Photometry of symbiotic stars – an international campaign VIIb

CQ Dra (4 Dra), YY Her, V 443 Her, BX Mon, AG Peg, AX Per, V 741 Per, FG Sge, QW Sge, PU Vul

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Abstract. We present new observations of 10 symbiotic and symbiotic-like stars. The photoelectric UBV(R) observations cover the period 1994.75 to 1996.0. The CCD VRI, photographic and visual data cover also earlier times. The main results can be summarized as follows:

CQ Dra: The expected sudden brightening in the U colour has been observed around JD 2 449 700. After then, the star's brightness has declined smoothly in all three colours. YY Her: The steady decline of the star's brightness in the V and R colours has been observed. V443 Her: Variability with an amplitude of about 0.4 mag in the V colour has been detected, while nothing similar has been found in the R and I. AX Per: Our present data cover in part the primary mimimum of the star. During the autumn of 1995, a small increase in all three colours has been observed. PU Vul: A brightness minimum at JD 2 449 953, best pronounced in the V colour, has been observed.

Key words: stars - binaries - symbiotic - photometry

1. Introduction

This is the second part of the seventh paper of the series aimed to present the observational data compiled as a part of the campaign of long-term photometry of symbiotic stars (Hric & Skopal, 1989). The previous results were published in Skopal et al., 1990 - Paper I, Hric et al., 1991 - Paper II, Skopal et al., 1992 - Paper III, Hric et al., 1993 - Paper IV, Hric et al., 1994 - Paper V, Skopal et al., 1995 - Paper VI.

2. Observations

Photoelectric UBV(R) observations were performed at the Skalnaté Pleso Observatory (hereafter SP in Tables), at the Stará Lesná Observatory (SL), at the Hlohovec Observatory (H), at the Kryonerion Station of the National Observatory of Athens (KR - observers Rovithis, KN - observer Niarchos) and at the Astronomical Observatory of Ľviv University (L). The observations carried out at the Skalnaté Pleso Observatory, at the Stará Lesná Observatory, at the Kryonerion Station of the National Observatory of Athens and at the Hlohovec Observatory were performed in the same way as described in Paper II, III and VI.

The observations at the Astronomical Observatory of the Ľviv University were performed while using a single-channel photon counting photometer installed in the Cassegrain focus of the 0.48/7.3 m reflector AZT-14. The photometer is equipped with the photomultiplier FEU-79.

New photoelectric observations were obtained during the normal campaign period between October 1, 1994 and December 31, 1995 but numerous earlier observations (especially those from the Ľviv Observatory) are included.

CCD observations were performed at the private station near Považská Bystrica (PB) with the Newton 180/700 telescope equipped with an originally constructed CCD camera based on Texas Instruments chip TC 211 and using V (540 nm), R (680 nm), I (825 nm) filters for modified Johnson-Kron-Cousins system. The comparison stars for CCD photometry were calibrated to the standard stars published by Landolt (1973, 1983, 1992).

Photographic magnitudes of FG Sge were measured by A.V. Halevin on 345 8-minute exposures obtained with the Schmidt camera of the Abastumani Astrophysical Observatory in 1986/88 (JD 2446620-7420).

Photographic observations at the Trnava Observatory (T) were obtained by the Sonnar 4/300 equipped by filter Panchromar G3 on the emulsion ORWOPAN

400. This combination of filter and emulsion enables to cover spectral region from 570 to 650 nm.

The visual observations in both parts of our seventh campaign's paper were obtained near the Police nad Metují in The Czech Republik with the telescope Somet binar 25x100.

3. Results

The results for all the observed objects have been summarized in tables (UBVR photoelectric) and depicted in figures. Individual stars are arranged in alphabetic order and the relevant data are briefly discussed in subsections.

3.1. CQ Draconis (4 Dra)

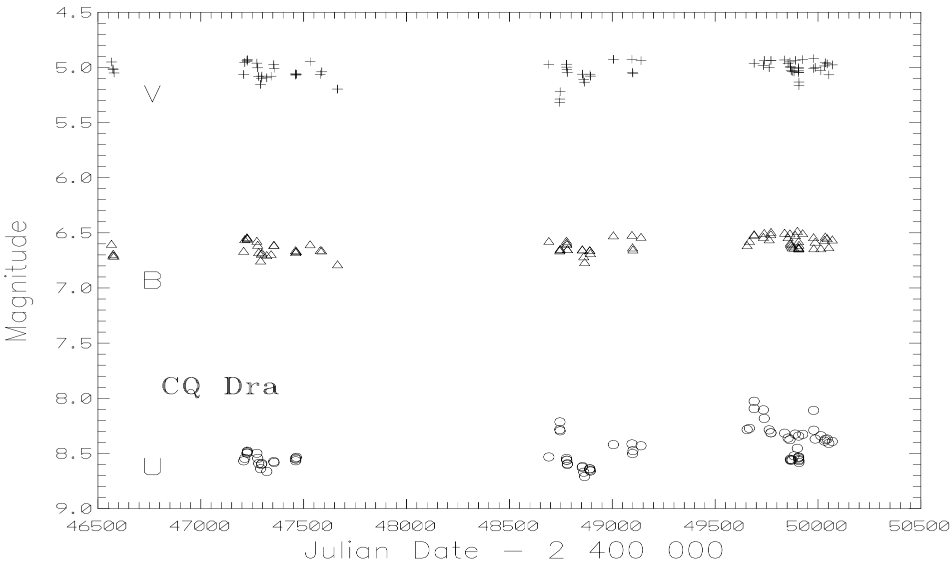


Figure 1. UBV Observations of CQ Dra

The 86 UBV photoelectric observations of this star were taken on 80 nights during the long period since May 15, 1986 till December 19, 1995. The standard stars are the same as used in Paper II. The data are summarized in Table 1 and shown in Figure 1. We have detected the expected sudden brightening of the star in the U colour around JD 2 449 700 after which the U brightness was declining smoothly. As for the B and V colours, the relevant LCs first showed a plateau-like behaviour accompanied by a very slight increase and then the star started to decline mildly.

Table 1. UBV observations of CQ Dra

JD_{hel} -2 400 000	U	B	V	Obs	JD_{hel} -2 400 000	U	B	V	Obs
46565.536	"*"	6.600	4.951	L	48891.344	8.639	6.658	5.061	L
46572.444	"*"	6.705	5.013	L	48893.342	8.660	6.683	5.079	L
46574.437	"*"	6.690	5.020	L	49005.370	8.420	6.523	4.927	L
46578.440	"*"	6.707	5.050	L	49095.370	8.414	6.519	4.926	L
47208.640	8.568	6.664	5.064	L	49098.465	8.501	6.632	5.045	L
47213.343	8.545	6.558	4.956	L	49100.478	8.475	6.651	5.056	L
47224.367	8.498	6.540	4.935	L	49139.422	8.431	6.536	4.939	L
47225.331	8.487	6.545	4.944	L	49655.638	8.284	6.612	"*"	SP
47225.513	8.496	6.544	4.934	L	49666.663	8.273	6.574	"*"	SP
47226.365	8.480	6.553	4.930	L	49689.631	8.027	6.520	"*"	SP
47272.410	8.499	6.572	4.961	L	49689.683	8.093	6.513	4.963	SP
47276.504	8.545	6.608	5.004	L	49734.503	8.105	6.537	4.983	SP
47281.447	8.592	6.674	5.082	L	49738.503	8.183	6.502	4.936	SP
47290.475	8.639	6.751	5.154	L	49762.387	8.287	6.559	5.003	SP
47294.473	8.600	6.691	5.098	L	49770.480	8.313	6.513	4.937	SP
47296.479	8.593	6.679	5.079	L	49771.436	8.314	6.492	4.935	SP
47320.444	8.664	6.702	5.094	L	49837.520	8.317	6.499	4.932	SP
47341.517	"*"	6.693	5.080	L	49854.415	8.361	6.540	4.963	SP
47354.446	8.574	6.610	4.975	L	49863.436	8.376	6.505	4.950	SP
47356.469	8.582	6.610	5.007	L	49865.423	8.553	6.589	4.992	L
47460.518	8.543	6.658	5.059	L	49866.398	8.563	6.601	5.001	L
47461.305	8.567	6.675	5.069	L	49869.438	8.559	6.615	5.029	L
47462.498	8.552	6.667	5.064	L	49874.413	8.560	6.632	5.037	L
47464.337	8.536	6.666	5.061	L	49883.402	8.522	6.635	5.041	L
47531.431	"*"	6.604	4.948	L	49889.468	8.325	6.520	4.936	SP
47580.379	"*"	6.657	5.063	L	49899.404	8.454	6.482	5.512	L
47587.496	"*"	6.660	5.040	L	49905.373	8.343	6.576	5.002	SP
47664.375	"*"	6.785	5.196	L	49905.395	8.533	6.631	5.010	L
48691.413	8.532	6.574	4.974	L	49905.395	8.542	6.636	5.031	L
48744.545	8.284	6.660	5.317	L	49906.410	8.534	6.642	5.047	L
48745.419	8.215	6.651	5.287	L	49906.410	8.557	6.638	5.044	L
48746.472	8.296	6.645	5.220	L	49907.428	8.566	5.636	5.165	L
48777.427	8.546	6.571	4.970	L	49907.428	8.582	5.609	5.132	L
48778.476	8.562	6.589	4.997	L	49925.374	8.327	6.503	4.930	SP
48779.442	8.563	6.602	5.018	L	49978.418	8.11	6.54	5.01	H
48781.448	8.600	6.648	5.045	L	49979.453	8.29	6.64	4.92	H
48782.371	8.594	6.648	"*"	L	49986.415	8.37	6.58	5.00	H
48853.362	8.626	6.650	"*"	L	50013.373	8.34	6.64	5.03	H
48855.383	8.620	6.650	5.061	L	50031.630	8.389	6.565	4.987	SP
48861.431	8.671	6.713	5.109	L	50035.616	8.374	6.533	4.958	SP
48865.404	8.710	6.765	5.134	L	50044.677	8.369	6.548	4.968	SP
48889.360	8.640	6.658	"*"	L	50052.683	8.409	6.630	5.067	SP
48890.357	8.652	6.658	"*"	L	50069.691	8.392	6.560	4.977	SP

3.2. YY Her

The BV photoelectric and VRI CCD observations of this star were carried out in 7 nights. The standard stars are the same as in Paper II. The results are summarized in Table 2. The brightness of the star shows steady decline in V and R colour towards a minimum.

Table 2. BVRI observations of YY Her

JD_{hel} -2 400 000	B	V	R	I	Obs
49899.411	"*"	12.46	11.44	10.34	PB
49935.376	"*"	12.51	11.48	10.38	PB
49955.35	13.76	13.08	"*"	"*"	KR
49971.37	12.92	12.49	"*"	"*"	KR
49979.348	"*"	12.54	11.53	10.34	PB
50000.311	"*"	12.81	11.63	10.37	PB
50012.319	"*"	12.82	11.70	10.44	PB

3.3. V 443 Herculis

Table 3. BVRI observations of V 443 Her

JD_{hel} -2 400 000	B	V	R	I	Obs
49480.431	"*"	11.60	10.06	8.42	PB
49505.407	"*"	"*"	10.00	8.27	PB
49505.436	"*"	11.43	"*"	"*"	T
49555.364	"*"	11.57	10.00	8.36	PB
49563.432	"*"	11.35	9.98	8.33	PB
49581.335	"*"	11.48	10.05	8.38	PB
49592.328	"*"	11.71	10.02	8.38	PB
49619.343	"*"	11.39	10.07	8.37	PB
49830.514	"*"	11.45	10.00	8.41	PB
49899.465	"*"	11.28	9.84	8.35	PB
49955.31	12.46	11.43	"*"	"*"	KR
49970.40	12.30	11.31	"*"	"*"	KR

The BV photoelectric and VRI CCD observations of this star were obtained in 11 nights. The standard stars are the same as used in Paper II and III. Only one photographic observation was taken during the campaign period. All the data are summarized in Table 3. The LC in V colour shows variability with an amplitude of 0.4 mag, while there are no variations in R and I colours in the LC.

3.4. BX Monocerotis

Only one BV photoelectric observation was obtained for this star. S1: HD 57678 (V = 8.72, B - V = 0.76, U - B = 0.34, K0), S2: SAO 134645 (m_v = 9.1, K0) and S3: SAO 134652 (m_v = 9.0, A0) were used as the standard stars. The result is in Table 4.

Table 4. UBV observations of BX Mon

JD$_{hel}$ -2 400 000	U	B	V	Obs
49812.35	"*"	11.88	10.41	KR

3.5. AG Pegasi

The UBV photoelectric observations of this star were performed in 7 nights. The standard stars are the same as used in Paper III. The photographic observations were obtained in 4 nights. All the data are compiled in Table 5 and depicted in Figure 2.

Table 5. UBV observations of AG Peg

JD$_{hel}$ -2 400 000	U	B	V	Obs
49328.245	"*"	"*"	8.20	T
49358.238	"*"	"*"	8.27	T
49371.226	"*"	"*"	8.28	T
49505.503	"*"	"*"	8.52	T
49955.39	"*"	9.80	8.49	KR
49979.526	9.28	9.70	8.41	H
49986.456	"*"	9.83	8.46	H
50013.477	9.23	9.87	"*"	H
50014.477	"*"	"*"	8.30	H
50016.511	"*"	9.69	8.38	H
50053.436	9.21	9.78	8.39	H

3.6. AX Persei

The UBVR photoelectric and VRI CCD observations were obtained in 41 nights. The standard stars are the same as used in Papers II and III. The data are summarized in Table 6. The UBV photoelectric and the V CCD photometry is shown in Figure 3. Our LCs cover partially the primary minimum corresponding to the eclipse of the hot component by the giant star in the binary. During the autumn of 1995, the star brightened by ~0.5 mag in all colours.

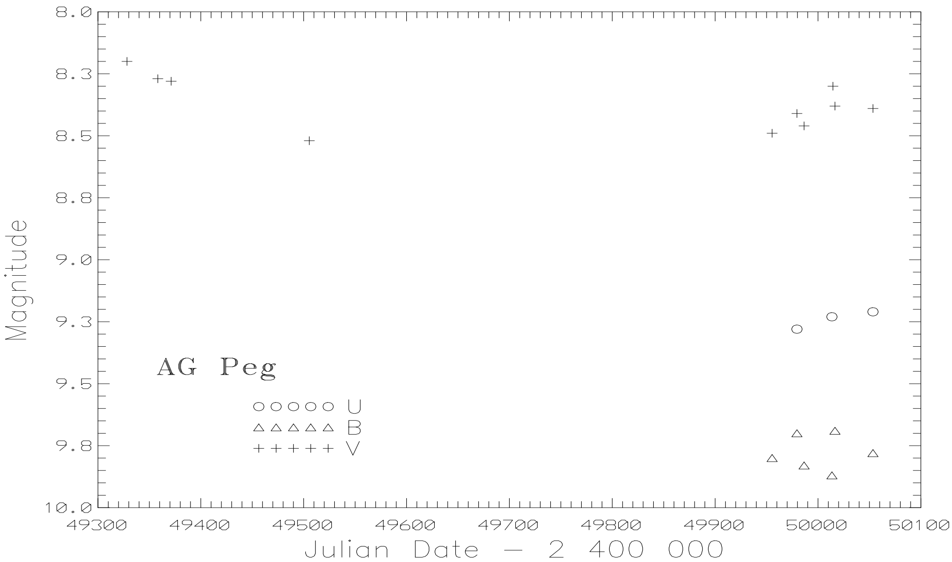


Figure 2. UBV and Photographic (V) Observations of AG Peg

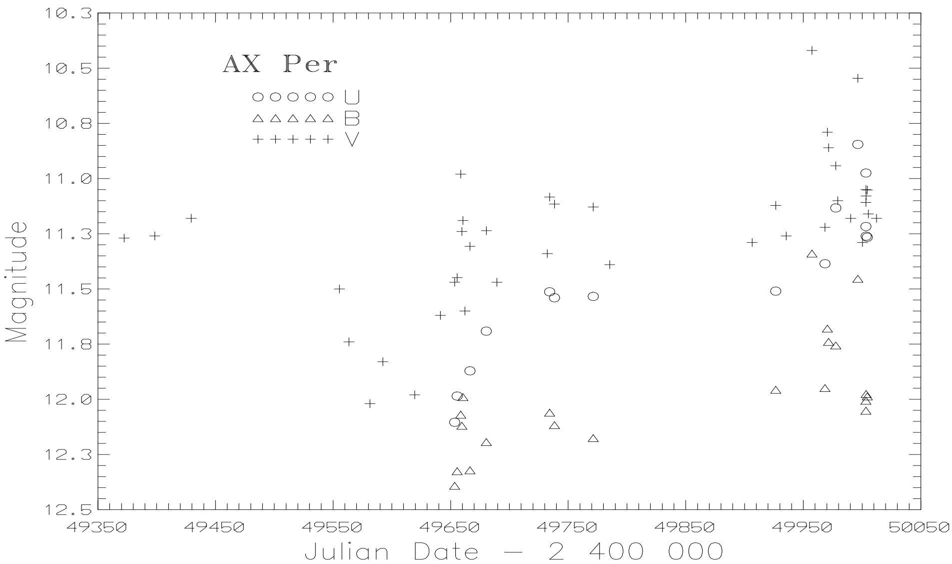


Figure 3. UBV Observations of AX Per

Table 6. UBVRI observations of AX Per

JD_{hel} -2 400 000	U	B	V	R/ΔR	I	Obs
49372.342	"*"	"*"	11.27	9.90	"*"	PB
49398.378	"*"	"*"	11.26	9.87	"*"	PB
49429.335	"*"	"*"	11.18	9.84	"*"	PB
49555.464	"*"	"*"	11.50	10.32	8.58	PB
49563.482	"*"	"*"	11.74	10.28	8.59	PB
49581.392	"*"	"*"	12.02	10.41	8.61	PB
49592.365	"*"	"*"	11.83	10.43	8.59	PB
49619.385	"*"	"*"	11.98	10.33	8.61	PB
49641.276	"*"	"*"	11.62	10.22	8.56	PB
49653.442	12.104	12.392	11.470	3.354	"*"	SP
49655.518	11.985	12.326	11.449	3.366	"*"	SP
49658.501	"*"	12.07	10.98	"*"	"*"	KN
49659.575	"*"	12.12	11.24	"*"	"*"	KN
49660.491	"*"	11.99	11.19	"*"	"*"	KN
49662.242	"*"	"*"	11.60	10.22	8.51	PB
49666.479	11.871	12.322	11.307	3.229	"*"	SP
49680.356	11.691	12.194	11.236	3.160	"*"	SP
49689.308	"*"	"*"	11.47	10.22	8.53	PB
49732.265	"*"	"*"	11.34	10.16	8.49	PB
49734.248	11.513	12.061	11.084	3.118	"*"	SP
49738.365	11.540	12.117	11.116	3.099	"*"	SP
49771.322	11.534	12.176	11.129	3.046	"*"	SP
49785.336	"*"	"*"	11.39	10.11	8.49	PB
49906.459	"*"	"*"	11.29	10.05	8.56	PB
49926.540	11.510	11.957	11.122	3.051	"*"	SP
49935.421	"*"	"*"	11.26	9.99	8.58	PB
49957.38	"*"	11.34	10.42	"*"	"*"	KR
49968.439	11.386	11.949	11.221	3.057	"*"	SP
49970.44	"*"	11.68	10.79	"*"	"*"	KR
49971.50	"*"	11.74	10.86	"*"	"*"	KR
49977.614	11.133	11.756	10.942	2.911	"*"	SP
49979.309	"*"	"*"	11.10	9.85	8.45	PB
49990.296	"*"	"*"	11.18	9.98	8.50	PB
49996.380	10.845	11.454	10.546	2.494	"*"	SP
50000.267	"*"	"*"	11.29	9.90	8.48	PB
50003.268	10.975	12.007	11.050	"*"	"*"	SL
50003.299	11.217	12.052	11.108	"*"	"*"	SL
50003.460	11.261	11.976	11.079	2.964	"*"	SP
50004.445	11.266	11.987	11.052	2.944	"*"	SP
50005.256	"*"	"*"	11.16	9.85	8.45	PB
50012.278	"*"	"*"	11.18	9.93	8.46	PB

3.7. V 741 Persei

We have observed this star in 7 nights. S1: HD 232588, SAO 022886 (V = 8.63, B - V = 0.07, U - B = -0.71, B1.5 III), S2: SAO 221832 (m_v = 8.8, m_{pg} = 10.0, K0) were used as the standard stars for the photoelectric photometry. The results are compiled in Table 7.

Table 7. UBVRI observations of V 741 Per

JD_{hel} -2 400 000	U	B	V	R	I	Obs
49398.458	10.19	9.51	9.61	"*"	"*"	H
49592.540	"*"	"*"	13.68	11.95	11.82	PB
49641.376	"*"	"*"	13.56	12.27	11.90	PB
49658.686	11.78	10.74	10.70	"*"	"*"	H
49689.340	"*"	"*"	13.59	12.33	11.79	PB
49732.313	"*"	"*"	13.19	12.25	11.89	PB
49906.490	"*"	"*"	13.12	12.19	11.79	PB

3.8. QW Sagittae

Only visual observations were available for this star. The data are shown in Figure 4. The LC shows the change of brigtness with an amplitude of 1 mag. For the more detailed study of this star, the photoelectric photometry is urgently needed.

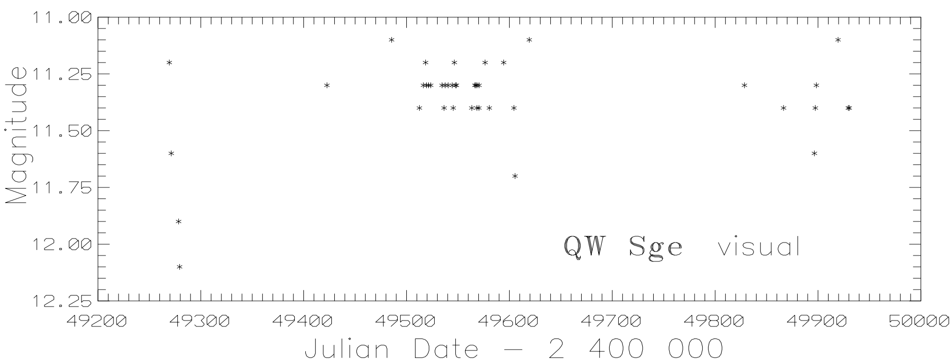


Figure 4. Visual Observations of QW Sge

3.9. FG Sagittae

The photographic magnitudes of this star were measured on 345 plates, taken on 18 nights. All the data are collected in Table 8.

Table 8. Photographic observations of FG Sge

JD_{hel} -2 440 000	m(pg)	JD_{hel} -2 440 000	m(pg)	JD_{hel} -2 440 000	m(pg)	JD_{hel} -2 440 000	m(pg)
6620.278	11.97	6621.383	11.41	6649.401	11.91	7055.434	11.31
6620.285	11.88	6621.390	11.41	6649.408	11.96	7055.442	11.81
6620.291	11.63	6621.397	11.47	6649.415	11.94	7055.450	11.41
6620.297	11.89	6621.403	11.35	6649.422	11.96	7055.458	11.41
6620.302	11.99	6621.411	11.52	6649.429	11.91	7056.267	11.91
6620.308	11.45	6621.418	11.42	6649.436	11.83	7056.273	11.88
6620.315	11.78	6621.424	11.35	6649.443	11.85	7056.279	11.95
6620.321	11.83	6621.430	11.35	6649.450	11.91	7056.286	11.91
6620.327	11.38	6621.437	11.31	6649.457	11.94	7056.292	11.91
6620.332	11.52	6621.443	11.52	6649.463	11.94	7056.299	11.85
6620.338	11.35	6621.457	11.40	6649.470	11.91	7056.305	11.88
6620.345	11.40	6621.463	11.41	6649.477	11.98	7056.311	11.95
6620.351	11.87	6621.470	11.67	6649.484	11.93	7056.318	11.67
6620.357	11.27	6621.477	11.41	6649.491	11.96	7056.324	11.91
6620.365	11.40	6621.483	11.31	6649.498	11.98	7056.330	11.91
6620.370	11.37	6621.497	11.67	6649.505	11.99	7056.337	11.91
6620.377	11.53	6621.504	11.45	6649.512	11.93	7056.343	11.91
6620.383	11.88	6626.387	11.88	6649.519	11.94	7056.349	11.86
6620.390	11.67	6635.275	11.40	7049.384	11.88	7056.356	11.86
6620.396	11.41	6635.379	11.74	7049.415	11.78	7056.362	11.89
6620.402	11.40	6638.359	11.89	7049.423	11.86	7056.368	11.99
6620.408	11.42	6640.288	11.52	7055.280	11.40	7056.374	11.59
6620.414	11.35	6640.292	11.59	7055.287	11.98	7056.381	11.88
6620.419	11.59	6640.297	11.45	7055.295	11.45	7056.387	11.67
6620.432	11.40	6640.301	11.47	7055.302	11.40	7056.394	11.70
6620.439	11.41	6640.306	11.70	7055.309	11.86	7056.400	11.88
6620.445	11.47	6640.314	11.40	7055.317	11.80	7056.407	11.97
6620.451	11.52	6640.319	11.59	7055.323	11.91	7056.414	11.91
6620.457	11.47	6640.326	11.46	7055.330	11.91	7056.420	11.88
6620.463	11.47	6640.332	11.82	7055.337	12.03	7056.426	11.87
6620.469	11.36	6640.337	11.80	7055.343	12.00	7056.434	11.83
6620.476	11.36	6640.343	11.40	7055.349	11.98	7056.440	11.80
6620.482	11.41	6640.354	11.52	7055.356	11.85	7056.454	11.83
6621.318	11.80	6640.358	11.58	7055.363	11.95	7056.460	11.91
6621.323	11.47	6640.366	11.40	7055.370	11.67	7056.461	11.78
6621.330	11.40	6640.371	11.59	7055.377	11.46	7056.466	11.66
6621.338	11.67	6640.377	11.59	7055.384	11.88	7056.472	11.52
6621.344	11.41	6649.360	11.90	7055.391	11.75	7056.479	11.83
6621.351	11.52	6649.367	11.91	7055.398	11.85	7056.485	11.88
6621.358	11.72	6649.374	11.96	7055.405	11.47	7058.349	11.32
6621.365	11.49	6649.381	11.96	7055.411	11.67	7058.356	11.83
6621.370	11.66	6649.387	11.96	7055.419	11.72	7058.362	11.83
6621.376	11.41	6649.394	11.95	7055.427	11.40	7058.370	11.86

Table 8. Photographic observations of FG Sge (continued)

JD_{hel} -2 440 000	m(pg)	JD_{hel} -2 440 000	m(pg)	JD_{hel} -2 440 000	m(pg)	JD_{hel} -2 440 000	m(pg)
7058.377	11.87	7060.317	11.53	7380.337	11.89	7418.417	11.98
7058.384	11.72	7060.323	11.67	7380.344	12.04	7418.419	11.99
7058.460	11.47	7060.329	11.52	7380.351	11.98	7418.434	11.95
7058.486	12.02	7060.335	11.81	7380.357	11.99	7418.443	12.01
7058.492	11.67	7060.347	11.67	7380.402	12.05	7418.453	11.83
7058.499	11.67	7060.360	11.70	7384.385	11.95	7420.268	11.88
7059.265	12.00	7060.367	11.83	7384.392	11.88	7420.276	11.95
7059.273	11.75	7060.373	11.36	7384.399	12.17	7420.283	11.95
7059.280	11.91	7060.381	11.78	7384.406	11.88	7420.291	11.97
7059.289	11.99	7060.387	11.83	7384.414	11.91	7420.299	12.15
7059.296	11.78	7060.393	11.52	7384.421	12.23	7420.307	11.95
7059.303	11.75	7060.400	11.53	7384.427	11.91	7420.315	11.91
7059.311	11.83	7060.406	11.63	7384.434	11.95	7420.334	11.99
7059.318	11.91	7060.412	11.69	7384.449	11.75	7420.342	11.63
7059.325	11.44	7060.418	11.63	7384.465	11.49	7420.351	11.60
7059.333	11.91	7090.202	11.60	7384.472	11.41	7420.358	11.99
7059.340	11.86	7090.211	11.49	7384.479	11.60	7420.380	11.86
7059.348	11.61	7090.219	11.36	7384.486	11.52	7420.393	11.91
7059.363	11.91	7090.227	11.55	7384.493	11.52	7420.401	11.91
7059.372	11.65	7090.235	11.70	7384.524	11.36	7420.426	11.88
7059.380	11.91	7090.243	11.83	7384.533	12.15	7420.435	11.86
7059.387	11.75	7090.252	11.75	7415.289	12.15	7420.444	11.72
7059.395	11.75	7090.260	11.86	7415.297	12.13	7420.453	11.63
7059.403	11.88	7090.266	11.40	7415.347	11.91	7420.462	11.83
7059.410	11.83	7090.268	11.86	7415.356	11.72	7421.271	12.00
7059.417	11.88	7090.285	11.70	7415.365	11.88	7421.280	11.98
7059.424	11.98	7090.293	11.78	7415.377	11.75	7421.288	12.09
7059.432	11.91	7090.302	11.88	7415.388	12.03	7421.314	11.95
7059.451	11.98	7090.311	12.04	7415.397	12.04	7421.322	11.98
7059.460	11.75	7090.319	11.59	7415.427	11.95	7421.333	11.98
7059.466	12.03	7090.328	11.81	7415.435	12.11	7422.305	11.32
7059.472	11.72	7090.338	11.88	7415.444	12.07	7422.314	11.40
7059.479	11.36	7090.347	11.78	7415.453	11.95	7422.322	11.32
7059.486	11.99	7090.356	11.88	7415.524	12.02	7422.329	11.47
7059.493	11.83	7095.303	11.44	7418.311	11.97	7422.336	11.40
7059.500	11.95	7095.312	11.85	7418.320	12.02	7422.344	11.59
7060.261	11.94	7095.321	11.67	7418.331	11.91	7422.351	11.46
7060.268	11.95	7095.329	11.78	7418.340	12.07	7422.366	11.67
7060.274	11.86	7095.337	11.35	7418.348	12.03	7422.375	11.53
7060.280	11.91	7095.346	11.60	7418.357	11.98	7422.403	11.35
7060.287	11.75	7095.354	11.63	7418.369	11.95	7422.411	11.91
7060.293	11.83	7095.363	11.70	7418.374	11.98	7422.425	11.70
7060.300	11.91	7380.311	11.98	7418.401	11.91	7422.446	11.45
						7422.460	11.45

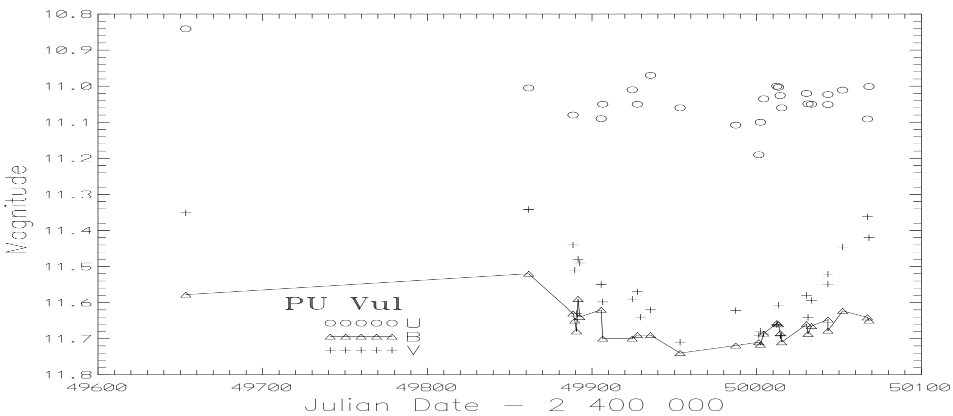
3.10. PU Vulpeculae

The photoelectric observations of this star were obtained on 30 nights. The results compiled in Table 9 are shown in Figure 5. The standard stars were the same as used in Paper II. The brightness minimum at JD 2 449 953, best visible in V (0.37 mag deep) and B (0.22 mag deep), has been observed during the observing period.

Table 9. UBV observations of PU Vul

JD_{hel} -2 400 000	U	B	V	Obs	JD_{hel} -2 400 000	U	B	V	Obs
49653.310	10.841	11.578	11.351	SP	50001.320	11.190	11.710	11.690	SL
49861.519	11.005	11.520	11.342	SP	50002.257	11.100	11.717	11.679	SL
49888.510	11.080	11.630	11.440	SP	50004.253	11.035	11.686	11.687	SL
49889.485	”*”	11.65	11.51	KN	50012.243	11.000	11.657	11.661	SL
49890.588	”*”	11.68	11.63	KN	50013.235	11.003	11.660	11.607	SL
49891.568	”*”	11.59	11.48	KN	50014.246	11.026	11.685	11.692	SL
49892.576	”*”	11.64	11.49	KN	50015.212	11.060	11.710	11.690	SL
49905.530	11.090	11.620	11.550	SP	50030.235	11.020	11.660	11.580	SL
49906.480	11.050	11.700	11.598	SP	50031.207	11.049	11.687	11.641	SL
49924.440	11.010	11.700	11.590	SP	50033.220	11.050	11.665	11.594	SP
49927.520	11.050	11.690	11.570	SP	50043.239	11.051	11.647	11.521	SP
49929.490	”*”	”*”	11.640	SL	50043.246	11.023	11.678	11.549	SL
49935.570	10.970	11.690	11.620	SP	50052.203	11.011	11.623	11.446	SP
49953.500	11.060	11.740	11.710	SP	50067.218	11.091	11.641	11.362	SL
49987.270	11.108	11.719	11.622	SP	50068.188	11.001	11.650	11.420	SP

Figure 5. UBV Observations of PU Vul



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