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The Miscellaneous Stars in OGLE Catalog of Periodic Variable Stars in the Galactic Bulge

by

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ABSTRACT

The first catalog of chromospherically active and ellipsoidal variable stars in the OGLE database is presented. The periods, the observed magnitudes and colors, their values free of interstellar extinction, and Fourier coefficients of light modulation are given for 549 stars. New color-magnitude diagrams based on new color determinations are presented. The chromospherically active stars are all among the bulge red giants, while the ellipsoidal binary stars are near the disk main sequence turn-off point. A discovery of a small group of very red ($2 < (V-I)_0 < 6$) and bright, chromospherically active bulge giants ($I_0 \approx 13$ mag) is also reported.

Key words: *Catalogs – Stars: variables: other – Stars: activity*

1. Introduction

The Optical Gravitational Lensing Experiment (OGLE) is a long term observing project of the Warsaw University Observatory, the Princeton University Observatory and the Carnegie Institution of Washington, which began in 1992. Its main goal is a search for dark matter in our Galaxy using the microlensing phenomena (Paczyński 1986, Udalski *et al.* 1992). For this purpose the CCD photometry of a few millions stars in dense Baade's Window fields in the Galactic bulge was performed. All the data were obtained with the 1-m Swope telescope at the Las Campanas Observatory in Chile, operated by Carnegie Institution of Washington, with a 2048 × 2048 Ford/Loral CCD detector. In four seasons of photometric observations (1992–1995) nineteen microlensing events have been detected (Udalski *et al.* 1993, Udalski *et al.* 1994a, Udalski *et al.* 1994b, Paczyński and Udalski 1996).

Such a large amount of precise photometric data give us an opportunity to obtain many light curves of variable stars in the Galactic bulge. The first results of the OGLE search for periodic variables in the Baade's Window were published by Udalski *et al.* (1994c, 1995a, 1995b, 1996) as The Catalog of Periodic Variable Stars in the Galactic Bulge. The first three parts of the catalog presented results for the central part of the Baade's Window (nine $15' \times 15'$ fields centered at $\alpha = 18^{\rm h}03^{\rm m}24^{\rm s}$ $\delta = -30°02'00''$), the fourth part contains data for three $15' \times 15'$ fields on the western side of the Baade's Window. The Catalog contained stars with $\langle I \rangle$ in the range 14–18 mag. The upper limit $I \approx 14$ mag is a result of saturation of stellar images on CCD frames, and the lower one is due to rapidly increasing photometric errors. Although the period search was limited to periods from 0.1 day to 100 days, the Catalog contains also a few δ Scuti stars with periods $< 0.1^{\rm d}$ which were identified with $2 \times P$, and a few Mira type variables with periods $> 100^{\rm d}$.

The variable stars discovered in every field were grouped into three categories: pulsating stars (mostly RR Lyr and δ Sct stars), eclipsing stars (mostly W UMa, β Lyr and Algol type) and miscellaneous variables (mostly late type, chromospherically active stars, some ellipsoidal variables and a few Miras).

Equatorial coordinates (epoch 2000.0) of the BW fields, the number of the variable stars detected in each category are given in Table 1.

Table 1

The equatorial coordinates and numbers of detected stars in OGLE Catalog

BW Field	Equatorial Coordinates	Pulsating Stars	Eclipsing Stars	Miscellan. Stars
BWC	$18^{\rm h}03^{\rm m}24^{\rm s}$ $-30°02'00''$	31	116	66
BW1	$18^{\rm h}02^{\rm m}24^{\rm s}$ $-29°49'05''$	24	128	70
BW2	$18^{\rm h}02^{\rm m}24^{\rm s}$ $-30°15'05''$	13	100	56
BW3	$18^{\rm h}04^{\rm m}24^{\rm s}$ $-30°15'05''$	18	113	74
BW4	$18^{\rm h}04^{\rm m}24^{\rm s}$ $-29°49'05''$	16	124	64
BW5	$18^{\rm h}02^{\rm m}24^{\rm s}$ $-30°02'05''$	18	91	65
BW6	$18^{\rm h}03^{\rm m}24^{\rm s}$ $-30°15'05''$	16	83	54
BW7	$18^{\rm h}04^{\rm m}24^{\rm s}$ $-30°02'05''$	18	93	55
BW8	$18^{\rm h}03^{\rm m}24^{\rm s}$ $-29°49'05''$	12	85	54
BW9	$18^{\rm h}00^{\rm m}50^{\rm s}$ $-29°49'05''$	19	125	81
BW10	$18^{\rm h}00^{\rm m}50^{\rm s}$ $-30°02'05''$	23	130	76
BW11	$18^{\rm h}00^{\rm m}50^{\rm s}$ $-30°15'05''$	17	93	67
Tot.	—	225	1281	782

The main aim of this paper is to provide more information for the "miscellaneous" variable stars in the BWC–BW8 fields. In our work we omitted stars unambiguously classified as Mira type variables, thus obtaining 549 stars suspected for chromospheric activity or ellipsoidal variability. The additional 224 miscellaneous stars from fields BW9–BW11 are not analyzed here as there is no extinction map for this part of the sky.

2. Light Curves

The OGLE Catalog of Periodic Variable Stars in the Galactic Bulge contains an atlas with phased light curves and $30'' \times 30''$ finding charts. The photometric data presented in the Catalog are available to astronomical community in electronic form via INTERNET (ftp host: *sirius.astrouw.edu.pl*, directory */ogle/var_catalog*). The photometry of each star is based on four seasons of observations (from 1992 to

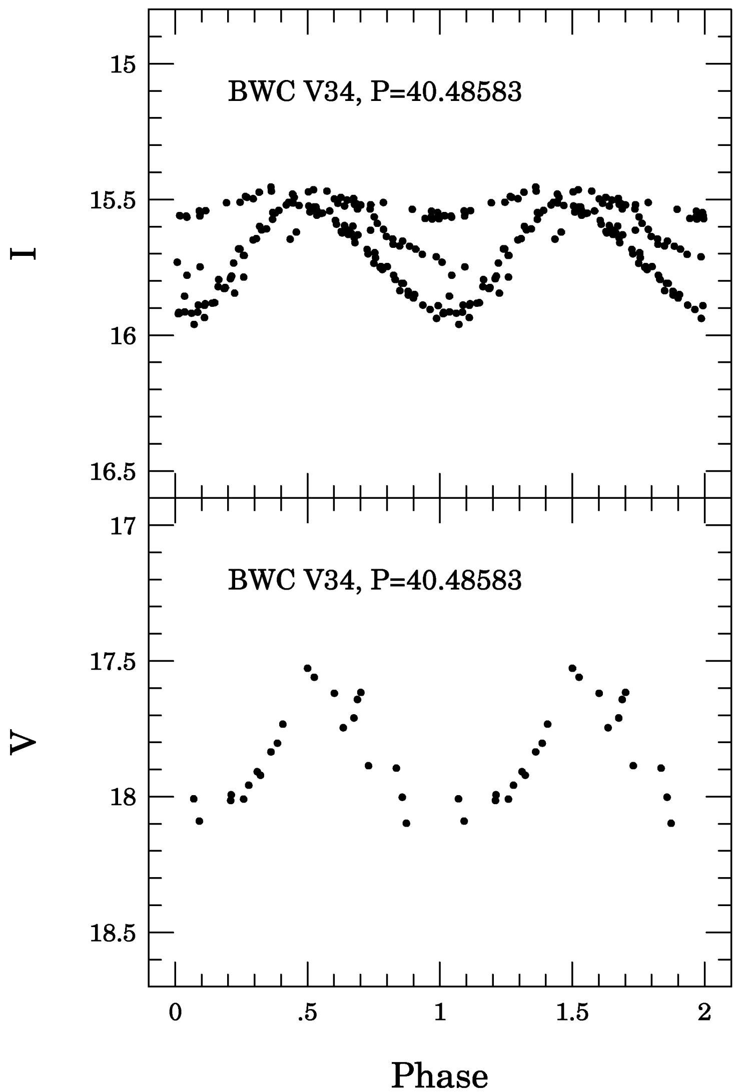

Fig. 1. I and V-band light curves of chromospherically active variable BWC V34. Majority of V-band measurements were obtained in 1995 season.

1995). It is clearly visible that many stars classified as miscellaneous change their light curves from season to season. The most prominent example of such behavior is provided by the variable BWC V34. The I and V photometry of this star is

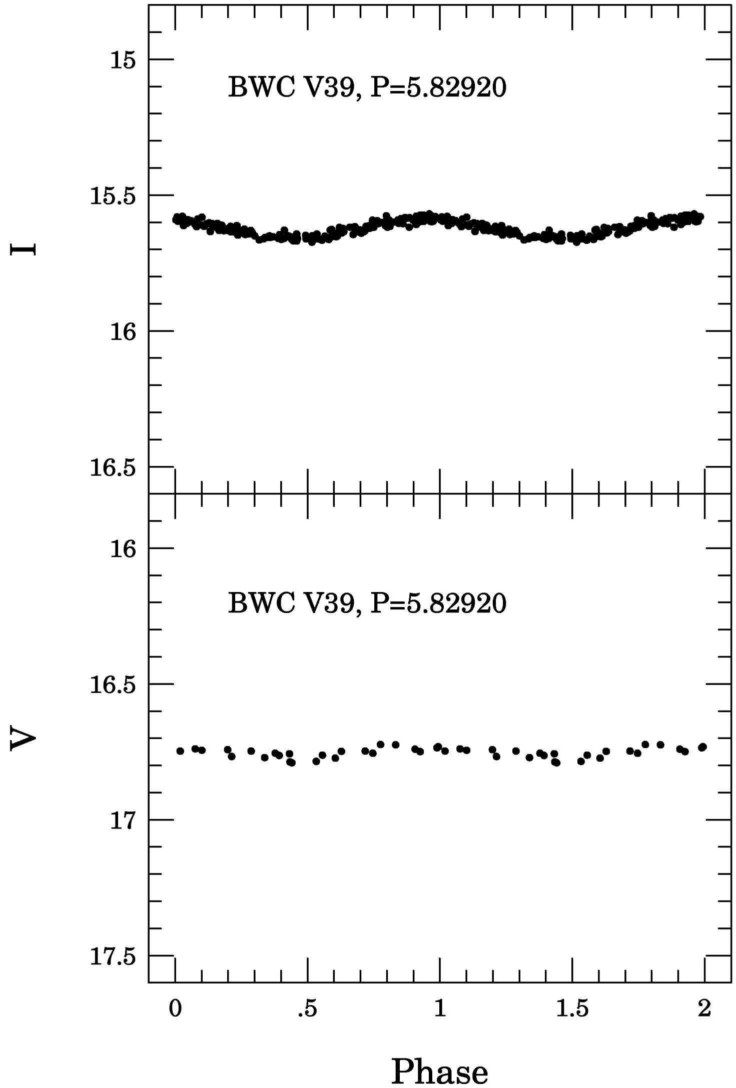

Fig. 2. I and V-band light curves of ellipsoidal variable BWC V39. Majority of V-band measurements were obtained in 1995 season.

presented in Fig. 1. On the other hand, there are variables with low amplitude, almost sinusoidal light curves, which do not vary from season to season. The variable BWC V39 is representative for this group. The I and V light curves of this star are shown in Fig. 2. It is not difficult to notice that the first group contains chromospherically active stars with spotted surface and the second one contains ellipsoidal variables. Unfortunately, distinguishing between these groups is not always as obvious as in the examples shown in Figs. 1 and 2.

It is desirable to be able to classify various light curves according to some algorithm, rather than by visual inspection. With a hope to make it possible we decided to construct Fourier fit to the light curves in the form:

$$I = a_0 + a_1 \cdot \sin 2\pi x + a_2 \cdot \sin 4\pi x + b_1 \cdot \cos 2\pi x + b_2 \cdot \cos 4\pi x \qquad (1)$$

The fitting was done for every light curve in every season. The coefficients a_0, a_1, a_2, b_1, b_2 were calculated by the Least Squares Method. Variable x is defined as $x \equiv \frac{t-t_0}{P}$ and t_0 is the time of the first observation. Table 2 summarizes our results. The columns of this Table contain the following informations: star designation (the letters a, b, c, d correspond respectively to seasons 1992, 1993, 1994, 1995), period in days, and the Fourier coefficients a_0, a_1, a_2, b_1, b_2.

Table 2

The Fourier coefficients for miscellaneous stars in Baade's Window

Star	Period	a_0	a_1	b_1	a_2	b_2
BWC V2a	32.97609	14.09021	0.023064	0.011731	0.017262	−0.005096
BWC V2b	32.97609	14.09256	0.016209	−0.016017	0.012159	0.013455
BWC V2c	32.97609	14.08128	0.032445	0.018259	−0.014888	−0.006545
BWC V2d	32.97609	14.04771	0.006442	0.003518	−0.002689	−0.010838
BWC V3a	16.71542	14.60547	0.023956	−0.000656	−0.003252	−0.008819
BWC V3b	16.71542	14.60150	0.026333	−0.006565	−0.006429	0.002929
BWC V3c	16.71542	14.62987	0.021163	−0.008829	−0.001963	−0.006445
BWC V3d	16.71542	14.65048	0.008020	0.021637	0.003580	0.001816
BWC V5a	55.86592	14.81393	0.009311	−0.010725	0.023869	−0.027545
BWC V5b	55.86592	14.81642	0.013807	−0.054756	−0.009974	0.012163
BWC V5c	55.86592	14.83434	0.007396	−0.069056	0.006381	0.002208
BWC V5d	55.86592	14.78340	−0.009743	−0.022556	−0.008720	0.015836
...	...	...	...	...	...	...
BW8 V124a	7.29094	17.48267	0.016595	−0.051869	−0.003592	0.030070
BW8 V124b	7.29094	17.45332	−0.014319	−0.063289	−0.003341	0.021064
BW8 V124c	7.29094	17.49105	0.012649	−0.015912	0.004545	0.000261
BW8 V124d	7.29094	17.52091	−0.003783	0.017662	0.009545	0.018678
BW8 V144a	10.53290	17.86874	0.010876	0.062736	−0.010694	−0.031686
BW8 V144b	10.53290	17.82579	0.024983	0.102135	0.001831	0.014178
BW8 V144c	10.53290	17.76231	0.015846	0.071763	0.013399	0.019214
BW8 V144d	10.53290	17.72626	−0.005544	0.077406	0.004279	0.009675

The full version of Table 2 is available in electronic form via INTERNET from URL *http://www.astrouw.edu.pl/∼olech/misc.html.*

Fig. 3 and Fig. 4 give the I-band light curves for all seasons for the above-mentioned representatives of our groups. Solid line corresponds to the fit given by the Eq. (1). Additionally, the values of a_1 and b_1 for twenty randomly chosen stars are shown in Fig. 5.

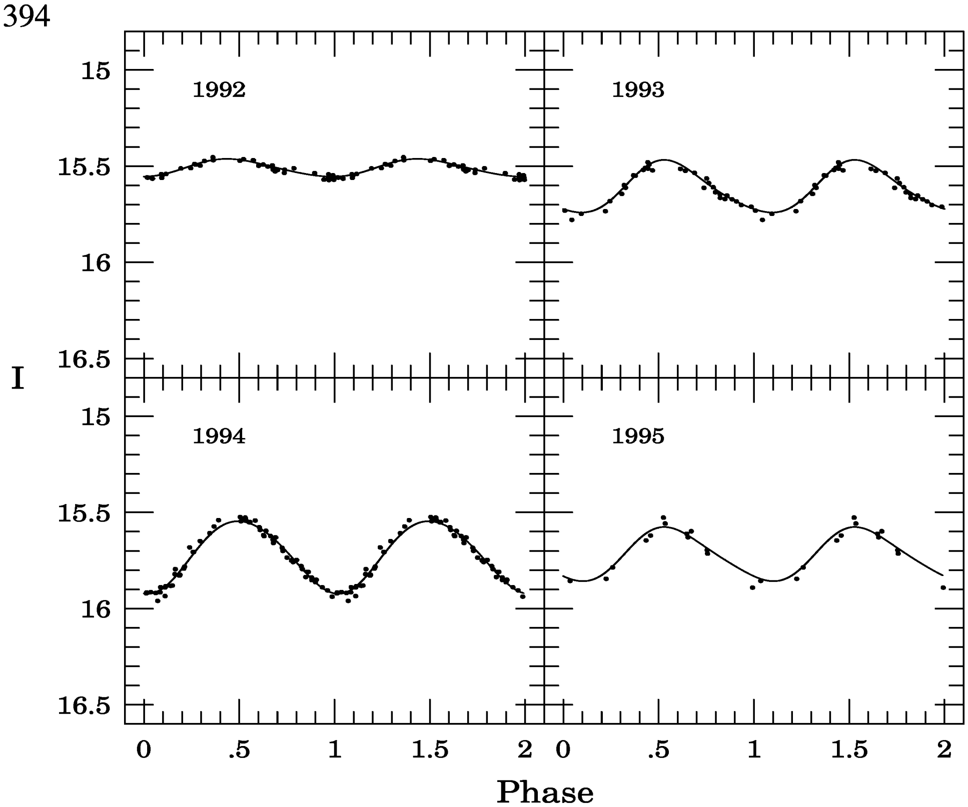

Fig. 3. Four seasons I-band light curves of BWC V34. Solid line corresponds to the fit given by Eq. (1).

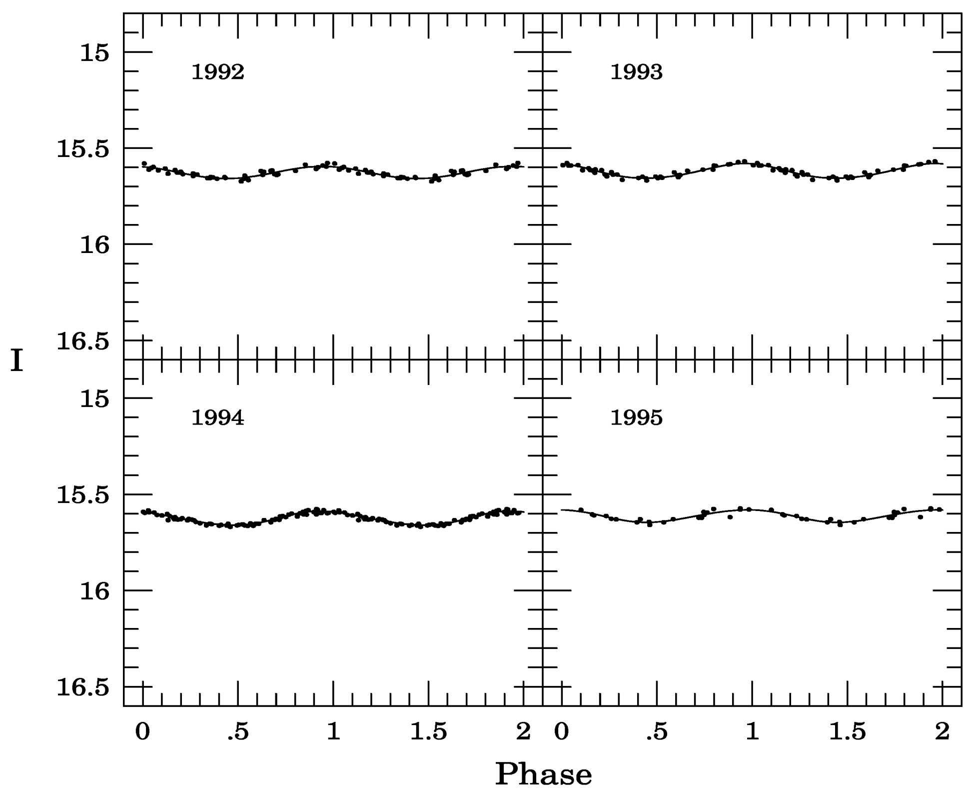

Fig. 4. Four seasons I-band light curves of BWC V39. Solid line corresponds to the fit given by Eq. (1).

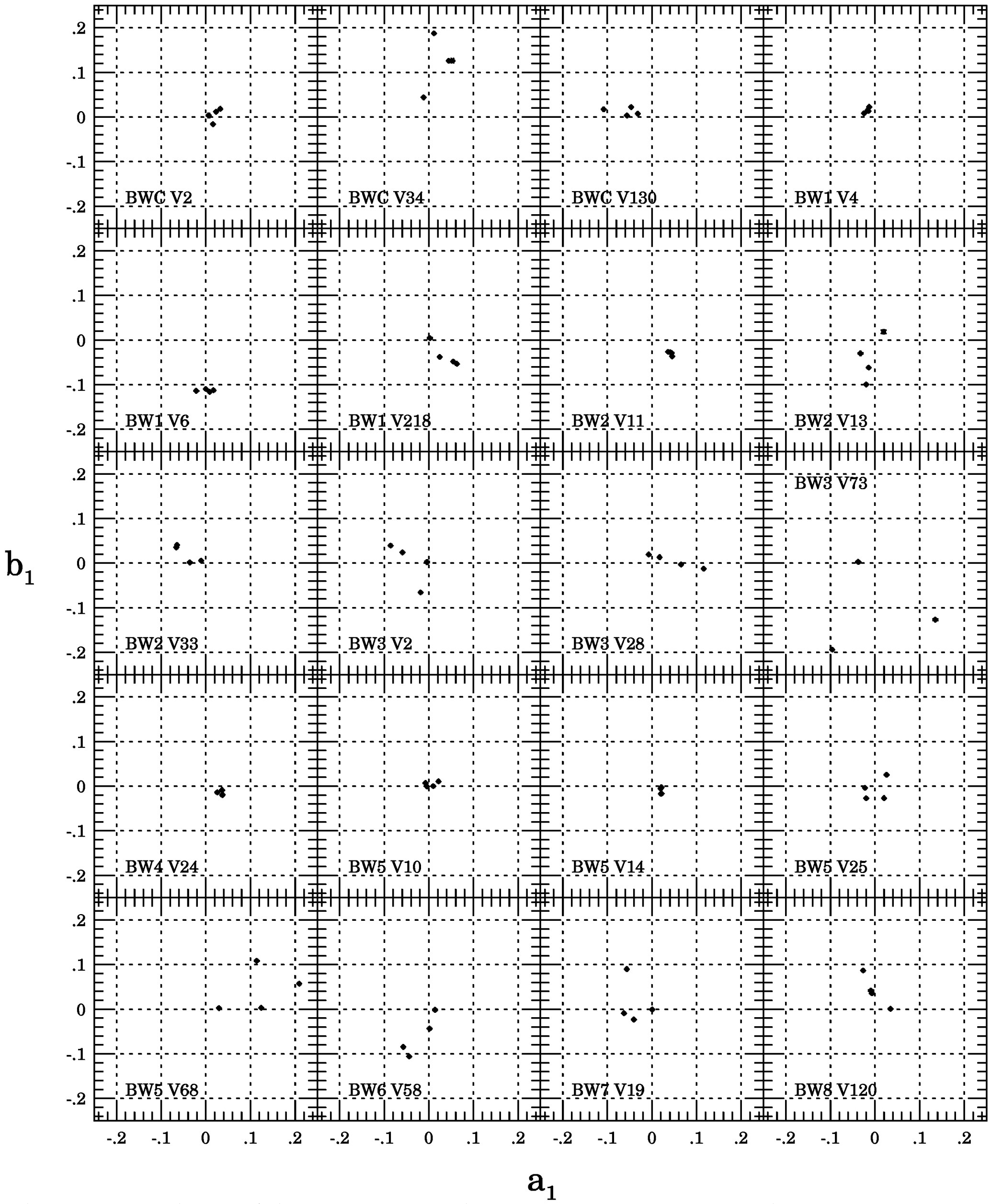

Fig. 5. The Fourier coefficients of twenty variable stars from the Baade's Window.

3. New Color Determination

The first edition of the Catalog published by Udalski *et al.* (1994c, 1995a, 1995b, 1996) gave $V-I$ colors of variable stars based on a very few V-band measurements made during the first three seasons. The accuracy of V magnitude was ~ 0.05 mag. The $V-I$ color was estimated only at maximum brightness. In the 1995 season many new V-band observations were made, and in many cases it became possible to obtain good V light curves. Therefore, we decided to make new color determinations. The first step of this procedure was to fit the Fourier function (1) to the phased I-band light curves for the fourth season. Next, for the phase corresponding to every V point we calculated the I magnitude with the fitted function. The final $V-I$ color of the star was obtained as an average value of all such determinations.

The new color-magnitude diagram (CMD) presented in Fig. 6 is based on new color determinations. The open circles represent miscellaneous variable stars and dots stars with constant brightness. Only 20% of non-variable stars are plotted for clarity.

Recently Woźniak and Stanek (1996) proposed a new method of investigating interstellar extinction, based on the two band (V and I) photometry, which uses the red clump stars to construct the reddening curve. Stanek (1996) applied this method to CMDs obtained by the OGLE collaboration and he constructed the extinction map of the central part of Baade's Window (fields BWC–BW8). We used this reddening map to calculate values of I_0 and $(V-I)_0$ free from extinction. Our results are summarized in Table 3. This Table gives the star designation, its period in days, I, $V-I$, I_0, $(V-I)_0$, the mean amplitude of the brightness of the star and the variation of this amplitude. The values of I_0 and $(V-I)_0$ are used to plot the CMD corrected for interstellar extinction, presented in Fig. 7. In this Figure only 5% of the non-variable stars were plotted.

It is worth to note that the values of interstellar extinction given by Stanek (1996) are correct only for the Galactic bulge stars, and not for the disk stars. Therefore the main sequence on our CMDs might be bluer than it reality should be.

4. The Distinguishing Between Chromospherically Active and Ellipsoidal Variable Stars

We attempted to divide the miscellaneous stars into two groups; the first one containing chromospherically active stars, and the second one with ellipsoidal variables. We expected that chromospherically active stars, due to their changing light curves, should have a large scatter of their amplitudes. Therefore we plotted a correlation between the mean amplitude of the modulation of each star and Gaussian variation – σ of this amplitude from season to season. The result of this procedure is shown in Fig. 8. Unfortunately, there is no clear distinction between the two groups, perhaps because many chromospherically active stars have small amplitudes.

Next, we tried another approach to separate the two types of variables. If a variable with a small amplitude and a sinusoidal light curve is an ellipsoidal variables then its true period should be twice longer than the one listed in Tables 2 and 3. Therefore, the light curve of such a star should be better described by coefficients $a_{0.5}$ and $b_{0.5}$ (corresponding to the period $2\times P$) than a_1 and b_1. This property could be visible in a graph showing the dependence of $\sqrt{a_1^2+b_1^2}$ on $\sqrt{a_{0.5}^2+b_{0.5}^2}$. Such a graph is presented in Fig. 9. Unfortunately, again no clear separation into two groups is apparent.

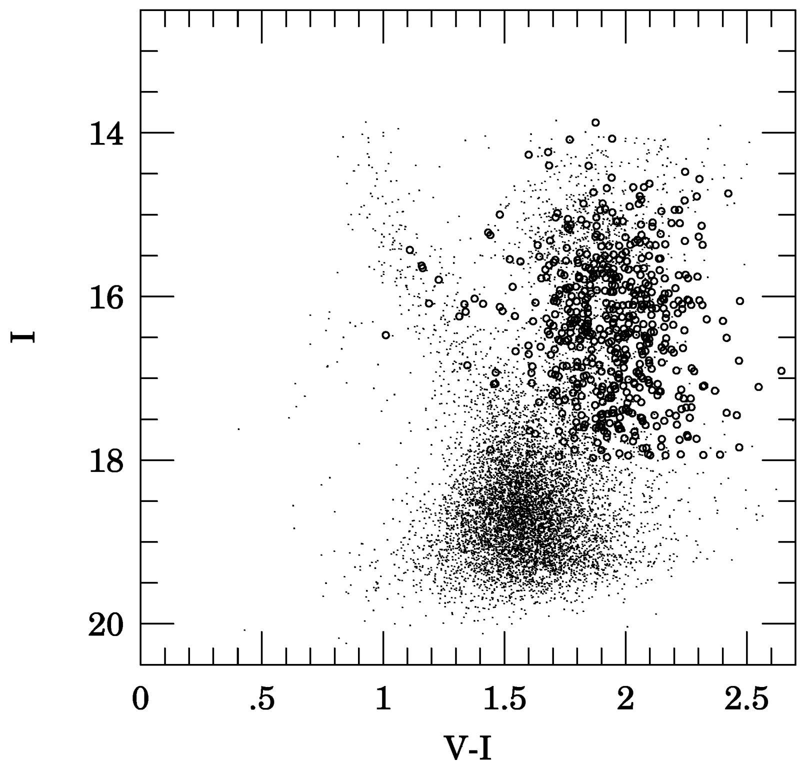

Fig. 6. The color-magnitude diagram for stars in the Baade's Window. Dots correspond to the non-variable stars and open circles to the variables. Only 20% of non-variable stars are plotted for clarity.

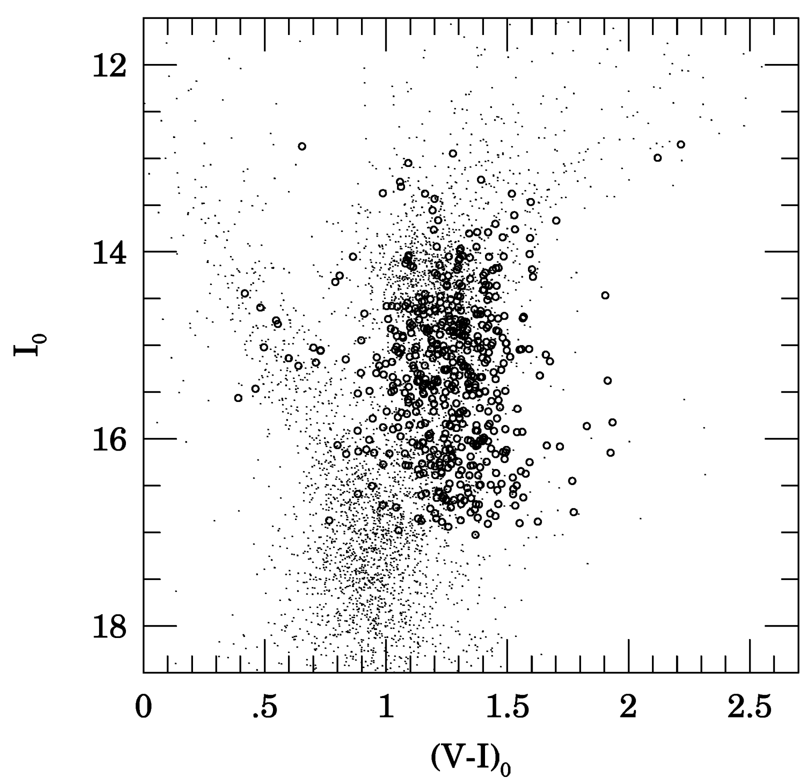

Fig. 7. The color-magnitude diagram free from interstellar extinction. Only 5% of non-variable stars are plotted for clarity.

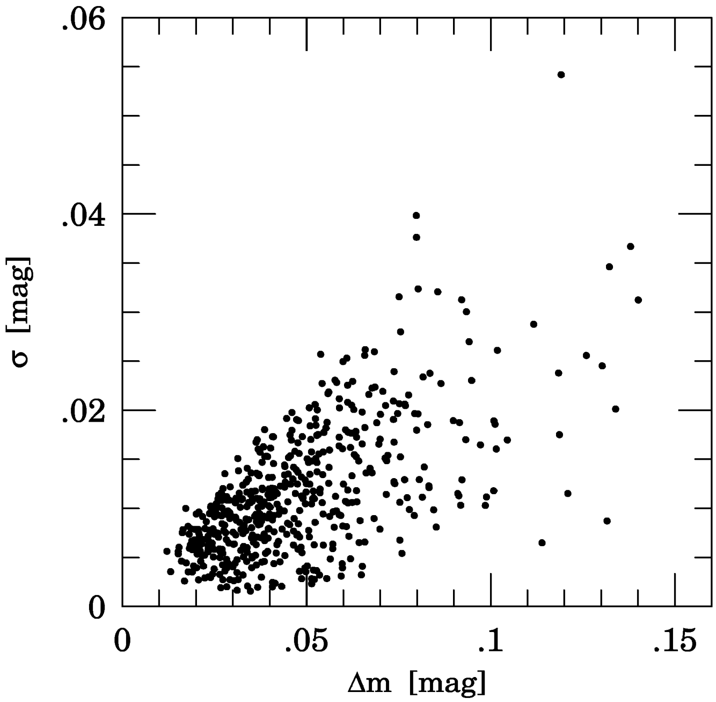

Fig. 8. Correlation between the amplitude of the star and the variation of this amplitude from season to season.

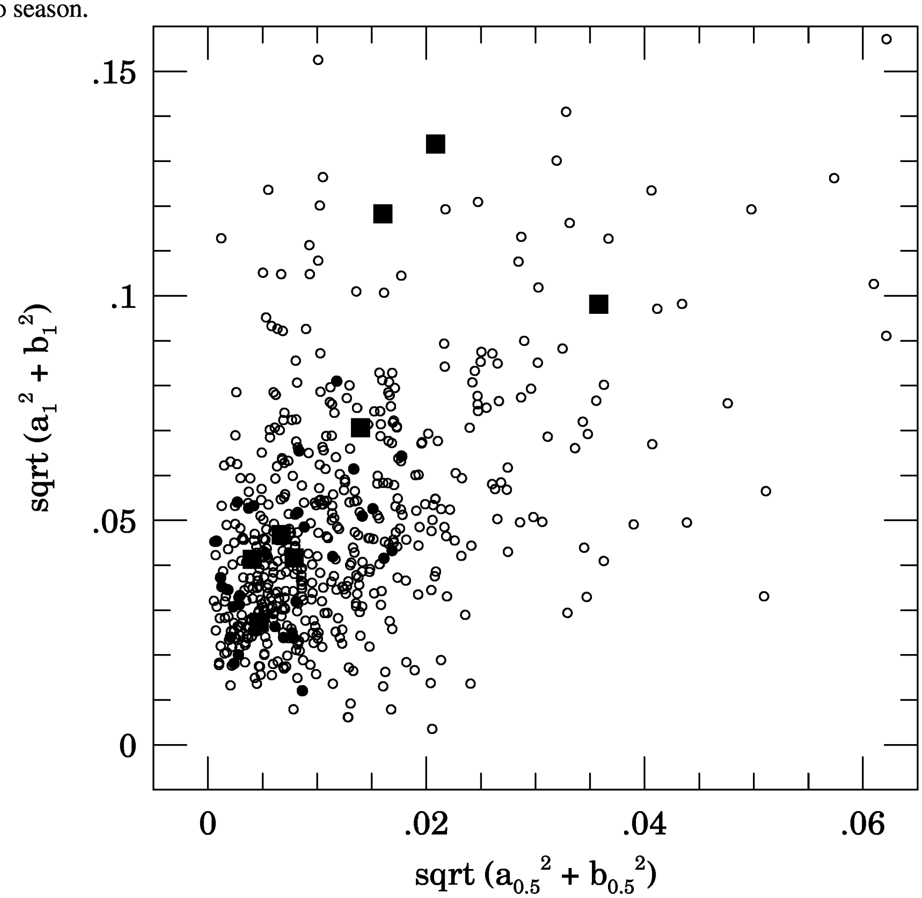

Fig. 9. Correlation between amplitudes of the stars. The filled circles correspond to the ellispidal variables (see Section 4), the filled squares to the red spotted stars (see Section 5), and the open circles to the other objects.

Table 3
Photometric parameters for stars from BWC.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BWC V2	32.97609	14.083	1.769	13.051	1.092	0.023308	0.007159
BWC V3	16.71542	14.621	2.098	13.760	1.532	0.024278	0.006255
BWC V5	55.86592	14.818	2.064	13.790	1.376	0.041173	0.011270
BWC V7	49.44376	14.863	1.905	13.966	1.308	0.048140	0.007086
BWC V8	45.45455	14.865	1.826	13.944	1.209	0.019363	0.004135
BWC V9	16.24036	14.869	2.054	13.803	1.343	0.018227	0.005924
BWC V10	37.73585	14.944	1.895	14.069	1.305	0.044042	0.014419
BWC V11	48.48485	15.053	1.762	14.038	1.093	0.036119	0.011772
BWC V12	23.86635	15.138	1.880	14.141	1.221	0.013127	0.003550
BWC V13	50.82592	15.151	1.760	14.124	1.080	0.021498	0.006383
BWC V16	26.42008	15.243	1.881	14.225	1.201	0.037942	0.014697
BWC V21	17.05030	15.307	2.049	14.362	1.425	0.038424	0.010656
BWC V27	33.11258	15.383	1.930	14.250	1.211	0.030079	0.007568
BWC V29	5.26870	15.512	1.644	14.578	1.024	0.050592	0.007750
BWC V31	22.33389	15.484	1.840	14.449	1.161	0.027283	0.005430
BWC V32	20.55498	15.556	1.801	14.601	1.152	0.061953	0.004863
BWC V34	40.48583	15.655	2.075	14.706	1.434	0.125967	0.025582
BWC V38	39.40887	15.663	2.047	14.668	1.373	0.062829	0.020074
BWC V39	5.82920	15.623	1.159	14.596	0.482	0.034766	0.001574
BWC V40	8.29876	15.640	1.925	14.628	1.257	0.044256	0.012675
BWC V42	40.00000	15.667	1.899	14.610	1.200	0.061204	0.011869
BWC V44	62.89309	15.735	2.247	14.710	1.564	0.077933	0.009876
BWC V45	6.67334	15.653	1.163	14.733	0.547	0.017891	0.003531
BWC V46	24.18380	15.674	1.856	14.751	1.233	0.049084	0.011107
BWC V49	21.32196	15.721	1.883	14.803	1.279	0.033775	0.008798
BWC V52	20.69322	15.727	1.950	14.779	1.316	0.019575	0.006778
BWC V55	3.41472	15.754	1.870	14.783	1.228	0.024937	0.003832
BWC V63	28.77393	15.880	1.795	14.998	1.208	0.036862	0.016026
BWC V67	39.52569	16.055	1.704	15.084	1.057	0.033922	0.005522
BWC V69	3.48129	16.085	1.189	15.020	0.497	0.030731	0.009110
BWC V71	5.23766	16.079	1.920	15.052	1.243	0.031152	0.001656
BWC V72	5.31773	16.089	1.412	15.052	0.731	0.036734	0.001969
BWC V74	45.81902	16.177	1.492	15.295	0.896	0.036302	0.009386
BWC V77	40.48583	16.284	1.800	15.244	1.116	0.047693	0.013675
BWC V78	3.79291	16.236	1.918	15.321	1.302	0.041226	0.012010
BWC V83	55.63283	16.333	1.771	15.377	1.139	0.028701	0.009737
BWC V84	61.53846	16.331	1.844	15.374	1.212	0.017355	0.004447
BWC V87	14.55075	16.395	1.893	15.464	1.267	0.051364	0.010452
BWC V94	3.81643	16.468	1.909	15.368	1.200	0.027279	0.002733
BWC V99	54.92400	16.545	1.870	–	–	0.065115	0.016565
BWC V105	2.314155	16.704	1.600	15.877	1.050	0.042418	0.009389
BWC V108	5.548358	16.800	1.800	15.832	1.161	0.049569	0.003920
BWC V113	19.753093	16.894	1.712	16.036	1.151	0.091850	0.010319
BWC V114	15.378704	16.914	2.282	16.082	1.717	0.052518	0.015076
BWC V119	4.092079	16.929	1.464	16.114	0.919	0.036154	0.005215
BWC V122	5.527922	16.965	1.838	15.961	1.175	0.047683	0.005845
BWC V130	5.791230	17.060	1.823	16.119	1.197	0.062343	0.013321
BWC V132	2.113722	17.070	1.800	16.073	1.139	0.056290	0.009183
BWC V133	15.670853	17.016	2.011	16.019	1.349	0.038651	0.015300
BWC V134	11.318624	17.062	1.800	16.113	1.162	0.050778	0.007101
BWC V135	17.050305	17.089	2.324	–	–	0.036412	0.008640
BWC V140	67.226890	17.113	1.800	16.197	1.182	0.026129	0.011340
BWC V144	4.497924	17.171	2.004	16.189	1.349	0.050189	0.015050
BWC V152	22.948942	17.207	1.697	16.157	1.014	0.034347	0.010601
BWC V162	57.803472	17.348	1.800	16.328	1.132	0.027334	0.012026
BWC V164	7.629224	17.422	2.416	16.449	1.768	0.093415	0.030033
BWC V167	23.460417	17.382	1.949	16.308	1.256	0.039570	0.011401
BWC V173	12.804103	17.520	2.159	16.536	1.525	0.073766	0.016752
BWC V180	20.449900	17.597	1.808	16.602	1.146	0.091351	0.011289
BWC V184	6.310144	17.607	1.877	16.658	1.248	0.073773	0.023943
BWC V185	25.990905	17.613	1.979	16.699	1.371	0.040748	0.008832
BWC V193	13.351133	17.730	1.788	16.850	1.207	0.065935	0.026185
BWC V196	8.244026	17.739	2.292	16.626	1.566	0.071670	0.011428
BWC V200	11.363640	17.742	2.149	16.696	1.463	0.065113	0.019819
BWC V209	6.570309	17.956	1.725	16.978	1.052	0.098550	0.010295
BWC V212	6.598482	17.929	2.227	16.901	1.551	0.079879	0.017974

Table 3

Photometric parameters for stars from BW1.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW1 V1	44.49321	13.765	2.832	12.852	2.216	0.035351	0.007286
BW1 V2	20.03884	13.875	1.876	12.948	1.276	0.026720	0.001914
BW1 V4	13.84663	14.665	2.075	13.701	1.451	0.023476	0.003025
BW1 V5	27.19010	14.727	1.867	13.764	1.197	0.023252	0.006202
BW1 V6	12.36486	14.826	2.243	13.853	1.594	0.113931	0.006492
BW1 V9	53.52672	15.034	1.879	14.160	1.298	0.038511	0.007379
BW1 V12	31.84225	15.119	1.838	14.255	1.256	0.015182	0.005360
BW1 V13	13.51360	15.136	2.313	14.025	1.592	0.038878	0.005423
BW1 V20	48.54883	15.372	1.637	14.543	1.088	0.043379	0.007885
BW1 V27	9.21642	15.545	1.522	14.661	0.911	0.057152	0.006359
BW1 V29	35.51243	15.581	1.703	14.726	1.136	0.036936	0.008332
BW1 V33	37.77960	15.671	2.011	14.628	1.309	0.037996	0.012064
BW1 V35	31.27149	15.751	1.807	14.820	1.205	0.077713	0.021559
BW1 V39	4.51325	15.775	1.809	14.819	1.157	0.075336	0.006767
BW1 V41	23.63620	15.737	2.061	14.850	1.463	0.028459	0.009375
BW1 V42	18.62322	15.765	1.673	14.821	1.020	0.047806	0.018947
BW1 V45	2.59006	15.882	1.534	14.946	0.898	0.043961	0.009736
BW1 V46	38.46042	15.868	1.956	14.864	1.294	0.053348	0.015549
BW1 V47	24.30004	15.927	2.049	14.964	1.414	0.052320	0.020588
BW1 V49	17.41614	15.934	1.830	14.964	1.191	0.015403	0.006037
BW1 V54	5.22448	16.042	1.835	15.098	1.212	0.031130	0.004776
BW1 V55	9.01797	16.062	1.716	15.120	1.098	0.059857	0.008197
BW1 V58	3.25106	16.094	1.335	15.183	0.711	0.052755	0.003658
BW1 V59	39.35166	16.075	1.628	15.177	1.025	0.035210	0.005078
BW1 V60	30.90940	16.142	1.843	15.265	1.247	0.057879	0.011220
BW1 V62	15.63547	16.094	1.943	15.004	1.237	0.019687	0.005950
BW1 V64	32.28293	16.158	1.761	15.071	1.050	0.027076	0.008439
BW1 V67	22.92884	16.240	2.014	15.119	1.269	0.037806	0.008731
BW1 V70	55.96138	16.293	1.844	—	–	0.045617	0.015348
BW1 V71	20.67085	16.274	1.926	15.263	1.241	0.022030	0.006829
BW1 V72	7.52251	16.269	1.673	15.217	0.972	0.020785	0.006694
BW1 V74	28.77161	16.316	1.947	15.255	1.253	0.023404	0.006166
BW1 V75	18.27833	16.375	1.775	15.428	1.155	0.046053	0.019769
BW1 V77	19.68038	16.437	1.838	–	–	0.051369	0.015756
BW1 V80	11.41615	16.360	1.841	15.410	1.195	0.024649	0.007921
BW1 V82	18.61344	16.435	2.104	15.341	1.389	0.016268	0.007523
BW1 V83	17.98353	16.454	1.999	15.449	1.343	0.045686	0.012464
BW1 V85	72.67150	16.503	2.081	15.493	1.409	0.071765	0.014849
BW1 V87	8.59993	16.527	1.763	15.549	1.102	0.059913	0.024959
BW1 V88	62.85491	16.479	1.820	15.521	1.156	0.053649	0.011586
BW1 V92	2.64927	16.545	1.731	15.500	1.022	0.032784	0.003218
BW1 V94	58.54812	16.647	1.707	15.733	1.086	0.034285	0.008854
BW1 V100	15.18447	16.807	2.149	15.781	1.458	0.101519	0.016054
BW1 V104	20.50896	16.825	2.058	15.915	1.445	0.070707	0.021924
BW1 V105	61.66878	16.708	2.070	15.706	1.422	0.056454	0.004850
BW1 V106	74.50331	16.756	1.957	15.776	1.303	0.027047	0.010054
BW1 V108	51.01530	16.751	1.861	15.864	1.268	0.035928	0.009189
BW1 V113	46.73329	16.855	1.801	15.945	1.182	0.038436	0.009196
BW1 V114	28.26313	16.854	1.615	15.876	0.988	0.024041	0.010224
BW1 V119	77.86564	16.916	1.900	15.997	1.293	0.039470	0.005613
BW1 V120	18.75404	16.976	2.064	15.986	1.404	0.098856	0.011159
BW1 V132	58.21074	17.021	1.782	16.070	1.129	0.039813	0.009081
BW1 V135	2.37136	17.101	1.904	16.122	1.245	0.058835	0.009365
BW1 V137	20.03639	17.070	2.037	16.054	1.371	0.056119	0.014180
BW1 V146	15.98629	17.144	2.109	16.215	1.489	0.040774	0.017300
BW1 V150	11.23989	17.172	1.705	16.286	1.092	0.030783	0.010961
BW1 V158	17.60513	17.247	2.268	16.249	1.592	0.061180	0.020806
BW1 V161	2.13293	17.288	1.905	16.280	1.222	0.064298	0.006516
BW1 V172	4.15503	17.427	2.027	–	–	0.040484	0.011117
BW1 V174	59.76631	17.478	1.902	16.535	1.254	0.060037	0.012468
BW1 V179	7.19138	17.574	1.971	16.702	1.383	0.084515	0.009852
BW1 V180	31.21091	17.547	1.934	16.627	1.308	0.073758	0.012720
BW1 V182	59.52903	17.564	1.832	16.631	1.209	0.058119	0.009757
BW1 V192	74.27654	17.619	1.972	16.659	1.323	0.054706	0.017735
BW1 V193	6.02602	17.654	1.782	16.745	1.183	0.057254	0.009653
BW1 V196	12.60082	17.678	1.627	16.708	0.986	0.083240	0.012288
BW1 V201	4.78296	17.717	1.922	16.733	1.267	0.063418	0.017843
BW1 V206	4.93867	17.704	2.039	16.825	1.451	0.050761	0.020248
BW1 V218	18.25773	17.974	1.865	16.876	1.146	0.051371	0.014823
BW1 V220	13.79357	17.918	1.974	17.026	1.369	0.075137	0.031559

Table 3

Photometric parameters for stars from BW2.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW2 V1	15.40912	14.476	2.245	13.467	1.597	0.057120	0.005893
BW2 V2	22.73657	14.564	2.304	13.379	1.519	0.035265	0.004947
BW2 V3	50.87169	14.774	2.058	–	–	0.034830	0.011396
BW2 V4	48.26455	14.777	2.293	13.608	1.529	0.037869	0.010218
BW2 V7	8.86706	15.083	1.965	14.049	1.259	0.048767	0.005490
BW2 V9	12.06175	15.236	2.144	14.174	1.453	0.029222	0.002725
BW2 V11	5.65549	15.373	2.123	14.362	1.456	0.051401	0.002316
BW2 V12	54.49756	15.455	2.000	–	–	0.059291	0.009281
BW2 V13	83.47512	15.460	4.469	–	–	0.058900	0.021169
BW2 V16	18.50881	15.503	1.914	14.507	1.267	0.025038	0.009150
BW2 V19	71.02460	15.717	1.904	14.725	1.262	0.049897	0.011668
BW2 V20	47.23417	15.735	2.106	14.713	1.462	0.093227	0.017002
BW2 V26	8.20814	15.855	1.944	–	–	0.018937	0.006124
BW2 V27	69.86135	15.966	2.161	14.919	1.481	0.052923	0.020036
BW2 V28	37.49704	15.921	1.986	14.894	1.312	0.021669	0.005168
BW2 V30	27.70692	16.091	2.232	15.047	1.551	0.130273	0.024519
BW2 V32	37.24496	16.102	1.833	15.089	1.177	0.041142	0.011961
BW2 V33	37.76769	16.056	2.145	14.902	1.378	0.049642	0.012896
BW2 V34	40.28120	16.104	2.316	15.100	1.659	0.036492	0.011018
BW2 V35	21.51934	16.121	2.071	15.032	1.378	0.034172	0.012972
BW2 V36	6.22197	16.173	1.975	15.149	1.309	0.024495	0.003300
BW2 V37	7.04935	16.156	2.063	15.133	1.398	0.022449	0.002930
BW2 V40	21.38065	16.227	2.106	15.186	1.408	0.032954	0.006128
BW2 V41	5.72792	16.251	1.985	15.226	1.318	0.028363	0.002011
BW2 V48	20.02223	16.357	1.702	15.338	1.028	0.025632	0.010146
BW2 V49	2.62768	16.396	2.047	15.337	1.361	0.065160	0.004100
BW2 V53	15.52283	16.510	2.167	15.487	1.492	0.075224	0.020661
BW2 V57	7.51588	16.505	2.416	15.322	1.634	0.039712	0.013140
BW2 V60	30.30054	16.533	1.900	15.421	1.183	0.046483	0.007694
BW2 V62	11.53778	16.522	2.097	15.421	1.368	0.031864	0.008572
BW2 V63	33.76559	16.577	2.162	15.512	1.458	0.080260	0.019640
BW2 V66	3.83093	16.614	1.649	15.487	0.932	0.041144	0.004366
BW2 V73	2.25325	16.698	1.967	15.699	1.319	0.049819	0.003545
BW2 V76	72.31699	16.772	1.995	15.730	1.301	0.024882	0.009889
BW2 V77	81.06660	16.905	2.209	15.925	1.562	0.092104	0.031257
BW2 V79	35.02924	16.817	1.862	15.610	1.093	0.040687	0.013170
BW2 V81	5.01689	16.877	2.272	15.662	1.470	0.053538	0.003211
BW2 V84	47.08314	16.923	2.045	15.913	1.377	0.036637	0.008822
BW2 V93	18.55383	17.061	2.097	16.024	1.421	0.079373	0.019652
BW2 V104	45.89275	17.139	1.937	16.120	1.264	0.036504	0.009011
BW2 V105	68.01165	17.152	2.368	16.071	1.663	0.071560	0.014988
BW2 V107	47.72583	17.151	1.715	16.156	1.078	0.061281	0.010556
BW2 V110	32.26713	17.208	1.940	16.185	1.273	0.047993	0.015594
BW2 V111	26.56416	17.240	1.930	16.210	1.250	0.079801	0.039844
BW2 V115	6.25551	17.292	1.643	16.134	0.886	0.044637	0.007360
BW2 V118	2.90533	17.283	1.793	16.263	1.149	0.030206	0.006342
BW2 V121	54.29644	17.328	1.874	16.281	1.185	0.031460	0.002750
BW2 V125	55.16442	17.384	2.000	–	–	0.065826	0.006565
BW2 V129	13.83683	17.406	2.012	16.336	1.311	0.050892	0.012468
BW2 V133	1.34497	17.537	1.796	–	–	0.057512	0.008078
BW2 V137	37.14954	17.493	1.876	–	–	0.035073	0.006989
BW2 V140	80.94580	17.525	2.070	16.384	1.301	0.051853	0.011757
BW2 V147	12.26046	17.601	1.827	16.581	1.165	0.054523	0.015742
BW2 V164	3.63403	17.874	1.789	16.852	1.132	0.052426	0.019138
BW2 V165	7.06960	17.937	2.320	16.885	1.626	0.118661	0.017511
BW2 V169	10.34326	17.964	1.923	16.939	1.257	0.067793	0.013634

Table 3
Photometric parameters for stars from BW3.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW3 V1	72.28220	13.842	5.970	12.478	5.080	0.101824	0.026111
BW3 V2	62.38395	14.230	5.846	12.813	4.930	0.057753	0.023059
BW3 V4	12.28564	14.402	1.847	13.252	1.058	0.039481	0.009027
BW3 V5	19.06577	14.399	1.684	12.872	0.654	0.019685	0.007869
BW3 V6	55.52133	14.548	1.942	13.378	1.161	0.037364	0.008382
BW3 V9	10.80051	14.943	2.220	13.791	1.421	0.034011	0.002084
BW3 V14	61.12658	15.337	2.038	14.193	1.292	0.048530	0.006045
BW3 V15	30.81210	15.380	1.973	14.366	1.313	0.035089	0.011722
BW3 V19	25.77540	15.549	1.974	14.528	1.292	0.018139	0.007367
BW3 V25	5.49023	15.775	1.863	14.579	1.080	0.062158	0.017662
BW3 V27	33.66037	15.769	1.956	14.720	1.286	0.073969	0.012522
BW3 V28	22.58000	15.741	2.219	14.338	1.303	0.056050	0.021861
BW3 V30	6.86546	15.769	1.960	14.774	1.305	0.043260	0.002048
BW3 V31	5.51388	15.773	1.918	14.671	1.156	0.064891	0.003225
BW3 V32	28.57682	15.779	2.161	14.655	1.419	0.047679	0.016686
BW3 V33	48.49289	15.758	2.296	14.406	1.404	0.027046	0.011158
BW3 V34	4.32736	15.796	1.229	14.771	0.554	0.033068	0.008266
BW3 V35	30.42785	15.906	2.069	14.745	1.321	0.081641	0.023394
BW3 V36	6.96616	15.880	2.016	14.807	1.317	0.041175	0.007622
BW3 V37	5.36043	15.945	1.949	14.586	1.046	0.075904	0.005418
BW3 V42	15.23026	15.899	2.205	14.664	1.379	0.028261	0.006816
BW3 V44	32.19321	15.972	1.726	14.900	1.045	0.050552	0.014674
BW3 V47	23.26028	15.978	2.079	14.888	1.326	0.046246	0.013002
BW3 V49	1.57766	16.027	1.377	15.024	0.701	0.031124	0.003459
BW3 V50	31.66911	16.056	2.471	14.694	1.568	0.053173	0.017532
BW3 V52	26.71495	16.051	2.218	14.782	1.397	0.045124	0.015175
BW3 V55	63.08632	16.096	2.102	14.808	1.250	0.037630	0.007010
BW3 V57	11.54554	16.159	1.933	15.112	1.250	0.018833	0.006665
BW3 V59	34.00968	16.211	2.167	14.846	1.262	0.047570	0.007374
BW3 V60	4.98511	16.243	1.314	15.219	0.639	0.026402	0.005872
BW3 V63	25.31084	16.347	2.196	–	–	0.065851	0.018236
BW3 V64	38.20769	16.279	2.334	14.606	1.229	0.039776	0.007952
BW3 V67	27.03285	16.395	1.992	15.258	1.240	0.056247	0.015947
BW3 V68	52.29629	16.362	1.832	15.299	1.130	0.049698	0.010472
BW3 V71	8.44085	16.454	2.011	15.037	1.064	0.066176	0.013608
BW3 V72	7.11300	16.446	1.737	15.312	0.990	0.077332	0.011088
BW3 V73	79.94087	16.480	2.078	15.138	1.193	0.119118	0.054198
BW3 V77	14.46286	16.458	1.862	15.409	1.160	0.021138	0.005675
BW3 V82	86.57963	16.543	1.753	15.507	1.078	0.052149	0.010992
BW3 V86	24.54102	16.668	2.081	15.480	1.285	0.120943	0.011515
BW3 V87	55.97305	16.620	1.812	15.431	1.029	0.060590	0.010718
BW3 V88	42.72220	16.633	1.964	15.386	1.129	0.047363	0.007275
BW3 V89	15.55686	16.630	2.236	15.181	1.308	0.042934	0.012275
BW3 V90	27.27021	16.668	2.066	15.671	1.387	0.042019	0.010431
BW3 V91	23.04226	16.622	2.148	15.331	1.280	0.036915	0.008765
BW3 V98	32.51086	16.850	1.757	15.706	1.003	0.067813	0.022259
BW3 V102	1.44218	16.841	1.347	15.464	0.462	0.045034	0.013502
BW3 V103	74.05968	16.799	1.839	15.710	1.124	0.028355	0.010846
BW3 V106	9.53006	16.850	1.800	–	–	0.030797	0.010660
BW3 V108	57.69082	16.944	1.694	15.973	1.060	0.026164	0.009302
BW3 V110	68.73430	16.957	1.709	15.897	1.029	0.031750	0.011544
BW3 V114	6.04388	17.016	1.856	15.992	1.180	0.052894	0.013732
BW3 V118	1.80611	17.058	1.613	16.009	0.931	0.052110	0.002760
BW3 V120	21.95224	17.020	2.093	15.624	1.198	0.044936	0.010669
BW3 V124	44.90533	17.091	1.954	15.720	1.064	0.051676	0.010981
BW3 V125	11.50318	17.137	2.229	15.853	1.373	0.066917	0.021604
BW3 V126	69.02266	17.089	1.949	15.993	1.238	0.032034	0.010116
BW3 V130	57.54771	17.161	2.144	15.884	1.291	0.047529	0.012482
BW3 V134	67.55063	17.162	1.880	16.042	1.153	0.035181	0.010804
BW3 V136	14.57967	17.239	1.940	16.199	1.269	0.039962	0.009430
BW3 V137	4.01048	17.257	1.750	16.281	1.081	0.041354	0.011572
BW3 V143	1.59804	17.353	2.271	16.025	1.397	0.052088	0.006286
BW3 V145	20.11758	17.429	1.738	16.272	0.988	0.049007	0.011006
BW3 V153	83.86176	17.447	1.897	16.387	1.203	0.027784	0.008302
BW3 V156	11.09662	17.585	2.128	16.165	1.215	0.074736	0.019664
BW3 V160	28.40899	17.571	1.967	16.366	1.155	0.064177	0.014834
BW3 V168	17.65215	17.645	1.725	16.504	0.942	0.055578	0.018768
BW3 V169	4.56958	17.693	2.253	16.591	1.524	0.067252	0.014090
BW3 V176	7.84958	17.716	2.256	16.389	1.380	0.104508	0.016971
BW3 V177	3.98959	17.733	1.995	16.697	1.310	0.076842	0.020472
BW3 V186	9.39797	17.850	2.085	–	–	0.055811	0.021690
BW3 V190	36.41520	17.835	2.146	16.634	1.351	0.083519	0.023768
BW3 V195	13.76080	17.940	2.164	16.799	1.430	0.097219	0.016472
BW3 V203	1.26579	17.933	2.389	16.547	1.459	0.091077	0.011508

Table 3

Photometric parameters for stars from BW4.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW4 V3	17.40479	14.676	1.922	13.662	1.215	0.020181	0.003948
BW4 V6	50.61607	15.096	2.111	–	–	0.039976	0.011077
BW4 V7	26.19093	15.127	1.773	14.161	1.112	0.026486	0.004992
BW4 V14	23.10271	15.270	1.875	14.366	1.250	0.024391	0.006470
BW4 V18	52.37688	15.431	1.110	14.444	0.418	0.021277	0.004616
BW4 V19	6.39660	15.562	1.754	14.640	1.130	0.081972	0.014214
BW4 V23	25.20670	15.602	1.869	14.631	1.203	0.027555	0.007750
BW4 V24	6.17090	15.591	1.804	14.604	1.121	0.037757	0.002991
BW4 V28	10.25594	15.791	1.829	14.837	1.178	0.100811	0.011788
BW4 V29	35.10249	15.716	1.733	14.761	1.099	0.022798	0.008647
BW4 V33	3.70999	15.740	1.747	14.806	1.100	0.041473	0.002367
BW4 V34	21.38960	15.798	1.943	14.856	1.278	0.049942	0.012523
BW4 V35	11.79674	15.778	1.652	14.842	1.036	0.044044	0.013405
BW4 V36	24.60477	15.778	1.807	14.818	1.170	0.035240	0.010723
BW4 V38	24.95613	15.813	2.117	14.840	1.455	0.036316	0.016739
BW4 V45	27.98533	15.915	1.759	14.918	1.070	0.028942	0.006468
BW4 V47	73.43215	15.929	1.915	14.855	1.168	0.030782	0.007299
BW4 V48	24.06947	15.960	2.034	14.980	1.363	0.023552	0.006618
BW4 V49	56.79902	16.011	1.842	15.039	1.186	0.069637	0.016550
BW4 V50	31.84561	15.962	2.177	14.977	1.494	0.027262	0.011315
BW4 V53	62.47237	16.144	2.156	15.076	1.424	0.024896	0.005815
BW4 V54	36.95687	16.191	1.773	15.216	1.112	0.042060	0.011508
BW4 V56	18.77408	16.232	2.030	15.216	1.325	0.080312	0.032369
BW4 V58	62.54514	16.285	2.040	15.326	1.352	0.046503	0.014195
BW4 V59	42.31632	16.218	1.709	15.196	0.999	0.022333	0.005235
BW4 V60	36.86836	16.258	2.012	15.280	1.348	0.029188	0.008966
BW4 V65	66.47583	16.326	1.688	15.398	1.047	0.032997	0.008263
BW4 V70	16.73965	16.425	1.679	15.479	1.033	0.052321	0.008575
BW4 V77	2.11847	16.472	1.011	15.563	0.391	0.040785	0.002453
BW4 V81	37.27867	16.480	1.848	15.446	1.151	0.039979	0.011211
BW4 V83	39.52093	16.531	1.900	15.565	1.237	0.027222	0.004241
BW4 V85	5.49779	16.565	1.931	15.620	1.290	0.038547	0.004595
BW4 V87	83.90748	16.648	2.188	15.596	1.435	0.079261	0.009275
BW4 V90	64.00355	16.605	1.777	15.580	1.091	0.024730	0.005048
BW4 V97	61.30056	16.651	1.859	15.706	1.196	0.037197	0.009486
BW4 V98	73.71553	16.654	1.938	15.637	1.243	0.032704	0.012360
BW4 V103	50.05908	16.717	2.004	15.727	1.333	0.038317	0.016284
BW4 V104	58.92790	16.713	1.691	15.768	1.049	0.023286	0.005576
BW4 V105	20.62066	16.782	2.096	15.896	1.492	0.073773	0.012630
BW4 V106	38.57705	16.750	1.994	15.717	1.271	0.046465	0.006268
BW4 V108	36.72494	16.815	2.097	15.862	1.421	0.054401	0.013437
BW4 V115	91.52672	16.907	2.055	15.910	1.370	0.037110	0.013333
BW4 V118	3.71294	16.950	1.972	16.013	1.338	0.037287	0.010800
BW4 V119	7.43859	16.944	2.053	16.007	1.402	0.036392	0.004228
BW4 V120	21.20702	17.003	2.071	16.016	1.388	0.071473	0.020482
BW4 V126	7.26788	17.003	1.974	15.944	1.245	0.036726	0.009349
BW4 V128	2.56227	17.065	1.463	16.161	0.836	0.037746	0.008949
BW4 V130	80.91698	17.091	1.990	16.089	1.311	0.032912	0.005060
BW4 V138	2.19604	17.203	1.896	16.271	1.268	0.025677	0.010063
BW4 V139	5.69908	17.265	1.748	16.149	0.951	0.054271	0.010581
BW4 V140	1.92679	17.239	2.015	16.282	1.359	0.023666	0.009466
BW4 V143	20.98581	17.292	2.064	16.303	1.388	0.073593	0.020935
BW4 V147	4.50869	17.358	2.249	16.345	1.556	0.075503	0.015246
BW4 V149	17.75847	17.435	1.904	16.478	1.262	0.100859	0.018915
BW4 V152	6.53376	17.426	1.943	–	–	0.085223	0.008093
BW4 V155	50.90524	17.451	2.119	–	–	0.046865	0.015808
BW4 V157	72.01231	17.424	1.950	16.489	1.307	0.039897	0.011990
BW4 V158	4.39670	17.426	2.180	16.498	1.539	0.047203	0.013931
BW4 V162	7.53005	17.567	1.900	16.574	1.222	0.071341	0.015124
BW4 V171	66.28633	17.581	1.891	16.634	1.235	0.038037	0.011922
BW4 V189	4.30442	17.855	2.070	16.908	1.420	0.131602	0.008722
BW4 V198	53.91844	17.877	1.900	16.888	1.231	0.054516	0.009424
BW4 V202	64.80522	17.872	1.443	16.872	0.766	0.040234	0.016146

T a b l e 3
Photometric parameters for stars from BW5.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW5 V5	84.81194	13.801	3.567	12.757	2.865	0.030648	0.010768
BW5 V10	80.29020	14.665	2.031	13.433	1.200	0.012120	0.005629
BW5 V11	68.03547	14.741	2.423	13.666	1.702	0.015189	0.005609
BW5 V14	10.84705	15.248	2.065	14.251	1.402	0.023943	0.002951
BW5 V15	49.04656	15.273	1.897	14.274	1.232	0.032370	0.010894
BW5 V16	40.89635	15.362	2.163	14.090	1.300	0.029029	0.010840
BW5 V18	6.34142	15.406	1.757	14.527	1.158	0.054568	0.006258
BW5 V19	17.38755	15.370	2.099	14.311	1.404	0.025983	0.010963
BW5 V20	55.02341	15.370	2.317	14.053	1.425	0.032220	0.007841
BW5 V22	9.53511	15.467	1.811	14.507	1.183	0.036894	0.010081
BW5 V23	5.93693	15.489	1.986	14.472	1.297	0.048096	0.003581
BW5 V25	39.54131	15.521	1.879	14.541	1.224	0.031529	0.013826
BW5 V26	83.87127	15.537	1.931	14.477	1.224	0.041124	0.009280
BW5 V30	52.50898	15.640	1.834	14.625	1.153	0.017214	0.009998
BW5 V31	6.46085	15.663	1.949	14.730	1.310	0.050212	0.004141
BW5 V32	51.27785	15.675	1.924	14.531	1.148	0.022435	0.007946
BW5 V33	5.08597	15.678	2.140	14.353	1.252	0.018932	0.003514
BW5 V35	48.05378	15.760	1.972	14.750	1.319	0.033810	0.011648
BW5 V41	33.10956	15.981	2.040	14.906	1.324	0.081454	0.011143
BW5 V42	53.34601	15.965	1.857	14.867	1.104	0.032619	0.010980
BW5 V44	22.48507	15.967	2.064	14.865	1.305	0.021158	0.006281
BW5 V45	5.27153	16.016	1.709	15.014	1.044	0.032870	0.006093
BW5 V46	7.55661	16.108	1.988	14.783	1.108	0.094806	0.023032
BW5 V47	26.06557	16.021	2.152	14.973	1.439	0.033600	0.008915
BW5 V48	4.46362	15.996	1.777	15.016	1.125	0.016891	0.002601
BW5 V49	32.03807	16.078	1.768	–	–	0.065796	0.025589
BW5 V52	86.85193	16.060	1.798	15.047	1.119	0.042665	0.009948
BW5 V53	45.43707	16.103	2.030	14.830	1.169	0.059759	0.016078
BW5 V54	19.26265	16.046	2.304	14.667	1.389	0.027081	0.005834
BW5 V56	20.46293	16.143	2.108	15.191	1.485	0.063509	0.015271
BW5 V57	38.06893	16.102	2.198	14.832	1.335	0.025241	0.009681
BW5 V58	3.43618	16.128	1.481	15.150	0.834	0.026096	0.007060
BW5 V59	22.91398	16.115	1.965	14.941	1.187	0.026508	0.005646
BW5 V61	17.72081	16.155	2.233	15.053	1.498	0.020325	0.005348
BW5 V62	50.05010	16.189	1.797	15.215	1.160	0.039764	0.010264
BW5 V63	28.22404	16.328	1.783	15.128	0.962	0.133911	0.020125
BW5 V64	45.34768	16.210	1.824	15.047	1.038	0.031345	0.015087
BW5 V65	11.33925	16.240	1.543	15.059	0.730	0.036687	0.007068
BW5 V67	37.61872	16.299	2.401	15.040	1.559	0.048630	0.013204
BW5 V68	33.15339	16.434	2.116	15.338	1.396	0.132232	0.034619
BW5 V71	69.90875	16.371	2.159	15.288	1.444	0.041042	0.017297
BW5 V72	46.62596	16.444	1.772	15.443	1.094	0.072081	0.015410
BW5 V74	18.62244	16.445	1.853	15.485	1.199	0.020735	0.007509
BW5 V78	62.65500	16.528	1.813	15.571	1.190	0.031000	0.008778
BW5 V79	52.99741	16.515	1.971	15.308	1.143	0.036716	0.013466
BW5 V80	4.20611	16.500	1.997	15.413	1.255	0.023250	0.005608
BW5 V83	28.64288	16.605	2.059	15.432	1.273	0.041965	0.006304
BW5 V86	64.32339	16.648	1.998	–	–	0.036469	0.013582
BW5 V87	56.11225	16.669	1.546	15.782	0.945	0.022011	0.004127
BW5 V92	65.53993	16.867	1.819	15.848	1.144	0.021775	0.009166
BW5 V115	26.31510	17.220	2.219	15.779	1.276	0.030397	0.006379
BW5 V119	66.40814	17.301	2.007	16.287	1.349	0.062522	0.022948
BW5 V127	57.09556	17.451	1.818	16.563	1.216	0.034977	0.013611
BW5 V130	6.02419	17.482	2.264	16.245	1.415	0.045892	0.016960
BW5 V133	2.43080	17.567	2.211	16.480	1.476	0.082886	0.018540
BW5 V134	9.83938	17.599	1.900	16.654	1.280	0.101186	0.018573
BW5 V137	9.66567	17.571	2.082	16.251	1.221	0.048638	0.011253
BW5 V142	2.72042	17.639	1.604	16.589	0.884	0.069923	0.007880
BW5 V151	14.09706	17.673	1.923	16.613	1.239	0.046982	0.011515
BW5 V153	12.59493	17.773	1.745	16.733	1.042	0.061503	0.007160
BW5 V169	5.97793	17.924	2.092	16.842	1.378	0.058950	0.020238

Table 3
Photometric parameters for stars from BW6.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW6 V3	31.71974	14.140	5.106	13.105	4.441	0.073592	0.019061
BW6 V6	9.74668	14.942	2.202	13.844	1.481	0.027821	0.003612
BW6 V8	22.73534	15.080	1.988	14.044	1.318	0.059420	0.003106
BW6 V9	31.96290	15.176	1.766	14.149	1.102	0.050981	0.018408
BW6 V10	61.49166	15.103	2.189	14.049	1.485	0.016068	0.004619
BW6 V11	8.44017	15.219	1.433	14.254	0.809	0.059761	0.003941
BW6 V13	45.71110	15.321	2.244	–	–	0.038617	0.018027
BW6 V16	8.63610	15.342	2.059	14.353	1.411	0.028713	0.004405
BW6 V22	20.90165	15.503	2.096	14.473	1.425	0.039583	0.007889
BW6 V23	35.30915	15.534	2.066	14.514	1.418	0.062408	0.010602
BW6 V24	13.79071	15.535	2.143	14.408	1.400	0.040116	0.010135
BW6 V25	34.92813	15.539	2.137	14.481	1.452	0.044873	0.008479
BW6 V26	40.86276	15.543	1.896	14.575	1.274	0.035845	0.006978
BW6 V28	23.01410	15.650	1.848	14.643	1.180	0.020928	0.007250
BW6 V31	57.37017	15.704	1.937	14.684	1.260	0.025485	0.010123
BW6 V37	60.51068	15.821	2.023	14.721	1.286	0.044039	0.012165
BW6 V38	46.65810	15.860	1.853	14.886	1.222	0.018483	0.006270
BW6 V39	64.23162	15.863	2.093	14.811	1.415	0.048154	0.009782
BW6 V40	17.38282	15.859	2.000	–	–	0.018688	0.007914
BW6 V42	24.82598	15.943	1.937	14.993	1.303	0.063574	0.017263
BW6 V43	5.75943	15.922	1.729	14.898	1.069	0.022416	0.002912
BW6 V47	26.31908	16.025	2.086	15.000	1.434	0.040598	0.012065
BW6 V48	51.82852	16.097	2.087	15.027	1.390	0.052818	0.014672
BW6 V50	32.32681	16.103	2.270	15.039	1.590	0.035361	0.010900
BW6 V53	14.11170	16.144	2.126	14.992	1.336	0.030228	0.002624
BW6 V55	27.86406	16.197	1.844	15.107	1.122	0.030860	0.011033
BW6 V57	4.44300	16.203	2.215	15.123	1.512	0.028288	0.004811
BW6 V58	54.18283	16.338	2.073	15.181	1.276	0.068598	0.022363
BW6 V62	25.72845	16.333	2.012	15.310	1.339	0.030663	0.010566
BW6 V63	6.40086	16.375	1.749	15.353	1.085	0.025487	0.007512
BW6 V65	52.54579	16.414	2.242	15.263	1.475	0.033870	0.006008
BW6 V66	15.60482	16.422	1.931	15.403	1.285	0.061283	0.017761
BW6 V68	56.91641	16.518	1.809	15.506	1.153	0.042401	0.006631
BW6 V70	63.17546	16.547	1.941	15.440	1.187	0.058851	0.016357
BW6 V73	62.76061	16.572	2.096	15.507	1.386	0.026936	0.009236
BW6 V74	5.33264	16.600	1.599	15.514	0.884	0.025076	0.007358
BW6 V75	24.45740	16.685	2.198	15.679	1.542	0.068435	0.025959
BW6 V80	66.44970	16.805	1.966	15.779	1.302	0.024069	0.007454
BW6 V82	40.06350	16.835	1.891	15.853	1.262	0.037369	0.015729
BW6 V84	45.25305	16.909	2.642	15.823	1.934	0.033651	0.012676
BW6 V90	50.00727	17.157	2.137	16.103	1.433	0.075548	0.027994
BW6 V94	45.86837	17.100	2.318	15.928	1.540	0.033528	0.007734
BW6 V95	81.90938	17.112	2.057	16.050	1.360	0.027707	0.009666
BW6 V96	25.14130	17.130	1.957	16.052	1.254	0.020803	0.009622
BW6 V105	31.27999	17.247	2.239	16.140	1.483	0.041769	0.005451
BW6 V110	9.07198	17.386	1.986	16.390	1.344	0.075322	0.010616
BW6 V113	40.90034	17.451	2.458	–	–	0.091532	0.018739
BW6 V126	25.91748	17.476	1.976	16.365	1.229	0.039882	0.011818
BW6 V137	37.22044	17.751	2.222	16.713	1.533	0.080622	0.012930
BW6 V138	9.86750	17.770	2.030	16.755	1.366	0.045539	0.017486
BW6 V146	6.89557	17.844	2.468	16.783	1.774	0.063699	0.010668
BW6 V150	4.13222	17.939	2.101	16.788	1.349	0.067272	0.013829

Table 3
Photometric parameters for stars from BW7.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW7 V1	67.60137	13.751	5.308	12.751	4.636	0.079854	0.037622
BW7 V3	78.20470	13.974	5.017	–	–	0.063565	0.011807
BW7 V5	81.95052	14.055	6.463	12.729	5.592	0.052805	0.017439
BW7 V6	13.08307	14.236	1.680	13.304	1.062	0.051882	0.003707
BW7 V9	35.68800	14.957	2.147	13.556	1.192	0.026433	0.003265
BW7 V10	16.12127	14.999	1.481	14.052	0.864	0.076706	0.020634
BW7 V11	22.91952	14.928	1.915	13.989	1.305	0.016471	0.007836
BW7 V12	22.76244	15.033	1.711	14.086	1.085	0.041769	0.011642
BW7 V13	9.38792	15.120	2.063	14.195	1.440	0.047800	0.008431
BW7 V14	42.74467	15.105	2.223	14.187	1.602	0.037360	0.010968
BW7 V16	24.90946	15.146	2.110	14.172	1.464	0.025514	0.010475
BW7 V19	18.17578	15.276	1.999	14.289	1.347	0.054240	0.022730
BW7 V22	24.65321	15.368	2.019	–	–	0.027829	0.013531
BW7 V26	19.51234	15.553	1.710	14.609	1.095	0.020614	0.007869
BW7 V27	8.33108	15.618	1.684	14.580	1.003	0.029169	0.009588
BW7 V28	5.46395	15.671	1.669	–	–	0.040743	0.001998
BW7 V29	46.39122	15.650	1.996	14.591	1.298	0.020299	0.006627
BW7 V32	22.10853	15.723	1.867	14.843	1.277	0.020700	0.002719
BW7 V37	31.73217	15.940	1.946	14.896	1.281	0.137967	0.036684
BW7 V41	10.99356	15.924	1.881	15.036	1.277	0.029283	0.009423
BW7 V42	24.19501	15.932	1.832	14.984	1.210	0.039199	0.015315
BW7 V43	48.57952	15.952	2.931	14.466	1.904	0.051935	0.011075
BW7 V46	82.57250	16.048	2.261	14.787	1.422	0.017854	0.008164
BW7 V49	43.66656	16.101	2.012	15.054	1.335	0.037039	0.013481
BW7 V50	46.88185	16.097	2.066	14.952	1.339	0.036320	0.006310
BW7 V56	55.41189	16.264	2.165	15.061	1.400	0.052545	0.018470
BW7 V58	5.06138	16.302	1.618	15.297	0.960	0.023300	0.005807
BW7 V59	24.74845	16.342	2.110	15.361	1.452	0.044606	0.019159
BW7 V60	23.39821	16.324	1.817	15.362	1.163	0.023971	0.010125
BW7 V61	22.63404	16.334	1.949	15.411	1.339	0.023759	0.007693
BW7 V62	54.85621	16.417	1.820	15.383	1.136	0.048870	0.017308
BW7 V65	66.21955	16.433	2.016	15.449	1.368	0.038312	0.016252
BW7 V66	64.62867	16.468	2.043	15.273	1.283	0.086495	0.022727
BW7 V67	13.32412	16.476	1.990	15.534	1.357	0.053851	0.025701
BW7 V69	53.84867	16.528	1.723	15.639	1.124	0.032169	0.005714
BW7 V70	60.39169	16.516	2.086	15.491	1.408	0.023611	0.007778
BW7 V75	20.31727	16.576	2.087	15.463	1.343	0.025990	0.007469
BW7 V78	19.07965	16.681	1.956	15.713	1.307	0.050924	0.013485
BW7 V81	54.83512	16.660	2.156	15.585	1.464	0.026856	0.011573
BW7 V90	64.76485	16.847	1.741	15.852	1.097	0.039576	0.006975
BW7 V92	63.08331	16.884	2.107	15.838	1.427	0.042794	0.004559
BW7 V93	72.62366	16.869	1.992	15.839	1.316	0.026933	0.010803
BW7 V94	75.40107	16.916	1.940	15.841	1.246	0.035466	0.011712
BW7 V98	9.23756	16.975	1.723	16.036	1.109	0.038646	0.006713
BW7 V99	57.53259	17.071	1.457	16.067	0.800	0.140068	0.031236
BW7 V104	17.25661	17.051	2.034	16.068	1.377	0.060613	0.018004
BW7 V108	72.67028	17.106	2.548	16.148	1.926	0.041046	0.014564
BW7 V113	7.44911	17.208	2.131	16.162	1.452	0.062246	0.020518
BW7 V125	13.66301	17.376	2.230	16.372	1.576	0.056035	0.012557
BW7 V130	5.76375	17.457	2.207	16.413	1.523	0.076616	0.012924
BW7 V136	14.28712	17.480	2.062	16.490	1.390	0.046642	0.008975
BW7 V138	27.65712	17.643	1.911	16.645	1.248	0.111676	0.028762
BW7 V146	18.40633	17.653	2.036	16.576	1.339	0.062982	0.015481
BW7 V166	13.64761	17.943	2.011	16.870	1.308	0.085620	0.032069

Table 3
Photometric parameters for stars from BW8.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]	Mean Amplit.	σ [mag]
BW8 V2	33.61513	13.985	2.815	12.995	2.120	0.033826	0.010187
BW8 V3	14.58670	14.072	1.944	13.229	1.392	0.033764	0.004597
BW8 V4	13.67317	14.268	1.600	13.373	0.987	0.055491	0.002853
BW8 V6	46.34044	14.900	2.016	13.947	1.373	0.055281	0.018194
BW8 V9	6.42296	14.980	1.718	14.055	1.092	0.051413	0.002829
BW8 V10	25.21914	14.972	1.945	14.061	1.346	0.028295	0.011213
BW8 V11	37.99750	15.062	1.817	–	–	0.020184	0.006787
BW8 V12	49.52135	15.082	1.961	14.224	1.409	0.058889	0.017248
BW8 V14	22.41615	15.083	2.910	–	–	0.028410	0.003939
BW8 V17	6.51395	15.250	1.442	14.322	0.791	0.048675	0.002828
BW8 V19	48.61057	15.269	2.301	14.267	1.606	0.024406	0.009424
BW8 V22	12.38105	15.318	1.688	14.486	1.136	0.023377	0.006229
BW8 V23	12.00757	15.320	2.082	14.358	1.423	0.035592	0.006547
BW8 V25	71.62444	15.388	1.900	14.479	1.306	0.019010	0.005788
BW8 V29	26.64196	15.570	2.005	14.615	1.365	0.092204	0.012921
BW8 V30	22.76570	15.486	1.950	14.631	1.390	0.028034	0.007529
BW8 V32	36.97357	15.572	1.566	14.719	1.009	0.020370	0.006666
BW8 V33	17.94747	15.611	1.907	14.749	1.331	0.060838	0.008156
BW8 V37	33.34402	15.776	2.257	14.686	1.488	0.021795	0.006822
BW8 V38	29.18254	15.836	2.082	14.974	1.496	0.046041	0.017957
BW8 V39	28.97818	15.890	1.765	15.042	1.216	0.064537	0.008751
BW8 V40	19.51440	15.891	1.770	15.040	1.213	0.034722	0.010567
BW8 V41	8.99845	15.900	1.753	15.095	1.215	0.044130	0.005193
BW8 V42	50.38605	15.947	2.107	–	–	0.070074	0.019588
BW8 V43	40.85901	16.039	2.255	15.171	1.676	0.069990	0.017048
BW8 V44	3.73640	15.982	1.819	15.078	1.233	0.037879	0.004530
BW8 V47	3.05402	16.039	2.158	14.952	1.379	0.035118	0.003956
BW8 V48	37.73185	16.054	2.037	15.154	1.417	0.033915	0.014082
BW8 V51	10.46607	16.155	1.949	15.234	1.336	0.032732	0.007435
BW8 V52	3.19486	16.186	1.340	15.138	0.599	0.030611	0.004408
BW8 V54	28.42182	16.287	1.789	15.393	1.212	0.094153	0.026983
BW8 V58	73.24367	16.273	1.953	15.373	1.349	0.060947	0.025312
BW8 V59	16.85070	16.287	1.775	–	–	0.020070	0.009423
BW8 V61	9.86997	16.404	1.961	15.518	1.383	0.068350	0.008974
BW8 V64	5.72188	16.387	1.829	15.499	1.246	0.029999	0.004049
BW8 V65	73.53614	16.511	2.723	15.377	1.914	0.089872	0.018935
BW8 V66	46.42073	16.492	1.967	15.537	1.331	0.047317	0.019040
BW8 V67	26.80841	16.465	1.686	15.617	1.137	0.069064	0.018723
BW8 V76	39.90600	16.785	2.467	15.863	1.828	0.061945	0.016203
BW8 V83	2.61259	16.933	1.611	15.912	0.883	0.045423	0.008354
BW8 V87	48.48229	16.992	1.969	16.077	1.371	0.036617	0.016998
BW8 V88	49.96990	16.975	1.827	16.104	1.262	0.035101	0.008029
BW8 V91	74.37910	17.053	2.095	16.144	1.493	0.058177	0.022837
BW8 V92	79.63497	17.069	2.132	16.118	1.497	0.029290	0.012198
BW8 V97	57.27341	17.140	1.902	16.244	1.299	0.044118	0.014265
BW8 V98	12.11239	17.217	1.818	16.294	1.202	0.083255	0.012118
BW8 V100	26.78628	17.178	1.783	16.350	1.229	0.053703	0.011965
BW8 V105	41.30631	17.283	1.724	16.379	1.140	0.118438	0.023794
BW8 V107	55.83004	17.245	2.046	16.365	1.454	0.061155	0.022548
BW8 V115	15.94298	17.366	2.002	16.492	1.432	0.059691	0.004358
BW8 V120	21.94519	17.435	1.926	16.524	1.335	0.051175	0.017016
BW8 V124	7.29094	17.485	2.067	16.496	1.385	0.039434	0.015280
BW8 V144	10.53290	17.788	1.884	16.795	1.202	0.022515	0.005318

The next step was to plot the period of a star *vs.* its brightness, as shown in Fig 10a. All limits of the Catalog are clearly visible. The upper limit near $I = 14$ mag is a result of saturation of stellar images on the CCD frames. The $I = 18$ mag is a limiting magnitude of the present Catalog. The left and right boundaries result from the range of period search. A very interesting feature is the absence of stars in the upper-left part of the Fig. 10a. In order to check its

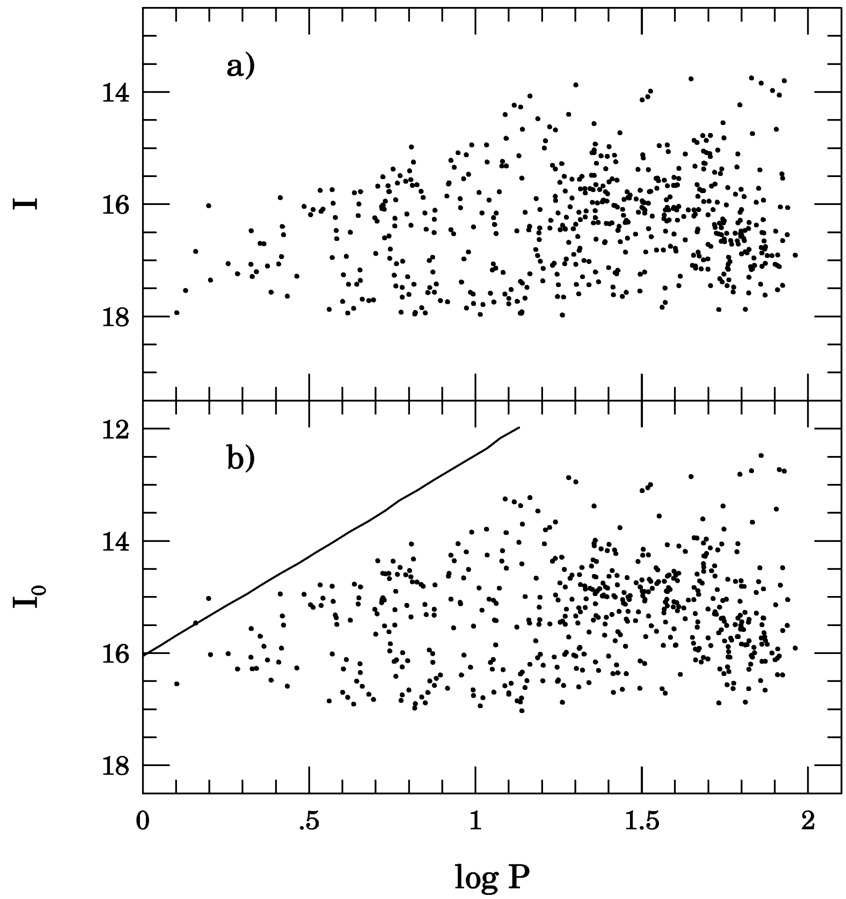

Fig. 10. a) Correlation between I-band brightness and period of the stars. b) Correlation between free from interstellar extinction brightness of the star and its period. Solid line corresponds to the minimal rotating period of the single star.

physical nature we slightly modified our graph. We changed vertical axis from I to I_0, and the absence of stars in the upper-left part of Fig. 10b is just as clear as it was in Fig. 10a. This phenomenon is not due to the Catalog incompleteness, but it has a physical cause: a variable of a given luminosity cannot have a period shorter than some limit. The solid line in Fig. 10b represents the minimal period of a rotating single star rotating at the so called "break-up". The line was obtained in the following way: we adopted a linear relation between V_0 and $(V-I)_0$, as calculated with the Least Squares Method: $(V-I)_0 = 0.07574 \cdot V_0 + 0.03272$. The dependence between $(V-I)_0$ and the effective temperature $T_{\rm eff}$ of a star was taken from Bartelli *et al.* (1994), with $T_{\rm eff} = 5000$ K corresponding to

$(V-I)_0 = 0.97$ mag and $T_{\rm eff} = 3500$ K to $(V-I)_0 = 2.40$ mag. Assuming a typical stellar mass as $1 M_\odot$ and the distance of 8 kpc we obtained a relation which may be well approximated with:

$$I_0 = -3.58 \cdot \log P + 16.05 \qquad (2)$$

where the period P is measured in days.

Table 4

Photometric parameters for blue stars classified as ellipsoidal variables.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]
BWC V39	5.82920	15.623	1.159	14.596	0.482
BWC V45	6.67334	15.653	1.163	14.733	0.547
BWC V69	3.48129	16.085	1.189	15.020	0.497
BWC V72	5.31773	16.089	1.412	15.052	0.731
BW1 V58	3.25106	16.094	1.335	15.183	0.711
BW3 V5	19.06577	14.399	1.684	12.872	0.654
BW3 V34	4.32736	15.796	1.229	14.771	0.554
BW3 V49	1.57766	16.027	1.377	15.024	0.701
BW3 V60	4.98511	16.243	1.314	15.219	0.639
BW3 V102	1.44218	16.841	1.347	15.464	0.462
BW4 V77	2.11847	16.472	1.011	15.563	0.391
BW5 V58	3.43618	16.128	1.481	15.150	0.834
BW5 V65	11.33925	16.240	1.543	15.059	0.730
BW6 V11	8.44017	15.219	1.433	14.254	0.809
BW6 V74	5.33264	16.600	1.599	15.514	0.884
BW7 V58	5.06138	16.302	1.618	15.297	0.960
BW8 V4	13.67317	14.268	1.600	13.373	0.987
BW8 V17	6.51395	15.250	1.442	14.322	0.791
BW8 V52	3.19486	16.186	1.340	15.138	0.599
BW8 V83	2.61259	16.933	1.611	15.912	0.883

The line in Fig. 10b is a good envelope to the distribution of stars, and this demonstrates that the absence of stars in the upper-left part of the Fig. 10b is due to the physical limit. Only one star is placed considerably above the limiting line for a single rotating star. It might be a one star which is a result of mixing two stars of a binary system.

The color-magnitude diagram presented in Fig. 7 contains a few blue stars with $(V-I)_0 < 1$, which are placed mainly at the Galactic disk main sequence turn-off point. These stars are clearly separated from other miscellaneous variables, which are distributed above the bulge main sequence turn-off point, on the red subgiant and the red giant branch. We decided to use a subjective judgment about the nature

Table 5

Photometric parameters for blue stars suspected as ellipsoidal variables.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]
BWC V74	45.81902	16.177	1.492	15.295	0.896
BWC V119	4.09207	16.929	1.464	16.114	0.919
BW1 V27	9.21642	15.545	1.522	14.661	0.911
BW1 V45	2.59006	15.882	1.534	14.946	0.898
BW1 V72	7.52251	16.269	1.673	15.217	0.972
BW2 V115	6.25551	17.292	1.643	16.134	0.886
BW3 V72	7.11300	16.446	1.737	15.312	0.990
BW3 V118	1.80611	17.058	1.613	16.009	0.931
BW3 V145	20.11758	17.429	1.738	16.272	0.988
BW3 V168	17.65215	17.645	1.725	16.504	0.942
BW4 V18	52.37688	15.431	1.110	14.444	0.418
BW4 V59	42.31632	16.218	1.709	15.196	0.999
BW4 V128	2.56227	17.065	1.463	16.161	0.836
BW4 V139	5.69908	17.265	1.748	16.149	0.951
BW5 V142	2.72042	17.639	1.604	16.589	0.884

Table 6

Photometric parameters for blue stars classified as spotted.

Star Designation	Period [days]	I [mag]	$V-I$ [mag]	I_0 [mag]	$(V-I)_0$ [mag]
BW1 V114	28.26313	16.854	1.615	15.876	0.988
BW1 V196	12.60082	17.678	1.627	16.708	0.986
BW2 V66	3.83093	16.614	1.649	15.487	0.932
BW4 V202	64.80522	17.872	1.443	16.872	0.766
BW5 V63	28.22404	16.328	1.783	15.128	0.962
BW7 V10	16.12127	14.999	1.481	14.052	0.864
BW7 V99	57.53259	17.071	1.457	16.067	0.800

of these blue variables, and for every star with $(V-I)_0 < 1$ we classified its light curve: those with most regular variations were expected to be ellipsoidal variables, those with the most irregular light curves were expected to be chromospherically active. Three groups were formed, and they are listed in Tables 4, 5, 6.

Table 4 contains periods, magnitudes and colors of those blue stars which have light curves strongly resembling ellipsoidal variables. It is worth to note that almost all stars selected that way have very short periods and colors in the range

$0.3 < (V - I)_0 < 0.8$. Table 5 contains blue stars which light curves could belong to ellipsoidal variables but its relation to the chromospherically active stars cannot be excluded. It is clearly visible that periods of these stars are not restricted to such a small range as in Table 4, but in many cases the periods are still short. The colors of these stars are mostly in the range 0.8–0.9 mag. The last group is presented in Table 6 and contains blue stars which light curve definitely rules out any relation to the ellipsoidal variability. The range of periods of stars in this group is very large, and the colors are very close to 1.0 mag.

We believe that objects listed in Table 4 and the majority of these listed in Table 5 are ellipsoidal variable stars. These blue stars are shown in the color-period diagram in Fig. 11 with open circles, and they form a narrow branch of a few points with blue color and short period.

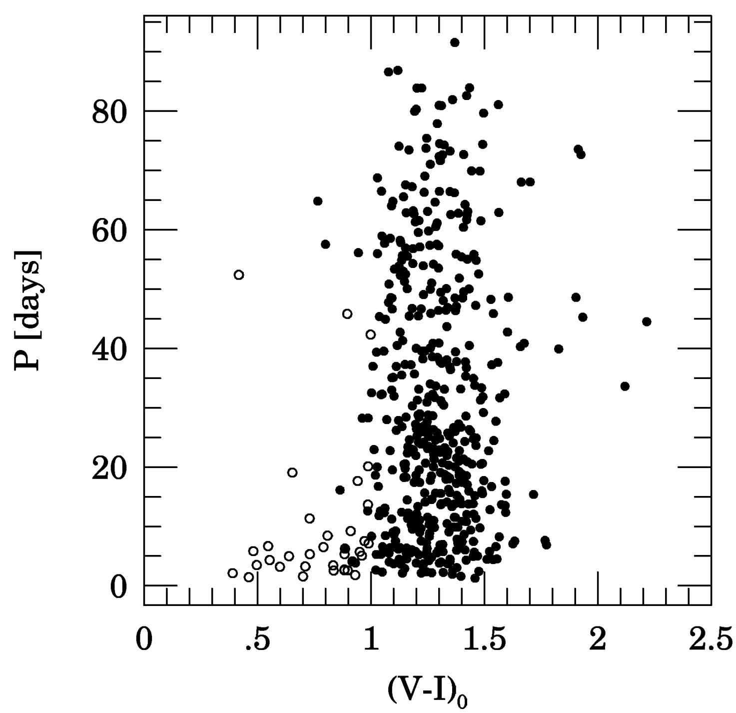

Fig. 11. Correlation between color and period of the miscellaneous star. Open circles correspond to the stars suspected for ellipsoidal variability and filled circles denote remaining stars.

The full list of OGLE stars with V and I data contains 528 138 objects. It is not a precise estimate because of photometric errors (see for comparison Szymański *et al.* 1996). We estimate that in area below the red clump *i.e.*, for $14.5 < I_0 < 16$ and $(V - I)_0 > 1$, there are 24 744 non-variable stars. In the same region there are 273 miscellaneous variable stars. It means that about 1% of all stars in that part of CMD is chromospherically active with amplitude of modulation large enough to be detected in the OGLE search. Of course there are also variables classified as miscellaneous outside the above-mentioned area, but their highest concentration is observed inside that region.

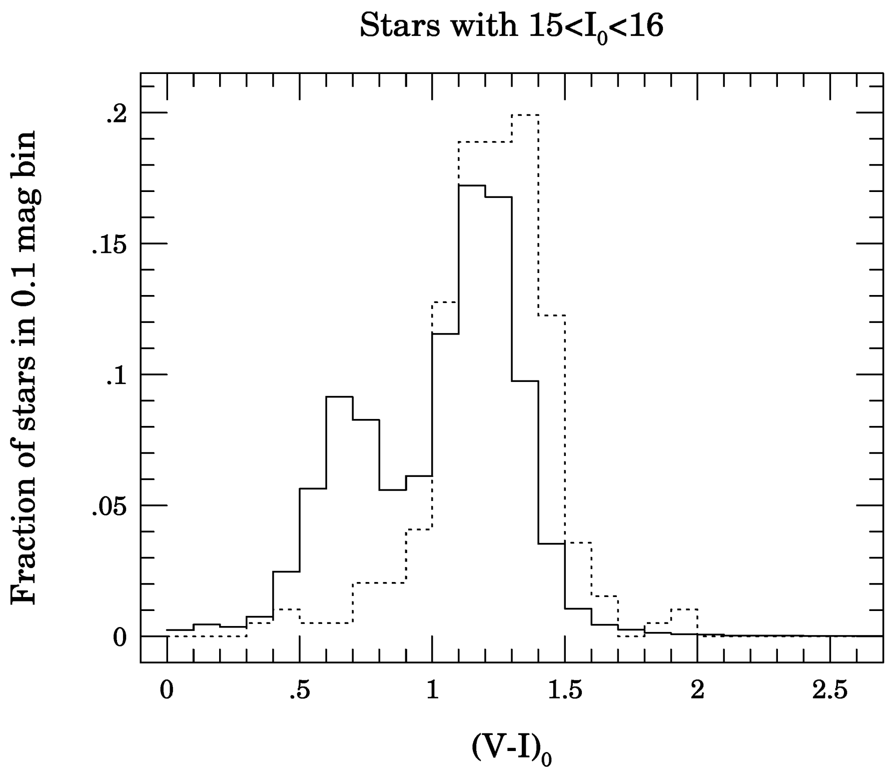

Fig. 12. Distribution of the color of the stars. Solid line corresponds to the non-variable stars and dotted one to the variables.

Two normalized histograms of color distribution in 0.1 mag bins are presented in Fig. 12 for stars with $15.0 < I_0 < 16.0$. The solid and dotted lines correspond to non-variable and to variable stars respectively. The distribution of the colors in both cases seems to be similar, but the dotted line is slightly redder than the solid one.

5. Red Stars

Among a few hundred miscellaneous variables we found eight exceptionally red stars which are clearly visible in the CMD presented in Fig. 13. Our first impression was that V-band brightness of these star was measured incorrectly. Therefore, we investigated V-band light curves of these stars and we found that they phase with the same periods as the I-band light curves. A large number of V data points excludes possibility of a mistake, as demonstrated in Fig. 14 and 15, where I and V light curves of these stars are presented.

The following stars belong to this group: BW1 V1, BW3 V1, BW3 V2, BW5 V5, BW6 V3, BW7 V1, BW7 V5, BW8 V2 and also variable V1 in the field BW9. These red stars are distinguished not only by their large values of $(V - I)_0$ but also by their high brightness and long periods. They are often the brightest variable stars in their fields. It would be interesting to search for such red variables

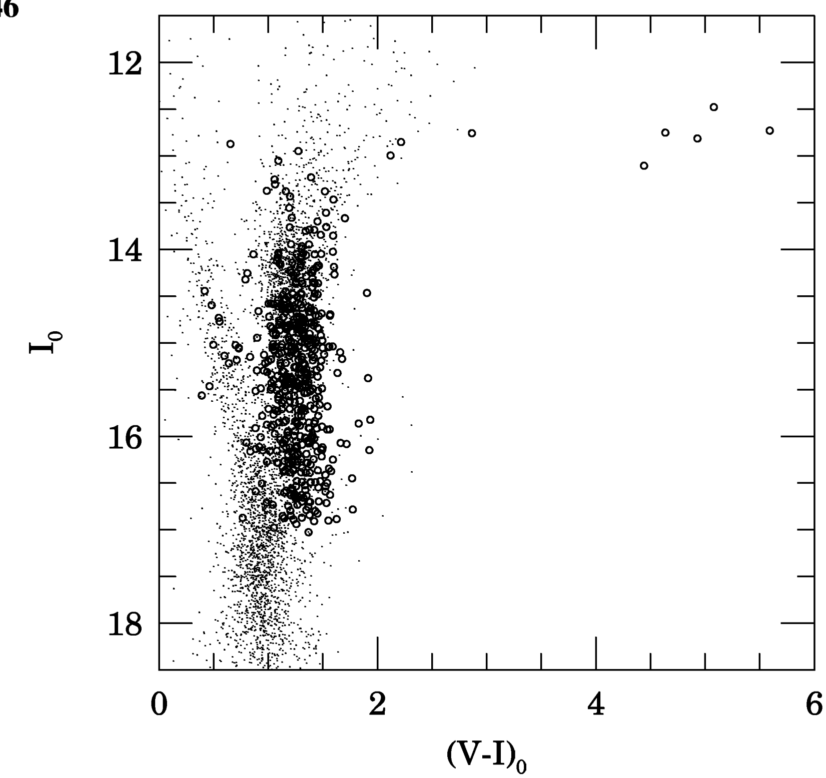

Fig. 13. Fig. 13 The color-magnitude diagram free from interstellar extinction for red stars.

among the stars brighter than $I \approx 14$, which is the upper limiting magnitude of the Catalog, to have more complete sample.

Previous surveys of Baade's Window region (Frogel and Whitford 1987, Blanco *et al.* 1984, Lloyd Evans 1976) also revealed examples of such red and bright objects. The majority of the reddest stars in those surveys were variable, and because of their large amplitudes and long periods they were classified as Mira type variables. Additionally a large part of their variables was semiregular. The red stars presented in this paper are certainly not Miras, but they may be semiregular variables. Their periods are shorter than 100 days, their light curves are unstable and change from season to season. That suggests that these objects very likely belong to the group of chromospherically active variables, but we cannot exclude a possibility that they are semiregular variables.

Similar red and bright objects were also found in a few open clusters. For instance, Garnavich *et al.* (1994) reported observations of the red giant branch in old and metal rich open cluster NGC 6791. They found at least 12 such stars. These objects are placed at the end of evolutionary sequences of stars with masses near $1.1 M_\odot$. In the same cluster Kałużny and Ruciński (1993) discovered 17 variable stars. One of them was very red $B - V = 1.595$ evolved giant and was located above the horizontal branch red clump. They suggested that variability of this star was caused by pulsations and classified it as RV Tau type star.

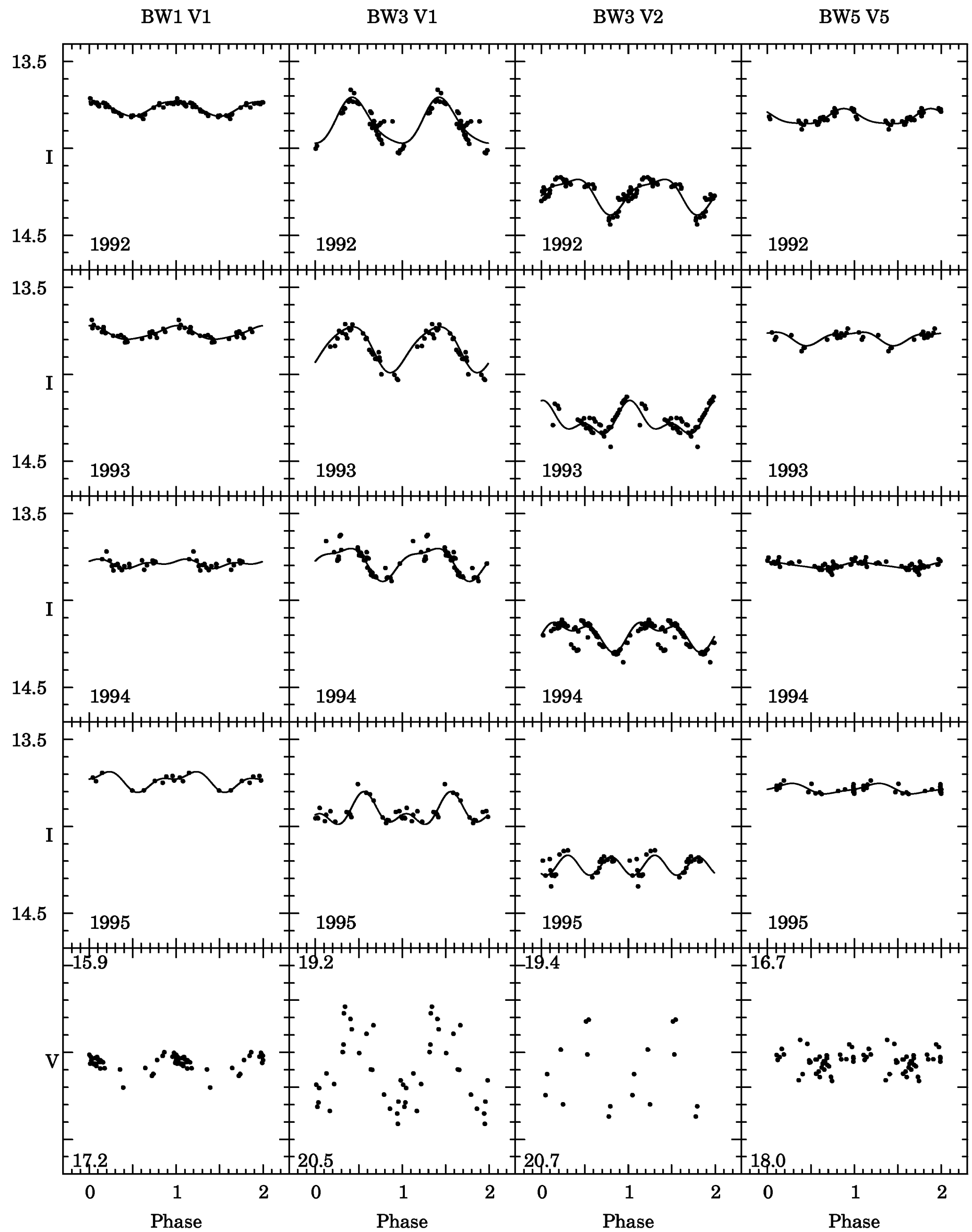

Fig. 14. I and V-band light curves of four red stars.

6. Conclusion and Summary

We have presented the first catalog of stars classified as miscellaneous in the OGLE search for variable stars in the Galactic bulge. Our catalog contains 549 objects. The periods, the magnitudes and colors as observed and free of interstellar extinction, the coefficients of Fourier fit and amplitudes of the light modulation are given for each star. 517 objects are suspected for chromospherical activity. Some of these stars are likely to be single rotating spotted stars of the

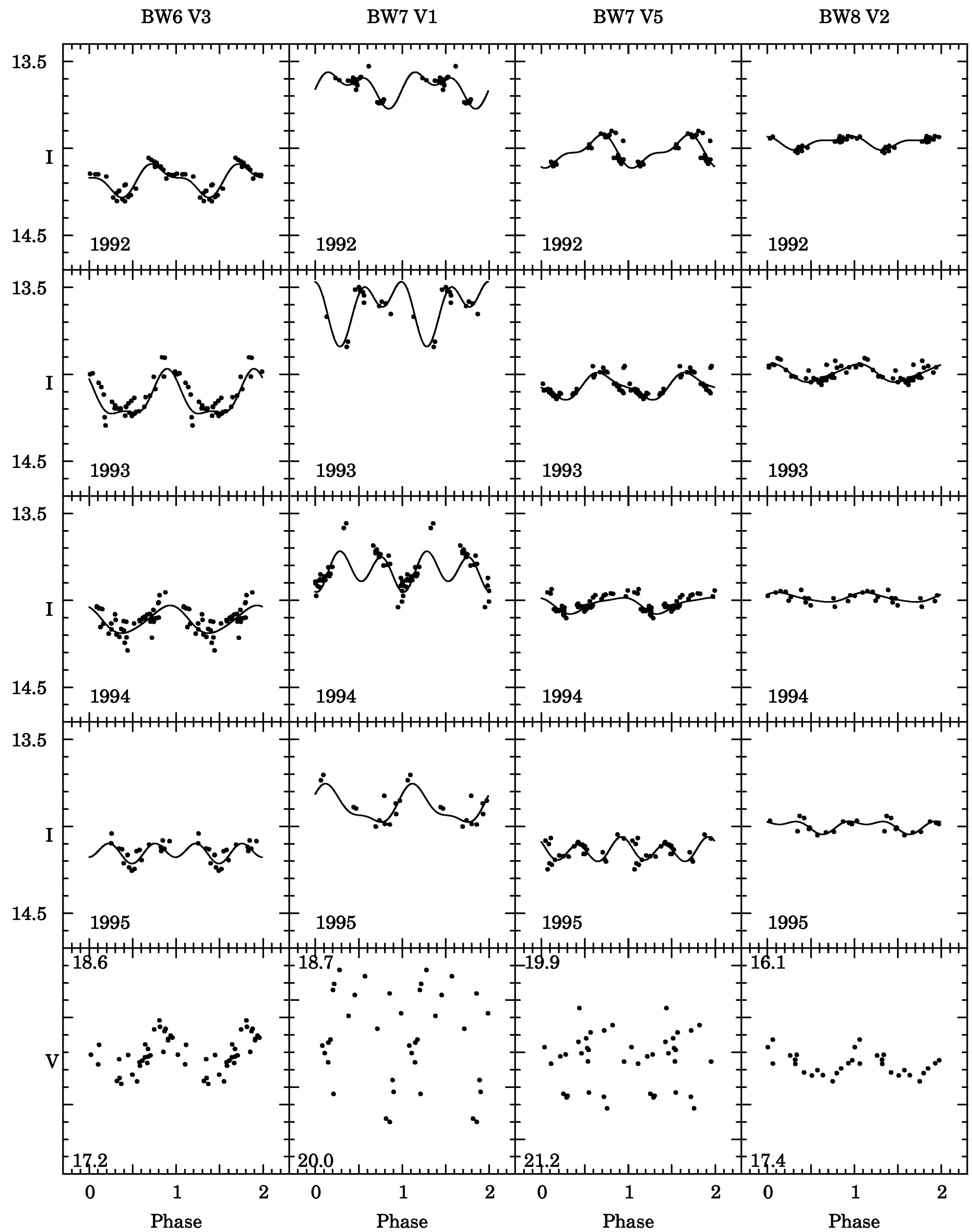

Fig. 15. I and V-band light curves of four red stars.

FK Com type. Other objects from this group could be binary systems with spotted component, like RS CVn binaries. 32 stars with colors $(V-I)_0 < 1$, short periods and sinusoidal, small amplitude light curves are classified as ellipsoidal variables *i.e.*, binary systems with ellipsoidal components not showing eclipses.

A group of 8 stars from our list is distinguished by the very large values of $(V-I)_0$ color (in range 2.5–6 mag), and high and similar I-band brightness, near the bright limit of the OGLE catalog. These are likely to be chromospherically active red giants. It is interesting that there are no non-variable stars at the part of CMD where our reddest variables are located. Similar property was presented by Frogel and Whitford (1987) where variables were also the reddest M giants found. It might suggests that the spots on the stellar star cause a considerable reddening of the star.

The chromospherically active stars are almost uniformly spread along red sub-giant and giant branches, where they constitute about 1% of all stars in the OGLE database. There is no clear concentration of these variables in the red clump region of the CMD, which suggest that spotted stars evolve for the first time along the red giants branch.

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