Photometry of symbiotic stars

IX. TX CVn, CH Cyg, AX Per and AR Pav

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Abstract. We present new photometric observations of TX CVn, CH Cyg, AX Per and AR Pav. The main results can be summarized as follows: **TX CVn**: The historical 1893 – 2000 photographic/B-band light curve (LC) is presented for the first time. From 1892 to ~1920, the star was quiet, but then entered a series of outbursts peaking in 1920, 1945, 1952 and 1962. From ~1988 till the present time, TX Cvn has gradually declined. **CH Cyg**: Our observations cover an active phase, which began in May 1998. At the beginning of June 1999 the star's brightness in the U band rapidly decreased due to an eclipse of the active inner binary (the symbiotic pair) by a cool giant in the outer orbit. **AX Per**: The historical 1887 – 2000 photographic/B-band LC is summarized here for the first time. It is characterized by long-lasting periods of quiescence with the superposition of a few bright stages lasting about 1.5 orbital cycles. Our photoelectric U, B, V observations revealed a drastic change in the LC profile, which occurred after JD 2 450 000 (1995.8). A small 0.6 mag flare at that time and consequently very broad wave-like variation in the LC developed. This event was caused by the dilution of a shell around the hot star. **AR Pav**: Our observations show that the recent active phase, which began in 1985.7 is over. During the activity, AR Pav developed a complex wave-like variation at the level of ~1.5 mag in the visual band. The transition to a quiet phase was rapid – the wave-like variation disappeared.

Key words: stars - binaries - symbiotic - photometry

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1. Introduction

Symbiotic stars are long-period interacting binaries (typical values of orbital period are 1-3 years) consisting of a red giant and a hot compact object embedded in a gaseous nebula. Many systems show stages of activity, during which the star's brightness increases by ≈2-3 mag. However, the majority of the time symbiotic systems persist in quiet phases.

During *quiet phases* the hot star radiation ionizes a portion of the neutral material supplied into the binary mainly by the cool giant wind, giving rise to the nebular continuum, which dominates the optical spectrum. The geometry of the optically thick part of the ionized region (mainly the H II zone) determines the observed shape of the LC. Generally, in such a case, we observe a wave-like variation as a function of the orbital phase. During *active phases* the hot component expands in radius and becomes significantly cooler. As a result the ionized region is suppressed and the source of the optical light is restricted mostly to the hot star pseudo-photosphere. The wave-like variation disappears, and, in the case of a high inclination of the orbital plane, a deep narrow minimum in the LC, caused by eclipse of the hot star by its giant companion, is observed.

There is a significant difference in the energy distribution of the hot star spectrum during the quiet and active phases of a symbiotic binary. The transition between these two stages then causes a variation of the geometry and location of the source of the optical light in the binary, which produces an adequate variation of the LC profile (cf. Skopal, 1998a). Therefore, the LCs of symbiotic binaries bear a great deal of information about the interaction and energetic balance in the system.

The main aim of this contribution is to present new photometric observations of selected classical symbiotic stars and to illustrate the complex behaviour of their LC resulting from different levels of activity.

2. Observations

The majority of the U, B, V, R measurements were performed in the standard Johnson system using single-channel photoelectric photometers mounted in the Cassegrain foci of 0.6-m reflectors at the Skalnaté Pleso (hereafter SP in Tables) and Stará Lesná observatories (SL). Further details about observation procedure are given in Skopal et al. (1990) and Hric et al. (1991). These new photoelectric observations continue those published by Skopal (1998b) and cover a period from May 1998 to December 1999.

Other U, B, V, R_C, I_C magnitudes in the Johnson-Cousin system, were obtained for AR Pav with the modular photometer utilizing a Hamamatsu GaAs R943-02 photomultiplier on the 0.5-m telescope at the Sutherland site of the South African Astronomical Observatory (SAAO) during two weeks in August 1999. Each observation of a variable was accompanied by the observation of a local comparison star. The measurements were done with a 20 second integration time. All observations were reduced to the Cousin E-region standard system (Menzies et al., 1989).

Photographic magnitude estimates were obtained for TX CVn from the plates collected in the archive of the Sonneberg Observatory. The data cover a period from 1935 to 1976.

About 2300 visual magnitude estimates of AR Pav were obtained during 1982 – 2000 by one of us (AJ).

3. Results

3.1. TX CVn

The results of our photometric measurements of TX CVn (HD 63173, BD+37-2318) are in Tab. 1. Stars BD+382374 (SAO 63223, V = 9.36, $B-V$ = 0.30, $U-B$ = 0.03) and HD 111113 (SAO 63189, V = 9.18, $B-V$ = 0.38, $U-B$ = -0.07), were used as a comparison and a check star, respectively. We obtained the magnitudes of the check star by its long-term measurement (1996 – 1999) with respect to the comparison star. Our observations indicate a gradual fading of TX CVn from about 1988 (cf. Fig. 1).

For the first time we summarized the historical 1893 – 2000 photographic/B-band LC of TX CVn (Fig. 1). Our new data are listed in Tab. 2. At the beginning of the recorded LC, between 1893 and 1920, the star was quiet, and its brightness was around $m_{\rm pg} \sim 11.7$ – the lowest recorded level. Then TX CVn entered a series of outbursts with maxima in 1920 (the main maximum), 1945, 1952 and 1962. However, there is a gap in photographic observations between 1975 and 1982. According to the visual magnitude estimates, there are two additional maxima located around 1978 and 1988 (Fig. 1).

Table 1. U, B, V, R observations of TX CVn

Date	JD$_{hel}$ -2 400 000	U	B	V	ΔR	Obs
Nov 13, 98	51130.630	10.767	10.635	9.962	0.196	SP
Dec 12, 98	51159.616	10.762	10.624	9.970	0.196	SP
Mar 14, 99	51252.345	10.899	10.720	10.031	–	SL
Apr 3, 99	51272.380	10.879	10.689	10.028	–	SL
Apr 10, 99	51278.563	10.889	10.698	10.050	–	SL
May 3, 99	51302.349	10.878	10.725	10.085	0.328	SP
May 19, 99	51318.358	10.925	10.709	10.049	–	SL
May 28, 99	51327.422	10.888	10.706	10.046	0.501[a]	SP
Nov 26, 99	51509.587	10.972	10.808	10.145	0.363	SP
Nov 27, 99	51510.664	10.977	10.805	10.129	0.595[a]	SP

a - ΔR = TX CVn – HD 111113.

Table 2. Photographic observations of TX CVn

JD_{hel} -2 400 000	m_{pg}	JD_{hel} -2 400 000	m_{pg}	JD_{hel} -2 400 000	m_{pg}	JD_{hel} -2 400 000	m_{pg}
27505.51	11.16	28245.51	11.86	32174.69	10.38	36628.51	11.20
27505.56	11.30	28247.49	11.62	32616.51	10.59	36629.58	11.18
27511.56	11.86	29376.47	11.73	32887.69	10.71	36630.57	11.30
27513.49	11.86	29638.70	11.89	32912.64	10.81	36637.59	11.30
27516.51	11.95	29691.64	11.95	32998.49	10.92	36657.54	11.38
27532.48	11.69	29728.52	11.92	33742.51	10.98	36659.54	11.37
27533.45	11.92	30457.44	11.72	35861.50	11.18	36660.54	11.35
27534.40	11.75	30464.44	11.81	35861.50	11.30	36661.55	11.33
27535.41	11.81	30486.44	11.93	35868.54	11.18	36663.51	11.34
27535.52	11.71	30496.42	11.81	35872.62	11.10	36686.49	11.18
27536.44	11.62	30499.44	11.71	35874.63	11.13	36694.47	11.09
27539.44	11.88	30516.44	11.71	35892.54	11.13	36698.47	11.34
27543.48	11.81	30711.67	11.75	35899.55	11.19	36700.46	11.18
27544.42	11.76	30735.44	11.71	35902.54	11.19	36715.41	11.19
27545.51	11.44	30764.65	11.77	35906.53	11.14	36723.42	11.15
27546.53	11.71	30782.45	11.77	35907.61	11.10	36972.62	11.30
27564.43	11.35	30787.44	11.76	35924.46	11.13	37000.55	11.45
27568.45	11.44	30811.44	11.76	35924.50	11.33	37000.65	11.15
27570.45	11.65	30813.35	11.81	35931.48	11.14	37017.53	11.35
27572.39	11.40	30813.44	11.89	35932.48	11.19	37350.60	11.20
27573.41	11.72	30813.53	11.85	35933.53	11.15	37351.55	11.30
27588.42	11.55	30817.39	11.89	35951.45	11.20	37351.59	11.12
27841.61	11.71	30818.50	11.69	35962.46	11.20	37351.63	11.15
27860.49	11.90	30819.33	11.76	35977.42	11.19	37351.67	11.40
27866.52	11.69	30820.45	11.73	35982.42	11.30	37353.50	10.66
27871.47	11.69	30828.60	11.86	35985.43	11.20	37353.53	10.66
27871.59	11.55	30847.40	11.81	35987.40	11.30	37368.55	11.14
27924.47	11.71	30849.44	11.92	35988.43	11.30	37374.52	11.11
27925.42	12.03	30874.44	11.81	36229.60	11.20	37375.48	11.12
27927.45	11.40	30874.44	11.71	36232.59	11.14	37376.52	11.05
27928.43	11.69	30876.43	11.77	36233.59	11.19	37378.49	11.30
27929.38	11.75	30883.45	11.73	36274.49	11.14	37380.52	11.14
27943.38	11.73	30933.40	11.81	36286.62	11.15	37396.40	10.73
27944.40	11.69	30936.41	11.81	36287.51	11.07	37406.45	10.51
27947.41	11.47	31144.59	11.90	36288.49	11.18	37424.39	10.25
27950.40	11.75	31145.47	11.65	36344.47	11.34	37467.42	10.74
27951.41	11.44	31181.44	11.71	36369.43	11.35	37544.33	10.53
27952.42	11.44	31231.44	11.42	36370.42	11.18	37648.68	9.61
27955.42	11.58	31238.48	11.62	36556.66	11.30	37650.61	9.68
27959.44	11.55	31443.69	10.99	36584.67	11.42	37650.63	9.30
28193.64	11.69	31447.70	10.36	36602.66	11.30	37651.67	9.30
28219.62	11.71	31555.46	10.41	36604.57	11.43	37652.66	9.40
28229.68	11.68	31587.45	11.60	36612.67	11.30	37667.66	9.66

Table 2. continued

JD$_{hel}$ -2 400 000	$m_{\rm pg}$	JD$_{hel}$ -2 400 000	$m_{\rm pg}$	JD$_{hel}$ -2 400 000	$m_{\rm pg}$	JD$_{hel}$ -2 400 000	$m_{\rm pg}$
37668.60	9.81	38060.62	9.80	38472.50	10.05	41059.42	9.90
37668.64	9.66	38083.54	9.94	38501.43	10.30	41061.45	10.34
37669.66	9.72	38084.53	9.95	38522.41	10.35	41088.40	9.99
37696.55	9.88	38088.54	9.96	38525.44	10.35	41155.41	10.22
37696.58	9.83	38090.55	9.96	38531.43	10.40	41163.39	9.99
37705.51	9.81	38092.59	9.91	38551.45	10.40	41181.39	10.05
37705.55	9.94	38106.47	9.91	38555.41	10.16	41217.30	10.11
37731.49	10.25	38112.47	10.00	38583.41	10.05	41241.25	10.34
37731.52	10.45	38116.48	10.18	38613.38	10.15	41333.55	9.94
37732.53	10.30	38116.48	10.13	38635.33	10.18	41335.59	10.12
37737.60	10.18	38134.43	10.25	38709.68	10.30	41365.60	9.99
37749.41	10.35	38140.43	10.00	38739.67	10.27	41369.59	10.05
37752.44	10.05	38142.47	10.00	38817.52	10.25	41389.44	10.28
37752.49	9.85	38146.45	10.12	38827.51	10.28	41391.44	10.20
37759.40	9.83	38162.40	10.18	38830.57	10.49	41948.30	10.34
37761.44	9.71	38171.45	10.29	38849.47	10.39	42095.50	10.34
37761.44	9.80	38287.31	10.32	38851.47	10.32	42127.48	10.30
37778.42	9.87	38322.64	10.38	38853.50	10.32	42148.38	10.25
37779.49	9.89	38327.65	10.38	38854.47	10.30	42152.43	10.30
37788.45	9.85	38331.66	10.52	38856.51	10.30	42161.41	10.27
37790.39	9.97	38383.67	10.30	39056.25	10.28	42183.44	10.30
37812.43	9.64	38385.66	10.11	39144.61	10.35	42186.42	10.25
37821.41	9.50	38387.61	10.28	39145.57	10.39	42224.42	10.34
37841.41	9.40	38407.58	10.27	39146.59	10.30	42251.40	10.35
37871.40	9.30	38410.57	10.34	39184.58	10.25	42276.38	10.35
37872.40	9.40	38412.61	10.22	39200.48	10.22	42405.64	10.30
37878.40	9.77	38414.57	10.25	39204.48	9.96	42448.44	10.38
37897.34	9.81	38416.61	10.12	40837.33	10.00	42534.41	10.32
37903.33	9.87	38440.53	10.28	40853.29	10.25	42546.43	10.49
37910.36	9.91	38446.60	10.25	40924.63	10.28	42569.41	10.37
37970.67	9.72	38463.47	10.00	40981.51	10.25	42609.43	10.32
37992.68	9.88	38464.50	10.12	41039.44	10.16	42631.40	10.25
38050.61	9.87	38465.52	10.22	41056.40	9.93	42654.33	10.32
						42712.24	10.16

3.2. CH Cyg

Our new photometry of CH Cyg (HD 182917, BD+49 2999) is listed in Tab. 3. Stars HD 182691 (SAO 31623, V = 6.525, $B-V$ = -0.078, $U-B$ = -0.24, $V-R$ = 0) and HD 183123 (SAO 48428, V = 8.355, $B-V$ = 0.478, $U-B$ = -0.031, $V-R$ = 0.312) were used as a comparison and a check star, respectively. We obtained magnitudes of the check star by its long-term measurements (1994 –

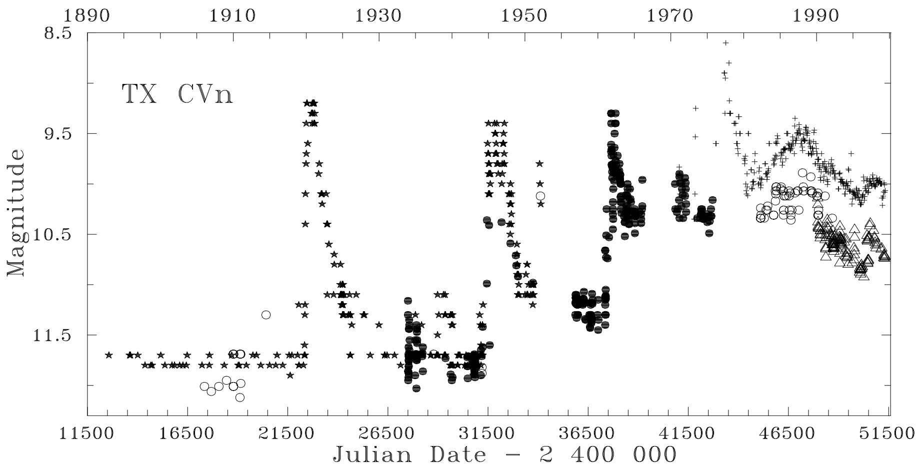

Figure 1. The historical 1893–2000 LC of TX CVn. It consists of the photographic magnitudes published by Mumford (1956) - (⋆), Skopal et al. (1995) - (∘), and in this paper (•). In addition, B-band magnitudes (Δ), were taken from our previous papers (Hric et al., 1991, 1993, 1994, 1996a; Skopal et al., 1992, 1995; Skopal, 1998b). Visual magnitude estimates (+), were taken from the CDS database in Strasbourg. They represent the means of 20-day bins.

1999) with respect to the above mentioned comparison star.

Fig. 2 displays the U and V LCs covering a major part of the 'symbiotic life' of CH Cyg, which has been observed from ≈1963. The U LC demonstrates the active phases best. This symbiotic object was recognized as a triple-star system (Hinkle et al., 1993). The eclipsing nature of CH Cyg was suggested by Skopal (1995), Skopal et al. (1996a, 1996b) and confirmed by Skopal et al. (1998) and Iijima (1998). Both eclipses, in the inner (the symbiotic pair) and the outer binary are seen well in the U LC (Fig. 2). Fig. 3 shows our recent U, B, V photometry covering the current active phase, which began in May 1998. At the beginning of June 1999 the star's brightness suddenly decreased by ∼2 mag due to the eclipse of the symbiotic pair by the giant in the outer orbit. To date (6th December 1999) the total eclipse has lasted 6 months.

3.3. AX Per

The recent measurements of AX Per (MWC 411, GCRV 896) in the U, B, V, R bands are given in Tab. 4. Star BD+54 331 (HD 9839, SAO 22444, $V = 7.43$, $B-V = 1.02$, $U-B = 0.63$) and the neighbouring star ($\alpha_{2000} = 1\,\mathrm{h}\ 36\,\mathrm{m}\ 32\,\mathrm{s}$ $\delta_{2000} = 54° \ 15' \ 5''$, $V = 9.48$, $B-V = 1.37$, $U-B = 1.20$, Skopal 1998b) were used as a comparison and a check star, respectively.

Fig. 4 displays the historical 1887 − 2000 LC of AX Per. The majority of the time AX Per persists in quiescence. From the end of the last century, four

Table 3. U, B, V, R observations of CH Cyg

Date	JD_{hel} -2 400 000	U	B	V	ΔR	Obs
Jun 29, 98	50994.381	9.100	9.476	8.444	0.076	SP
Jul 20, 98	51015.421	8.042	8.339	7.469	—	SL
Jul 29, 98	51024.435	8.214	8.538	7.621	—	SL
Jul 30, 98	51025.437	8.192	8.529	7.602	—	SL
Jul 30, 98	51025.387	8.000	8.318	7.477	-0.454	SP
Aug 8, 98	51034.378	8.184	8.572	7.675	-0.357	SP
Aug 10, 98	51035.502	8.288	8.680	7.777	-0.339	SP
Aug 12, 98	51038.450	8.106	8.420	7.561	-0.410	SP
Aug 16, 98	51042.364	7.968	8.324	7.486	—	SL
Aug 16, 98	51042.430	7.957	8.345	7.537	-0.381	SP
Sep 3, 98	51060.375	8.077	8.487	7.769	-0.141	SP
Sep 22, 98	51079.383	7.503	8.011	7.325	-0.425	SP
Oct 14, 98	51101.237	8.151	8.628	7.741	—	SL
Oct 16, 98	51103.331	8.055	8.552	7.732	-0.315	SP
Oct 23, 98	51110.208	8.112	8.446	7.608	—	SL
Nov 7, 98	51125.209	8.320	8.817	7.845	—	SL
Nov 12, 98	51130.323	8.425	8.810	7.885	-0.294	SP
Nov 13, 98	51131.202	8.371	8.711	7.799	-0.306	SP
Nov 14, 98	51132.263	8.340	8.610	7.710	—	SL :
Nov 22, 98	51140.175	8.618	8.963	7.941	—	SL
Nov 30, 98	51148.267	8.696	8.966	7.961	-0.283	SP
Dec 2, 98	51150.313	8.313	8.627	7.723	-0.383	SP
Dec 3, 98	51151.262	8.378	8.682	7.758	-0.377	SP
Dec 11, 98	51159.317	7.914	8.329	7.484	-0.516	SP
Dec 14, 98	51162.224	8.069	8.486	7.613	—	SL
Dec 18, 98	51166.194	7.982	8.390	7.477	-0.521	SP
Dec 18, 98	51166.229	7.950	8.420	7.420	—	SL ::
Jan 1, 99	51180.181	8.114	8.568	7.604	—	SL
Jan 17, 99	51196.191	8.065	8.530	7.622	—	SL
Jan 21, 99	51200.197	7.927	8.448	7.576	—	SL
Apr 3, 99	51272.473	8.314	8.689	7.613	—	SL
May 26, 99	51325.475	8.196	8.398	7.368	-0.787	SP
May 29, 99	51327.500	8.558	8.710	7.516	-0.769	SP
Jun 6, 99	51336.459	10.062	9.505	7.917	-0.593	SP
Jul 6, 99	51366.390	10.932	9.826	8.174	-0.381	SP
Jul 19, 99	51379.410	10.314	8.725	7.268	—	SL
Jul 29, 99	51389.401	10.083	9.641	8.003	—	SL
Aug 9, 99	51400.403	10.216	9.522	7.821	—	SL
Aug 14, 99	51405.407	10.118	9.454	7.727	—	SL
Aug 21, 99	51412.458	9.960	9.342	7.713	-0.708	SP
Aug 26, 99	51417.334	10.230	9.441	7.645	—	SL
Sep 4, 99	51426.304	10.368	9.456	7.620	—	SL
Sep 10, 99	51432.317	10.437	9.460	7.600	—	SL

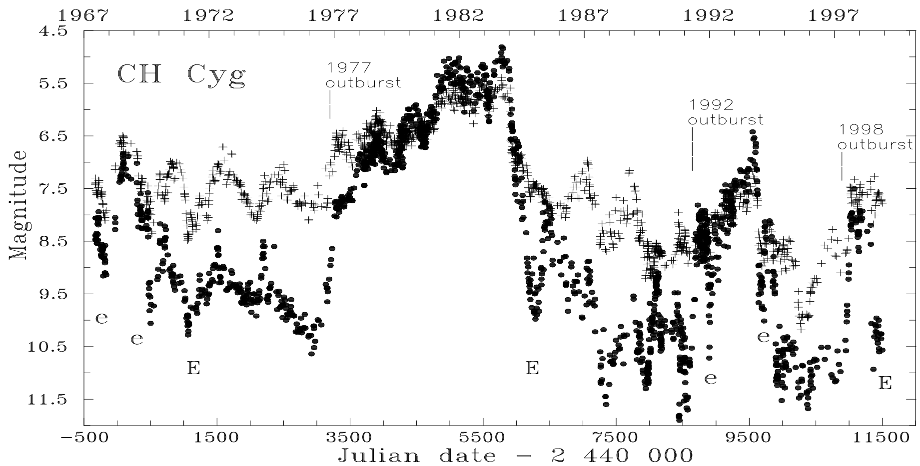

Figure 2. The $U(\bullet)$ and $V(+)$ LCs of CH Cyg collected during its 'symbiotic life', which began in ~1963. Eclipses in the inner and outer binary are denoted by **e** and **E**, respectively.

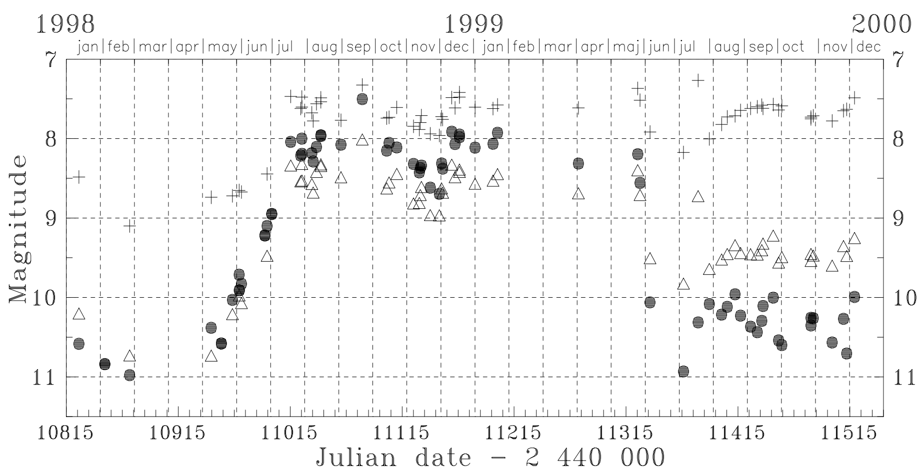

Figure 3. The $U(\bullet)$, $B(\triangle)$, $V(+)$ LCs of CH Cyg covering the period of the current active phase. At the beginning of June 1999 the system entered the eclipse in the outer binary (the giant in the outer orbit eclipses the active symbiotic inner binary). It is only seen well in U and B.

Table 3. continued

Date	JD_{hel} -2 400 000	U	B	V	ΔR	Obs
Sep 14, 99	51436.268	10.295	9.405	7.579	—	SL
Sep 15, 99	51437.405	10.107	9.322	7.619	-0.796	SP
Sep 25, 99	51446.531	10.003	9.222	7.570	-0.841	SP
Sep 29, 99	51451.357	10.540	9.560	7.640	—	SL ::
Oct 2, 99	51454.224	10.650	9.492	7.587	—	SL ::
Oct 28, 99	51480.230	10.257	9.453	7.752	-0.705	SP
Oct 28, 99	51480.218	10.353	9.540	7.729	—	SL
Oct 30, 99	51482.284	10.261	9.473	7.713	—	SL
Nov 16, 99	51499.180	10.567	9.600	7.777	—	SL
Nov 26, 99	51509.294	10.269	9.353	7.649	-0.795	SP
Nov 29, 99	51512.181	10.706	9.477	7.631	—	SL
Dec 6, 99	51519.176	9.994	9.252	7.486	—	SL

main phases of activity were observed (1895, 1924, 1950, and 1989). They are characterized by a wave-like modulation at the 2-mag level in the optical light and last a short time, about of 1.5 orbital cycles. This variation is periodic ($P \approx P_{\rm orb}$) and phase dependent: maxima occur around orbital phase $\varphi \sim 0.5$ and minima at $\varphi \sim 0$. The possible nature of such type of variability during active phases was suggested by Skopal (1994). More detailed discussion of the historical LC of AX Per is presented in Skopal et al. (2000b).

Fig. 5 shows part of the U, B, V LCs obtained at our observatories (SP, SL). The presented photometry covers a transition period of AX Per to a nebular quiet phase, up to 2000. The most interesting variation can be seen in the evolution of the minima profile. A drastic change in the LC profile occurred after a 0.6 mag brightening observed at JD 2 450 000 (October 1995). Prior to this time, the minima were narrow, while after this flare they developed abruptly in a very broad wave-like phase dependent variation (Fig. 5). In addition, the maximum level of the star's brightness decreased by about 0.5, 0.2 and 0.1 mag in the U, B, V and R bands, respectively. All these features result from the transition of AX Per to its nebular phase, which happened around JD 2 450 000 and lasted a short time of 30–40 days. The transition was caused by the dilution of the shell around the hot star. The new emitters, which were injected into the ionized region, then transferred part of the far-UV radiation of the hot star by the recombination process into the optical region, where we observed it as the 0.6 mag flare (see Skopal et al. (2000b) for more details). Finally, we note that the previous suggestion that AX Per is possibly a triple-star system (Skopal, 1998b) and the broad minimum observed around JD 2 450 280 (1996.5) resulted from the eclipse on the outer binary, has not been confirmed.

Table 4. U, B, V, R observations of AX Per

Date	JD_{hel} -2 400 000	U	B	V	ΔR	Obs
May 29, 98	50963.479	–	–	11.771	–	SL
Jun 6, 98	50971.479	12.830	12.960	11.763	–	SL:
Jun 30, 98	50994.509	12.640	12.903	11.947	3.694	SP
Jul 31, 98	51025.523	12.692	12.910	11.729	–	SL
Aug 8, 98	51034.473	12.647	12.906	11.724	3.475	SP
Aug 17, 98	51042.528	12.649	12.947	11.655	3.436	SP
Sep 3, 98	51060.485	12.733	13.049	11.649	3.435	SP
Sep 23, 98	51079.542	12.756	13.000	11.655	3.410	SP
Oct 14, 98	51101.323	12.545	12.924	11.605	–	SL
Oct 23, 98	51110.278	12.609	12.891	11.497	–	SL
Nov 7, 98	51125.296	12.527	12.822	11.445	–	SL
Nov 12, 98	51130.425	12.492	12.812	11.538	3.326	SP
Nov 22, 98	51140.218	12.396	12.867	11.539	–	SL
Dec 3, 98	51151.437	12.269	12.716	11.410	3.213	SP
Dec 11, 98	51159.487	12.289	12.691	11.413	3.205	SP
Jan 1, 99	51180.229	12.048	12.545	11.244	–	SL
Jan 17, 99	51196.217	12.213	12.718	11.400	–	SL
Jan 21, 99	51200.241	12.067	12.676	11.375	–	SL
Feb 27, 99	51237.245	12.317	12.703	11.454	–	SL
Mar 14, 99	51252.263	12.126	12.704	11.410	–	SL
Apr 3, 99	51272.286	12.063	12.662	11.400	–	SL
Sep 4, 99	51426.340	12.232	12.659	11.322	–	SL
Sep 10, 99	51432.413	12.268	12.693	11.354	–	SL
Sep 14, 99	51436.350	12.289	12.747	11.390	–	SL
Sep 16, 99	51437.597	12.382	12.748	11.450	3.211	SP
Sep 25, 99	51446.573	12.432	12.751	11.459	3.244	SP
Oct 30, 99	51482.330	12.564	12.762	11.350	–	SL
Nov 26, 99	51509.377	12.660	12.801	11.437	3.270	SP
Nov 27, 99	51510.558	12.68:	12.69:	11.423	3.244	SP

3.4. AR Pav

Photoelectric $U, B, V, R_{\rm C}, I_{\rm C}$ observations of AR Pav (HIP 89886, PPM 363277, SBC 668) are collected in Tab. 5. Stars in the E-region, E813, E707 (Menzies et al. 1989), and two other stars, GCS 1017 (α_{2000} = 18 h 20 m 37.3 s, δ_{2000} = -66° 10' 26.1", V = 9.981, $B-V$ = 0.256, $U-B$ = 0.162) and GCS 1220 (α_{2000} = 18 h 20 m 43.7 s, δ_{2000} = -66° 07' 41.8", V = 9.147, $B-V$ = 1.654, $U-B$ = 1.906) in the local field around the variable, were used as comparison stars.

Fig. 6 shows the visual LC from 1982 to December 1999. A major part of this period, from 1985.7 to 1998.8, AR Pav was in an active stage. The LC was characterized by a wave-like modulation at the 1.5 mag level. The star's brightness varies periodically as a function of orbital phase, φ. A maximum

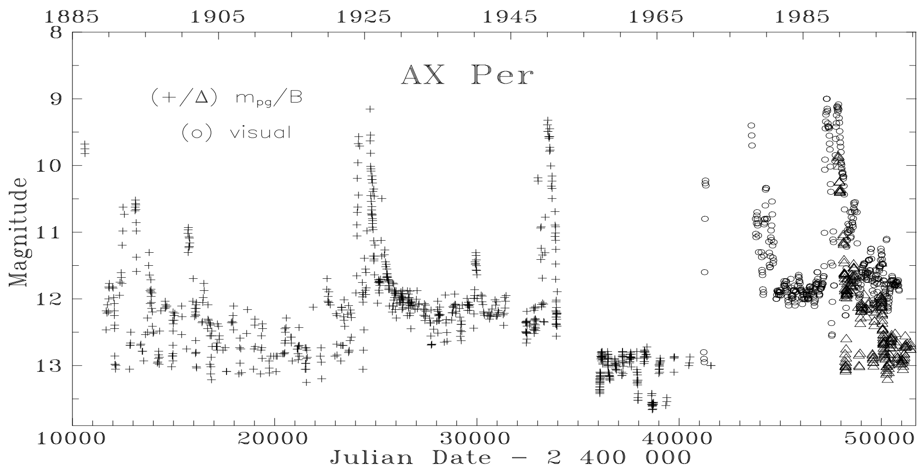

Figure 4. The historical, 1887 – 2000, LC of AX Per. Photographic measurements were taken from Lindsay (1932), Payne-Gaposchkin (1946), Wenzel (1956) and Mjalkovskij (1977). Visual magnitude estimates are from CDS database in Strasbourg and B magnitudes from our previous papers (Hric et al., 1991, 1993, 1994, 1996b; Skopal et al., 1992, 1995; Skopal 1998b) and this paper.

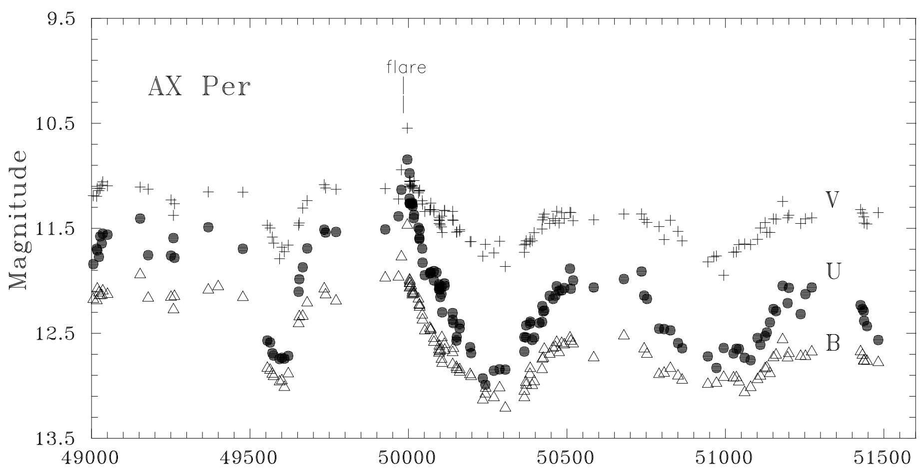

Figure 5. The U, B, V LCs covering a transition of AX Per to its nebular phase, which happened at/around JD 2 450 000. Note three main features of this event: (i) A small ∼0.6 mag brightening at that time, (ii) the development of a very broad wave-like variation in the LC, and (iii) general decrease of the maximum level of the star's brightness after the flare.

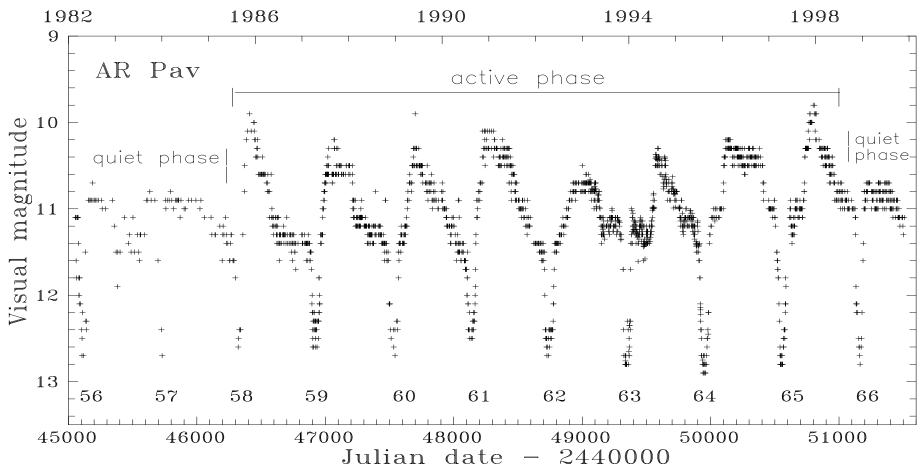

Figure 6. Visual LC (made by AJ) covering the period 1982 to 2000. The recent active phase lasted from 1985.7 to 1998.8, much longer than outbursts in 1900 and 1935 (cf. Mayall, 1937). Individual epochs are denoted by numbers at the bottom, and were calculated according to ephemeris given by Skopal et al. (2000a).

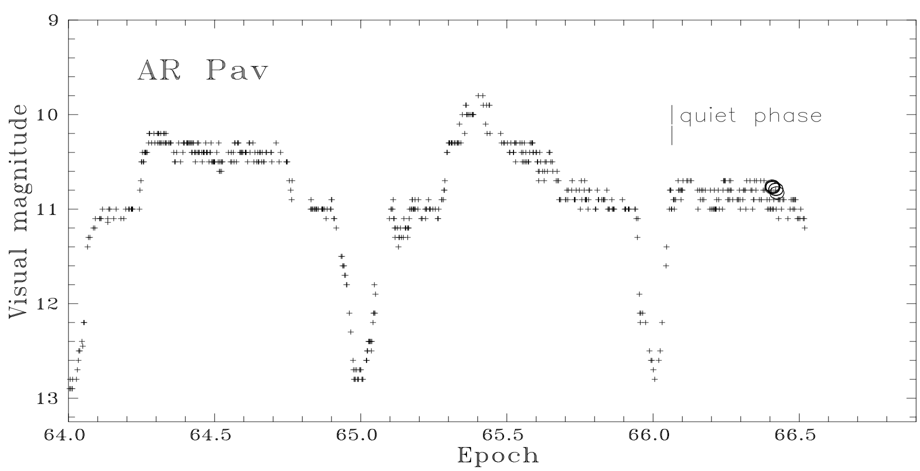

Figure 7. A detail of the LC displaying its part from 1995.6. It shows a sudden transition to a quiet phase during the epoch 66. Open circles represent the photoelectric V measurements from Tab. 5.

Table 5. U, B, V, R_C, I_C observations of AR Pav

Date	JD_{hel} -2 400 000	U	B	V	R_C	I_C	Obs
Aug 17, 99	51408.430	10.996	11.420	10.753	10.031	9.297	SAAO
——	51408.437	11.043	11.435	10.761	10.031	9.301	SAAO
——	51408.444	11.079	11.460	10.775	10.047	9.306	SAAO
Aug 19, 99	51410.235	11.046	11.410	10.771	10.058	9.318	SAAO
——	51410.242	11.060	11.417	10.768	10.047	9.316	SAAO
——	51410.248	11.041	11.418	10.760	10.043	9.310	SAAO
——	51410.259	11.046	11.416	10.767	10.045	9.314	SAAO
Aug 25, 99	51416.233	11.125	11.489	10.787	10.070	9.342	SAAO
——	51416.240	11.136	11.489	10.790	10.067	9.344	SAAO
——	51416.249	11.123	11.494	10.794	10.074	9.348	SAAO
Aug 27, 99	51418.365	11.168	11.521	10.830	10.099	9.364	SAAO
——	51418.372	11.163	11.538	10.826	10.095	9.355	SAAO

of light appears around $\varphi \sim$0.5 and a minimum at $\varphi = 0$, where deep minima caused by eclipses of the hot star by the red giant are also seen. Both transitions, quiescence $\Longleftrightarrow$ activity, happened during a short time with respect to other symbiotics (Skopal et al., 1997; Skopal, 1998a). Simply, the wave-like variation appears/disappears suddenly. This type of the LC during outbursts resembles that of AX Per. The nature of such behaviour is discussed in more detail by Skopal (1994) and Skopal et al. (2000a).

Fig. 7 shows the recent evolution in the LC of AR Pav. The transition from active to quiet phase is seen well. In addition, the basic characteristics of the quiet LC (a standstill in eclipses and a secondary minimum around $\varphi = 0.5$) appear again (cf. Mayall, 1937; Skopal et al., 2000a). Note a very good agreement between our visual magnitude estimates and the photoelectric V measurements.

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