PHOTOMETRY OF SYMBIOTIC STARS - AN INTERNATIONAL CAMPAIGN.

II. Z And, EG And, R Aqr, UV Aur, TX CVn, T CrB, BF Cyg, CH Cyg, CI Cyg, V1016 Cyg, V1329 Cyg, AG Dra, CQ Dra (4 Dra), NQ Gem, YY Her, V443 Her, RW Hya, SS Lep, BX Mon, RS Oph, Hen 1341 Oph, AG Peg, AX Per, HM Sge, QW Sge (AS 360), FR Sct, FG Ser (AS 296), AS 289 Ser, PU Vul.

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Received 4 October 1990

ABSTRACT. We present new photoelectric UBV, photographic and visual observations of 29 selected symbiotic stars. The observations were made, with a few exceptions, in the years 1988 - 1990. The periodic light variations of UV Aur in the V colour are not related to orbital motion, but are connected rather with the Mira-like pulsational activity of its cool component. We have determined a new value of the period of about 365 days for these variations. Our visual observations allow us to propose a new ephemeris for T CrB. We have observed an outburst phase indication and a gradual increase in the value of the U - B index over the whole observational interval of BF Cyg. As for CH Cyg, we have observed a deep minimum in the V colour (≈ 9.2) followed by a rather strong increase in the U-filter (by ≈ 1.8 mag). We have accomplished the first optical photometric detection of the orbital motion within the CQ Dra (4 Dra) A + BC system. Our UBV light curves for AX Per have revealed for the first time evidence of an eclipse of the cool component by its hot companion. The data for PU Vul show a general decrease in all UBV colours since about JD 2447000, suggesting the occurrence of a new eclipse/obscuration event.

1. INTRODUCTION

This is the second paper of a series presenting the results collected as part of the campaign of long-term photometry of symbiotic stars (Hric and Skopal, 1989). As regards CH Cyg, UV Aur and CQ Dra (4 Dra) it represents a continuation of the first paper (Skopal et al.,1990). The other 26 objects appear for the first time in this series.

2. OBSERVATIONS

Photoelectric UBV observations were performed at the Skalnaté Pleso Observatory (hereafter SP in the tables), at the Observatory of the Astronomical Institute of the Wroclaw University (W), at the Observatory of the Masaryk University in Brno (B), at the N. Copernicus Observatory and Planetarium in Brno (B) and at the Kryonerion Station of the National Observatory of Athens (K).

Photographic observations were made by Z. Velič at his private station near Považská Bystrica.

Visual observations were collected by a group of members of the Variable Star Section of the British Astronomical Association (J.E. Isles as the coordinator).

The observations at the Skalnaté Pleso Observatory were made with the use of a single-channel pulse-counting photoelectric photometer installed in the Cassegrain focus of the 0.6/ 7.5 m reflector. The photometer is equipped with an EMI 6295B photomultiplier. The integration time of one measurement was 10 s. The results of the integrations as well as the time registrations were recorded using a PP 01-16 computer (an IBM PC/XT compatible). The observations

were then corrected for the influence of differential extinction with the coefficients 0.55, 0.27 and 0.17 for the U, B and V colours, respectively. All the UBV measurements were reduced to the international system.

The observations carried out at the Observatory of the Astronomical Institute of the Wroclaw University were made with a 0.6 m Cassegrain reflecting telescope equipped with a single-channel photoelectric photometer. The electronics consisted of an uncooled EMI 6256S photomultiplier, 100 MHz CAMAC amplifier an amplitude discriminator and 10 MHz pulse counter. The results of the integrations and the time registrations were recorded by an IBM PC/XT computer. The integration time of one measurement was 5 s. All the observations were corrected for the effect of differential extinction with the extinction coefficients determined for each night separately. When this was not possible, average extinction coefficients (0.70, 0.44, and 0.26 for the U, B and V, respectively) were used. The measurements were reduced to the international system.

The observations at the Observatory of the Masaryk University in Brno were made with a 0.6 m Newton reflector equipped with a single-channel analog-recording photometer.

The observations carried out at the N. Copernicus Observatory and Planetarium in Brno were made with a 0.4 m Nasmyth telescope equipped with a single-channel pulse-counting photoelectric photometer.

The observations at the Kryonerion Station were made using a 1.2/ 15.6 m Cassegrain reflector equipped with a two-beam multi-mode photometer and the pass-band filters used are in close accordance with the standard U, B, V colour system. (The details for this photometer can be found in : Goudis and Meaburn, 1973, and for the telescope in: Contopoulos and Banos, 1976). The U observations are of lower quality than the V and B ones.

The photographic observations at the station near the city of Považská Bystrica were performed using panchromatic emulsions (format 135 - 36) Black and White 200, ORWO NP 27 and Foma Special 800 and a six-lens Sonnar 4/300 mm objective. The observations cover the spectral region from 400 to 700 nm.

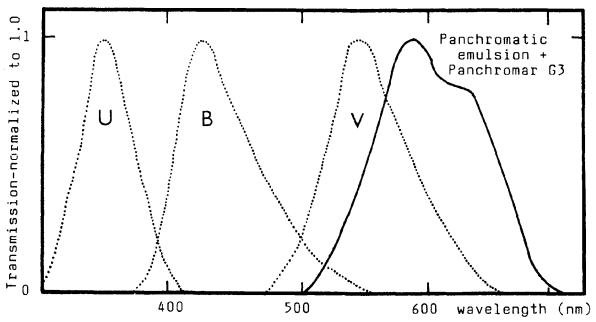

Fig. 1 Relative spectral sensitivity of the UBV system and our photographic receptor.

A panchromar G3 wide-band filter was used on 1990 Aug 25. These filter observations cover the spectral region from 500 to 700 nm (Fig. 1). Exposure times of 10 to 30 minutes, depending on the particular circumstances, were used with the camera mounted on a 80/1200 mm guiding refractor or a 240/1440 mm guiding reflector. All the negatives were measured on a double-beam microdensitometer.

The visual observations reported in this paper consist of 4877 visual magnitude estimates of 28 symbiotic stars in the years 1988 and 1989.

3. RESULTS

The results for all 29 objects are sumarized in tables and depicted in figures. The stars for which new interesting results were obtained are discussed below individually.

a/ Z And

This star was observed on 2 nights of 1990 Jul 23 and 27. S1: HD 222304 (V = 5.30, B − V = −0.06, U − B = −0.15, B9), S2: SAO 53150 (m_v = 8.9, m_{pg} = 9.1) and S3: SAO 53133 (m_v = 8.6, m_{pg} = 10.1) were used as standard stars. The results are in Table 1, the visual observations are displayed in Fig. 2.

Table 1.

Photoelectric observations of Z And

Date	2447000.+	V	B−V	U−B	ΔU	ΔB	ΔV	Obs
23 Jul 90	1095.548	10.773	1.420	0.158*	−4.504	−4.204	−3.709+	W
27 Jul 90	1100.491	2.697	2.696	1.793*	−2.147	−1.140	−0.202#	W

* Z And − S2 (Δ U, Δ B, Δ V respectively), + S1 − S2, # S2 − S3

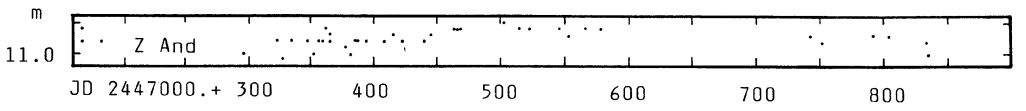

Fig. 2 Visual observations of Z And.

b/ EG And

The photoelectric observations were carried out on 6 nights during 1989 Nov (5 nights) and on 1990 Jul 28. The stars S1: HD 4143 (m_v = 8.6, m_{pg} = 10.0, M), S2: HD 3914 (V = 7.00, B − V = 0.44) and S3: HD 4322 (V = 7.55, B − V = 0.47, F5) were used as standard stars. The average values of S1 − S2 were determined:

U = 4.640 + 0.015 (from 5 nights, without 1989 Nov 14),

B = 2.722 + 0.017 (from 5 nights),

V = 1.563 + 0.006 (from 5 nights).

The results are compiled in Table 2 and are included in the data taken from the literature (Skopal et al.,in press and references therein) and depicted in Fig. 3. Our observations are not in contradiction with the characteristics of the star described in the literature. We have observed rather large light variations in the U-filter (0.15 mag) on 3 nights of 1989 Nov 17 - 20. These are probably caused by the differences of the brightness of the star measured on the individual nights, mainly in the U-filter.

Table 2.

Photoelectric observations of EG And

Date	2447000.+	ΔU	ΔB	ΔV	ΔU	ΔB	ΔV	Obs
14 Nov 89	844.558	3.006	1.276	0.174*	4.476	2.669	1.669#	SP
					0.707	0.568	0.545$	SP
17 Nov 89	848.311	3.042	1.311	0.101*				
17 Nov 89	848.333	3.031	1.312	0.102*				
17 Nov 89	848.358	3.045	1.308	0.097*	4.610	2.697	1.556#	SP
					0.605	0.581	0.549$	SP
17 Nov 89	848.390	3.023	1.304	0.093*				
17 Nov 89	848.412	3.044	1.310	0.099*				
18 Nov 89	849.319	2.947	1.314	0.096*				
18 Nov 89	849.343	2.945	1.308	0.094*				
18 Nov 89	849.374	2.940	1.310	0.100*	4.635	2.714	1.558#	SP
					0.589	0.586	0.544$	SP
18 Nov 89	849.398	2.947	1.302	0.098*				
18 Nov 89	849.419	2.944	1.301	0.094*				
19 Nov 89	850.271	2.919	1.293	0.098*	4.635	2.714	1.562#	SP
					0.594	0.583	0.544$	SP
19 Nov 89	850.302	2.912	1.300	0.096*				
20 Nov 89	851.319	2.892	1.312	0.098*	4.697	2.788	1.553#	SP
					0.586	0.579	0.546$	SP
28 Jul 90	1100.505	-1.690	-1.368	-1.440+	4.624	2.697	1.588#	W

* EG And - S2, + EG And - S1, # S1 - S2, $ S3 - S2

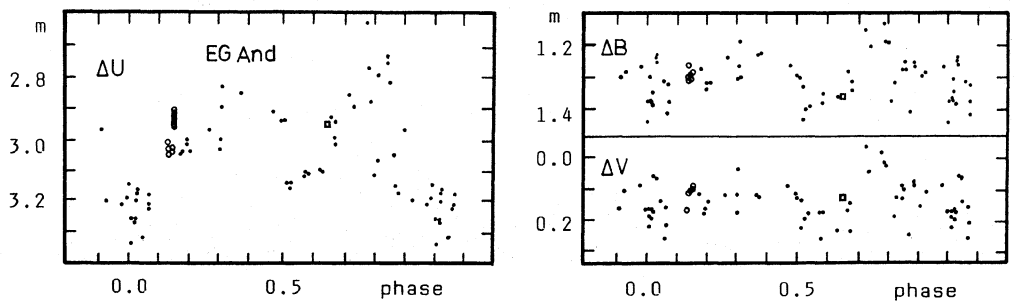

Fig. 3 UBV observations of EG And:. - data from literature, ∘ - observations from the Skalnaté Pleso Observatory, □ - observations from the Wroclaw Observatory. Phase was derived from ephemeris: JD_{min} = 2446336.7 + 481.7 x E (Skopal et al., 1988).

The visual observations indicate light variations between 7^{th} and

8^{th}mag, although a minimum between JD 2447300 and JD 2447400 (Fig. 4) lies quite near the minimum derived from the photoelectric U light curve: JD_{min} = 2446336.7 + 481.7 x E (Skopal et al., 1988). New observations should confirm it is real.

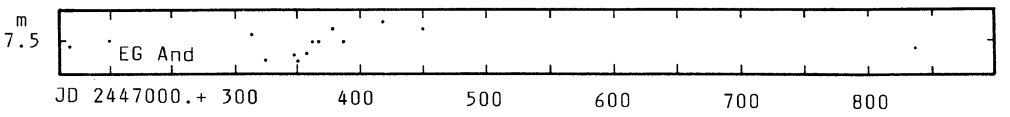

Fig. 4 Visual observations of EG And.

c/R Aqr

The visual observations show normal Mira-like variations (Fig. 5). Two maxima were observed on 1988 Oct 13 (JD 2447448, mag = 7.0) and 1989 Nov 9 (2447840, mag = 6.7). These were delayed with respect to the AAVSO ephemerides by 17 and 13 days, respectively. Minima over 10.8 mag were unobserved due to twilight.

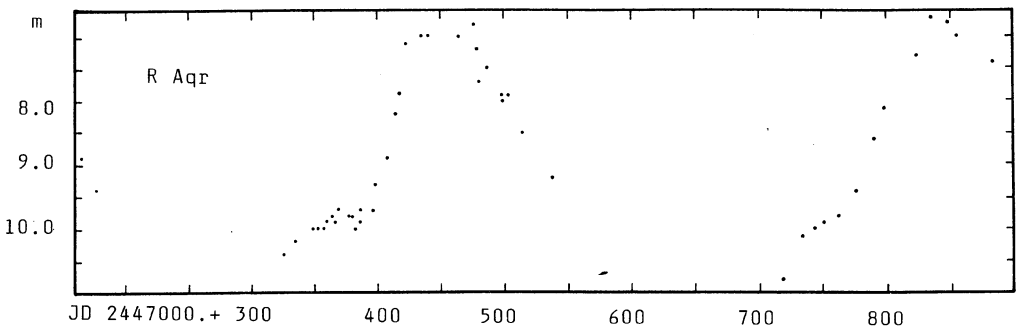

Fig. 5 Visual observations of R Aqr.

d/UV Aur

The photoelectric observations of this star were obtained on 13 nights between 1989 Nov 17 and 1990 sep 18. The stars S1: HD 242810 (V = 10.7, B - V = 0.28, U - B = -0.23, B9), S2: SAO 57940 (m_v = 8.8, m_{pg} = 9.3, A) and S3: SAO 57937 (m_v = 8.7, m_{pg} = 9.8, K0) were used as comparisons. Unfortunately almost all the photoelectric observations (except that of 1990 Sep 18) are concentrated around the minimum of brightness of the variable. As we have already shown in Paper I of this series (Skopal et al., 1990), the brightness changes are most pronounced in the V colour. For this particular reason, it has proved to be very fruitful to observe this star photographically. Since we have at the moment only a few observations of all three comparison stars with not very satisfactory results, it would be very important to carry out such

observations at several observatories. The results are compiled in Table 3 and depicted in Fig. 6.

Table 3.

Photoelectric observations of UV Aur

Date	2447000.+	ΔU	ΔB	ΔV	ΔU	ΔB	ΔV	Obs
17 Nov 89	848.490	0.518	1.015	0.627#				SP
18 Nov 89	849.498	0.467	1.019	0.601#				SP
19 Nov 89	850.406	0.489	1.040	0.605#				SP
20 Nov 89	851.415	0.460	1.032	0.622#				SP
29 Nov 89	860.350	-0.303	-0.134	-1.277$				SP
3 Dec 89	864.336	-0.346	-0.139	-1.273$				SP
27 Dec 89	888.426	-0.305	-0.052	-0.981$				SP
4 Jan 90	896.398	-0.385	-0.097	-0.901$				SP
13 Jan 90	905.483	-0.322	-0.046	-1.016$				SP
10 Feb 90	933.463	-0.290	-0.013	-0.579$				SP
13 Mar 90	964.334	1.196	1.229	0.836&	0.812	0.174	-0.397*	B
					1.550	1.268	1.109+	B
17 Mar 90	968.360	0.297	1.135	1.255#	0.871	0.161	-0.440*	B
					0.793	1.201	1.551@	B
18 Sep 90	1152.575	-0.384	-0.433	-2.270$				SP

UV Aur - S2, $ UV Aur - S1, & UV Aur - S3, * S2 - S3, + S1 - S3, @ S1-S2

The photographic observations were taken on 17 nights between 1989 Feb 10 and 1990 Aug 25. A total of 13 stars were selected as comparisons (together with 3 standard stars from the photoelectric photometry). The relevant UBV and photographic magnitudes together with the visual ones were adopted from Blanco et al. (1968) and the SAO Star Catalogue (1966), respectively. The data for all the comparison stars can be found in Table 4. The results from the photo-

Table 4.

Comparison stars used for photografic photometry of UV Aur

No	Star	$\alpha_{1950.0}$	$\delta_{1950.0}$	m_{pg}	m_v	V	B-V	U-B	Sp
1	SAO 57753	$05^h09^m54^s.257$	$33^\circ15'37''.47$	9.	8.1	8.54	0.43	0.04	F2
2	SAO 57853	05 14 53.588	33 19 17.00		4.8	4.54	1.25	1.27	K0
							1.27	1.31	
3	SAO 57884	05 15 42.409	33 41 50.28		5.4	5.41	-0.17	-0.55	A0
						5.35	-0.22	-0.63	
							-0.21		
							-0.19		
4	SAO 57906	05 16 42.951	33 54 27.90		5.2	5.03	0.27	0.37	A5
						4.99	0.25	0.44	
						5.04	0.28	0.35	
						5.07		0.39	
5	SAO 58056	05 24 27.729	33 54 18.05	7.7	7.1	7.44	0.12	-0.75	B0
6	SAO 58053	05 24 24.128	34 29 28.72	8.4	8.5	8.04	0.32	-0.66	B0
7	SAO 58047	05 24 14.716	31 21 30.02	9.0	8.3	9.65	0.13	-0.44	B8
8	SAO 58051	05 24 19.833	34 26 06.82		5.3	5.08	1.41		K0
						5.06	1.40	1.66	
						5.07	1.41		
9	SAO 58048	05 24 16.584	34 42 51.44	8.8	8.8	8.55	0.24	-0.71	B0
						8.60	0.23	-0.69	
10	SAO 58028	05 23 29.931	34 20 59.08		5.9	5.94	0.14	0.21	A0
S1	HD 242810	05 18 27.0	32 53 01.0			10.70	0.28	0.23	B9
S2	SAO 57940	05 18 32.2	32 20 24.4	9.3	8.8				A
S3	SAO 57937	05 18 19.6	32 15 51.3	9.8	8.7				K0

graphic measurements are compiled in Table 5 and depicted in Fig. 6. The observed light curve of UV Aur is consistent with Mira-like variability. Our observations suggest that the light variations with a period of about 390 days are related to the cool component as proposed by Khudyakova (1985, 1988) and not to the orbital motion as claimed by Garcia and Kenyon (1988) on the basis of the radial velocity curve. Our UBV and photographic measurements demonstrate that the variations are connected with the pulsations of the cool component.

Table 5.

Photographic observations of UV Aur

Date	2447000.+	mag	ASA	Date	2447000.+	mag	ASA
10 Feb 89	568.335	10.05	200	24 Oct 89	824.431	8.82	400
10 Feb 89	568.359	10.07	200	29 Nov 89	860.320	9.51	400
10 Feb 89	568.379	10.34	200	25 Dec 89	886.283	9.32	400
4 Mar 89	590.331	10.53	200	17 Feb 90	940.256	10.01	400
5 Mar 89	591.341	10.29	200	17 Feb 90	940.269	10.11	400
26 Mar 89	612.327	9.71	200	17 Feb 90	940.288	10.19	400
26 Mar 89	612.353	9.73	200	22 Feb 90	945.275	10.19	400
31 Mar 89	617.310	10.15	200	22 Feb 90	945.289	10.31	400
7 Apr 89	624.330	10.11	200	13 Mar 90	964.299	9.99	400
2 Sep 89	771.558	8.05	400	19 Mar 90	970.316	9.95	400
2 Sep 89	771.571	8.3	400	25 Aug 90	1128.547	7.8	800
2 Sep 89	771.585	8.09	400	25 Aug 90	1128.561	7.87	800/f
24 Sep 89	794.445	8.08	400	25 Aug 90	1128.575	8.25	800/f
5 Oct 89	804.469	8.29	400				

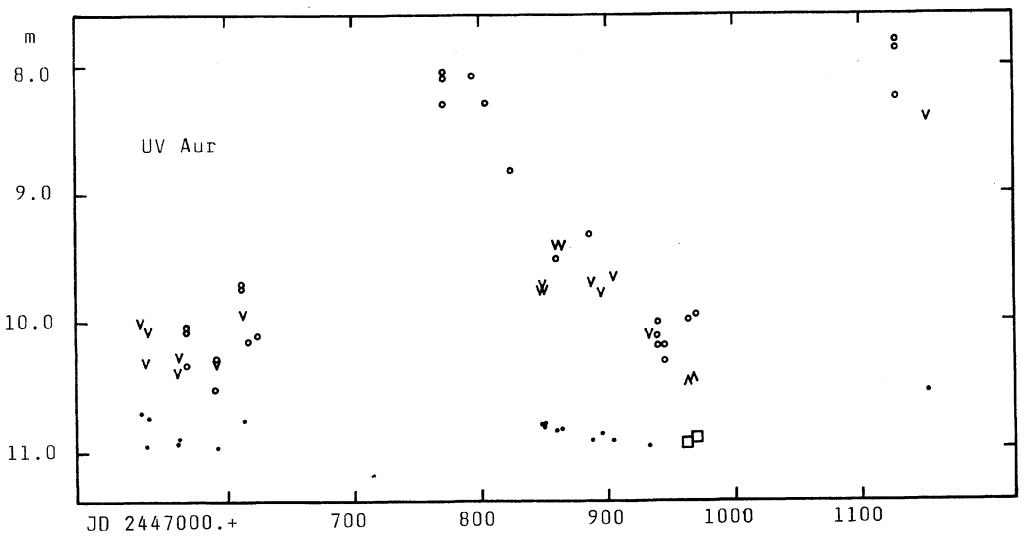

Fig. 6 . , □ (V , ^) photoelectric B (V) observations from Skalnaté Pleso, Brno, respectively and ◦ photographic observations of UV Aur.

The visual observations were not continuous but are consistent with Mira-like variability. Minimum (mag = 10.3:) occured on 1988 Feb 18 (JD 2447210:),

maximum (8.4:) on 1988 Jul 7: (JD 2447350:). The observations represent the combined magnitude of UV Aur and its 11.0 mag companion. The visual observations are depicted in Fig. 7.

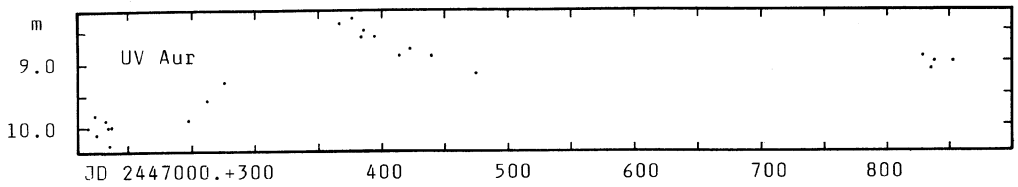

Fig. 7 Visual observations of UV Aur.

By combining photoelectric, photographic and visual observations we were able to distinguish 3 cycles of brightness variations. Based on the determination of the times of minima (JD 2447215, JD 2447580 and JD 2447945), a new value for the period of long-term brightness variations of UV Aur was determined (about 365 days). It is considerably shorter than the previously published period of about 394 days. A detailed period analysis will appear elsewhere.

e/ TX CVn

Table 6a.

Photoelectric observations of TX CVn

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
13 Mar 90	964.412	9.708	0.418	-0.167	0.261	0.127	0.173 *	B
					0.471	-0.258	-0.700 +	B
17 Mar 90	968.412	9.780	0.412	-0.131	0.284	0.141	0.177 +	B
					0.673	-0.272	-0.763 *	B
18 Mar 90	969.457	9.819	0.546	-0.045	0.186	0.101	0.179 #	W
					0.916	-0.248	-1.072 *	W
2 Apr 90	983.501	9.860	0.562	-0.075	0.136	0.073	0.159 *	W
2 Apr 90	983.507	9.846	0.562	-0.068	0.154	0.092	0.169 *	W
2 May 90	1014.363	9.863	0.564	-0.050	0.161	0.095	0.164 #	W
19 May 90	1031.372	9.857	0.566	0.056	0.889	-0.217	-1.037 #	SP
12 Jul 90	1085.364	9.917	0.605	0.095	0.898	-0.205	-1.095 *	SP
16 Jul 90	1089.380	9.865	0.629	-0.019	0.114	0.091	0.191 *	W
22 Jul 90	1095.377	9.887	0.599	-0.058	0.256	0.100	0.192 *	W
26 Jul 90	1099.369	9.870	0.578	0.058	0.168	0.140	0.182 #	W
					0.962	-0.312	-1.065 *	W
27 Jul 90	1100.366	9.861	0.591	-0.061	0.201	0.142	0.193 *	W
					0.862	-0.329	-1.089 #	W

* S1 - S2, + S3 - S2, # S3 - S1

The photoelectric photometry of TX CVn was carried out on 11 nights between 1990 Mar 13 and Jul 27. The stars S1: SAO 63223 (V = 9.36, B - V = 0.30, U - B = 0.03, F05), S2: SAO 63189 (m_v = 8.4, m_{pg} = 9.4, F5) and S3: SAO 63200 (m_v = 8.0, m_{pg} = 9.3, K2) were used as standards. The results are summarized in Table 6a, b. The data obtained at the Brno Observatory display a large scatter. Its reality, however, is rather problematic. Except for this, a slight decrease of the star's brightness in all three colours has been observed. The visual observations are shown in Fig. 8.

Table 6b.

Two choosen nights of UBV observations of TX CVn carried out at the Kryonerion Observatory on March 24./ 25. and 28./ 29., 1990

2447975.+	V	B-V	U-B	2447979.+	V	B-V	U-B
.5091	9.287	1.244	-0.227	.4924	9.424	1.109	0.130
.5152	9.295	1.114	-0.176	.4964	9.378	1.148	0.094
.5192	9.323	1.128	-0.158	.5044	9.448	1.098	0.115
.5237	9.337	1.135	-0.180	.5098	9.484	1.070	0.001
.5292	9.406	1.079	-0.204	.5142	9.449	1.146	-0.123
.5339	9.405	1.132	-0.252	.5267	9.291	1.170	0.006
.5520	9.436	1.121	-0.212	.5312	9.365	1.102	0.043
.5605	9.451	1.186	-0.221	.5348	9.350	1.176	0.049
.5838	9.483	1.144	-0.184	.5388	9.380	1.225	-0.026
.5873	9.427	1.210	-0.257	.5431	9.376	1.254	-0.045
.5924	9.437	1.136	-0.199	.5583	9.383	1.259	-0.123
.5970	9.383	1.170	-0.240	.5623	9.371	1.252	-0.159
.6006	9.291	1.032	-0.027	.5661	9.338	1.170	-0.047
.6047	9.342	1.090	0.011	.5708	9.320	1.162	0.038

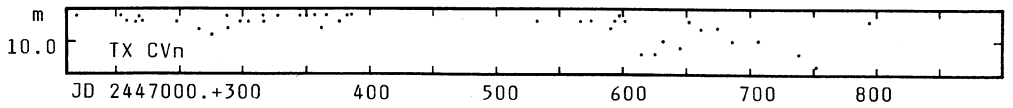

Fig. 8 Visual observations of TX CVn.

f/ T CrB

T CrB was observed photoelectrically on 7 nights in the 1990 Mar 18 - Jul 27 interval. Three standard stars were used: S1: HD 142929 (V = 8.41, B - V = 0.51, U - B = 0.03, F8V), S2: HD 143313 (V = 8.33, B - V = 1.00, U - B = 0.72, K2V) and S3: HD 143455 = BD +25° 3009. The values for S1 - S2 slightly varied in all three filters. The differential magnitudes of S1 - S3 do not manifest any variations. This indicates that the star S2 is probably variable. T CrB changed its brightness in the range V = 10.0 - 10.4. Changes of a similar amplitude also appeared in the U and B colours. The results are compiled in Table 7.

The visual observations reveal maxima of the ellipsoidal variations (mag 10.2 - 10.3) in 1988 Mar, Jul, Oct, minima (10.4 - 10.6) in 1988 May, Sep, 1989 Jan, May, Aug, Nov. When compared with the elements given by Peel (1990), who used an orbital period of 227.53 days, the estimated mean O - C values are as follows: Min I +9 days, Max I +6 days, Min II +14 days, Max II +2days (where we have used calculated phases of 0.25, 0.5 and 0.75 for Max I, Min II, Max II, respectively). When compared with the elements derived on the basis of the earlier BAA results (Isles, 1974), which imply an orbital period of 227.8 days, the mean O - C is zero. The following elements fit all the available BAA data from 1956, since when our observations have been continuous:

JD (Min I) = 2435571 + 227.8 x E.

The visual observations of T CrB are depicted in Fig 9. This character of va-

riations is supported by the photoelectric observations.

Table 7.

Photoelectric observations of T CrB

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
18 Mar 90	969.479	10.344	1.451	0.668	-1.023	-0.292	0.192+	W
2 May 90	1014.460	10.023	1.347	0.390	-0.770	-0.246	0.242+	W
30 May 90	1042.412	9.962	1.392	0.416	-1.011	-0.269	0.230+	W
15 Jul 90	1088.400	10.255	1.323	0.257	-1.006	-0.266	0.232+	W
					-2.108	-0.360	0.624*	W
16 Jul 90	1089.409	10.277	1.262	0.192	-1.085	-0.310	0.204+	W
					-2.088	-0.368	0.612*	W
22 Jul 90	1095.408	10.277	1.218	0.007	-0.908	-0.208	0.256+	W
					-2.041	-0.361	0.616*	W
27 Jul 90	1100.384	10.326	1.352	0.304	-1.032	-0.289	0.197+	W
					-2.087	-0.374	0.612*	W

+ S1 - S2, * S1 - S3

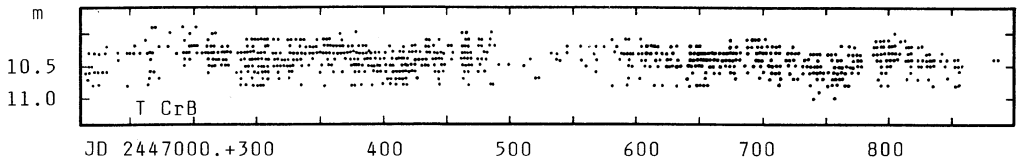

Fig. 9 Visual observations of T CrB

g/ BF Cyg

The photoelectric observations of BF Cyg were obtained on 19 nights

Table 8.

Photoelectric observations of BF Cyg

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
29 Nov 89	860.187	9.743	0.281	-0.242				SP
3 Dec 89	864.192	9.692	0.302	-0.235				SP
29 Dec 89	890.188	9.683	0.380	-0.222				SP
6 Jan 90	898.192	9.682	0.420	-0.210				SP
18 Mar 90	969.625	9.636	0.416	-0.419	4.595	3.282	2.564*	W
1 Apr 90	983.558	9.690	0.422	-0.431	4.565	3.267	2.552*	W
2 May 90	1014.511	9.666	0.422	-0.450	4.556	3.271	2.561*	W
30 May 90	1042.466	9.709	0.445	-0.498	4.548	3.265	2.557*	W
15 Jul 90	1088.417	9.627	0.379	-0.625	4.501	3.275	2.576*	W
22 Jul 90	1095.483	9.642	0.372	-0.606				SP
22 Jul 90	1095.488	9.677	0.378	-0.586	4.427	3.272	2.561*	W
23 Jul 90	1096.490	9.639	0.352	-0.603				SP
24 Jul 90	1097.450	9.678	0.356	-0.611				SP
26 Jul 90	1099.498	9.715	0.358	-0.615				SP
27 Jul 90	1100.432	9.753	0.420	-0.662	4.509	3.275	2.554*	W
5 Aug 90	1108.553	9.702	0.405	-0.657				SP
25 Aug 90	1128.550	9.773	0.401	-0.660				SP
26 Aug 90	1129.505	9.743	0.410	-0.666				SP
31 Aug 90	1135.328	9.820	0.349	-0.751				SP

* S2 - S1

between 1989 Nov 29 and 1990 Aug 31. The neighbouring stars S1: HD 183650 (V = 6.96, B - V = 0.71, U - B = 1.7) were used as the comparison and the check, respectively. The results are sumarized in Table 8 and displayed in Fig. 10. our data indicate an outburst phase for BF Cyg in the 1989 Nov - Dec period. According to our observations, the magnitude V ≈ U during this period, although the cool component of this symbiotic binary is a M5 III giant (Kenyon and Fernandez-Castro, 1987). The outburst phase has been confirmed by visual magnitude estimates (Green, 1989) and by our data (9.9) from 1989 Nov. The value of the U - B index has been increasing up to our most recent observations of 1990 Aug 31 (Fig. 9). The values of the B - V colour index and the V magnitude itself were more or less constant or varied irregularly around 0.4 and 9.7, respectively. This increase in the blue continuum probably reflects a strong interaction in the UV spectral region.

The visual observations are displayed in Fig. 10. They indicate a minimum near mag = 11.6 in 1988 May - Dec and an outburst at mag = 9.9 in 1989 Nov.

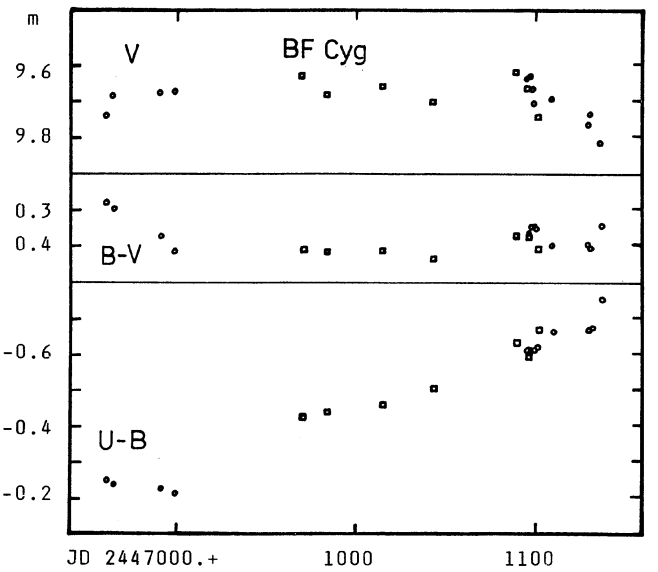

Fig. 10 UBV observations of BF Cyg: ∘ Skalnaté Pleso, □ Wroclaw Observatories.

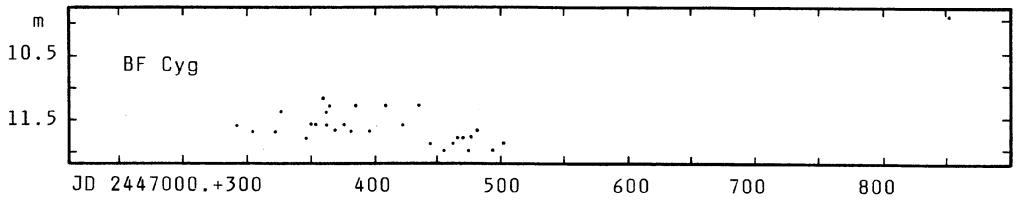

Fig. 11 Visual observations of BF Cyg.

h/ CH Cyg

This star was observed photoelectrically on 37 nights between 1989 Oct 24 and 1990 Aug 31. The stars S1: HD 184786 (V = 5.91, B − V = 1.62, U − B = 1.74, M8), S2: SAO 48428 (m_v = 8.0, m_{pg} = 8.6, F8) and S3: HD 182691 (V = 6.525, B−V = −0.078, U−B = −0.240) were used as comparisons. However, S1 ex-

Table 9.

Photoelectric observations of CH Cyg

Date	2447000.+	V	B−V	U−B	ΔU	ΔB	ΔV	Obs
24 Oct 89	824.217	8.103	1.671	0.783				SP
13 Nov 89	844.228	8.483	1.403	0.424				SP
14 Nov 89	845.211	8.500	1.442	0.498				SP
17 Nov 89	848.245	8.478	1.398	0.426				SP
18 Nov 89	849.239	8.425	1.375	0.262				SP
19 Nov 89	850.206	8.438	1.395	0.397				SP
20 Nov 89	851.238	8.475	1.487	0.630				SP
29 Nov 89	860.233	8.398	1.339	0.373				SP
3 Dec 89	864.227	8.334	1.608	0.861	−0.409	1.225	2.374*	SP
29 Dec 89	890.253	7.984	1.770	1.023	−0.469	1.160	2.317*	SP
8 Jan 90	900.227	8.211	1.769	0.969	−0.547	1.161	2.301*	SP
6 Feb 90	928.658	8.812	1.674	0.677	−0.561	1.113	2.291*	SP
18 Mar 90	968.625	8.548	1.691	0.865	−0.623	1.094	2.256*	SP
19 Mar 90	969.588	8.693	1.813	0.400	2.694	2.414	1.836+	W
19 Mar 90	969.610	8.697	1.792	0.422	2.689	2.397	1.834+	W
20 Mar 90	970.617	8.514	1.717	0.860	−0.605	1.109	2.273*	SP
25 Mar 90	975.604	8.507	1.703	0.773	−0.544	1.172	2.333*	SP
1 Apr 90	982.608	8.570	1.727	0.907	−0.482	1.225	2.355*	SP
2 Apr 90	983.515	8.602	1.782	0.411	2.670	2.388	1.836+	W
2 Apr 90	983.524	8.585	1.808	0.423	2.695	2.397	1.837+	W
2 Apr 90	983.545	8.596	1.791	0.478	2.696	2.387	1.830+	W
2 Apr 90	983.570	8.600	1.814	0.472	2.700	2.405	1.837+	W
2 Apr 90	983.588	8.577	1.716	0.885	−0.469	1.223	2.399*	SP
2 Apr 90	983.596	8.598	1.817	0.450	2.702	2.416	1.837+	W
2 Apr 90	983.619	8.595	1.814	0.445	2.688	2.404	1.823+	W
2 May 90	1014.469	9.022	1.622	−0.046	2.696	2.399	1.830+	W
2 May 90	1014.498	9.028	1.649	−0.058	2.732	2.402	1.837+	W
3 May 90	1014.520	9.021	1.617	−0.104	2.705	2.420	1.839+	W
3 May 90	1014.546	9.038	1.647	−0.089	2.694	2.405	1.834+	W
20 May 90	1031.526	9.039	1.309	−0.171	−0.501	1.187	2.366*	SP
30 May 90	1042.393	9.097	1.338	−0.498	2.708	2.428	1.840+	W
30 May 90	1042.452	9.107	1.315	−0.466	2.726	2.421	1.850+	W
31 May 90	1042.530	9.116	1.327	−0.469	2.668	2.406	1.843+	W
3 Jun 90	1046.495	9.028	1.265	−0.250	−0.547	1.148	2.326*	SP
27 Jun 90	1069.503	8.993	1.409	−0.060				SP
27 Jun 90	1070.492	8.881	1.202	−0.274	−0.519	1.206	2.392*	SP
11 Jul 90	1084.496	8.672	1.215	−0.285	−0.591	1.155	2.346*	SP
13 Jul 90	1085.506	8.650	1.177	−0.340	−0.627	1.134	2.323*	SP
15 Jul 90	1088.375	8.717	1.346	−0.511	2.708	2.416	1.844+	W
23 Jul 90	1095.536	8.600	1.222	−0.540	2.675	2.404	1.828+	W
24 Jul 90	1097.495	8.646	1.123	−0.419	−0.494	1.251	2.448*	SP
27 Jul 90	1099.527	8.646	1.124	−0.427	−0.496	1.257	2.426*	SP
27 Jul 90	1100.414	8.622	1.329	−0.576	2.689	2.414	1.843+	W
28 Jul 90	1100.537	8.533	1.223	−0.519	2.692	2.408	1.840+	W
29 Jul 90	1101.537	8.599	1.091	−0.509	−0.517	1.225	2.417*	SP
3 Aug 90	1106.554	8.546	1.310	−0.590	2.705	2.426	1.840+	W
3 Aug 90	1106.565	8.542	1.239	−0.564	2.710	2.420	1.848+	W
26 Aug 90	1129.543	8.606	1.142	−0.540	−0.537	1.198	2.314*	SP
31 Aug 90	1135.375	8.694	1.274	−0.464	−0.559	1.177	2.423*	SP

+ S2 − S3, * S2 − S1

hibited light variations of $\Delta U_{max} \approx \pm 0.1$ mag, $\Delta B_{max} \approx \pm 0.08$mag and $\Delta V_{max} \approx \pm 0.09$ mag (Table 9). Therefore, it cannot be used as a standard star anymore. The U and V light curves of CH Cyg are shown in Fig. 12. The strong and rapid brightness variations in all three filters were characteristic for CH Cyg over the whole observational period. The greatest brightness change by about 1.8 mag was observed in the U colour from mid-March (11.0) to August 1990 (9.2), as in the summer of 1989. The V brightness decreased at a rather regular rate of about 0.6 mag / 100 days. It reached two minima near V = 9.2 at the beginning of 1990 March and in 1990 May.

A total of 953 visual magnitude estimates of CH Cyg were obtained during the years 1988 - 1989 (Fig. 13). They indicate a steady decrease in the star's brightness from 7.8 in 1988 Jan to 9.2 in Jun, when the star was fainter than when previously seen. Subsequent oscillations with maxima of 7.7 - 8.6 and minima of 8.3 - 9.0 in a cycle of 100 days are probably due to the semiregular variations in the red giant component.

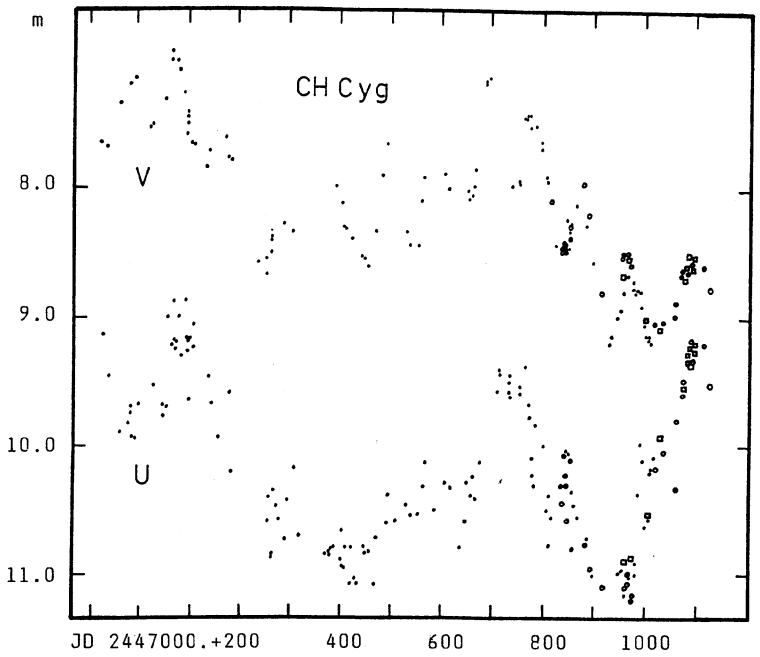

Fig. 12 U and V light curves of CH Cyg: • data from the literature, ◦ observations from Skalnaté Pleso and □ Wroclaw observatories.

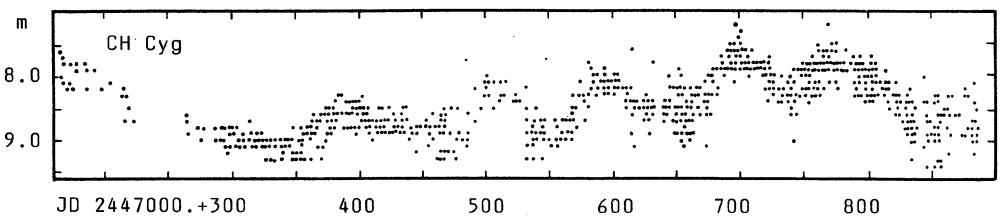

Fig. 13 Visual observations of CH Cyg.

i/ CI Cyg

The star was observed photoelectrically on 5 nights between 1990 Apr 2 and Jul 27. The stars S1: SAO 68948 (V = 8.55, B - V = -0.04, U - B = -0.33, B9) and S2: BD +35° 3821 (V = 10.49, B - V = 0.31, U - B = 0.13) were used as the standard and the check star, respectively. CI Cyg changed its V brightness in the range of 10.6 - 10.8 and was near 12 in the U and B filters during this period. The results are summarized in Table 10.

As for the visual observations (Fig. 14), we can see only minor variations around mag 11.0 until 1989 May when the star began to fade reaching 11.7 mag by 1989 Sep - Dec. From the elements in the GCVS (Kholopov et al., 1985), an eclipse of 137 days centered on 1989 Oct 23 followed.

Table 10.

Photoelectric observations of CI Cyg

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
2 Apr 90	983.583	10.674	1.438	0.065	-2.673	-2.271	-1.823*	W
2 May 90	1014.534	10.819	1.345	-0.108	-2.694	-2.282	-1.853*	W
30 May 90	1042.492	10.588	1.395	-0.109	-2.686	-2.260	-1.848*	W
22 Jul 90	1095.506	10.643	1.350	-0.133	-2.642	-2.268	-1.835*	W
27 Jul 90	1100.443	10.646	1.361	-0.165	-2.691	-2.291	-1.844*	W

* S1 - S2

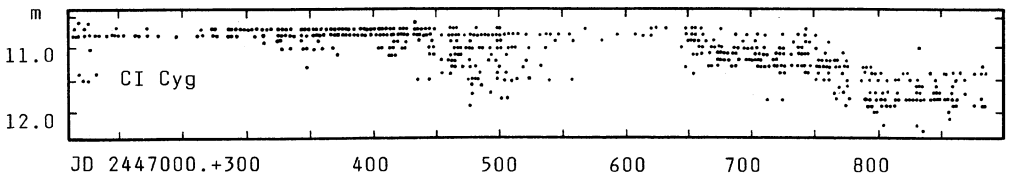

Fig. 14 Visual observations of CI Cyg.

j/ V1016 Cyg

Only one measurement was made on 1990 Jul 28. The stars S1: HD 188326 (V = 7.56, B - V = 0.78, U - B = 0.35, G8) and S2: SAO 48986 (m_v = 9.1, m_{pg} = 10.2) were used as the comparison and the check, respectively. The single result can be found in Table 11.

The visual observations are depicted in Fig. 15.

Table 11.

Photoelectric observations of V1016 Cyg

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
28 Jul 90	1100.556	11.282	0.180	-0.629	-1.485	-1.788	-2.005*	W

* S1 - S2

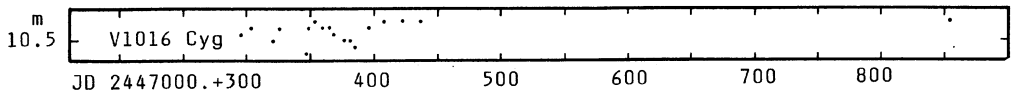

Fig. 15 Visual observations of V1016 Cyg.

k/ V1329 Cyg

The star was observed photoelectrically on 3 nights between 1988 Sep 26 and 1988 Sep 30. The stars S2, S4 and S5 were used as comparisons (the relevant data for these stars can be found in Table 12 and is depicted in Fig. 16). The observations (Table 13) were made shortly after the maximum of the star's brightness. The V magnitudes are depicted together with the visual observations in Fig. 17.

Table 12.

Comparison stars for V1329 Cyg

No	Star	V	B-V	U-B
1	BD+35 4294	10.16	1.07	
2	BD+35 4290	10.34	1.07	0.88
3		11.06	1.22	1.11
4		11.61	1.39	1.49
5		12.28	1.11	1.29
6		13.59	0.82	
7		13.46	1.02	
8		B = 15.9		
9		B = 16.2		

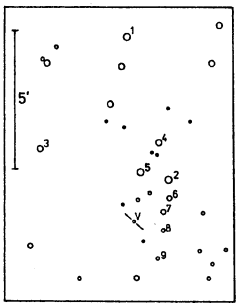

Fig. 16 The identification chart for V1329 Cyg

Table 13

Photoelectric observations of V1329 Cyg

Date	2447000.+	ΔU	ΔB	ΔV	ΔU	ΔB	ΔV	Obs
26 Sep 88	431.320		0.69	1.34$		-0.46	-0.55*	K
26 Sep 88	431.358	-1.6	0.24	0.83&				K
28 Sep 88	433.270	1.1	2.28	2.69@	-2.4	-2.06	-1.82+	K
			0.65	1.34$	-2.2	-1.63	-1.34#	K
		-1.2	0.21	0.87&				K
30 Sep 88	435.320	1.2	2.29	2.71@	-2.4	-2.06	-1.84+	K
		-1.2	0.227	0.85&				K

$ V1329 Cyg - S4, & V1329 Cyg - S5, @ V1329 Cyg - S2;
* S4 - S5, + S2 - S5, # S2 - S4

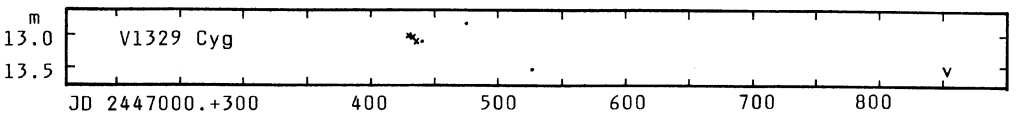

Fig. 17 x - V magnitudes and . - visual observations of V1329 Cyg.

1/ AG Dra

The photoelectric observations were obtained on 6 nights between 1990 Mar 18 and Jul 27. The stars S1: SAO 16952 = BD +67° 925 (V = 9.88, B − V = 0.56, U − B = −0.04, G0) and S2: SAO 16935 (m_v = 9.8. m_{pg} = 10.6) were used as the comparison and the check, respectively. AG Dra seems to stay at its minimum brightness phase with V about 9.8. The results are sumarized in Table 14.

The visual observations are displayed in Fig. 18.

Table 14.

Photoelectric observations of AG Dra

Date	2447000.+	V	B−V	U−B	ΔU	ΔB	ΔV	Obs
18 Mar 90	969.505	9.809	1.455	0.783	−2.363	−0.530	0.416*	W
2 Apr 90	983.634	9.800	1.410	0.829	−2.374	−0.516	0.385*	W
2 May 90	1014.402	9.778	1.426	0.809	−2.271	−0.546	0.396*	W
30 May 90	1042.440	9.806	1.429	0.719	−2.442	−0.540	0.393*	W
15 Jul 90	1088.384	9.827	1.435	0.646	−2.282	−0.549	0.387*	W
27 Jul 90	1100.396	9.971	1.432	0.696	−2.270	−0.493	0.416*	W

* S1 − S2

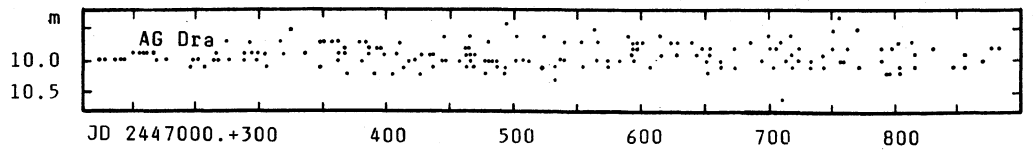

Fig. 18 Visual observations of AG Dra

m/ CQ Dra (4 Dra)

In addition to our first 10 observational runs of this unique symbiotic-like/cataclysmic triple system, presented and briefly discussed in Paper I of this series (Skopal et al., 1990), we have obtained 36 more runs on 35 nights between 1989 Sep 1 and 1990 Sep 23. The data of 1989 Sep 1, although taken during the time interval described in Paper I, were recovered too late to be included in that earlier paper. Their inclusion, however, affects the discussion presented in Paper I as far as the comparison of the 1989 Aug − Sep "mini-flare" between the individual filters is concerned. Table 15 contains the mean differences in the U, B and V colours between 4 Dra and our main standard star, 6 Dra, for the individual runs. As can easily be seen in looking at Fig. 20 (in this figure, for the sake of completeness and clarity, we have also included the data points presented in Paper I), where the results of our long-term UBV monitoring of CQ Dra (4 Dra) are displayed, the behaviour of the star over the whole observational interval is clearly different in the individual filters. The data reveal a steady decline of about 0.3 mag in U and 0.2 mag in B. This decline is hardly visible in V, if present at all. The

slope of the decline in U and B changes at about JD 2447950 when it levels out and then turns into a rise after about JD 2447980. It seems that the slope of the rise is much steeper than that of the decline although, given the occurrence of an irregular variability during the decline, this particular point has to be verified by further data. The light curves in all three filters exhibit an irregular variability on a time scale of weeks with an amplitude of up to 0.15 mag. As for this mode of variability, there exists a general morphological similarity between all three filters. The data show that, towards the end of the decline and during levelling out and rise, the level of the irregular activity of the star on a time scale of weeks is rather low. The U and (less apparently) B light curves are well correlated with the radial-velocity-based 1703-day orbital ephemeris for the CQ Dra (4 Dra) system given by Reimers et al. (1988). The time span of our observations corresponds to the phase interval 0.777 - 0.106 of their ephemeris. As we have already discussed in a conference paper to appear in these Contributions, on the basis of a more limited observational material obtained up to 1990 Apr 1 (Urban and Hric, 1990), the data lead us to the conclusion that we have accomplished the first optical photometric detection of the orbital motion within the CQ Dra (4 Dra) A +BC system. Our new more numerous observational material fully supports this earlier conclusion (see Fig.19). The evidence for the presence of rapid (hours) variations in CQ Dra, best pronounced in the U colour, is now stronger than at the time Paper I was written, but the issue has still not been settled

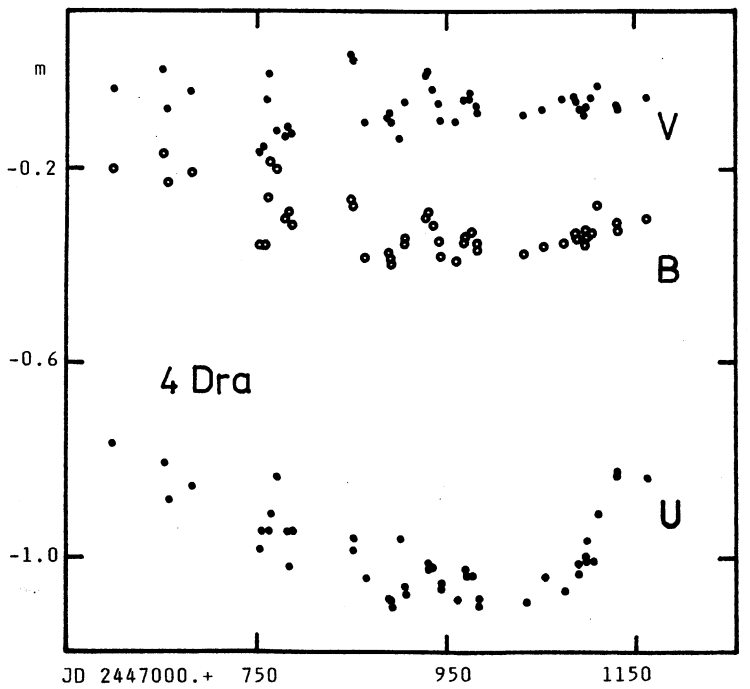

Fig. 19 UBV observations of CQ Dra (4 Dra).

definitely (see Urban and Hric, 1990). A full scale detailed analysis of our UBV photometry of CQ Dra (4 Dra) is now underway and the results will appear elsewhere.

Table 15.

Photoelectric observations of CQ Dra (4 Dra).

Date	2447000.+	ΔU	ΔB	ΔV	Obs
1 Sep 89	771.441	0.826	0.198	0.115	SP
18 Sep 89	787.594	0.936	0.314	0.118	SP
18 Nov 89	848.606	0.949	0.259	−0.042	SP
19 Nov 89	849.613	0.972	0.264	−0.040	SP
3 Dec 89	864.411	1.033	0.380	0.098	SP
28 Dec 89	888.671	1.077	0.372	0.086	SP
29 Dec 89	889.648	1.079	0.370	0.082	SP
30 Dec 89	890.667	1.090	0.377	0.092	SP
31 Dec 89	891.634	1.087	0.387	0.093	SP
8 Jan 90	900.488	0.952	–	0.131	SP
13 Jan 90	905.400	1.049	0.341	0.056	SP
14 Jan 90	905.612	1.063	0.346	0.056	SP
7 Feb 90	929.509	1.010	0.293	−0.005	SP
8 Feb 90	930.540	1.001	0.287	−0.001	SP
14 Feb 90	936.546	1.011	0.314	0.030	SP
18 Feb 90	940.578	1.042	0.347	0.060	SP
20 Feb 90	942.537	1.041	0.379	0.091	SP
8 Mar 90	958.527	1.079	0.387	0.095	SP
17 Mar 90	968.495	1.015	0.346	0.055	SP
19 Mar 90	970.497	1.024	0.342	0.054	SP
24 Mar 90	975.450	1.030	0.329	0.039	SP
1 Apr 90	982.555	1.072	0.351	0.068	SP
1 Apr 90	983.454	1.090	0.364	0.077	SP
19 May 90	1031.428	1.080	0.372	0.085	SP
9 Jun 90	1052.492	1.029	0.357	0.072	SP
30 Jun 90	1073.405	1.057	0.350	0.050	SP
11 Jul 90	1084.423	1.004	0.330	0.055	SP
12 Jul 90	1085.440	1.022	0.341	0.049	SP
23 Jul 90	1095.534	0.991	0.349	0.082	SP
23 Jul 90	1096.442	0.988	0.342	0.063	SP
25 Jul 90	1097.537	0.961	0.344	0.072	SP
28 Jul 90	1101.370	0.996	0.337	0.051	SP
4 Aug 90	1108.495	0.903	0.272	0.025	SP
25 Aug 90	1128.592	0.817	0.307	0.064	SP
26 Aug 90	1129.589	0.817	0.320	0.063	SP
23 Sep 90	1158.345	0.828	0.300	0.048	SP

n/ YY Her

Only one photoelectric measurement was obtained on 1990 Mar 18. The stars S1: HD 167193 (V = 6.13, B − V = 1.47, U − B = 1.72, K4 III) and S2: SAO 85839 (m_v = 8.6, m_{pg} = 9.3, K0) were used as comparisons. The result can be found in Table 16.

The visual observations are shown in Fig. 20.

Table 16.

Photoelectric observation of YY Her

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
19 Mar 90	969.551	12.826	1.359	-0.249	-1.604	-2.014	-2.231*	W

* S1 - S2

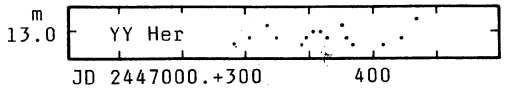

Fig. 20 Visual observations of YY Her.

o/ V443 Her

Again, only one photoelectric measurement was obtained on 1990 Mar 18. The stars S1: HD 168958 (V = 6.99, B - V = -0.12, U - B = -0.56, B3) and S2: SAO 85979 (m_v = 8.5, m_{pg} = 9.6, K5) were used as the comparison as the check, respectively. The result is in Table 17.

The visual observations were obtained only in 1988 and are depicted in Fig. 21.

Table 17.

Photoelectric observation of V443 Her

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
19 Mar 90	969.571	11.501	-0.115	0.750	-5.425	-3.157	-1.589*	W

* S1 - S2

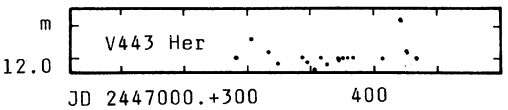

Fig. 21. Visual observations of V443 Her

p/ BX Mon

The visual observations of this symbiotic star do not fit the GCVS elements with the period of 1374 days which predict a minimum in 1989 May and maximum on 1990 Nov 11. The results of the visual observations are shown in Fig. 22.

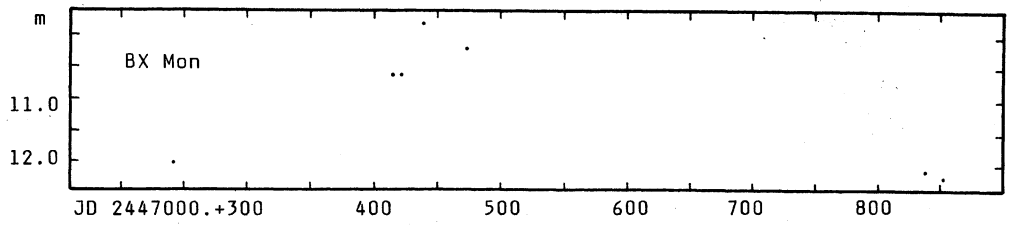

Fig. 22. Visual observations of BX Mon

q/ RS Oph

In looking at the visual observations depicted in Fig. 23, we can easily distinguish erratic variations in the range 11.2 - 12.0, including a dip of about 0.5 mag lasting about 15 days and centered on 1989 Sep 28 (JD 2447798).

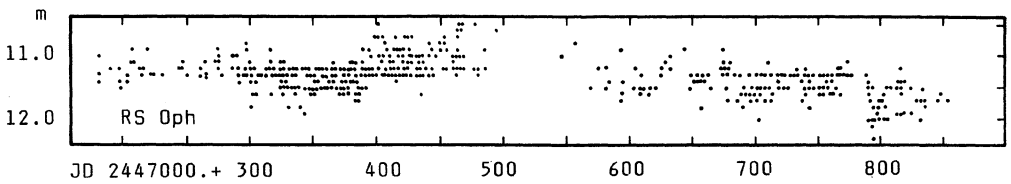

Fig. 23 Visual observations of RS Oph.

r/ AG Peg

This star was observed photoelectrically on 3 nights, 1990 Jul 21, 23 and 27. Unfortunately, the comparison star S1 was identified erroneously in our campaign's chart material. An S1 star: $\alpha_{1950} = 21^h47^m48^s.5$, $\delta_{1950} = +12^o06'06"$ was used as the comparison, instead of the S2: BD $+11^o$ 4681 (V = 8.10, B - V = -1.06, U - B = 0.97, K0) which was used as the check star. We determined the S1 star: V = 10.360, B - V = 0.355, U - B = 0.213 from the S1 - S2 differences: Δ U = 0.808 ± 0.015 (3 nights), Δ B = 1.565 ± 0.006 (3 nights) and Δ V = 2.260 ± 0.036 (3 nights). Al the results are summarized in Table 18.

The light variations evident in the visual observations (Fig. 24) with a period of about 800 days are apparently linked to the orbital motion. It is hard to date exactly the maxima and minima owing to the small amplitude and the seasonal gaps. The minimum (8.7) may have occurred at about 1988 Apr (JD 2447260:), the maximum (8.4) at about 1988 Dec (JD 2447525:). This is, again, in contradiction with the GCVS elements (760-day period) which predict

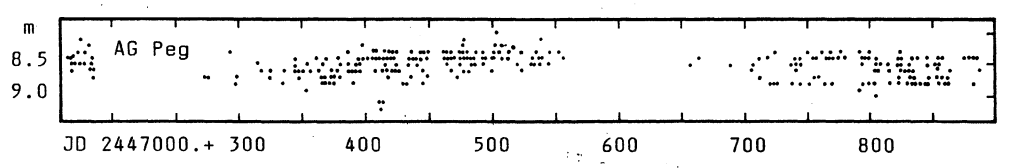

Fig. 24 Visual observations of AG Peg.

the minimum for 1989 June.

Table 18.

Photoelectric observations of AG Peg

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
21 Jul 90	1093.542	8.689	1.344	0.153	0.835	1.575	2.321*	W
23 Jul 90	1095.529	8.724	1.273	0.124	0.804	1.553	2.231*	W
27 Jul 90	1100.466	8.699	1.247	0.167	0.784	1.567	2.217*	W

* S1 - S2

s/ AX Per

The photoelectric observations of this star were obtained on 18 nights between 1989 Nov 29 and 1990 Aug 31. The stars S1: HD 10063 (V = 7.39, B - V = 0.25, U - B = -0.33, B8) and S2: SAO 22444 (m_v = 7.8, m_{pg} = 8.3, K0) were used as the comparison and the check, respectively. The differences Δ U (S2 - S1) = 1.765 ± 0.004 (18 nights), Δ B (S2 - S1) = 0.803 ± 0.004 (18 nights) and Δ V (S2 - S1) = 0,037 ± 0.003 (18 nights) derived from our measurements yield V = 7.427, B - V = 1.016 and U - B = 0.632 for the check star.

The results are compiled in Table 19 and displayed in Fig. 25. In 1989 Dec, AX Per reached the maximum of its brightness: V = 9.28, B - V = 0.58, U - B = -0.40. During the period from 1990 Jan to Feb 22, a gradual decrease of the star's brightness in all filters of about 0.4 - 0.5 mag is indicated. During the time interval from 1990 Feb 22 to Mar 20, the light curve probably exhibited a flat minimum around the phase of about 0.55 (according to the ephemeris JD_{min} = 2436679.4 + 681.6 x E (Kenyon, 1982)). This behaviour can be interpreted as an eclipse of the cool component by its hot companion. The fact that the minima in the U abd B light curves are deeper than that in the V light curve along with the eclipsed star being a M3 III giant, implies the existence of an additional radiation source in these spectral bands, probably displaced on the red-giant hemisphere facing the hot companion. We have discussed this phenomenon in more detail elsewhere (Skopal and Komarek, 1990).

The visual observations cover the period from 1988 Jan to 1989 Dec and are displayed in Fig. 26. Between 1988 Jan 12 and 1989 Mar, the star's brightness increased from 11.7 to 9.2. An outburst had clearly begun. A deep minimum, corresponding to an eclipse of the hot component by the cool one, lasted for about 390 days and took the star below 12.2 for about 60 days. Although minimum brightness was not actually observed, the date of its occurrence can be estimated as 1989 Jan 25 (JD 2447552). One can note that this estimate is not consistent with the ephemeris given by Kenyon (the difference is about 33 days). The interval from the beginning of the decline to the minimum, lasting about 150 days, was shorter than the rise which took about 240 days. In late 1989, AX Per was again near 9.2 and possibly beginning to fade.

Table 19.

Photoelectric observations of AX Per

Date	2447000.+	V	B-V	U-B	ΔU	ΔB	ΔV	Obs
29 Nov 89	860.300	9.276	0.597	-0.397	1.769	0.816	0.038	SP
3 Dec 89	864.284	9.289	0.557	-0.393	1.786	0.833	0.053	SP
27 Dec 89	888.324	9.262	0.598	-0.422	1.785	0.831	0.055	SP
8 Jan 90	900.292	9.304	0.621	-0.432	1.777	0.816	0.042	SP
13 Jan 90	905.330	9.357	0.642	-0.441	1.786	0.816	0.051	SP
29 Jan 90	921.360	9.575	0.665	-0.497	1.764	0.803	0.032	SP
6 Feb 90	929.384	9.562	0.673	-0.489	1.755	0.787	0.025	SP
7 Feb 90	930.378	9.582	0.655	-0.461	1.760	0.795	0.031	SP
10 Feb 90	933.364	9.576	0.662	-0.483	1.764	0.794	0.030	SP
17 Feb 90	940.258	9.659	0.736	-0.555	1.766	0.813	0.040	SP
21 Feb 90	944.266	9.631	0.731	-0.501	1.749	0.784	0.014	SP
22 Feb 90	945.277	9.636	0.752	-0.508	1.762	0.802	0.027	SP
23 Feb 90	946.259	9.637	0.719	-0.488	1.739	0.790	0.019	SP
25 Feb 90	948.260	9.625	0.756	-0.491	1.744	0.791	0.022	SP
17 Mar 90	968.273	9.635	0.752	-0.480	1.754	0.798	0.043	SP
19 Mar 90	970.269	9.634	0.710	-0.479	1.752	0.799	0.047	SP
27 Jul 90	1100.517	10.229	0.827	-0.378	1.793	0.776	0.058	W
31 Aug 90	1134.556	10.336	0.840	-0.368	1.770	0.805	0.041	SP

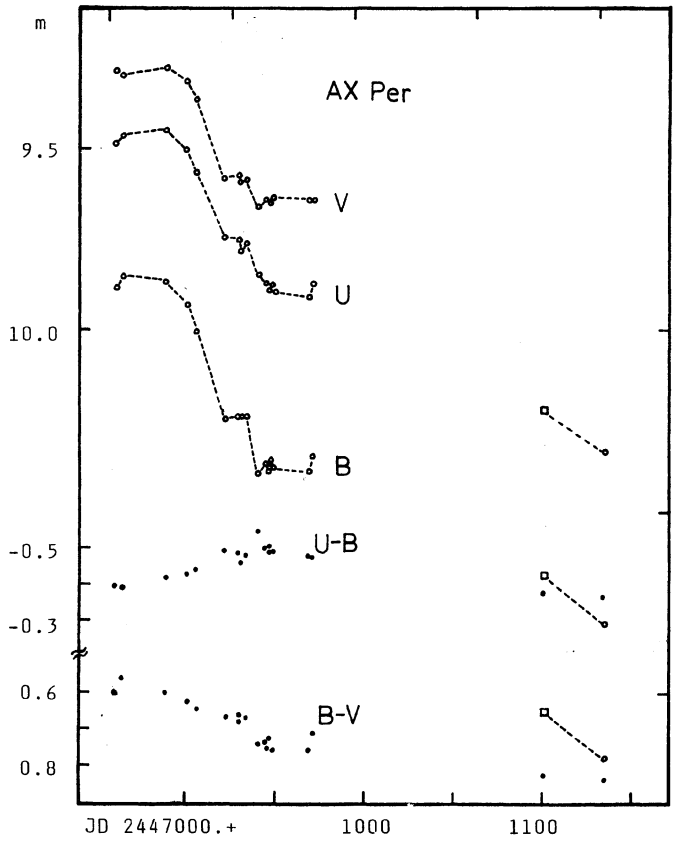

Fig. 25 UBV observations of AX Per: ∘ Skalnate Pleso and □ Wroclaw Observatories.

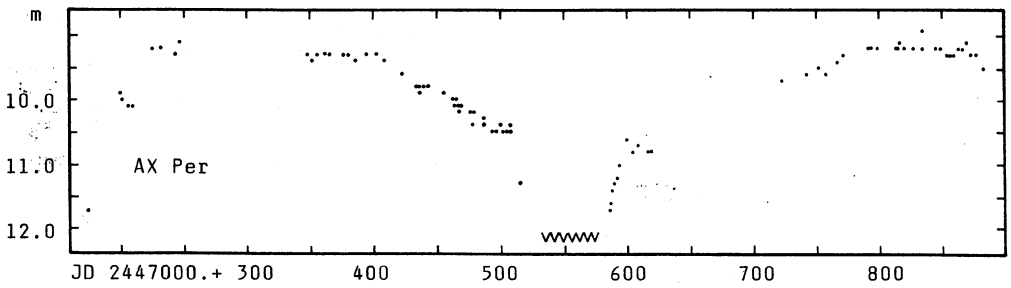

Fig. 26 Visual observations of AX Per.

t/ PU Vul

The photoelectric UBV observations of PU Vul were made in the period from 1983 Sep 28 to 1990 Jul 27. The parameters of the standard stars used can be found in Table 20. PU Vul kept its brightness virtually constant between 1983 Sep 28 (JD 2445606) and 1985 Jun 30 (JD 2446247): V ≈ 8.5, B − V ≈ 0.4 and U − B ≈ 0.0. During the period from 1986 Jun 27 (JD 2446609) to 1986 Oct 4 (JD 2446708), small decreases of about 0.2 and 0.15 in the V and B filters, respectively, were observed, although the U magnitude did not change significantly until 1987 Oct 29 (JD 2447098). Thereafter a gradual decrease was recorded in all three colours over the whole interval up to the most recent observations. Moreover, the U-B colour index significantly changed its value by about −0.7 mag, while the value of the B-V index remained almost the same.

Table 20.
Photometric data for standard stars of PU Vul

	Object	V	B−V	U−B	Sp
S1	HD 193706	7.84	1.64	1.98*	K5
	SAO 88555	7.900	1.625	1.93+	
	BD+21 4167	±6	±5	±2	
S2	HD 193859	8.22	−0.04	−0.46*	A0
	SAO 88572	8.200	−0.100	−0.500+	
	BD+20 4533	±8	±10	±10	
S3	BD+21 4165	9.23	0.57	−0.01*	F8
	SAO 88548	9.245	0.520	−0.025+	
		±5	±3	±10	
S4	BD+21 4130	6.120	1.040	0.90+	K1
	SAO 88433	±5	±5	±1	
S5	BD+23 3943	7.180	0.960	0.73+	G5
	SAO 88417	±5	±5	±1	

* According to Blanco, D.M., Demers, S., Douglas, G.G., Fitzgerald, M.P.: 1968, Publ. U. S. Naval Obs., 2nd ser. 21.
+ According to the measurement carried out at the Brno Observatory

The results are summarized in Tables 21 and 22 and displayed in Fig. 27.

The visual observations (Fig. 28) support the above behaviour distinguished from the photoelectric data. The large scatter of the visual observations might reflect personal and instrumental effects.

Table 21.

Photoelectric observations of PU Vul

Date	2440000.+	V	B − V	U − B	Obs
28 Sep 83	5606.35	8.522 ±.008	0.465 ±.010	0.070 ±.005	B
1 Oct 83	5609.44	8.510 .015	0.46 .02	– –	B
5 Oct 83	5613.40	8.576 .011	0.422 .012	0.02 .01	B
7 Oct 83	5615.35	8.542 .005	0.41 .01	0.04 .01	B
13 Oct 83	5621.31	8.494 .017	0.44 .02	0.075 .005	B
7 Nov 83	5646.21	8.520 .005	0.413 .010	0.130 .010	B
19 Apr 84	5810.60	8.520 .008	–	–	B
1 Jun 84	5853.54	8.591 .007	0.40 .02	0.06 .04	B
27 Aug 84	5940.35	8.517 .008	0.447 .010	0.13 .02	B
28 Aug 84	5941.50	8.530 .006	0.445 .010	0.03 .05	B
4 Sep 84	5948.36	8.523 .003	0.426 .003	0.063 .007	B
20 Apr 85	6176.60	8.545 .010	0.433 .010	–	B
21 Apr 85	6177.58	8.568 .015	0.470 .015	0.00 .02	B
11 May 85	6197.55	8.490 .005	0.445 .010	0.04 .01	B
26 May 85	6212.54	8.480 .008	0.428 .013	0.025 .010	B
4 Jun 85	6221.52	8.491 .005	0.42 .02	0.06 .02	B
30 Jun 85	6247.48	8.518 .008	0.430 .015	0.09 .04	B
4 Jul 85	6251.55	8.500 ±.007	0.416 ±.008	0.112 ±.013	B
6 Jul 85	6253.55	8.503 .005	0.443 .012	0.082 .013	B
12 Aug 85	6290.47	8.550 .005	0.445 .007	0.10 .02	B
14 Aug 85	6292.48	8.510 .013	0.440 .017	0.103 .011	B
15 Aug 85	6293.45	8.543 .006	0.463 .014	0.044 .015	B
22 Aug 85	6300.45	8.504 .008	0.49 .03	0.00 .04	B
30 Aug 85	6308.42	8.513 .015	0.42 .02	0.080 .013	B
31 Aug 85	6309.43	8.540 .010	0.458 .011	0.001 .014	B
2 Sep 85	6311.46	8.555 .008	0.459 .012	−0.055 .012	B
9 Sep 85	6318.34	8.570 .006	0.405 .009	−0.019 .009	B
18 Sep 85	6327.36	8.530 .005	0.404 .006	−0.022 .006	B
25 Sep 85	6334.34	8.495 .014	0.402 .017	0.030 .012	B
29 Sep 85	6338.33	8.503 .007	0.418 .007	−0.019 .008	B
1 Oct 85	6340.38	8.499 .008	0.413 .010	−0.015 .006	B
4 Oct 85	6343.33	8.506 .008	0.404 .009	0.012 .006	B
24 Oct 85	6363.28	8.559 .011	0.443 .011	0.038 .003	B
3 Nov 85	6373.31	8.538 .008	0.407 .008	0.072 .009	B
6 Nov 85	6376.32	8.50 .04	0.48 .04	0.04 .02	B
11 Nov 85	6381.30	8.53 .03	0.47 .03	0.041 .014	B
27 Jun 86	6609.53	8.650 .009	0.430 .010	0.012 .006	B
30 Jun 86	6612.51	8.67 .01	0.44 .01	0.07 .01	B
2 Jul 86	6614.49	8.675 .006	0.462 .014	−0.012 .013	B
14 Jul 86	6626.50	8.570 .003	0.426 .003	−0.027 .012	B
4 Sep 86	6678.40	8.69 .04	0.43 .04	−0.20 .02	B
19 Sep 86	6693.36	8.69 .02	0.44 .03	−0.090 .014	B
26 Sep 86	6700.35	8.665 .005	0.378 .012	−0.065 .014	B
1 Oct 86	6705.32	8.723 .009	0.415 .009	−0.079 .007	B
4 Oct 86	6708.33	8.760 .011	0.428 .015	−0.130 .012	B
21 Sep 87	7060.41	8.870 .005	0.490 .004	−0.380 .014	B
24 Sep 87	7063.35	8.905 .010	0.484 .009	−0.42 .01	B
9 Oct 87	7078.28	8.927 .007	0.498 .010	−0.434 .009	B
14 Oct 87	7083.32	8.937 .008	0.455 .008	−0.495 .010	B
27 Oct 87	7096.29	9.021 .008	0.500 .010	−0.612 .010	B
29 Oct 87	7098.27	9.02 .03	0.48 .03	−0.575 .004	B
9 May 88	7291.58	9.650 .005	0.416 .007	−0.611 .009	B
9 Jun 88	7322.58	9.68 .02	0.445 .015	−0.590 .015	B

Table 21 (continued)

Date	2440000.+	V		B − V		U − B		Obs
12 Jun 88	7325.53	9.740	.010	0.400	.007	−0.615	.012	B
16 Jun 88	7329.53	9.647	.004	0.405	.005	−0.615	.005	B
25 Jul 88	7368.51	9.710	.015	0.440	.015	−0.645	.005	B
13 Aug 88	7387.48	9.753	.008	0.420	.007	−0.625	.010	B
14 Aug 88	7388.45	9.770	.018	0.395	.015	−0.66	.01	B
17 Aug 88	7391.44	9.811	.008	0.390	.010	−0.630	.010	B
28 Aug 88	7402.37	9.793	.009	0.40	.01	−0.62	.01	B
1 Sep 88	7406.39	9.78	.02	0.40	.02	−0.62	.03	B
8 Sep 88	7413.39	9.860	.010	0.390	.010	−0.655	.010	B
10 Sep 88	7415.40	9.795	.010	0.38	.02	−0.61	.03	B
28 Sep 88	7433.32	9.830	.009	0.40	.02	−0.71	.02	B
3 Oct 88	7438.32	9.900	.013	0.372	.014	−0.700	.007	B
4 Nov 88	7470.24	9.886	.014	0.435	.015	−0.66	.02	B
2d Apr 89	7641.58	10.255	.011	0.364	.012	−0.737	.007	B
17 May 89	7664.53	10.323	.016	0.345	.012	−0.69	.02	B
23 May 89	7670.54	10.35	.02	0.39	.02	−0.66	.03	B
9 Jun 89	7687.53	10.316	.008	0.364	.010	−0.662	.013	B
18 Jun 89	7696.52	10.35	.02	0.35	.04	-		B
24 Aug 89	7763.42	10.50	.01	0.338	.015	−0.682	.011	B
31 Aug 89	7770.41	10.48	.03	0.35	.03	−0.68	.01	B
1 Sep 89	7771.40	10.470	.010	0.37	.02	−0.64	.02	B
6 Sep 89	7776.49	10.49	.03	0.38	.03	−0.67	.02	B
7 Sep 89	7777.36	10.40	.01	-		-		B
9 Sep 89	7779.38	10.49	.02	0.38	.03	−0.65	.02	B
12 Sep 89	7782.38	10.48	.03	0.40	.03	−0.66	.02	B
18 Sep 89	7788.31	10.49	.02	-		-		B
19 Sep 89	7789.34	10.50	.01	0.37	.02	−0.70	.02	B
22 Sep 89	7792.35	10.525	.015	0.32	.02	−0.62	.04	B
4 Oct 89	7804.30	10.505	.009	0.39	.013	−0.70	.01	B
23 Oct 89	7823.27	10.62	.03	-		-		B
26 Oct 89	7826.29	10.55	.02	-		-		B
2 Nov 89	7833.30	10.60	.02	-		-		B
17 Nov 89	7860.22	10.56	.02	-		-		B
29 Nov 89	7860.22	10.56	.02	-		-		B
21 Mar 90	7971.64	10.580	.004	-		-		B

Table 22.

Photoelectric observations of PU Vul

Date	2447000.+	V	B−V	U−B	ΔU	ΔB	ΔV	Obs
19 Mar 90	969.654	10.465	0.460	−0.580	1.661	−0.273	−1.334*	W
2 Apr 90	983.607	10.506	0.453	−0.519	1.648	−0.267	−1.327*	W
3 May 90	1014.568	10.569	0.397	−0.528	3.796	1.451	−0.282+	W
31 May 90	1042.506	10.603	0.427	−0.507	3.775	1.392	−0.310+	W
21 Jul 90	1093.528	10.605	0.376	−0.633	3.835	1.425	−0.359+	W
23 Jul 90	1095.519	10.625	0.392	−0.552	3.728	1.399	−0.342+	W
27 Jul 90	1100.454	10.599	0.379	−0.488	3.748	1.445	−0.297+	W

* S1 − S3, + S1 − S2

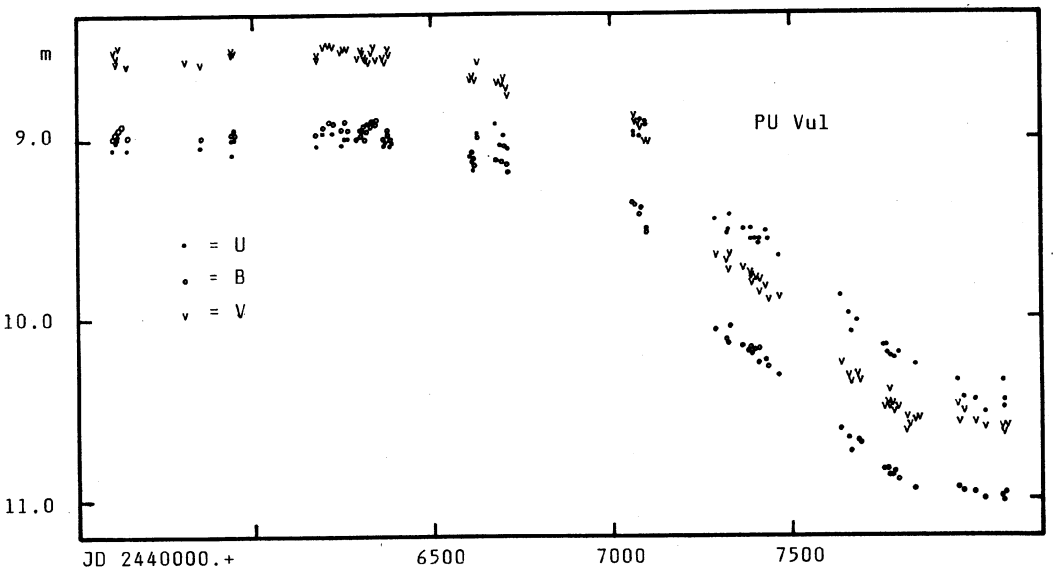

Fig. 27 UBV observations of PU Vul taken at Brno and from JD 2447969 at Wroclaw Observatories.

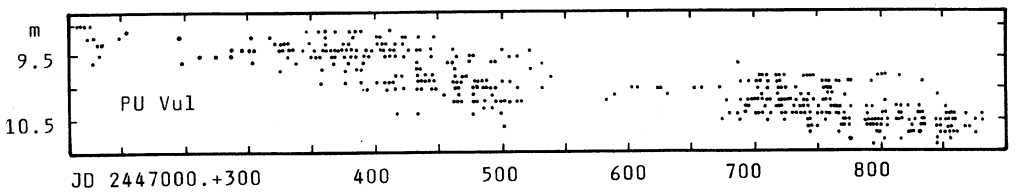

Fig. 28 Visual observations of PU Vul.

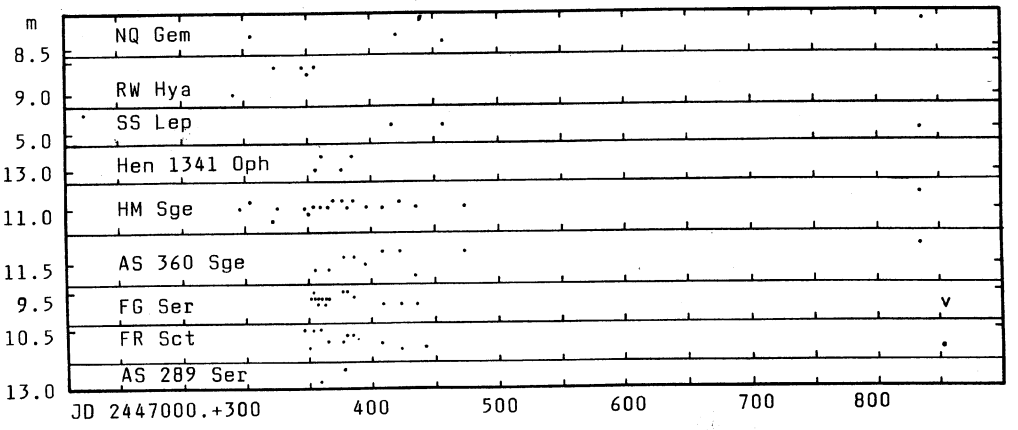

Fig. 29 The visual observations of the remaining stars.

ACKNOWLEDGEMENTS.

The coordinators of the international campaign (L. H., A. S., Z. U.) wish to express their special thanks to the other co-authors of the present paper for making available their observational material. We gratefully acknowledge very precious systematic observations of the symbiotic stars by the members of the Variable Star Section of the British Astronomical Association. As regards the visual observations of symbiotics presented in this paper, besides our co-author Mr. J. E. Isles, we are also indebted to the following people: S. W. Albrighton, N. Bone, L. K. Brundle, R. H. Chambers, R. C. Dryden, R. W. Fleet, J. Fraser, R. Fraser, M. J. Gainsford, D. Gavine, M. Harris, G. M. Hurst, C. P. Jones, R. E. Kelly, N. S. Kiernan, S. J. Lubbock, J. W. Macvey, R. J. McKim, I. A. Middlemist, R. W. Middleton, M. J. Nicholls, R. A. H. Paterson, R. D. Pickard, G. Pointer, G. Poyner, G. Ramsay, J. D. Shanklin, A. Smeaton, J. S. Smith, S. R. Srinivasan, D. Scott, D. M. Swain, A. Tanti, M. D. Taylor, J. Toone, K. West, P. J. Wheeler, W. J. Worraker, K. Xylaris and E. G. D. Youngs.

NOTE

Unfortunately, BV photometry made at the Skalnaté Pleso Observatory between JD 2447160 (December 1987) and JD 2447820 (October 1989) is not correct. We had problems with the pulse-counting amplifier-discriminator and with the correct value of the dead time. Therefore, the V and B values (more bright than about 10 - 9 mag) were shifted by 0.7 and 0.5 mag, respectively. The U values (weaker than this limit) were well defined. By October 1989 the new instrument (voltage to frequency convertor) is used. Since that time (JD 2447820) our UBV photometry is correct.

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