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Photometry of symbiotic stars

XI. EG And, Z And, BF Cyg, CH Cyg, CI Cyg, V1329 Cyg, TX CVn, AG Dra, RW Hya, AR Pav, AG Peg, AX Per, QW Sge, IV Vir and the LMXB V934 Her

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Abstract. We present new photometric observations of EG And, Z And, BF-Cyg, CH Cyg, CI Cyg, V1329 Cyg, TX CVn, AG Dra, RW Hya, AG Peg, AX Per, IV Vir and the peculiar M giant V934 Her, which were made in the standard Johnson $UBV(R)$ system. QW Sge was measured in the Kron-Cousin B, V, $R_{\rm C}$, $I_{\rm C}$ system and for AR Pav we present its new visual estimates. The current issue gathers observations of these objects to December 2003. The main results can be summarized as follows: **EG And**: The primary minimum in the U light curve (LC) occurred at the end of 2002. A 0.2 – 0.3 mag brightening in U was detected in the autumn of 2003. **Z And**: At around August 2002 we detected for the first time a minimum, which is due to eclipse of the active object by the red giant. Measurements from 2003.3 are close to those of a quiescent phase. **BF Cyg**: In February 2003 a short-term flare developed in the LC. A difference in the depth of recent minima was detected. **CH Cyg**: This star was in a quiescent phase at a rather bright state. A shallow minimum occurred at $\sim$JD 2 452 730, close to the position of the inferior conjunction of the giant in the inner binary of the triple-star model of CH Cyg. **CI Cyg**: Our observations cover the descending branch of a broad minimum. **TX CVn**: At/around the beginning of 2003 the star entered a bright stage containing a minimum at $\sim$JD 2 452 660. **AG Dra**: New observations revealed two eruptions, which peaked in October 2002 and 2003 at $\sim$9.3 in U. **AR Pav**: Our

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new visual estimates showed a transient disappearance of a wave-like modulation in the star's brightness between the minima at epochs E = 66 and E = 68 and its reappearance. **AG Peg**: Our measurements from the end of 2001 showed rather complex profile of the LC. **RW Hya**: Observations follow behaviour of the wave-like variability of quiet symbiotics. **AX Per**: In May 2003 a 0.5 mag flare was detected following a rapid decrease of the light to a minimum. **QW Sge**: CCD observations in $B, V, R_{\rm C}, I_{\rm C}$ bands cover a period from 1994.5 to 2003.5. An increase in the star's brightness by about 1 mag was observed in all passbands in 1997. Less pronounced brightening was detected in 1999/2000. **V934 Her**: Our observations did not show any larger variation in the optical as a reaction to its X-ray activity.

Key words: Techniques: photometry – Stars: binaries: symbiotic

1. Introduction

The symbiotic stars are currently understood as interacting binary systems consisting of a cool giant and a hot compact star, which is in most cases a white dwarf. Typical orbital periods are between 1 and 3 years, but they can be significantly larger. The mass loss from the giant represents the primary condition for appearance of the symbiotic phenomenon. A part of the material lost by the giant is transferred to the more compact companion via accretion from the stellar wind or Roche-lobe overflow. This process generates a very hot ($T_{\rm h} \approx 10^5$ K) and luminous ($L_{\rm h} \approx 10^2 - 10^4\,{\rm L}_{\odot}$) source of radiation. On the basis of the way in which the generated energy is being liberated, we distinguish two phases of symbiotic binary. *Quiescent phases* during which the hot component releases its energy approximately at a constant rate and spectral distribution. Generally, we observe a wave-like variation in their LCs as a function of the orbital phase. During *active phases* the hot component radiation changes significantly, which leads to a 2-3 mag brightening of the object in the optical. A common feature of active phases is a high-velocity mass ejection.

Generally, the hot radiation ionizes a fraction of the neutral circumbinary material, which gives rise to a strong nebular emission. This component of radiation is physically displaced from the hot star and its optically thick part can be very complex in its shape. In addition, its location and shaping in the binary depend on the level of the activity. As a result we often observe unexpected variation in the LCs as, for example, flares, drops in brightness, the effect of eclipses and outbursts. A very interesting feature of variability in this respect is the effect of eclipses, which is very sensitive to physical displacement and radiative contributions of individual components in the system. In the case that a significant fraction of radiation at the wavelength under consideration comes from the region which is subject to eclipse, a minimum in the LC is well observable. In the opposite case, the eclipse effect is very faint. Therefore the eclipse effect can be observed only at specific brightness phases, at which the radiative contribution from a pseudophotosphere in the optical rivals that from the nebula.

Accordingly, to reveal the above mentioned peculiarities in the LCs of symbiotic stars, it requires a very careful long-term monitoring programme. In this paper we present the recent observational results of such our programme obtained during the period December 2001 to December 2003. We note that this paper continues the work of Skopal *et al.* (2002, hereafter S+02, and references therein).

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). Values in tables represent means of the whole observing cycle. Usually, a 1-hour cycle contained about 10 to 20 individual differences between the target and the comparison. This approach reduced the *inner* uncertainty of such the means to $\sim$ 0.020, $\sim$ 0.005, $\sim$ 0.005 and $\sim$ 0.005 mag in the U, B, V and R filter, respectively. Larger uncertainties (about 0.1 mag) during some nights are marked in tables by ':'. Further details about observation procedure are given in Skopal *et al.* (1990).

Some observations in the B and V bands were made with the 50/70/172 cm Schmidt telescope of the National Astronomical Observatory Rozhen, Bulgaria (R). Other details about utilities and treatment of observations as well as standard stars were already presented in S+02.

The U, B, V observations of RW Hya and IV Vir were carried out at the San Pedro Mártir Observatory, Baja California, Mexico (M), in 2003 April. Also in this case further details are given in S+02.

Observations of QW Sge were performed by one of us (ZV) at his private station Beluša near Považská Bystrica (PB) with a Newton 180/700 telescope equipped with a CCD camera based on the Texas Instruments chip TC 211 (from 01/01/2002 the chip was changed to TC-237B). A set of B, V, R, I filters for a modified Johnson-Kron-Cousins system was used. All frames were dark subtracted and flat fielded. Transformation to the international system was made by measuring the standard stars in the star-cluster M 67. Magnitudes of comparison stars were obtained in the same way as described in Hric*et al.* (1996). Influence of a few arcsec distant companion (F0 V star reddened with $E_{\rm B-V}$ = 0.20, U = 13.84, B = 13.59, V = 13.14, R = 12.53 and I = 11.52, Munari, Buson (1991)) has not been subtracted.

In addition, 2 800 visual magnitude estimates of AR Pav were obtained during 1982.2 – 2003.9 by one of us (AJ) with a private 12".5 f/5 reflector. Other details concerning observations of AR Pav can be found in Skopal *et al.* 2001).

3. Results

3.1. EG And

We measured EG And (HD 4174, BD+39 167) with respect to HD 4143 (SAO 63-173, BD+37 2318). To obtain magnitudes in B and V we used the standard star HD 3914 ($V = 7.00$, $B-V = 0.44$) and conversion between both stars, HD4143 – HD3914 = 4.640, 2.722 and 1.563 in the U, B and V bands, respectively (Hric *et al.* 1991).

The data are compiled in Table 1. Figure 1 shows recent observations in U and B. At/around JD 2 452 600 (November 2002) the primary minimum occurred in the U-LC. It is relatively narrow in profile with respect to those previously observed (e.g. at $\sim$JD 2 451 160, see Fig. 1). A broad wave-like variation is less pronounced and, in addition, a 0.2 – 0.3 mag brightening in U was detected by the latest observations in the autumn of 2003. These changes mean that the nebular component of radiation decreased and, instead, a pseudophotosphere with a more significant contribution in the optical was created around the central star. In such a case the light in U should be rather of stellar nature. This view should be confirmed by spectroscopic observations.

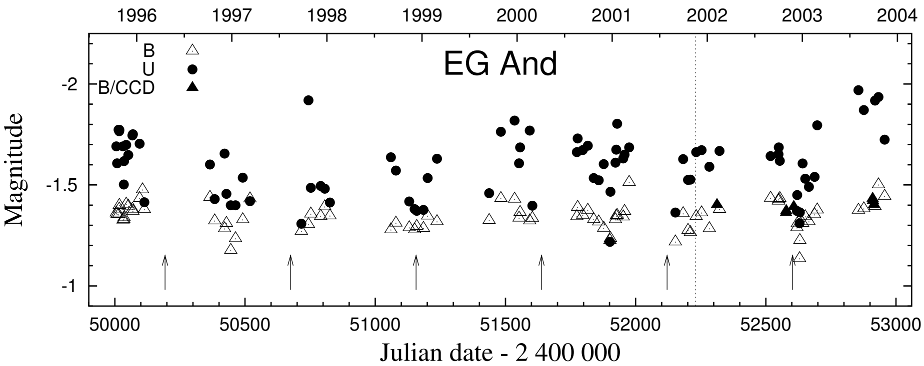

Figure 1. The U and B LCs of EG And. Arrows mark positions of the primary minima. New data are plotted to the right of the vertical dotted line.

3.2. Z And

This star (HD 221650) was measured with respect to the comparison SAO 53150 (BD+47 4192; $V = 8.99$, $B-V = 0.41$, $U-B = 0.14$, $V-R = 0.16$). Other details are the same as in S+02. Results are given in Table 2.

Figure 2 shows our photometric observations from 2000 covering a recent major outburst with the beginning at September 2000 and a maximum in De-

Table 1. U and B observations of EG And

Date	JD 24...	Phase*	ΔU	B	V	ΔR	Obs
Nov 18, 01	52232.417	0.232	-1.662	8.818	7.191	-1.480	SP
Dec 09, 01	52253.381	0.275	-1.672	8.800	7.182	-1.453	SP
Jan 08, 02	52283.288	0.337	-1.590	8.878	7.253	-1.400	SP
Feb 06, 02	52312.277	0.397	–	8.760	7.210	–	R
Feb 16, 02	52322.257	0.418	-1.668	8.783	7.148	-1.495	SP
Aug 31, 02	52518.484	0.825	-1.643	8.728	7.078	-1.584	SP
Sep 30, 02	52548.464	0.887	-1.652	8.742	7.097	-1.567	SP
Oct 02, 02	52549.522	0.890	-1.686	8.735	7.097	-1.548	SP
Oct 06, 02	52553.615	0.898	-1.619	8.729	7.084	-1.589	SP
Oct 29, 02	52577.465	0.948	–	8.800	7.220	–	R
Oct 30, 02	52578.413	0.950	–	8.790	7.240	–	R
Nov 28, 02	52607.345	0.010	–	8.770	7.240	–	R
Dec 10, 02	52619.351	0.035	-1.371	8.874	7.220	-1.453	SP
Dec 11, 02	52620.346	0.037	-1.450	8.854	7.213	-1.460	SP
Dec 20, 02	52629.368	0.055	-1.310	9.027	7.393	-1.325	SP
Dec 21, 02	52630.408	0.057	-1.364	8.937	7.303	-1.442	SP
Jan 01, 03	52641.346	0.080	-1.606	8.852	7.219	-1.449	SP
Jan 11, 03	52651.316	0.101	-1.531	8.819	7.189	-1.467	SP
Jan 25, 03	52665.380	0.130	-1.490	8.844	7.198	-1.478	SP
Feb 16, 03	52687.254	0.175	-1.540	8.809	7.174	-1.489	SP
Feb 26, 03	52697.249	0.196	-1.795	8.786	7.164	-1.507	SP
Aug 04, 03	52855.559	0.525	-1.969	8.787	7.171	-1.505	SP
Aug 24, 03	52876.487	0.568	-1.871	8.780	7.144	-1.526	SP
Sep 27, 03	52910.448	0.638	–	8.730	7.200	–	R
Sep 28, 03	52911.396	0.640	–	8.740	7.170	–	R
Oct 02, 03	52915.447	0.649	–	8.760	7.200	–	R
Oct 06, 03	52919.471	0.657	-1.918	8.769	7.140	-1.521	SP
Oct 19, 03	52932.475	0.684	-1.935	8.661	7.007	-1.665	SP
Nov 12, 03	52956.229	0.733	-1.724	8.718	7.049	–	SL

$JD_{\rm Min} = 2\,446\,336.7 + 482 \times E$ (Skopal 1997)

cember of that year (Skopal *et al.* 2000 a). Then a gradual decrease lasted up to June 2002. At around August 2002 we detected for the first time a minimum, which was due to eclipse of the active object by the red giant (Skopal 2003). This result suggests a very high inclination of the orbital plane of Z And. Further observations indicated an increase in the star's brightness to the spring of 2003. The latest measurements from 2003.3 are close to those of the quiescent phase. This indicates a low level of activity and/or just a maximum of the wave-like variability at the orbital phase 0.5 (see Fig. 2, Table 2). Further observations will demonstrate that.

3.3. BF Cyg

The photometric measurements of BF Cyg are given in Table 3. Stars HD 183650 (V = 6.96, $B-V$ = 0.71, $U-B$ = 0.34, $V-R$ = 0.56) and BD+30 3594 (V = 9.54, $B-V$ = 1.20, $U-B$ = 1.70) were used as the comparison and check, respectively.

Figure 3 shows the U, B, V LCs from 1999.6. A few V/CCD observations available from VSNET (made by O. Pejcha) were added for comparison. The periodic wave-like variation in the optical continuum reflects a quiescent phase

Table 2. U, B, V, R observations of Z And

Date	JD 24...	Phase⋆	U	B	V	R	Obs
Nov 23, 01	52237.255	0.653	9.743	10.827	10.027	–	SL
Dec 09, 01	52253.338	0.674	9.753	10.745	10.025	9.027	SP
Dec 14, 01	52258.200	0.681	9.691	10.808	10.065	–	SL
Jan 08, 02	52283.247	0.714	9.605	10.568	9.822	8.933	SP
Jan 15, 02	52290.357	0.723	9.642	10.564	9.910	8.959	SP
Jan 16, 02	52291.235	0.724	9.601	10.597	9.922	8.977	SP
Jan 18, 02	52293.244	0.727	9.696	10.710	10.011	9.040	SP
Feb 02, 02	52308.224	0.747	9.88:	10.94:	10.18:	–	SL
Feb 16, 02	52322.221	0.765	9.981	10.948	10.222	9.167	SP
May 08, 02	52402.538	0.871	10.002	10.805	10.150	9.179	SP
Jun 19, 02	52445.457	0.928	10.346	11.279	10.309	–	SL
Jul 01, 02	52456.508	0.942	10.775	11.557	10.517	9.306	SP
Aug 19, 02	52506.451	0.008	11.414	11.794	10.633	9.420	SP
Aug 27, 02	52514.396	0.019	11.275	11.629	10.545	–	SL
Sep 01, 02	52518.539	0.024	11.250	11.637	10.516	9.323	SP
Sep 04, 02	52522.386	0.029	11.118	11.601	10.485	–	SL
Sep 08, 02	52525.507	0.033	11.098	11.582	10.482	–	SL
Sep 19, 02	52537.383	0.049	10.848	11.415	10.418	9.267	SP
Sep 29, 02	52547.301	0.062	10.561	11.170	10.207	–	SL
Sep 30, 02	52548.426	0.064	10.568	11.163	10.188	9.081	SP
Oct 01, 02	52549.483	0.065	10.552	11.151	10.161	9.070	SP
Oct 06, 02	52553.520	0.070	10.399	11.083	10.113	9.032	SP
Oct 25, 02	52573.225	0.096	10.19:	10.87:	9.94:	8.940	SP
Oct 29, 02	52577.341	0.102	10.082	10.784	9.918	–	SL
Oct 30, 02	52578.402	0.103	–	10.790	9.960	–	R
Nov 12, 02	52591.216	0.120	10.114	10.738	9.854	–	SL
Nov 28, 02	52607.333	0.141	–	10.810	9.970	–	R
Nov 29, 02	52608.181	0.143	10.215	10.866	9.922	8.813	SP
Dec 10, 02	52619.317	0.157	10.197	10.844	9.947	8.843	SP
Dec 11, 02	52620.313	0.159	10.133	10.842	9.951	8.853	SP
Dec 20, 02	52629.325	0.170	10.176	10.829	9.918	8.857	SP
Dec 21, 02	52630.370	0.172	10.260	10.880	10.020	8.900	SP
Dec 23, 02	52632.325	0.174	10.120	10.781	9.989	8.857	SP
Dec 26, 02	52635.260	0.178	9.949	10.897	10.040	–	SL
Jan 01, 03	52641.292	0.186	10.009	10.905	10.024	8.858	SP
Jan 11, 03	52651.261	0.199	9.978	10.966	10.106	8.929	SP
Feb 03, 03	52674.216	0.230	10.450	11.300	10.310	9.090	SP
Feb 16, 03	52687.223	0.247	10.509	11.335	10.367	9.091	SP
Feb 25, 03	52696.283	0.259	10.580	11.363	10.472	–	SL
Feb 25, 03	52696.240	0.259	10.608	11.393	10.474	9.169	SP
Feb 27, 03	52698.251	0.261	10.765	11.456	10.509	9.195	SP
Apr 16, 03	52745.576	0.324	11.051	11.668	10.743	–	SL
May 06, 03	52765.543	0.350	11.037	11.652	10.705	9.387	SP
May 07, 03	52766.540	0.352	11.097	11.648	10.691	9.382	SP
Jun 03, 03	52794.474	0.388	10.829	11.638	10.643	–	SL
Jun 07, 03	52798.399	0.394	–	–	10.6::	9.30:	SP
Jun 29, 03	52820.416	0.423	10.752	11.520	10.475	9.193	SP
Aug 04, 03	52855.525	0.469	10.716	11.497	10.420	9.145	SP
Aug 06, 03	52858.487	0.473	10.756	11.535	10.454	9.160	SP
Aug 17, 03	52869.400	0.487	10.695	11.522	10.447	9.154	SP
Aug 24, 03	52876.452	0.497	10.766	11.627	10.571	–	SP
Sep 08, 03	52890.588	0.515	10.648	11.431	10.369	9.078	SP
Sep 18, 03	52900.560	0.529	10.677	11.486	10.374	9.093	SP
Sep 27, 03	52910.434	0.542	–	11.490	10.500	–	R
Sep 28, 03	52911.384	0.543	–	11.510	10.510	–	R
Oct 02, 03	52915.408	0.548	–	11.530	10.550	–	R
Oct 06, 03	52919.425	0.553	10.647	11.503	10.436	9.150	SP
Oct 19, 03	52932.441	0.571	10.697	11.492	10.361	9.078	SP
Nov 08, 03	52952.222	0.597	10.612	11.472	10.414	–	SL

$JD_{\rm Min} = 2\,414\,625.2 + 757.5 \times E$ (Skopal 1998)

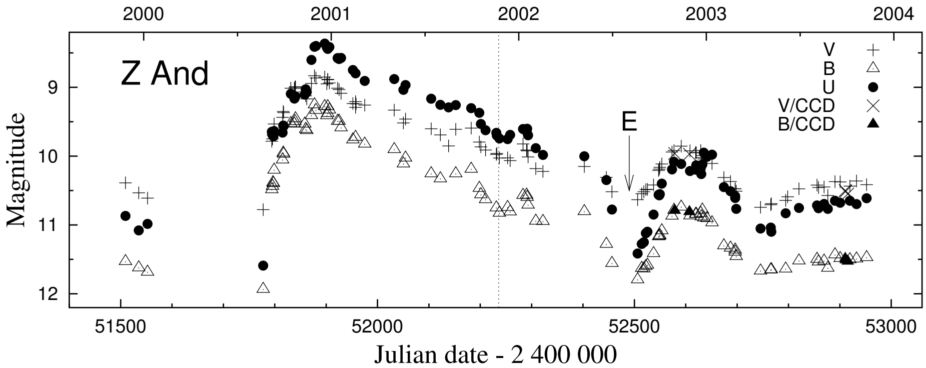

Figure 2. The U, B, V photometry of Z And covering the recent active phase. The eclipse of the active component by the red giant is denoted by E.

of this star. However, the profile of the LC is not a simple sinusoid through the orbital cycle. It differs in many details from cycle to cycle. Generally, such behaviour reflects a complex shape and variation of the nebula in the binary (Skopal 2001). For example, the minimum around JD 2 452 160 was rather flat for about 110 days (best seen in B). The current minimum ($\sim$ JD 2 452 930) seems to follow the same behaviour, but very close to its mid ($\varphi = 0.986$, see Table 3) we detected a dip in U (= 13.08) and B (= 13.52), which represents the lowest brightness ever observed for BF Cyg. We note that shortly after this detection, on 15th October 2003 ($\varphi = 0.996$), BF Cyg fell down in its brightness under the limit of detection within our devices (data quality was poor due to high background). The latest observations follow those taken just prior to this dip (Fig. 3). Additional peculiarity in the LC developed in February 2003 in a form of a short-term flare. This transient brightening lasted for about 1 month (our observations did not record its accurate profile) and was most pronounced in B ($\Delta B \sim 0.7$ mag). It occurred at the orbital phase 0.68, very close in the phase to that observed for AX Per (see below, Sect. 3.12). The nature of such brightening is not well understood. It differs from flares/outbursts currently observed for other symbiotics (e.g. AG Dra, here in Fig. 7), amplitude of which is largest in U.

3.4. CH Cyg

Our new photometry of CH Cyg is listed in Table 4. Stars HD 183123 (SAO 48428, V = 8.355, $B - V$ = 0.478, $U - B$ = − 0.031, $V - R$ = 0.312) and HD 182691 (SAO 31623, V = 6.525, $B - V$ = − 0.078, $U - B$ = − 0.24, $V - R$ = 0) were used as a comparison and a check star, respectively. In addi-

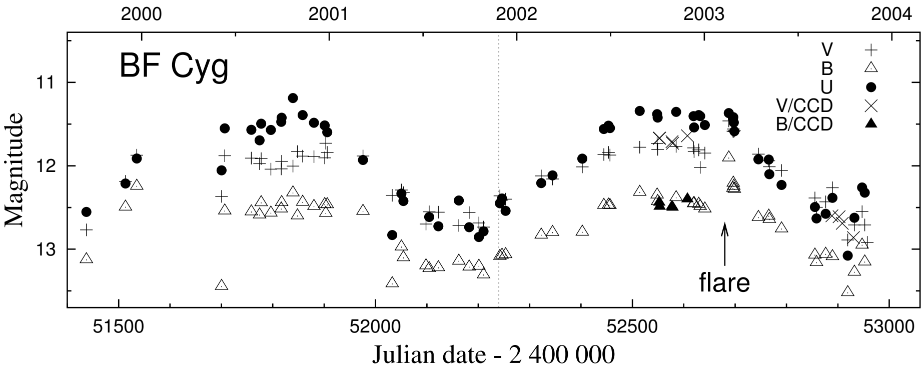

Figure 3. The UBV LCs of BF Cyg. A small flare developed in February 2003.

tion, we also measured the nearby star SAO 31628 (BD+49°2997) to examine its variability suggested by Sokoloski, Stone (2000). However, our type of measurements was not suitable for such a short-period variable ($P_{\rm orb}$ = 3.74783 d). We were able to confirm only the position of the primary minimum according to the ephemeris suggested by Sokoloski, Stone (2000). Further observations are required to determine the whole LC-profile.

Figure 4 shows the recent photometric observations covering the last 1998-00 activity including the eclipse at the outer, 14.5-year period, orbit. Our new observations indicated evolution in LCs, which is similar to that occurred after the previous active phases, in 1970, 1987 and 1996.5 (see Fig. 1 of Eyres *et al.* 2002). This is characterized by a 750-day wave-like variation in LCs and rather bright magnitudes ($V \sim 7{-}7.5$, $B \sim 9{-}9.5$ and $U \approx 10$). The colour indices are typical for a quiescent phase of this star. At $\sim$JD 2 452 730 a shallow minimum occurred in the UBV LCs. Its position is very close to that predicted according to the ephemeris, $Min = JD\,2\,445\,888 + 756 \times E$ (Skopal 1995).

3.5. CI Cyg

The photometric measurements of CI Cyg are given in Table 5. Stars HD 226107 (SAO 68948; $V = 8.55$, $B - V = -0.04$, $U - B = -0.33$) and HD 226041 (SAO 68923; $V = 8.60$, $B{-}V = 0.35$, spectrum F 5) were used as the comparison and check, respectively.

We started monitoring of CI Cyg from September 30, 2002 (the orbital phase $\varphi = 0.53$, see Table 5, Fig. 5). At that time it was around its maximum, which lasted to about March 2003 ($\varphi \sim 0.75$) with a small diminution in U. Then the star's brightness was decreasing to a minimum at $\varphi \sim 0$ by about of 1 mag in U and B and by about 0.5 mag in V. Such behaviour is typical for a quiescent

Table 3. U, B, V, R observations of BF Cyg. A few points were added from the VSNET database.

Date	JD 24...	Phase*	U	B	V	ΔR	Obs
Nov 28, 01	52242.257	0.092	12.450	13.085	12.360	4.751	SP
Dec 02, 01	52246.214	0.097	12.392	13.071	12.411	–	SL
Dec 09, 01	52253.195	0.106	12.541	13.065	12.400	4.684	SP
Feb 17, 02	52322.630	0.198	12.207	12.831	12.121	4.382	SP
Mar 11, 02	52344.616	0.227	12.116	12.798	12.159	4.449	SP
May 07, 02	52402.485	0.303	11.915	12.795	12.013	4.175	SP
Jun 18, 02	52444.482	0.359	11.560	12.474	11.865	4.057	SP
Jun 27, 02	52453.456	0.371	11.520	12.470	11.840	4.140	SP
Jun 30, 02	52456.462	0.375	11.548	12.476	11.872	4.106	SP
Aug 27, 02	52514.357	0.451	11.343	12.318	11.778	–	SL
Sep 30, 02	52548.250	0.496	11.381	12.349	11.732	3.888	SP
Oct 01, 02	52549.321	0.497	11.423	12.428	11.803	3.956	SP
Oct 04, 02	52552.309	0.501	–	12.440	11.670	–	R
Oct 05, 02	52553.234	0.502	–	12.490	11.670	–	R
Oct 29, 02	52577.244	0.534	–	12.490	11.710	–	R
Oct 30, 02	52578.206	0.535	–	12.500	11.730	–	R
Nov 06, 02	52585.244	0.545	11.354	12.381	11.768	3.945	SP
Nov 28, 02	52607.179	0.574	–	12.400	11.640	–	R
Dec 10, 02	52619.180	0.590	11.405	12.454	11.786	3.989	SP
Dec 11, 02	52620.192	0.591	11.540	12.451	11.830	4.045	SP
Dec 20, 02	52629.188	0.603	11.393	12.461	11.810	4.110	SP
Dec 23, 02	52632.189	0.607	11.405	12.487	12.020	1.910†	SP
Jan 01, 03	52641.199	0.619	11.511	12.516	11.848	4.091	SP
Feb 17, 03	52687.681	0.680	11.368	11.905	11.463	1.584†	SP
Feb 25, 03	52695.650	0.691	11.435	12.270	11.585	–	SL
Feb 26, 03	52696.597	0.692	11.418	12.207	11.559	3.848	SP
Feb 27, 03	52697.599	0.693	11.481	12.245	11.590	3.848	SP
Feb 28, 03	52698.622	0.694	11.587	12.281	11.579	3.899	SP
Apr 15, 03	52745.473	0.756	11.923	12.618	11.860	–	SL
May 05, 03	52765.459	0.783	11.926	12.603	11.940	4.166	SP
May 06, 03	52766.476	0.784	12.101	12.642	12.011	4.233	SP
May 30, 03	52790.494	0.816	12.230	12.755	12.057	4.289	SP
Aug 03, 03	52855.448	0.902	12.495	13.070	12.386	4.656	SP
Aug 06, 03	52858.338	0.905	12.631	13.158	12.498	4.718	SP
Aug 24, 03	52876.346	0.929	12.575	13.060	12.433	4.658	SP
Sep 05, 03	52888.437	–	–	–	12.60	–	VSNET
Sep 06, 03	52889.369	0.946	12.38:	13.09:	12.26:	4.49:	SP
Sep 19, 03	52902.495	–	–	–	12.61	–	VSNET
Sep 25, 03	52908.521	–	–	–	12.69	–	VSNET
Oct 06, 03	52919.306	0.986	13.08:	13.52:	12.890	4.99:	SP
Oct 15, 03	52928.292	0.036	↓	↓	12.918	–	SL
Oct 17, 03	52930.401	–	–	–	12.86	–	VSNET
Oct 19, 03	52932.296	0.003	12.624	13.275	12.710	4.981	SP
Nov 03, 03	52947.256	0.023	12.26:	12.95:	12.55:	4.737	SP
Nov 08, 03	52952.247	0.029	12.322	13.152	12.709	–	SL

* $Min = JD\,2\,415\,065 + 757.3 \times E$ (Pucinskas 1970)

† ΔR = BF Cyg - BD+30 3594

↓ target within the backround

phase of symbiotic stars, and for CI Cyg was recently nicely demonstrated by Dmitrienko (2000) by a large series of the $UBVRI$ observations during 1996 – 1999. In addition to the orbitally related variability, the V-LC displays 40 – 60-day variations with the amplitude of 0.2 – 0.4 mag, which is also seen well in the averaged visual LC (Fig. 5). This type of variability was originally revealed

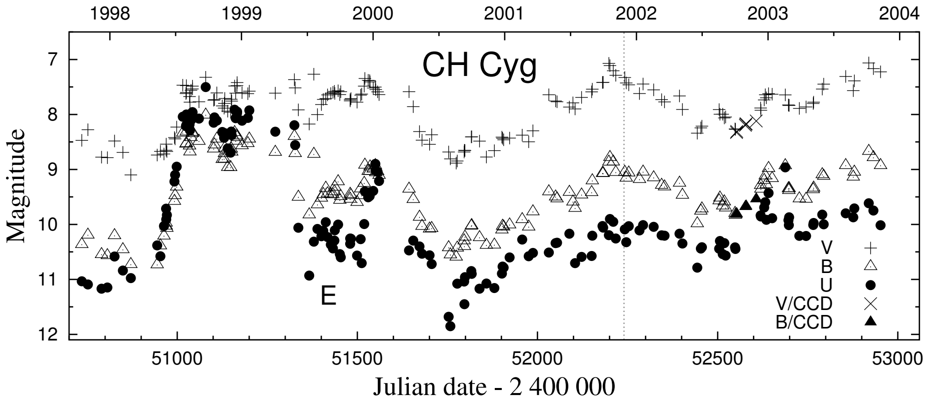

Figure 4. The UBV LCs of CH Cyg.

by Belyakina, Prokofieva (1991), who ascribed it to the cool giant in CI Cyg.

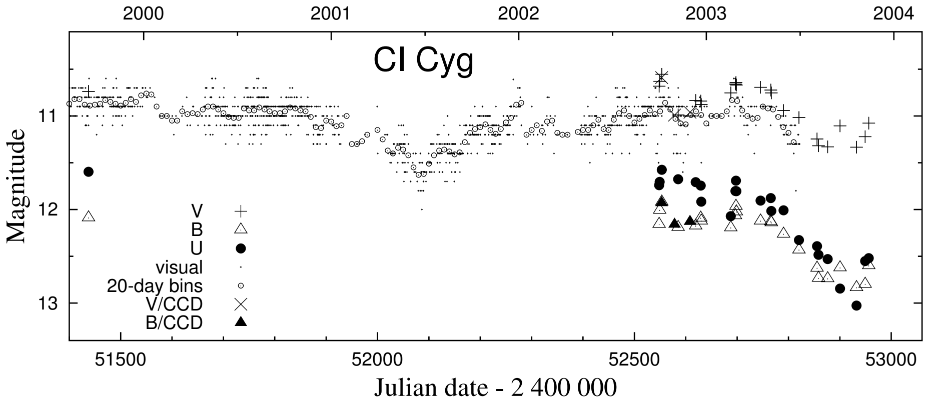

Figure 5. The UBV LCs of CI Cyg.

3.6. V1329 Cyg

Our observations of the symbiotic nova V1329 Cyg (HBV 475) are given in Table 6. In this paper we present only the CCD observations made at the Rozhen Observatory. The stars BD+35 4290 ($V = 10.34$, $B - V = 1.07$, $U - B = 0.88$) and BD+35 4294 ($V = 10.16$, $B - V = 1.07$) were used as the comparison and check, respectively.

Table 4. U, B, V, R observations of CH Cyg

Date	JD 24...	Phase*	U	B	V	ΔR	Obs
Nov 28, 01	52242.308	0.405	10.091	9.053	7.328	-1.006	SP
Dec 02, 01	52246.179	0.410	10.324	9.158	7.428	–	SL
Dec 09, 01	52253.291	0.420	10.032	9.064	7.461	-0.972	SP
Jan 08, 02	52283.196	0.459	10.109	9.183	7.620	-0.846	SP
Jan 18, 02	52293.202	0.472	10.014	9.048	7.447	-0.977	SP
Feb 17, 02	52322.517	0.511	10.044	9.150	7.552	-0.848	SP
Mar 11, 02	52344.568	0.540	10.199	9.287	7.732	-0.733	SP
Mar 19, 02	52352.563	0.551	10.206	9.318	7.772	-0.692	SP
Apr 29, 02	52394.400	0.606	10.169	9.249	7.663	-0.734	SP
May 07, 02	52402.435	0.617	10.349	9.468	7.909	-0.551	SP
Jun 17, 02	52443.455	0.671	10.787	9.987	8.341	–	SL
Jun 27, 02	52453.405	0.684	10.440	9.757	8.244	-0.326	SP
Jun 30, 02	52456.416	0.688	10.416	9.717	8.214	-0.346	SP
Aug 17, 02	52504.325	0.752	10.442	9.569	7.913	–	SL
Aug 20, 02	52506.500	0.755	10.303	9.520	7.996	-2.034	SP
Aug 27, 02	52514.307	0.765	10.542	9.663	7.996	–	SL
Aug 31, 02	52518.430	0.770	10.342	9.590	8.063	-1.983	SP
Sep 04, 02	52522.344	0.776	10.568	9.700	8.047	–	SL
Sep 30, 02	52548.343	0.810	10.419	9.798	8.263	-1.765	SP
Oct 01, 02	52549.448	0.811	10.447	9.832	8.272	-1.785	SP
Oct 04, 02	52552.351	0.815	–	9.820	8.330	–	R
Oct 05, 02	52553.217	0.816	–	9.810	8.310	–	R
Oct 29, 02	52577.209	0.848	–	9.680	8.200	–	R
Oct 30, 02	52578.224	0.850	–	9.680	8.180	–	R
Oct 31, 02	52579.190	0.851	–	9.670	8.170	–	R
Nov 28, 02	52607.162	0.888	–	9.540	8.120	–	R
Dec 10, 02	52619.223	0.904	9.837	9.290	7.884	-2.094	SP
Dec 11, 02	52620.233	0.905	9.857	9.359	7.923	-2.038	SP
Dec 20, 02	52629.285	0.917	9.692	9.198	7.735	-2.194	SP
Dec 23, 02	52632.226	0.921	9.596	9.117	7.643	-2.241	SP
Dec 26, 02	52635.191	0.925	9.916	9.277	7.698	–	SL
Jan 01, 03	52641.238	0.933	9.429	8.983	7.622	-2.325	SP
Jan 11, 03	52651.209	0.946	9.887	9.166	7.633	-2.341	SP
Feb 17, 03	52687.620	0.994	8.962	8.932	7.645	-2.307	SP
Feb 26, 03	52696.665	0.006	9.924	9.350	7.827	-2.217	SP
Feb 27, 03	52697.640	0.007	10.014	9.381	7.835	-2.205	SP
Feb 28, 03	52698.584	0.009	9.872	9.347	7.835	-2.212	SP
Mar 28, 03	52726.609	0.046	10.209	9.533	7.890	–	SL
Apr 15, 03	52745.401	0.071	10.211	9.542	7.864	–	SL
May 05, 03	52765.414	0.097	10.010	9.368	7.802	-2.225	SP
May 06, 03	52766.424	0.098	9.974	9.338	7.778	-2.235	SP
May 30, 03	52790.450	0.130	9.824	9.095	7.538	-2.426	SP
Jun 03, 03	52794.423	0.135	9.998	9.125	7.450	–	SL
Aug 03, 03	52855.403	0.216	9.798	8.928	7.310	-2.617	SP
Aug 24, 03	52876.414	0.244	9.870	9.138	7.568	-2.420	SP
Aug 27, 03	52879.331	0.248	9.710	9.050	7.390	-2.420	SP
Oct 06, 03	52919.350	0.301	9.615	8.671	7.065	-2.737	SP
Oct 19, 03	52932.406	0.318	9.748	8.785	7.167	-2.757	SP
Nov 08, 03	52952.277	0.344	10.015	8.928	7.225	–	SL

* $Min = JD\,2\,445\,888 + 756 \times E$ (Skopal 1995)

3.7. TX CVn

The results of our photometric measurements of TX CVn (HD 63173, BD+37-2318) are depicted in Table 7. 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,

Table 5. U, B, V observations of CI Cyg

Date	JD 24...	Phase*	U	B	V	ΔR	Obs
Sep 15, 99	51437.474	0.227	11.597	12.088	10.738	0.779	SP
Sep 30, 02	52548.296	0.526	11.740	12.158	10.682	0.674	SP
Oct 01, 02	52549.387	0.527	11.704	12.007	10.630	0.664	SP
Oct 05, 02	52553.254	0.531	–	11.930	10.590	–	R
Oct 05, 02	52553.422	0.532	11.576	11.919	10.555	0.582	SP
Oct 30, 02	52578.238	0.561	–	12.160	10.990	–	R
Nov 06, 02	52585.357	0.569	11.676	12.190	10.989	0.885	SP
Nov 29, 02	52608.184	0.596	–	12.130	10.960	–	R
Dec 10, 02	52619.277	0.609	11.708	12.174	10.834	0.774	SP
Dec 20, 02	52629.231	0.620	11.745	12.091	10.841	0.819	SP
Dec 21, 02	52630.180	0.621	11.92:	12.12:	10.88:	0.92:	SP
Feb 17, 03	52687.653	0.689	12.071	12.195	10.753	0.744	SP
Feb 26, 03	52696.633	0.699	11.803	12.065	10.659	0.701	SP
Feb 27, 03	52697.666	0.700	11.692	11.965	10.642	0.695	SP
Feb 28, 03	52698.661	0.701	11.804	12.024	10.669	0.720	SP
Apr 16, 03	52745.530	0.756	11.905	12.122	10.694	–	SL
May 06, 03	52765.507	0.780	11.878	12.129	10.723	0.780	SP
May 07, 03	52766.509	0.781	12.016	12.141	10.753	0.807	SP
May 31, 03	52790.529	0.809	12.008	12.263	10.942	0.974	SP
Jun 29, 03	52820.379	0.844	12.327	12.432	11.018	1.028	SP
Aug 03, 03	52855.492	0.885	12.392	12.626	11.246	1.247	SP
Aug 06, 03	52858.405	0.888	12.484	12.734	11.318	1.266	SP
Aug 24, 03	52876.381	0.909	12.530	12.739	11.329	1.310	SP
Sep 17, 03	52900.466	0.937	12.845	12.622	11.105	1.112	SP
Oct 19, 03	52932.347	0.975	13.026	12.833	11.334	1.256	SP
Nov 03, 03	52949.195	0.994	12.551	12.798	11.222	1.182	SP
Nov 12, 03	52956.191	0.003	12.520	12.599	11.077	–	SL

$\star$ $JD_{Min} = 2\,411\,902 + 855.25 \times E$

Table 6. CCD B and V observations of V1329 Cyg from the Rozhen Observatory. Three points were added from the VSNET database for comparison.

Date	JD 24...	Phase*	B	V	Obs
Oct 04, 02	52552.362	0.955	14.86	13.94	R
Oct 05, 02	52553.270	0.956	14.86	13.96	R
Oct 29, 02	52577.267	0.981	14.78	13.92	R
Oct 30, 02	52578.250	0.983	14.76	13.91	R
Nov 28, 02	52607.196	0.013	14.62	13.80	R
Apr 03, 03	52732.609	0.144	14.15	13.28	R
May 03, 03	52762.529	0.175	14.08	13.20	R
May 05, 03	52765.499	0.178	14.09	13.22	R
Aug 06, 03	52858.433	0.275	–	13.17	VSNET
Aug 15, 03	52867.458	0.284	–	12.98	VSNET
Aug 28, 03	52880.408	0.298	–	12.79	VSNET
Sep 27, 03	52910.246	0.329	13.66	12.95	R
Sep 28, 03	52911.345	0.330	13.66	12.93	R
Oct 02, 03	52915.371	0.334	13.69	13.00	R

* $JD_{\rm eclipse} = 2\,427\,687 + 958.0 \times E$ (Schild, Schmid 1997)

$U - B = -0.07$), were used as a comparison and a check star, respectively.

Figure 6 shows our recent U, B, V measurements. With respect to the evolution in the historical LC, TX CVn still remains at a high level of its activity ($B \sim 10.5$), while at low stages the photographic LC was at $m_{\rm pg} \sim 11.6$ (see Fig. 1 of Skopal *et al.* 2000 b). In addition, we indicated two brightenings on our recent U, B, V LCs. First occurred at the end of 1996 and the second one at the beginning of 2003. During both we detected a minimum, which can be ascribed to the eclipse of the active component by its cool giant companion in the TX CVn binary. The reasons are as follows: (i) The minima occurred very close to the inferior conjunction of the giant according to solution for the spectroscopic orbit as proposed by Kenyon, Garcia (1989) and, (ii) both minima were more pronounced in U than in B. The mid points of these minima (JD 2450 477.6 ± 1.0 and JD 2452 660 ± 10) suggest the orbital period

$$P_{\rm orb} = 198.4 \pm 0.9 \text{ days},$$

which agrees within uncertainties with that suggested by Kenyon, Garcia (1989) for a circular orbit solution. The eclipsing nature of the observed minima suggest a high inclination of the orbital plane of TX CVn.

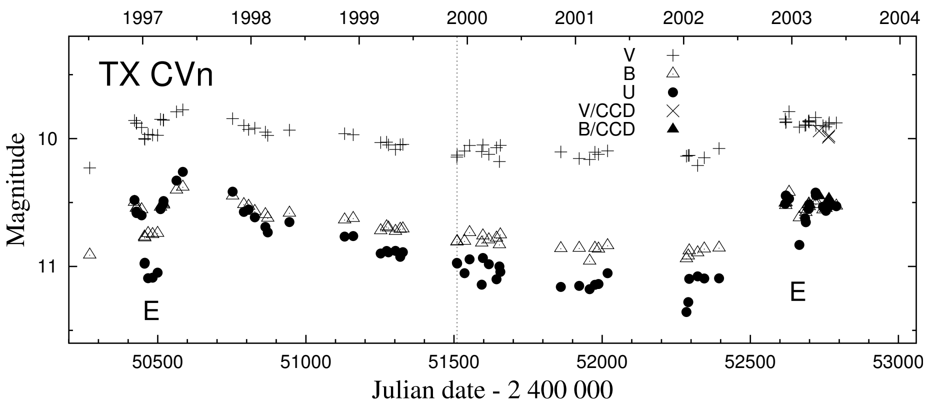

Figure 6. The UBV LCs of TX CVn. Eclipses of the active star by its giant companion are denoted by E.

3.8. AG Dra

Our measurements of AG Dra are summarized in Table 8. Stars BD+67 925 (SAO 16952, $V = 9.88$, $B - V = 0.56$, $U - B = -0.04$) and BD+67 923 (SAO 16935, $V = 9.46$, $B - V = 1.50$, $U - B = 1.89$) were used as the comparison and check, respectively.

Table 7. $U,\ B,\ V,\ R$ observations of TX CVn

Date	JD 24...	Phase*	U	B	V	ΔR	Obs
Nov 28, 99	51510.664	0.223	10.977	10.805	10.129	0.592†	SP
Dec 23, 99	51535.688	0.350	11.053	10.803	10.097	0.324	SP
Jan 08, 00	51552.437	0.434	10.944	10.735	10.054	0.495†	SP
Feb 18, 00	51593.410	0.641	11.143	10.816	10.102	–	SL
Feb 22, 00	51597.420	0.661	10.934	10.760	10.050	0.512†	SP
Mar 13, 00	51617.372	0.762	10.982	10.791	10.123	0.343	SP
Apr 08, 00	51643.496	0.894	11.100	10.778	10.072	–	SL
Apr 18, 00	51653.320	0.944	11.000	10.830	10.180	0.610†	SP
Apr 21, 00	51656.350	0.959	11.042	10.752	10.053	–	SL
Nov 12, 00	51860.668	0.991	11.160	10.860	10.105	0.344	SP
Jan 13, 01	51922.550	0.304	11.152	10.858	10.156	0.368	SP
Feb 16, 01	51957.462	0.480	11.178	10.958	10.163	0.381	SP
Mar 06, 01	51975.403	0.570	11.144	10.857	10.107	0.308	SP
Mar 18, 01	51987.404	0.631	11.137	10.864	10.123	0.338	SP
Apr 18, 01	52018.340	0.787	11.05:	10.837	10.096	0.311	SP
Jan 10, 02	52284.544	0.132	11.356	10.939	10.138	0.323	SP
Jan 16, 02	52290.543	0.162	11.279	10.917	10.133	0.314	SP
Jan 19, 02	52293.637	0.178	11.09:	10.877	10.132	0.336	SP
Feb 16, 02	52322.362	0.323	11.077	10.893	10.211	0.351	SP
Mar 10, 02	52344.483	0.435	11.094	10.863	10.150	0.342	SP
Apr 29, 02	52394.323	0.686	11.093	10.855	10.078	0.258	SP
Dec 09, 02	52617.608	0.814	10.510	10.504	9.847	0.088	SP
Dec 11, 02	52619.557	0.824	10.447	10.523	9.875	0.115	SP
Dec 12, 02	52620.506	0.829	10.445	10.501	9.870	0.061	SP
Dec 22, 02	52630.560	0.879	10.47:	10.42:	9.79:	0.04:	SP
Jan 26, 03	52665.529	0.056	10.832	10.619	9.910	0.132	SP
Feb 13, 03	52684.466	0.152	10.623	10.554	9.897	0.131	SP
Feb 16, 03	52687.368	0.166	10.654	10.578	9.894	0.134	SP
Feb 25, 03	52696.451	0.212	10.551	10.518	9.866	0.104	SP
Feb 26, 03	52697.404	0.217	10.548	10.512	9.861	0.111	SP
Feb 27, 03	52698.426	0.222	10.515	10.532	9.871	0.116	SP
Mar 21, 03	52720.365	0.333	10.423	10.487	9.836	0.095	SP
Mar 22, 03	52721.334	0.338	10.444	10.516	9.898	0.111	SP
Apr 02, 03	52732.419	0.394	–	10.450	9.940	–	R
Apr 15, 03	52745.321	0.459	10.533	10.557	9.899	–	SL
Apr 25, 03	52755.320	0.509	10.565	10.547	9.908	–	SL
May 03, 03	52763.367	0.550	–	10.490	9.99	–	R
May 05, 03	52765.326	0.560	–	10.470	9.98	–	R
May 05, 03	52765.333	0.560	10.490	10.520	9.887	0.130	SP
May 06, 03	52766.345	0.565	10.529	10.524	9.875	0.118	SP
May 30, 03	52790.374	0.686	10.529	10.527	9.877	0.106	SP

* $JD_{\rm sp.conj.} = 2\,445\,130.45 + 198 \times E$ (Kenyon, Garcia 1989)

† ΔR = TX CVn - HD 111113

Figure 7 shows the U, B, V LCs covering the recent declining part of the massive outburst, which began in 1994 July. The LC from 1994 was characterized by numerous eruptions (see Fig. 6 of S+02). Between 1994.5 and 1998.5 they appeared regularly with a period of about 1 year. After 1998.5, eruptions were not so regular, they had a lower amplitude and were not so massive as prior to this time. New observations revealed two short-term eruptions, which peaked in October 2002 and 2003, respectively, at ~ 9.3 in U. This indicates that the recent activity of AG Dra gradually dies away. However, the wave-like variation, typical for a quiescent phase, has not been developed yet.

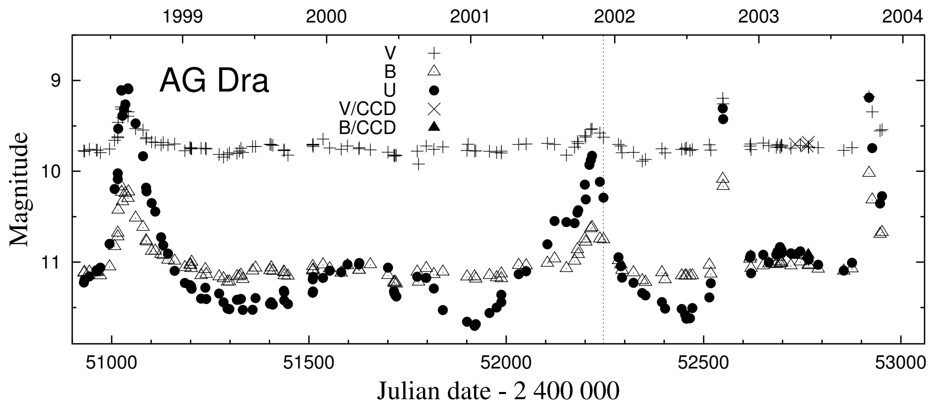

Figure 7. The UBV LCs of AG Dra.

3.9. RW Hya

The U, B, V measurements of RW Hya (HD 117970) are listed in Table 9. The observation was carried out at the San Pedro Observatory during April 2003, at its orbital phase $\varphi \sim 0.75$. Note that the orbital period is very close to just 1 year (Table 9). Stars HD 118102 (CD-24 10984; $V = 8.944$, $B - V = 0.528$, $U - B = 0.105$), HD 117971 (CD-25 9879; $V = 9.688$, $B - V = 0.439$, $U - B = -0.034$) and HD 117803 (CD-24 10970; $V = 8.925$, $B - V = 0.417$, $U - B = -0.025$) were used as standard stars, to which RW Hya was compared.

Magnitudes are brighter, mainly in the U band, with respect to our previous observations made at $\varphi \sim 0.89$. This is in a good agreement with the wave-like variation as a function of the orbital phase suggested by visual estimates (see Fig. 7 of S+02). Observations at other positions of the binary, mainly at $\varphi \sim 0.5$, are very desirable.

3.10. AR Pav

Figure 8 shows the visual LC from 1982 to December 2003. Some qualitative discussion of a major part of these data can be found in Skopal *et al.* (2000 b, 2001). Our new visual estimates cover the period from the epoch 67 (1999.8, bottom panel of Fig. 8). The most interesting feature of LC is a transient disappearance of a wave-like modulation of the star's brightness as a function of the orbital phase for the period of just two cycles, between the minima at epochs E = 66 and E = 68. Also variation in the depth of the minima (e.g. minima at E = 61, 68 are by about 0.3-0.4 mag brighter than those at E = 64) and in its profile (see also Fig. 2 of Skopal *et al.* 2001) reflect a strong variation in both geometry and radiation of the active component of AR Pav. The latest obser-

Table 8. U, B, V, R observations of AG Dra

Date	JD 24...	Phase*	U	B	V	ΔR	Obs
Dec 02, 01	52246.277	0.675	10.291	10.753	9.625	–	SL
Jan 09, 02	52284.493	0.745	10.948	10.982	9.704	-0.704	SP
Jan 16, 02	52290.500	0.756	11.046	11.029	9.721	-0.690	SP
Jan 19, 02	52293.594	0.761	11.172	11.090	9.796	-0.600	SP
Feb 16, 02	52322.402	0.814	11.229	11.117	9.792	-0.645	SP
Mar 11, 02	52344.535	0.854	11.341	11.203	9.888	-0.560	SP
Mar 19, 02	52352.525	0.868	11.368	11.223	9.869	-0.561	SP
Apr 29, 02	52394.365	0.945	11.440	11.116	9.753	-0.588	SP
May 07, 02	52402.397	0.959	11.512	11.193	9.798	-0.594	SP
Jun 18, 02	52444.429	0.036	11.516	11.150	9.759	-0.631	SP
Jun 27, 02	52453.367	0.052	11.581	11.153	9.752	-0.611	SP
Jun 30, 02	52456.369	0.057	11.624	11.154	9.744	-0.635	SP
Jul 09, 02	52465.452	0.074	11.619	11.153	9.771	-0.632	SP
Jul 15, 02	52471.426	0.085	11.507	11.149	9.761	-0.623	SP
Aug 27, 02	52514.499	0.163	11.390	11.033	9.709	–	SL
Aug 31, 02	52518.365	0.170	11.233	11.131	9.767	-0.589	SP
Oct 01, 02	52548.500	0.225	9.307	10.087	9.196	-0.984	SP
Oct 02, 02	52549.576	0.227	9.426	10.167	9.258	-0.932	SP
Dec 09, 02	52617.643	0.351	10.947	10.966	9.723	-0.683	SP
Dec 10, 02	52619.413	0.354	10.927	10.943	9.700	-0.722	SP
Dec 11, 02	52620.418	0.356	11.12:	11.067	9.761	-0.637	SP
Jan 11, 03	52651.457	0.412	10.9::	11.04:	9.69:	-0.550	SP
Jan 25, 03	52665.481	0.438	11.004	11.019	9.719	-0.682	SP
Feb 13, 03	52684.393	0.472	10.918	11.026	9.736	-0.690	SP
Feb 16, 03	52687.328	0.477	10.885	10.946	9.705	-0.703	SP
Feb 23, 03	52693.617	0.489	10.835	11.019	9.739	–	SL
Feb 25, 03	52696.397	0.494	10.885	10.994	9.713	-0.700	SP
Feb 26, 03	52697.360	0.496	10.865	11.010	9.728	-0.699	SP
Feb 27, 03	52698.375	0.498	10.900	11.009	9.715	-0.709	SP
Mar 22, 03	52721.398	0.539	10.903	11.040	9.745	-0.674	SP
Apr 02, 03	52732.451	0.560	–	10.93	9.70	–	R
May 02, 03	52762.417	0.614	–	10.94	9.72	–	R
Apr 15, 03	52745.353	0.583	10.882	10.998	9.716	–	SL
May 05, 03	52765.343	0.619	–	10.92	9.68	–	R
May 05, 03	52765.381	0.619	10.957	11.029	9.735	-0.691	SP
May 06, 03	52766.393	0.621	10.974	11.039	9.733	-0.681	SP
May 30, 03	52790.413	0.665	11.030	11.076	9.741	-0.681	SP
Aug 03, 03	52855.364	0.783	11.094	11.098	9.770	-0.644	SP
Aug 24, 03	52876.303	0.821	11.008	11.074	9.740	-0.664	SP
Oct 06, 03	52919.387	0.900	9.189	10.022	9.181	-1.072	SP
Oct 14, 03	52927.251	0.914	9.745	10.314	9.345	–	SL
Nov 03, 03	52947.198	0.950	10.355	10.693	9.555	-0.846	SP
Nov 08, 03	52952.190	0.959	10.275	10.673	9.542	–	SL

* $Min = JD\,2\,443\,629.17 + 549.73 \times E$ (Gális *et al.* 1999)

vations from E = 68 indicate a follow-up transition to a high state similar to that observed prior to the cycle 66. Perfect agreement between the photoelectric photometry and our visual estimates suggests that the described details in the visual LC are real (see Skopal *et al.* 2001). Finally, we determined position of the recent minimum to Min(68) = JD $2\,452364.5 \pm 0.7$. This position and those of Min(66) = JD $2\,451\,158.9 \pm 0.7$ and Min(67) = JD $2\,451\,762.8 \pm 0.7$ (Skopal *et al.* 2001), which occurred during the low stage, correspond to the period of only 602.8 ± 0.3 days. This is by 1.65 day shorter than that given by all available mid-points. On the other hand, it is close to that predicted by the parabolic

Table 9. U, B, V observations of RW Hya

Date	JD 24...	Phase⋆	U	B	V	Obs
Apr 20, 03	52749.772	0.741	10.295	10.184	8.743	M
Apr 20, 03	52749.814	0.741	10.229	10.159	8.758	M
Apr 20, 03	52749.816	0.741	10.233	10.183	8.748	M
Apr 22, 03	52751.814	0.747	10.314	10.193	8.739	M
Apr 22, 03	52751.817	0.747	10.284	10.135	8.737	M
Apr 23, 03	52752.849	0.750	10.373	10.174	8.754	M
Apr 23, 03	52752.852	0.750	10.278	10.180	8.720	M

⋆ $JD_{\rm sp.conj.} = 2\,449\,512 + 370.4 \times E$ (Schild *et al.* 1996)

ephemeris derived by Skopal *et al.* (2000 c).

3.11. AG Peg

We began monitoring this star (HD 207757) from November 2001. The results are summarized in Table 10. Stars HD 207933 (SAO 107460, V = 8.10, $B-V$ = 1.05, $U-B$ = 0.97) and HD 207860 (SAO 107453, V = 8.73, $B-V$ = 0.42, spectrum F8), were used as a comparison and a check star, respectively.

Figure 9 shows our U, B, V measurements of AG Peg. They show a rather complex profile of the LC with respect to, for example, recently published photometry of Tomov, Tomova (1998). We can see a relatively slow increase in the brightness from the beginning of our observations ($\varphi = 0.14$) to a maximum at $\varphi = 0.54$, then a sudden transition from the maximum to a flat minimum in U, a plateau at/around the maximum in B and a zig-zag variation in V. The last feature of the V-LC is similar to that observed for CI Cyg, which suggests its origin in the cool giant's semiregular variability. However, our data do not cover the whole orbital cycle and only further observations can tell us more about evolution of individual components of radiation in the system.

3.12. AX Per

The recent measurements of AX Per in the U, B, V, R bands are given in Table 11 and showed in Fig. 10. Star HD 9839 (SAO 22444, V = 7.43, $B-V$ = 1.02, $U-B$ = 0.63) and BD+53 340 (V = 9.48, $B-V$ = 1.37, $U-B$ = 1.20) were used as the comparison and check, respectively.

Figure 10 shows evolution of the U, B, V LCs. The wave-like profile along the orbital phase indicates that AX Per still remains at a quiescent phase, which means that the nebular emission dominates the near-UV and, in part, optical spectral region, mainly around phase 0.5. The minimum which occurred at JD 2 452 310, was the deepest one during the post-outburst period from 1990. On the other hand, the minimum indicated by our latest observations was brighter by about 0.5 mag in U and was relatively flat. One can see some similarities with the LC evolution of BF Cyg. In May 2003 a 0.5 mag flare in B an U was detected,

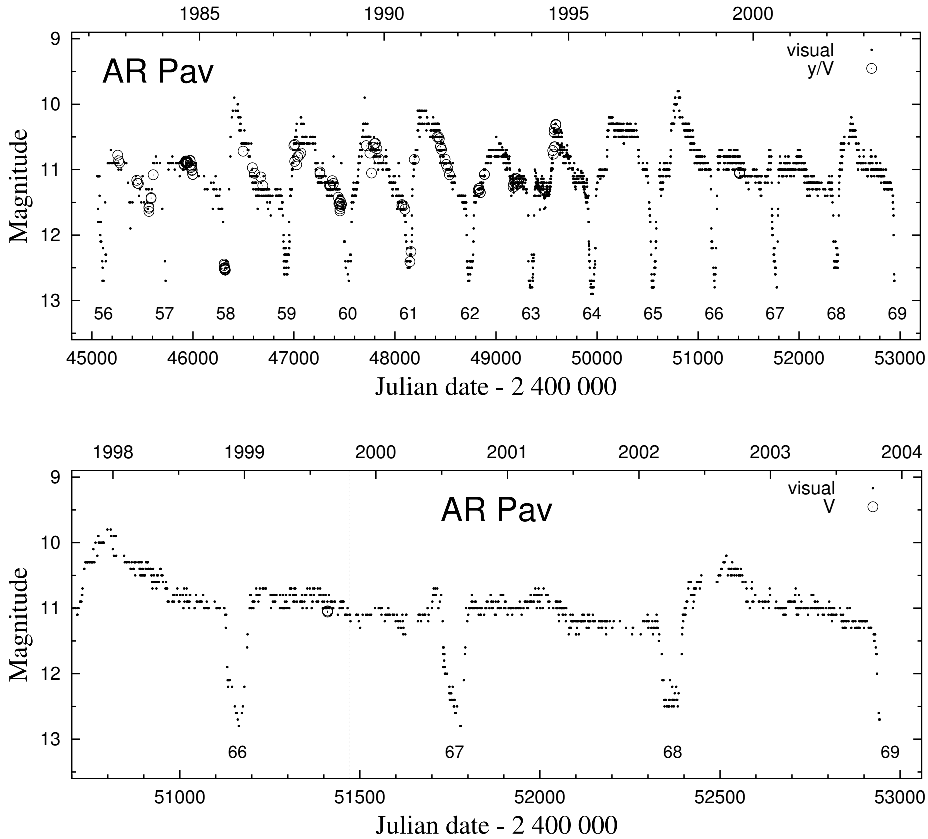

Figure 8. Top: Our visual estimates from 1982.2 to date (made by Albert Jones). Bottom: Recent evolution covering a low stage between epochs 66 and 68.

followed by a rapid decrease of the light. Its phase position ($\varphi \sim 0.72$) and other characteristics are similar to that observed in the BF Cyg LC (Sect. 3.3).

3.13. QW Sge

Figure 11 shows our CCD $B,\ V,\ R_{\rm J},\ I_{\rm J}$ photometry. We converted our measurements in the $I_{\rm C}$ and $R_{\rm C}$ bands of the Cousins system into the Johnson system according to Bessell (1983) by using his transformation equations for M giants:

$$(V-R)_{\rm J} = 2\times(V-R)_{\rm C} - 0.48, \qquad (R-I)_{\rm J} = (R-I)_{\rm C} + 0.10. \qquad (1)$$

Observations cover the period from 1994.5 to 2003.5 and are given in Table 12. Particularly interesting part of the LCs includes an active phase, which began

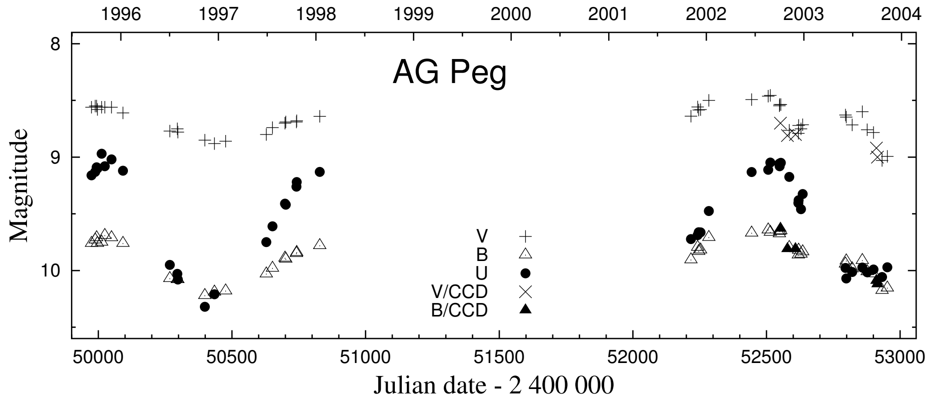

Figure 9. *UBV* LCs of AG Peg. Data to 1998 are from Tomov, Tomova (1998).

Table 10. *U*, *B*, *V*, *R* observations of AG Peg

Date	JD 24...	Phase*	U	B	V	ΔR	Obs
Nov 03, 01	52217.206	0.137	9.723	9.905	8.639	–	SL
Nov 28, 01	52242.203	0.167	9.688	9.795	8.558	-0.040	SP
Dec 02, 01	52246.242	0.172	9.663	9.831	8.584	–	SL
Dec 09, 01	52253.247	0.181	9.664	9.818	8.581	-0.022	SP
Jan 09, 02	52284.191	0.219	9.475	9.708	8.500	-0.077	SP
Jun 19, 02	52444.513	0.414	9.131	9.669	8.493	-0.167	SP
Aug 20, 02	52506.583	0.490	9.112	9.641	8.462	-0.177	SP
Aug 27, 02	52514.441	0.499	9.048	9.663	8.455	–	SL
Sep 30, 02	52548.384	0.541	9.057	9.675	8.547	-0.138	SP
Oct 01, 02	52549.420	0.542	9.080	9.654	8.535	-0.131	SP
Oct 04, 02	52552.383	0.546	–	9.63	8.70	–	R
Oct 05, 02	52553.477	0.547	9.050	9.648	8.537	-0.126	SP
Oct 30, 02	52578.273	0.577	–	9.81	8.81	–	R
Nov 06, 02	52585.297	0.586	9.175	9.796	8.763	0.064	SP
Nov 29, 02	52608.196	0.614	–	9.81	8.80	–	R
Dec 10, 02	52619.251	0.627	9.405	9.862	8.790	0.107	SP
Dec 11, 02	52620.274	0.628	9.380	9.820	8.720	0.080	SP
Dec 20, 02	52629.259	0.639	9.459	9.855	8.750	0.071	SP
Dec 26, 02	52635.220	0.646	9.325	9.834	8.714	–	SL
Jun 04, 03	52795.497	0.842	9.977	9.942	8.629	–	SL
Jun 07, 03	52798.450	0.845	10.070	9.914	8.647	-0.009	SP
Jun 29, 03	52820.463	0.872	10.013	9.984	8.715	0.074	SP
Aug 06, 03	52858.458	0.919	9.974	9.911	8.599	-0.043	SP
Aug 25, 03	52876.560	0.941	10.016	10.010	8.758	0.074	SP
Sep 18, 03	52900.514	0.970	9.991	10.028	8.783	0.126	SP
Sep 28, 03	52911.371	0.983	–	10.09	8.92	–	R
Oct 02, 03	52915.398	0.988	–	10.12	9.00	–	R
Oct 19, 03	52932.378	0.009	10.057	10.175	9.029	0.329	SP
Nov 08, 03	52952.301	0.033	9.972	10.154	8.993	–	SL

* $Min = JD\,2\,427\,495.9 + 820.3 \times E$ (Skopal 1998)

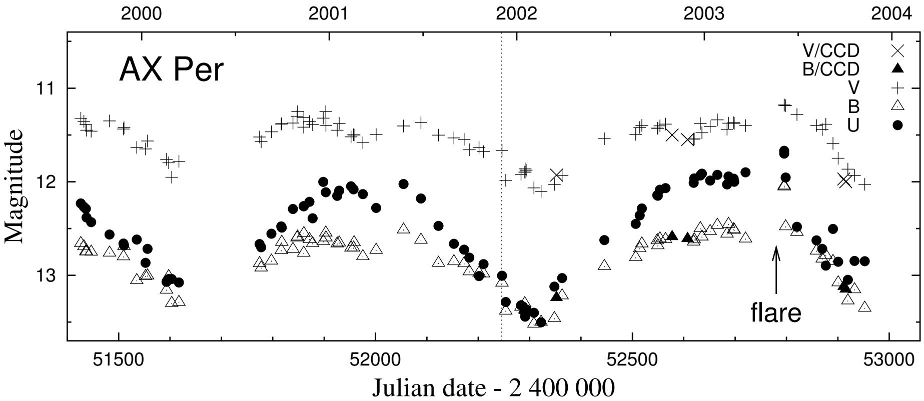

Figure 10. The UBV LCs of AX Per. A small flare developed here in May/June 2003.

at 1997 May and showed two maxima in 1997 November and at the beginning of 2000 in all wavelengths. The latter is poorly covered, because of a season gap. Amplitudes of the first brightening were $\Delta B = 1.3$ mag, $\Delta V = 1.4$ mag, $\Delta R = 1.2$ mag, and $\Delta I = 0.8$ mag. The brightening in R and I was indicated by our first observations at $\sim$JD 2 450 580, while in B and V it started later at about JD 2 450 660. These characteristics make the brightening of QW Sge very different from those usually observed for other symbiotic stars - they are significantly pronounced at shorter wavelengths (mainly in U, see Figs. 1, 2, 7) and also are first detected here. To reveal the origin of the observed brightenings in the QW Sge LCs requires a more detailed study.

3.14. IV Vir

The U, B, V measurements of IV Vir (BD-21 3873) are listed in Table 13. Observations were carried out at the San Pedro Observatory in 2003 April at the orbital phase 0.25. The star HD 124991 (BD-21 3877; $V = 8.072$, $B - V = 1.048$, $U - B = 0.730$) was used as the comparison.

The brightness of IV Vir is very close to that obtained by us at the orbital phase 0.84 (Table 9 of S+02). This confirms the wave variability of this quiet symbiotic, which produces a roughly symmetrical LC. Here, the measurements at phases 0.84 and 0.25 lie on the descending and the ascending branch of the broad minimum (see Fig. 9 of S+02).

3.15. V934 Her

This peculiar M giant (HD 154791) is the only optical counterpart of a hard X-ray source (4U1700+24) and can be classified as a LMXB (Gaudenzi, Polcaro

Table 11. U, B, V, R observations of AX Per

Date	JD 24...	Phase⋆	U	B	V	ΔR	Obs
Dec 02, 01	52246.315	0.905	13.004	13.083	11.665	–	SL
Dec 09, 01	52253.426	0.915	13.286	13.382	11.985	3.750	SP
Jan 08, 02	52283.332	0.959	13.321	13.340	11.921	3.670	SP
Jan 15, 02	52290.422	0.970	13.379	13.303	11.896	3.638	SP
Jan 16, 02	52291.282	0.971	13.442	13.375	11.898	3.685	SP
Jan 16, 02	52291.406	0.971	13.400	13.363	11.863	–	SL
Jan 18, 02	52293.287	0.974	13.364	13.373	11.877	3.581	SP
Feb 02, 02	52308.290	0.996	13.40:	13.52:	12.065	–	SL
Feb 16, 02	52322.309	0.017	13.502	13.500	12.103	3.748	SP
Mar 14, 02	52348.332	0.055	13.120	13.461	12.028	–	SL
Mar 18, 02	52352.251	0.061	–	13.24	11.93	–	R
Mar 29, 02	52363.295	0.077	13.030	13.219	11.935	–	SL
Jun 19, 02	52445.490	0.198	12.624	12.905	11.540	–	SL
Aug 20, 02	52506.533	0.288	12.45:	12.81:	11.494	3.284	SP
Aug 27, 02	52514.468	0.299	12.360	12.714	11.419	–	SL
Sep 01, 02	52518.595	0.305	12.286	12.663	11.398	3.150	SP
Oct 01, 02	52548.501	0.349	12.144	12.629	11.427	3.166	SP
Oct 02, 02	52549.549	0.351	12.149	12.684	11.429	3.171	SP
Oct 06, 02	52553.570	0.357	12.086	12.610	11.402	3.164	SP
Oct 16, 02	52564.421	0.373	12.069	12.617	11.384	3.146	SP
Oct 29, 02	52577.487	0.392	–	12.59	11.50	–	R
Nov 28, 02	52607.357	0.436	–	12.61	11.55	–	R
Dec 10, 02	52619.384	0.454	12.011	12.643	11.544	3.251	SP
Dec 11, 02	52620.386	0.455	11.965	12.620	11.541	3.257	SP
Dec 23, 02	52632.285	0.473	11.933	12.500	11.379	3.137	SP
Dec 26, 02	52635.300	0.477	11.914	12.590	11.477	–	SL
Jan 11, 03	52651.369	0.501	11.987	12.531	11.410	3.116	SP
Jan 25, 03	52665.430	0.521	11.926	12.465	11.338	3.046	SP
Feb 13, 03	52684.307	0.549	12.029	12.559	11.440	3.114	SP
Feb 16, 03	52687.288	0.553	11.943	12.455	11.374	3.060	SP
Feb 26, 03	52697.306	0.568	11.967	12.512	11.368	3.067	SP
Feb 27, 03	52698.302	0.570	12.001	12.517	11.376	3.066	SP
Mar 21, 03	52720.314	0.602	11.900	12.611	11.400	3.068	SP
Jun 05, 03	52795.515	0.713	11.699	12.054	11.179	–	SL
Jun 05, 03	52795.515	0.713	11.670	12.044	11.181	–	SL
Jun 07, 03	52798.475	0.717	11.955	12.480	11.187	2.990	SP
Jun 30, 03	52820.500	0.749	12.482	12.540	11.282	3.099	SP
Aug 07, 03	52858.538	0.805	12.626	12.740	11.399	3.240	SP
Aug 17, 03	52869.451	0.821	12.718	12.825	11.442	3.247	SP
Aug 25, 03	52876.521	0.832	12.896	12.787	11.385	3.253	SP
Sep 08, 03	52890.612	0.852	12.505	12.851	11.590	3.387	SP
Sep 18, 03	52900.607	0.867	12.855	13.079	11.749	3.523	SP
Sep 28, 03	52911.409	0.883	–	13.12	11.97	–	R
Oct 02, 03	52915.463	0.889	–	13.15	12.00	–	R
Oct 07, 03	52919.511	0.895	13.048	13.273	11.866	3.726	SP
Oct 20, 03	52932.507	0.914	12.846	13.154	11.932	3.607	SP
Nov 08, 03	52952.328	0.943	12.849	13.350	12.027	–	SL

⋆ $Min = JD\,2\,436\,673.3 + 679.9 \times E$ (Skopal 1991)

1999). This object was included in our observing programme to indicate possible optical variability as a response to an X-ray outburst, which peaked between August and September 2002 (Galloway, private communication).

Our photometric observations are summarized in Table 14. Star HD 155104 (SAO 84873, $V = 6.85$, $B-V = 0.13$, $U-B = 0.10$, spectrum B5) and GCS:02060-00124 ($V = 10.06$, $B-V = 0.73$, spectrum F1 V) were used as the comparison and check, respectively.

Table 12. B, V, R, I observations of QW Sge

Date	JD 24...	I_C	R_C	V	B	Obs
Jul 30, 94	49563.561	10.136	11.073	–	–	PB
Aug 16, 94	49581.448	10.211	11.174	11.917	–	PB
Aug 27, 94	49592.406	10.304	11.373	12.368	–	PB
Sep 23, 94	49619.423	10.258	11.325	–	–	PB
Jun 30, 95	49899.494	10.605	11.806	12.529	–	PB
May 10, 97	50579.470	10.574	11.707	12.509	13.154	PB
Jun 04, 97	50604.415	10.507	11.667	12.546	13.167	PB
Jun 11, 97	50611.440	10.472	11.643	12.513	13.179	PB
Jul 09, 97	50639.443	10.414	11.635	12.551	13.273	PB
Jul 11, 97	50641.443	10.338	11.584	12.490	13.152	PB
Jul 28, 97	50658.416	10.404	11.615	12.468	13.114	PB
Sep 01, 97	50693.355	9.905	10.792	11.468	12.328	PB
Sep 16, 97	50708.329	9.933	10.843	11.524	12.338	PB
Sep 28, 97	50720.343	9.780	10.609	11.220	11.998	PB
Oct 28, 97	50750.281	9.635	10.477	11.074	11.858	PB
Nov 20, 97	50773.242	9.635	10.442	11.120	11.958	PB
Jun 21, 98	50986.428	10.086	10.989	11.771	12.630	PB
Jul 03, 98	50998.476	10.066	10.989	11.805	12.578	PB
Aug 02, 98	51028.484	10.044	11.051	–	–	PB
Sep 09, 98	51066.338	10.056	11.013	11.855	12.638	PB
Sep 23, 98	51080.382	10.053	11.059	11.875	12.600	PB
Nov 05, 98	51123.289	10.158	11.184	12.021	12.773	PB
Mar 13, 99	51250.633	10.341	11.387	12.221	12.850	PB
Apr 09, 99	51277.561	10.393	11.402	12.162	12.869	PB
May 18, 99	51317.473	10.370	11.415	12.243	12.934	PB
Jul 03, 99	51363.431	10.374	11.452	12.254	12.925	PB
Aug 03, 99	51394.429	10.267	11.337	12.089	12.915	PB
Oct 19, 99	51471.363	10.112	11.113	11.881	12.586	PB
Mar 13, 00	51616.631	9.974	10.868	11.618	12.322	PB
Apr 09, 00	51643.562	10.089	11.032	11.793	12.501	PB
Apr 30, 00	51665.487	10.112	11.025	11.774	12.476	PB
Jun 02, 00	51698.455	10.171	11.129	11.898	12.658	PB
Jun 09, 00	51705.449	10.139	11.077	11.835	12.550	PB
Jun 21, 00	51717.452	10.155	11.095	11.828	12.579	PB
Jul 05, 00	51731.457	10.113	11.110	11.881	12.702	PB
Jul 25, 00	51751.472	10.142	11.127	11.944	12.686	PB
Aug 10, 00	51767.413	10.126	11.117	11.884	12.649	PB
Aug 21, 00	51778.378	10.142	11.166	11.980	12.717	PB
Sep 09, 00	51797.336	10.175	11.167	11.944	12.700	PB
Sep 27, 00	51815.308	10.236	11.251	12.074	12.731	PB
Nov 05, 00	51854.274	10.187	11.214	12.045	12.706	PB
Nov 29, 00	51878.230	10.249	11.296	12.086	12.832	PB
Apr 02, 01	52001.563	10.293	11.388	12.247	12.836	PB
May 01, 01	52031.478	10.294	11.359	12.130	12.814	PB
May 19, 01	52049.440	10.362	11.416	12.197	12.797	PB
Jun 26, 01	52087.427	10.433	11.484	12.227	12.861	PB
Jul 30, 01	52121.447	10.381	11.430	12.195	12.865	PB
Aug 12, 01	52134.418	10.355	11.446	12.230	12.834	PB
Aug 26, 01	52148.361	10.346	11.455	12.234	12.847	PB
Sep 20, 01	52173.321	10.313	11.428	12.179	12.839	PB
Oct 15, 01	52198.296	10.331	11.447	12.230	12.845	PB
Nov 14, 01	52228.264	10.359	11.547	–	–	PB
Nov 15, 01	52229.247	10.372	11.507	12.247	12.787	PB
Mar 12, 02	52345.618	10.227	11.391	12.205	12.947	PB
Mar 30, 02	52363.574	10.274	11.357	12.145	12.891	PB
May 01, 02	52395.511	10.203	11.347	12.127	12.892	PB
May 15, 02	52410.454	10.240	11.343	12.111	12.910	PB
May 30, 02	52425.433	10.243	11.375	12.154	12.876	PB
Jun 11, 02	52437.455	10.292	11.396	12.180	12.947	PB
Jul 08, 02	52464.433	10.254	11.403	12.180	12.977	PB
Jul 27, 02	52483.407	10.302	11.375	12.152	12.886	PB

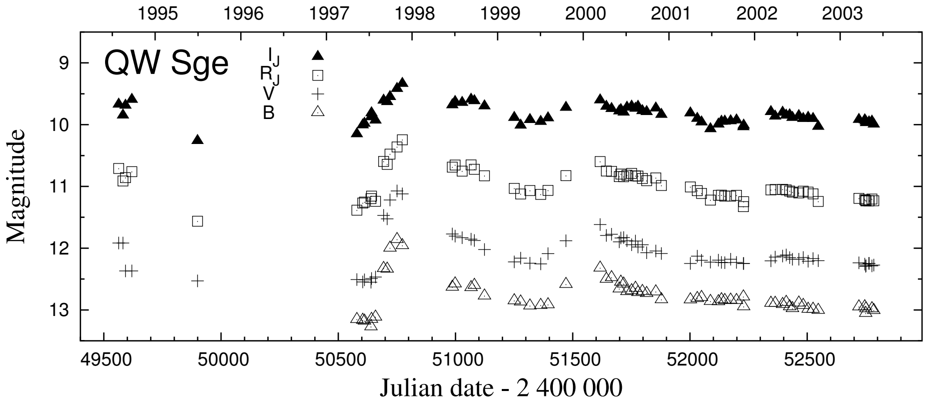

Figure 11. The CCD *BVRI* LCs of QW Sge.

Table 12. Continued

Date	JD 24...	I_C	R_C	V	B	Obs
Aug 17, 02	52504.369	10.305	11.412	12.211	12.925	PB
Sep 07, 02	52525.342	10.288	11.405	12.169	12.987	PB
Sep 29, 02	52547.290	10.372	11.483	12.203	12.987	PB
Mar 22, 03	52720.597	10.303	11.476	12.238	13.006	PB
Apr 16, 03	52745.533	10.309	11.497	12.259	12.949	PB
Apr 20, 03	52749.533	10.339	11.519	12.292	12.948	PB
Apr 21, 03	52750.533	10.356	11.519	12.284	13.054	PB
May 03, 03	52763.492	10.329	11.499	12.246	12.979	PB
May 16, 03	52776.455	10.350	11.505	12.286	12.980	PB
May 24, 03	52784.456	10.377	11.513	12.274	13.007	PB

Table 13. U, B, V observations of IV Vir

Date	JD 24...	Phase*	U	B	V	Obs
Apr 20, 03	52749.843	0.256	12.956	12.139	10.689	M
Apr 20, 03	52749.844	0.256	12.979	12.078	10.698	M
Apr 21, 03	52750.852	0.260	12.924	12.139	10.668	M
Apr 21, 03	52750.855	0.260	–	12.131	10.696	M

* $JD_{\rm sp.conj.} = 2\,449\,016.9 + 281.6 \times E$ (Smith *et al.* 1997)

Our observations did not show any larger variation in the optical. We detected only a small brightening by about 0.12 mag in U and by $0.06 - 0.07$ mag in other bands between observations made on 13-16 and 25-27 February 2003 (see Table 14). These values are well above the uncertainties of the given means of all individual measurements made during the night. We note that we measured V934 Her for about 1 hour to obtain $12 - 25$ individual points (i.e. the magnitude difference between the target and the comparison star).

The recent studies (e.g. Galloway *et al.* 2002; Masetti *et al.* 2002) suggest that the object consists of a wide binary system ($P_{\rm orb} = 400\,$d), in which a neutron star accretes matter from the wind of a M-type giant star. Their observations showed that the X-ray luminosity ranges from about 2×10^{32} to 1×10^{34} erg s^{-1}. Qualitatively, the very small and/or negligible response to the X-ray outburst in the optical wavelengths (also Tomasella *et al.* 1997) suggests too little amount of the circumstellar material in the system, which implies a small mass loss rate from the giant, and thus also a small accretion rate. If we assume that the only energy source is accretion, a neutron star has to accrete matter at the rate of $\sim\,1\times10^{-12}\,M_{\odot}\,{\rm yr}^{-1}$ to $\sim\,1\times10^{-10}\,M_{\odot}\,{\rm yr}^{-1}$ to balance the observed X-ray luminosities (we adopted $M_{\rm acc} = 1.4\,M_{\odot}$ and $R_{\rm acc} = 100\,$km). In the opposite case, a variability in the X-ray radiation would imply a more significant variation in the near-UV and optical continuum as well as in highly ionized emission lines (e.g. HeII 1640) as it is, generally, observed for classical symbiotic stars.

Table 14. U, B, V, R observations of V934 Her

Date	JD 24...	U	B	V	ΔR	Obs
Feb 14, 03	52684.609	11.030	9.255	7.623	-0.052	SP
Feb 17, 03	52687.569	11.110	9.252	7.671	-0.049	SP
Feb 26, 03	52696.553	10.983	9.197	7.593	-0.112	SP
Feb 27, 03	52697.557	10.989	9.188	7.582	-0.123	SP
Feb 28, 03	52698.547	10.983	9.184	7.580	-0.121	SP

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