 shows the timings of minimum observed in 1994-1995:

Tab.4 : TX Her's timings of minimum

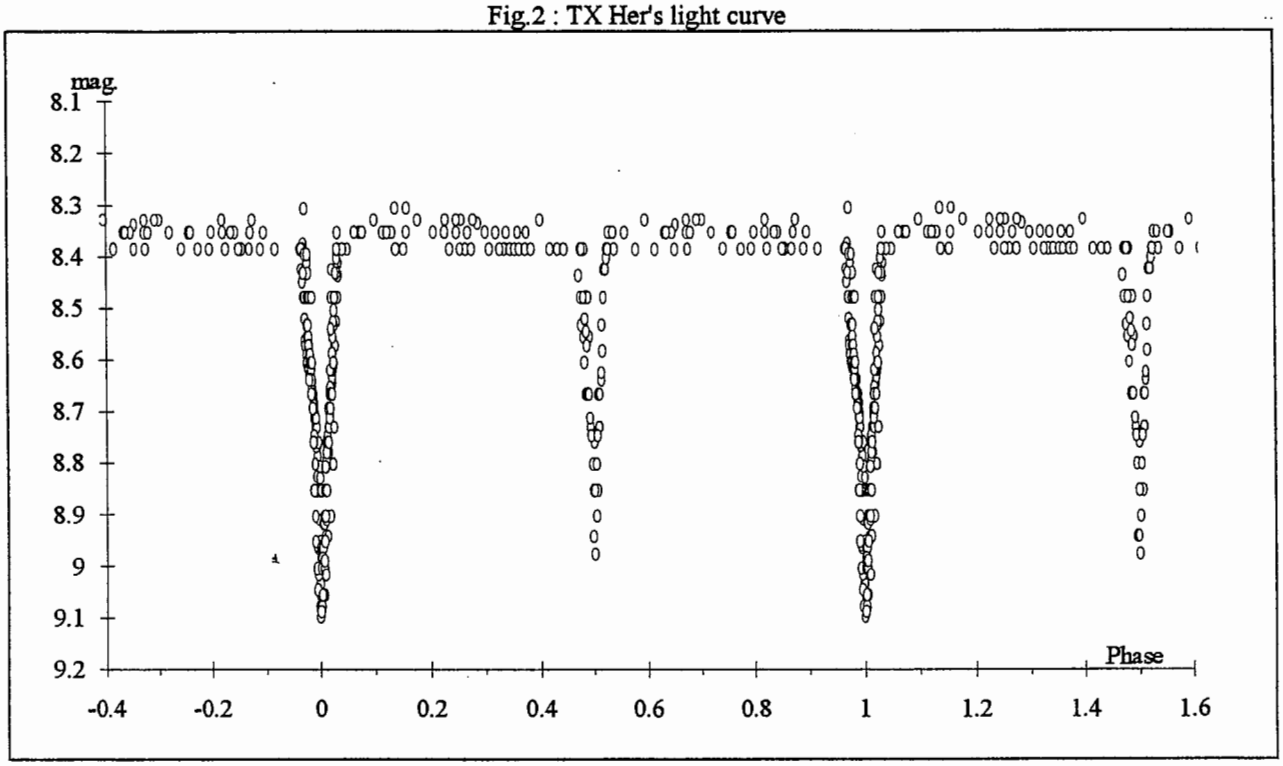
HJD	O-C	TYPE OF MINIMUM
49549.407	0.005	I
49582.361	0.002	I
49584.423	0.005	I
49650.333	0.001	I
49894.425	0.005	II
49895.459	0.009	I
49926.347	0.000	I
49927.377	0.000	II

Again, the mean O-C value confirms the validity of GCVS light elements:

$$O\text{-}C_{mean} = + 0.003 \pm 0.003 \text{ day}$$

This time, the light curve is accurate as much as a photoelectric one:

Fig.2 : TX Her's light curve



The estimated difference in depth of primary and secondary minimum is about 0.1 magnitude, and the calculated duration of each eclipses is 0.07-0.09 P, which confirms the D value in GCVS 1985.

FL Lyr: results and discussion

The next tab. 5 shows the timings of minimum observed from 1990 to 1995:

Tab.5 : FL Lyr's times of minimum

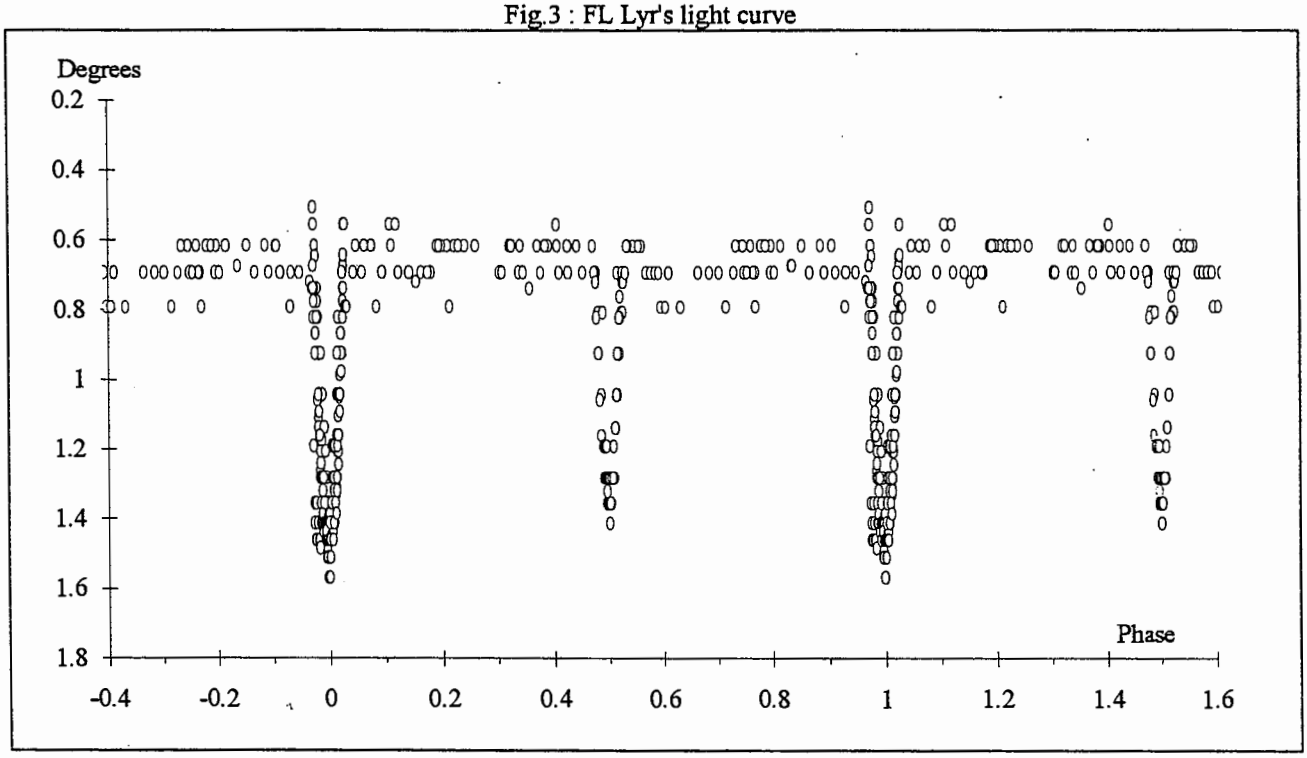
HJD	O-C	TYPE OF MINIMUM
48099.482	-0.001	I
48465.412	-0.001	I
49650.319	-0.010	I
49883.399	0.008	I
49895.375	0.004	II
49908.440	0.000	II
49919.335	0.004	II
49920.422	0.002	I

The mean O-C confirms again the period is very stable:

$$O\text{-}C_{mean} = + 0.001 \pm 0.005 \text{ day}$$

The light curve is very similar to that of TX Her, infact the secondary minimum is less deep than primary of about 0.1 magnitude and the duration of eclipses is 0.06-0.08 P.

Fig.3 : FL Lyr's light curve



U Oph: results and discussion

The 9 timings of observed minima are reported in the next tab.6 with O-Cs and the type of minimum:

Tab.6 : U Oph's timings of minimum

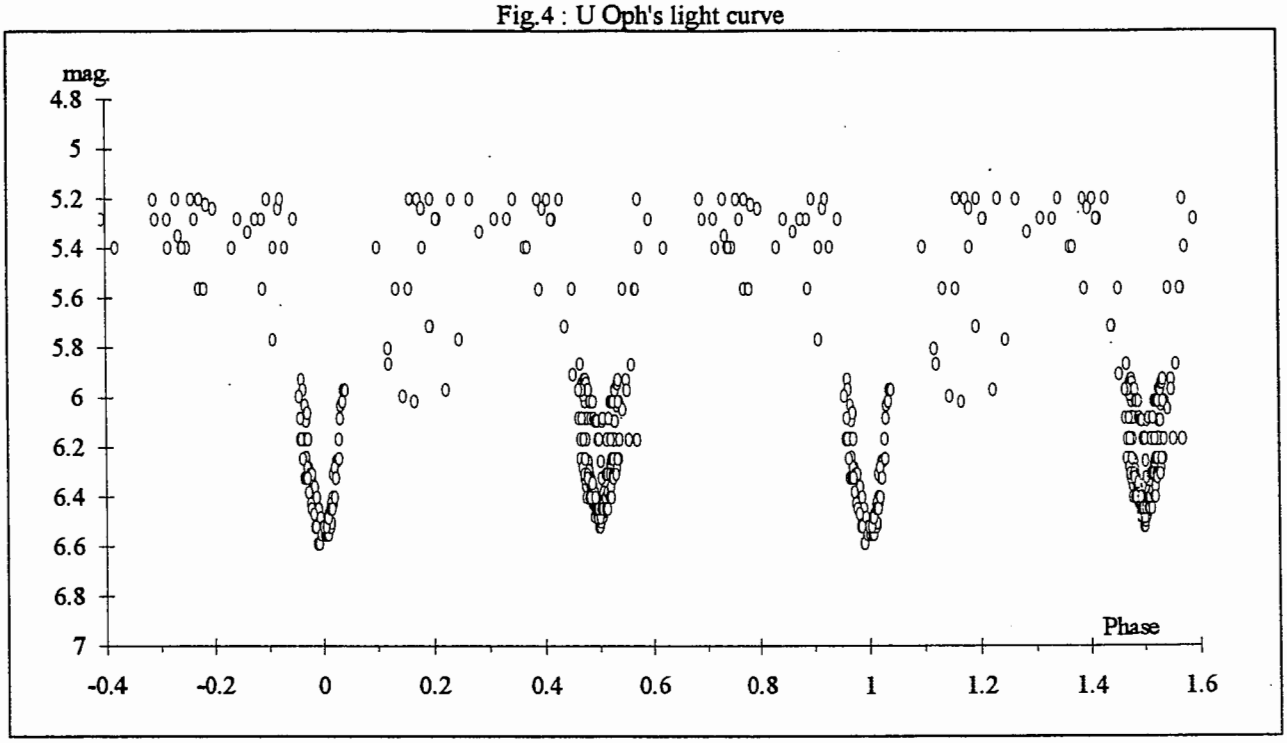
HJD	O-C	TYPE OF MINIMUM
49552.427	0.007	I
49568.359	0.004	II
49573.398	0.011	II
49874.476	0.005	I
49885.378	0.004	II
49890.407	0.001	II
49895.445	0.007	II
49916.402	-0.002	I
49937.382	0.011	II

Almost all O-Cs are positive, a fact that could indicate the need for a correction of the period of U Oph. Nevertheless the mean O-C is rather short to modify the elements given in GCVS 1985:

$$O\text{-}C_{mean} = + 0.005 \pm 0.004 \text{ day}$$

The light curve, as predicted by GCVS 1985, is different from those ones previously seen, owing to the width of minima. The estimated value of D is 0.14-0.19 P, both minima seems to be almost equal in depth.

Fig.4 : U Oph's light curve



Conclusions

This paper reports the study concerning 4 summer eclipsing binaries of EA/DM type. In the work 33 minima have been examined, calculating O-C in respect with ephemerides enclosed in GCVS 1985, and light curves of V477 Cyg, TX Her, FL Lyr, and U Oph are presented. All confirms the validity of light elements provided by GCVS 1985, both in period and in duration of eclipse. Probably we have to wait for several years to discover something strange in these so regular binary systems.

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References:

(1) KHOLOPOV et al., *General Catalogue of Variable Stars*, 4th edition (1985-1988)
(2) A.GASPANI, *Stochastic Optimization Program*, ver. 5 (1993)