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Search for Long-Period and Non-Periodic Variable Stars in the OGLE-I Databases[1]

by

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ABSTRACT

We present a list of long-period and non-periodic variable stars detected in the OGLE-I databases. These stars were not included in previous catalogs of periodic stars found in OGLE data. The catalog contains 116 stars in twelve Baade's Window fields and additionally in the Galactic bulge fields: MM1/5/7-A/B, MM3 and GB1.

The catalog and individual observations are available in digital form from the OGLE Internet archive.

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

1. Introduction

The Optical Gravitational Lensing Experiment (OGLE) is a long term observing project with the main goal of searching for dark matter in our Galaxy with microlensing phenomena (Paczyński 1986). The main result of the first phase of the OGLE experiment (OGLE-I) conducted during 1992–95 observing seasons was discovery of about 20 microlensing events (Woźniak and Szymański 1998). Description of the OGLE project can be found in Udalski *et al.* (1992). Another important result of the OGLE project was detection of thousands new variable stars presented in five parts of the OGLE catalog of periodic stars (Udalski *et al.* 1997a and references therein). These catalogs contain mostly objects with strictly periodic variability behavior, such as RR Lyr, eclipsing binaries and chromospherically active stars. Period search was limited within (0.1–100) days range.

Little is known about stellar variability in time scale exceeding 100 days. The main aim of this paper is to present the results of search for new variable stars not included in the previous catalogs because of their different properties, especially

[1] Based on observations obtained at the Las Campanas Observatory of the Carnegie Institution of Washington.

long periods. It is important to note that the microlensing survey databases are ideal for this purpose because of long span of the observations, expanding to over 1000 days and good photometric quality obtained with modern CCD techniques.

We have analyzed all 20 OGLE-I fields and searched particularly for objects with long term variation of brightness. Beside non-periodic objects we found also stars, that exhibit nearly periodic behavior. Some of these stars are irregular or quasiperiodic. All detected objects are presented in the form of catalog described in the following Section.

2. The Catalog

The photometric data presented in this paper were collected during the first phase of the OGLE microlensing search starting in 1992 and ending in 1995. The limited access to the telescope time during this phase of the OGLE project allowed monitoring of the fields for typically about 80 nights spanning about 180 days each season. Full logs of observations can be found in Udalski *et al.* (1992, 1994a, 1995, 1997b). Equatorial and galactic coordinates of the observed fields are given in Table 1.

Table 1

Coordinates of the OGLE-I fields

Field	α_{2000}	δ_{2000}	l	b
BWC	$18^h03^m24^s$	$-30°02'00''$	$1\overset{\circ}{.}0$	$-3\overset{\circ}{.}9$
BW1	$18^h02^m24^s$	$-29°49'05''$	$1\overset{\circ}{.}1$	$-3\overset{\circ}{.}6$
BW2	$18^h02^m24^s$	$-30°15'05''$	$0\overset{\circ}{.}7$	$-3\overset{\circ}{.}8$
BW3	$18^h04^m24^s$	$-30°15'05''$	$0\overset{\circ}{.}9$	$-4\overset{\circ}{.}2$
BW4	$18^h04^m24^s$	$-30°49'05''$	$1\overset{\circ}{.}3$	$-4\overset{\circ}{.}0$
BW5	$18^h02^m24^s$	$-30°02'05''$	$0\overset{\circ}{.}9$	$-3\overset{\circ}{.}7$
BW6	$18^h03^m24^s$	$-30°15'05''$	$0\overset{\circ}{.}8$	$-4\overset{\circ}{.}0$
BW7	$18^h04^m24^s$	$-30°02'05''$	$1\overset{\circ}{.}1$	$-4\overset{\circ}{.}1$
BW8	$18^h03^m24^s$	$-29°49'05''$	$1\overset{\circ}{.}2$	$-3\overset{\circ}{.}8$
MM5–A	$17^h47^m30^s$	$-34°45'00''$	$-4\overset{\circ}{.}8$	$-3\overset{\circ}{.}4$
MM5–B	$17^h47^m30^s$	$-34°57'00''$	$-4\overset{\circ}{.}9$	$-3\overset{\circ}{.}5$
MM7–A	$18^h10^m53^s$	$-25°54'20''$	$5\overset{\circ}{.}4$	$-3\overset{\circ}{.}3$
MM7–B	$18^h11^m47^s$	$-25°54'20''$	$5\overset{\circ}{.}5$	$-3\overset{\circ}{.}5$
BW9	$18^h00^m50^s$	$-29°49'05''$	$0\overset{\circ}{.}9$	$-3\overset{\circ}{.}3$
BW10	$18^h00^m50^s$	$-30°02'05''$	$0\overset{\circ}{.}7$	$-3\overset{\circ}{.}4$
BW11	$18^h00^m50^s$	$-30°15'05''$	$0\overset{\circ}{.}5$	$-3\overset{\circ}{.}5$
MM1–A	$18^h06^m52^s$	$-26°38'05''$	$4\overset{\circ}{.}4$	$-2\overset{\circ}{.}9$
MM1–B	$18^h06^m52^s$	$-26°51'05''$	$4\overset{\circ}{.}2$	$-3\overset{\circ}{.}0$
MM3	$18^h07^m56^s$	$-29°04'35''$	$2\overset{\circ}{.}3$	$-4\overset{\circ}{.}3$
GB1	$17^h54^m52^s$	$-29°45'30''$	$0\overset{\circ}{.}3$	$-2\overset{\circ}{.}2$

Each of these fields covers approximately $15' \times 15'$ on the sky. For BWC, BW1–8, MM7–A/B, and MM5–A/B fields four seasons of observations were available. The remaining fields BW9–11, MM3, GB1 and MM1–A/B were added after the first season of observations and therefore only three observing seasons were available.

Observations were made at the Las Campanas Observatory, Chile which is operated by the Carnegie Institution of Washington. The 1-m Swope telescope with 2048×2048 Ford/Loral CCD detector was used. Details of the data pipeline and reduction technique can be found in Udalski *et al.* (1992) and Szymański and Udalski (1993). Searching method used to find stars presented in this paper employs similar algorithm as for microlensing search, and its description can be found in Udalski *et al.* (1994b).

The catalog contains stars with the *I*-band brightness from 14 to 18.5 mag. The upper limit is caused by CCD saturation for stars brighter than 14 mag while the lower limit by observation errors for the faint objects.

Selected variable stars are divided into three groups, as described in the next Section. Majority of stars are bright objects with $I < 17.0$ mag and color index $(V - I)$ in the range of 1.3–3.0 mag. They are located typically on the giant branch on the color-magnitude diagram (Fig. 1) .

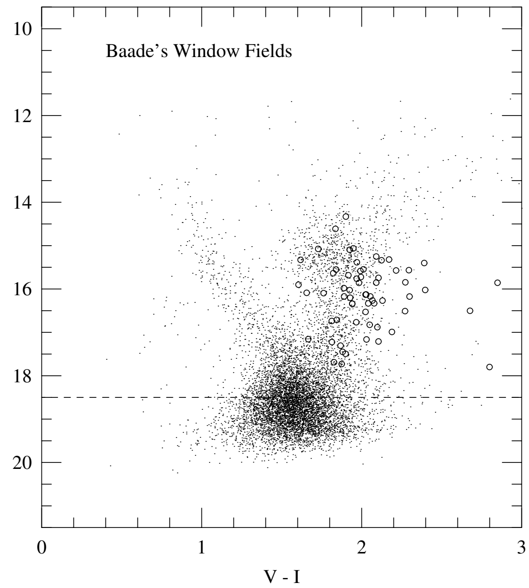

Fig. 1. CMD diagram for Bulge BW1–8 and BWC fields. Stars from the catalog are marked with open circles. For convenience only 5% of non-variable stars are plotted.

The catalog consists of a table with basic parameters for every variable star and an atlas containing non-phased light curves and $30'' \times 30''$ finding charts – part of the *I*-band frames. North is up and East is to the left on these charts. Time is expressed as (HJD-2448000).

The basic parameters include the star designation, field, right ascension and declination (J2000), *I*-band mean magnitude, $(V - I)$ – mean color index, and optional remarks. *I*-band magnitudes and $(V - I)$ indices were transformed to the standard Johnson-Cousins *VI* system except for stars without $(V - I)$ colors. Designations of objects are as following: OGLE-LT-Vnumber where LT stands for long term variability. The stars are initially sorted according to increasing mean magnitude.

The equatorial coordinates of variable stars were calculated using transformations based on positions of stars from the HST Guide Star Catalog (Lasker *et al.* 1988). The relative accuracy of coordinates is about $0\farcs2$ while the absolute accuracy is worse – about $1''$.

The vast majority of observations was obtained in the *I*-band, typically 150–250 exposures. For the *V* filter only about 10–30 exposures were collected during all seasons.

3. Variability Types

In total, we present 116 new variable stars in our catalog. They are listed in Table 2.

We have introduced three types of long term variability among our objects to help the reader distinguishing between different light curve behavior. The division is based on the light curve assessment and does not refer to known types of variability. The type for each star is listed in the remark column ff Table 2 with two letter abbreviation. Main features of groups are summarized below:

lh – long term variability and high amplitudes (> 0.5 mag). The stars might belong to Mira variables and one, in the MM1–B field, can be a R CrB type star.

lt – long term variability with small amplitude about (0.1–0.2 mag). Some of stars which decrease smoothly their brightness can be possibly novae returning to quiescence light (for this kind of stars such a process can take several years).

lv – this type stars exhibit changes in amplitude on shorter time scales (less than one season) and additionally this variability can be combined with very long term variations similar to type "lt". Some stars in this group exhibit also fairly periodic behavior. These objects were probably missed in the OGLE catalogs due to period longer or close to 100 days and are marked additionally with letter "p" in Table 2.

4. The Completeness of the Catalog

The first goal of the data analysis described in this paper was to check whether there are more microlensing events in the OGLE-I databases. The microlensing search strategy is similar to detection of long term variable stars. Then we modified our selection criteria and searched mostly for long term variable stars.

Algorithm used for this search differs only a little from that used for the microlensing search as described in Udalski *et al.* (1994b). First, the algorithm demanded a star to be constant during one full observing season (later we easied that demand to about one third of the observing season). Next, we required a star to be variable in the remaining part of observations.

Our selection criteria for variable star candidates were as follows:

1. A star was considered to be variable when:

   - At least 5 consecutive "good photometry" points deviated up or down from the average brightness during the "constant" period by more than $3\sigma_{\max}$. The value of $\sigma_{\max}$ was derived from the mean magnitude of the star during the period of constant brightness as described in Udalski *et al.* (1993)

2. A star was assumed as non-variable in the selected period when:

   - The star mean magnitude from all "good" measurements was $I < 19.5$.
   - Standard deviation from all "good photometric" measurements was smaller than $\sigma_{\max}$.

Taking shorter period of constant brightness (containing 20 and less measurements) we did not retrieve more candidates for variable stars. On the contrary, poor observation coverage of the observing seasons caused sometimes overlooking of some shorter period or very irregular candidates due to large dispersion of their mean magnitude which excluded them from constant stars sample.

Results of the algorithmic search were finally verified visually and only reasonable candidates which did not exhibit erratic behavior were included to our catalog.

To check completeness of our algorithm we examined efficiency of our search in two ways. First for BWC and MM5-A/B fields we selected many periods of constant brightness in all seasons, covering different parts of each season and in all cases we performed independent searches. The results were similar, we found mostly the same candidates. Additional objects, suspected to be variable were too noisy to be included to our candidate list. Next, we performed Monte Carlo simulation to obtain database of sinusoidal light curves. The sinusoidal light curves were generated in similar way as those for microlenses simulation (Udalski *et al.* 1994b). These artificial light curves were then put into our search routine and checked which passed criteria described above.

The light curve parameters used in this test were as follows:

1. Three ranges of amplitude: (0.0–0.2) mag, (0.2–0.5) mag and (0.5–3.0) mag.
2. For every amplitude range we simulated 100000 light curves with 60 different periods in the range of (100–5480) days.
3. Additionally we selected randomly the phase of the light curve at the beginning of all OGLE-I observations.

4. The simulation was repeated twice: first for four seasons of data for a simulated star and next when only three seasons were available.

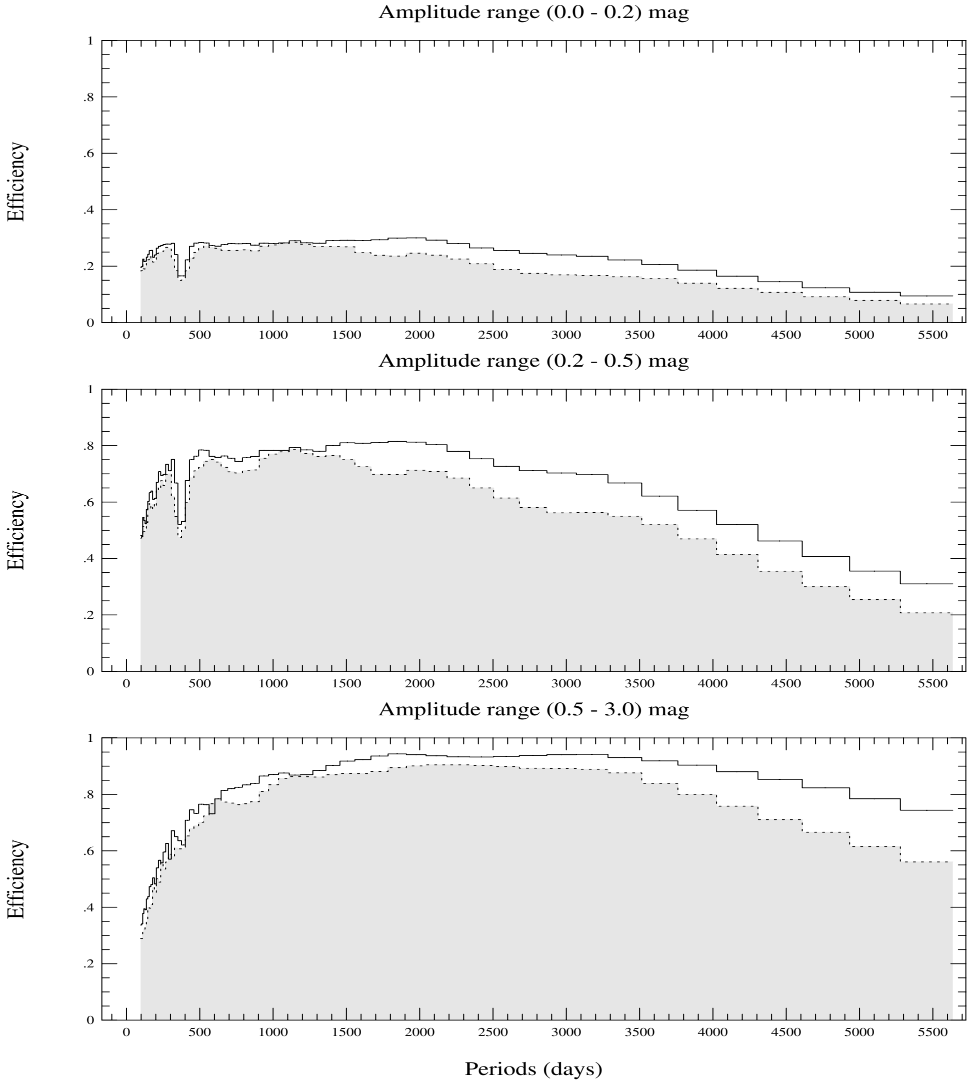

Fig. 2. Histograms showing results of test of detection efficiency. Solid line histogram is plotted for simulation with data from four seasons and shaded histogram for simulation with three seasons data. The panels show distribution of detection efficiency for three amplitude ranges.

Fig. 2 presents efficiency of our search for fields with four seasons of data and for fields with three seasons of observations. The upper panel shows detection efficiency for amplitudes in the range of (0.0–0.2) mag. It can be seen that these amplitudes are close to our detection limit. For the next interval, (0.2–0.5) mag, (middle panel in Fig. 2) efficiency increases and reaches reasonable value of more than 50%. For larger amplitudes, (0.5–3.0) mag, almost all stars are detected and efficiency reaches even about 90% (lower panel). As it can be noticed in the upper and middle panels the detection efficiency significantly falls for periods of about 1 year. This is probably caused by one year separation of the OGLE-I observing seasons. In this case almost the same parts of the light curve would be observed.

In the lower panel one can see that even large variations with short periods are difficult to be detected but with the increasing period the detection efficiency increases. When the period is very long even stars with high amplitudes are difficult to be detected. One can also notice that detection efficiency is slightly smaller for fields with three seasons of available data than for fields with four seasons, especially for longer period objects.

There are two additional factors which can affect completeness of our search. First, because of limitations due to the CCD detector saturation, some bright stars with high amplitude could be missed during the search. Such objects could only be observed close to minimum of light (*e.g.*, Mira variables). Second, some of our candidates are faint and noisy and albeit they passed our criteria it is difficult to conclude whether they are real variables.

Based on results of our tests we can conclude, that our search for long term and irregular variables should be relatively complete but for shorter periods and smaller amplitudes there is still possibility of missing some interesting stars. Finding these stars can, however, be difficult. Also for some stars which we classify as long period variables and mark them with "lt" abbreviation due to low variation amplitudes and very long periods, estimated to be more than duration of the OGLE-I observations, it is difficult to conclude whether they are indeed real variable stars.

5. Summary

In this paper we present results of search for long-term, long-period and non-periodic variable stars in the OGLE-I databases. We detected and cataloged 116 stars not present in previous catalogs. We propose a simple classification of objects based mostly on visual inspection of light curve characteristics. For some objects we attempted to derive periodicity as their variations seem to be quasi-periodic. Some objects have very long periods, longer than OGLE-I observation period.

Tests of completeness of our catalog show that it is relatively complete, especially for objects with high amplitude of light variations. Some objects could have been, however, rejected, especially those with lower brightness and amplitude. Also some highly irregular variables could have been lost due to small number of data, and observing gaps during every season.

Recently Woźniak and Szymański (1998) have shown, that many stars can exhibit variability only during one season. Such stars would be rejected by our search algorithm. Our potential variable star candidate was supposed to vary in more than one season. Therefore our procedure was insensitive for detection of such objects.

T a b l e 2

Long term variable stars in the Galactic bulge

Variable Star OGLE-LT-	Field	α_{2000}	δ_{2000}	I	$(V-I)$	Remarks
V001	MM1B	$18^h06^m51\overset{s}{.}92$	$-26°53'45\overset{''}{.}5$	14.241	2.204	lt
V002	BW8	$18^h03^m46\overset{s}{.}54$	$-29°44'20\overset{''}{.}6$	14.331	1.901	lv
V003	MM1-A	$18^h06^m18\overset{s}{.}57$	$-26°35'23\overset{''}{.}9$	14.374	—	lv,p
V004	MM5-A	$17^h47^m44\overset{s}{.}57$	$-34°39'40\overset{''}{.}3$	14.391	—	lv
V005	BW4	$18^h04^m16\overset{s}{.}52$	$-29°44'55\overset{''}{.}5$	14.613	1.836	lv,p
V006	BW9	$18^h00^m33\overset{s}{.}47$	$-29°44'52\overset{''}{.}6$	14.649	4.686	Mira,lh
V007	MM5-A	$17^h47^m24\overset{s}{.}06$	$-34°41'27\overset{''}{.}3$	14.703	1.971	lv
V008	MM1-A	$18^h07^m04\overset{s}{.}90$	$-26°36'60\overset{''}{.}0$	14.859	2.136	lv,p
V009	BW10	$18^h00^m59\overset{s}{.}80$	$-29°54'28\overset{''}{.}9$	15.000	—	lv,p
V010	BW4	$18^h04^m03\overset{s}{.}95$	$-29°49'30\overset{''}{.}8$	15.063	1.948	lt
V011	MM5-B	$17^h47^m58\overset{s}{.}15$	$-35°01'32\overset{''}{.}7$	15.067	1.865	lv
V012	BW7	$18^h03^m52\overset{s}{.}14$	$-30°03'21\overset{''}{.}9$	15.075	1.728	lv
V013	BW3	$18^h03^m57\overset{s}{.}84$	$-30°18'28\overset{''}{.}2$	15.095	1.925	lt
V014	GB1	$17^h54^m19\overset{s}{.}42$	$-29°43'51\overset{''}{.}1$	15.151	2.399	lt
V015	BW7	$18^h04^m14\overset{s}{.}03$	$-30°02'15\overset{''}{.}2$	15.158	—	lv
V016	MM5-A	$17^h47^m44\overset{s}{.}63$	$-34°49'00\overset{''}{.}9$	15.185	1.923	lt
V017	BW9	$18^h01^m16\overset{s}{.}28$	$-29°51'20\overset{''}{.}0$	15.252	2.091	lv,p
V018	MM1-A	$18^h06^m45\overset{s}{.}55$	$-26°34'42\overset{''}{.}9$	15.252	2.478	lv
V019	GB1	$17^h54^m35\overset{s}{.}01$	$-29°41'09\overset{''}{.}5$	15.304	2.759	lt
V020	BW11	$18^h00^m51\overset{s}{.}86$	$-30°21'08\overset{''}{.}5$	15.321	2.171	lt
V021	BW1	$18^h02^m36\overset{s}{.}07$	$-29°53'22\overset{''}{.}6$	15.328	1.618	lt
V022	BW3	$18^h04^m24\overset{s}{.}12$	$-30°08'21\overset{''}{.}9$	15.338	2.124	lv
V023	MM1-B	$18^h07^m17\overset{s}{.}22$	$-26°53'27\overset{''}{.}2$	15.339	2.215	lt
V024	MM7-B	$18^h11^m26\overset{s}{.}93$	$-25°51'24\overset{''}{.}2$	15.342	2.285	lt
V025	MM7-A	$18^h10^m24\overset{s}{.}70$	$-25°50'42\overset{''}{.}4$	15.344	2.188	lv
V026	MM1-A	$18^h07^m06\overset{s}{.}62$	$-26°38'58\overset{''}{.}9$	15.374	2.078	lv
V027	MM7B	$18^h11^m12\overset{s}{.}05$	$-25°48'35\overset{''}{.}2$	15.374	2.030	lt
V028	BW6	$18^h03^m48\overset{s}{.}01$	$-30°11'52\overset{''}{.}4$	15.384	1.970	lv
V029	BW3	$18^h03^m52\overset{s}{.}14$	$-30°18'13\overset{''}{.}2$	15.401	2.391	lt
V030	MM7-A	$18^h10^m22\overset{s}{.}89$	$-25°49'16\overset{''}{.}7$	15.423	2.676	lt
V031	GB1	$17^h55^m00\overset{s}{.}63$	$-29°49'36\overset{''}{.}6$	15.432	2.519	lv
V032	BWC	$18^h03^m15\overset{s}{.}25$	$-30°07'03\overset{''}{.}5$	15.438	1.708	lh
V033	MM5-A	$17^h47^m30\overset{s}{.}52$	$-34°43'53\overset{''}{.}2$	15.447	2.154	lt
V034	GB1	$17^h54^m32\overset{s}{.}02$	$-29°48'57\overset{''}{.}9$	15.476	2.769	lv,p
V035	MM1-B	$18^h06^m40\overset{s}{.}93$	$-26°54'56\overset{''}{.}5$	15.492	1.369	RCrB?,lh
V036	BW1	$18^h02^m31\overset{s}{.}98$	$-29°55'18\overset{''}{.}7$	15.547	2.011	lv
V037	BW1	$18^h02^m40\overset{s}{.}78$	$-29°49'08\overset{''}{.}6$	15.551	1.840	lv
V038	BW5	$18^h02^m35\overset{s}{.}95$	$-30°06'56\overset{''}{.}7$	15.566	2.295	lv,p
V039	BW11	$18^h01^m18\overset{s}{.}03$	$-30°13'43\overset{''}{.}4$	15.573	2.215	lv
V040	BW4	$18^h04^m16\overset{s}{.}34$	$-29°45'31\overset{''}{.}3$	15.584	1.992	lt
V041	MM7-B	$18^h11^m40\overset{s}{.}60$	$-26°00'10\overset{''}{.}3$	15.628	2.476	lv
V042	BW6	$18^h03^m38\overset{s}{.}78$	$-30°08'09\overset{''}{.}1$	15.636	1.822	lv
V043	MM1-B	$18^h06^m32\overset{s}{.}49$	$-26°54'32\overset{''}{.}2$	15.680	2.121	lv

Table 2

Continued

Variable Star OGLE-LT-	Field	α_{2000}	δ_{2000}	I	$(V-I)$	Remarks
V044	BW1	$18^h01^m52\overset{s}{.}10$	$-29°48'25\overset{''}{.}7$	15.683	1.917	lh
V045	MM5A	$17^h47^m46\overset{s}{.}26$	$-34°50'08\overset{''}{.}4$	15.714	1.872	lv
V046	BW1	$18^h02^m47\overset{s}{.}74$	$-29°50'19\overset{''}{.}3$	15.724	1.995	lv
V047	GB1	$17^h54^m24\overset{s}{.}59$	$-29°39'20\overset{''}{.}6$	15.734	—	lv,p
V048	BW9	$18^h00^m50\overset{s}{.}65$	$-29°54'38\overset{''}{.}0$	15.743	2.105	lt
V049	BWC	$18^h03^m17\overset{s}{.}25$	$-29°55'29\overset{''}{.}1$	15.762	1.969	lv
V050	MM5A	$17^h47^m17\overset{s}{.}99$	$-34°49'20\overset{''}{.}6$	15.771	1.893	lv
V051	MM7A	$18^h10^m30\overset{s}{.}58$	$-25°52'07\overset{''}{.}8$	15.776	2.419	lt
V052	MM5B	$17^h47^m05\overset{s}{.}58$	$-35°01'20\overset{''}{.}2$	15.816	1.975	lv
V053	BW6	$18^h03^m43\overset{s}{.}93$	$-30°19'26\overset{''}{.}7$	15.846	2.273	lt
V054	MM5B	$17^h47^m39\overset{s}{.}53$	$-34°54'41\overset{''}{.}3$	15.849	1.724	lt
V055	BW9	$18^h01^m03\overset{s}{.}95$	$-29°43'24\overset{''}{.}6$	15.854	2.091	lv
V056	BW5	$18^h01^m59\overset{s}{.}75$	$-30°04'32\overset{''}{.}7$	15.856	2.849	lt
V057	BW10	$18^h01^m04\overset{s}{.}86$	$-29°57'09\overset{''}{.}6$	15.858	1.983	lv
V058	BW10	$18^h00^m50\overset{s}{.}64$	$-29°54'37\overset{''}{.}5$	15.864	—	lv
V059	MM7B	$18^h12^m10\overset{s}{.}52$	$-25°53'41\overset{''}{.}4$	15.891	2.216	lt
V060	BWC	$18^h03^m20\overset{s}{.}33$	$-29°55'18\overset{''}{.}0$	15.901	1.605	lt
V061	BWC	$18^h02^m58\overset{s}{.}56$	$-30°00'01\overset{''}{.}2$	15.980	1.889	lv
V062	MM1A	$18^h06^m50\overset{s}{.}51$	$-26°33'36\overset{''}{.}5$	15.996	2.281	lv,p
V063	BW10	$18^h00^m51\overset{s}{.}21$	$-30°06'27\overset{''}{.}2$	16.022	2.397	lt
V064	BWC	$18^h03^m24\overset{s}{.}27$	$-29°55'14\overset{''}{.}7$	16.027	1.925	lv
V065	MM7B	$18^h11^m53\overset{s}{.}44$	$-25°55'49\overset{''}{.}9$	16.032	1.926	lv
V066	GB1	$17^h54^m39\overset{s}{.}22$	$-29°48'03\overset{''}{.}7$	16.063	2.220	lt
V067	BW1	$18^h02^m48\overset{s}{.}69$	$-29°48'54\overset{''}{.}3$	16.088	1.656	lt
V068	MM1A	$18^h06^m19\overset{s}{.}81$	$-26°36'45\overset{''}{.}9$	16.092	2.462	lv,p
V069	BW8	$18^h02^m48\overset{s}{.}61$	$-29°48'54\overset{''}{.}7$	16.096	1.762	lv
V070	MM1A	$18^h06^m22\overset{s}{.}92$	$-26°35'01\overset{''}{.}2$	16.111	2.563	lt
V071	BW11	$18^h00^m16\overset{s}{.}07$	$-30°12'19\overset{''}{.}2$	16.127	2.028	lv,p
V072	BWC	$18^h03^m08\overset{s}{.}16$	$-30°08'41\overset{''}{.}4$	16.130	2.024	lt
V073	MM5A	$17^h47^m39\overset{s}{.}25$	$-34°50'45\overset{''}{.}0$	16.147	1.735	lt
V074	BW2	$18^h02^m24\overset{s}{.}95$	$-30°22'30\overset{''}{.}0$	16.171	1.890	lv
V075	BW2	$18^h02^m15\overset{s}{.}54$	$-30°15'00\overset{''}{.}6$	16.172	2.054	lt
V076	BW4	$18^h04^m05\overset{s}{.}64$	$-29°48'49\overset{''}{.}4$	16.174	2.299	lv
V077	BW1	$13^h02^m34\overset{s}{.}85$	$-29°55'35\overset{''}{.}3$	16.201	1.928	lv
V078	MM7B	$18^h11^m58\overset{s}{.}13$	$-25°51'05\overset{''}{.}6$	16.233	2.149	lv
V079	BW6	$18^h03^m31\overset{s}{.}60$	$-30°21'16\overset{''}{.}8$	16.265	2.067	lv,p
V080	BW7	$18^h04^m14\overset{s}{.}37$	$-30°00'42\overset{''}{.}8$	16.268	2.130	lt
V081	MM5B	$17^h46^m58\overset{s}{.}85$	$-35°02'18\overset{''}{.}1$	16.276	1.711	lv,p
V082	MM5A	$17^h46^m52\overset{s}{.}38$	$-34°46'59\overset{''}{.}1$	16.311	1.971	lv
V083	BW3	$18^h04^m27\overset{s}{.}15$	$-30°20'34\overset{''}{.}0$	16.330	2.078	lt
V084	BW7	$18^h04^m28\overset{s}{.}73$	$-30°08'20\overset{''}{.}4$	16.332	2.041	lv,p
V085	BWC	$18^h03^m14\overset{s}{.}41$	$-30°03'36\overset{''}{.}1$	16.339	1.941	lv
V086	BW10	$18^h00^m15\overset{s}{.}04$	$-29°56'11\overset{''}{.}3$	16.502	2.677	lv,p

Table 2

Concluded

Variable Star OGLE-LT-	Field	α_{2000}	δ_{2000}	I	$(V-I)$	Remarks
V087	BW2	$18^h02^m06\overset{s}{.}83$	$-30°10'38\overset{''}{.}4$	16.510	2.271	lv,p
V088	BW7	$18^h04^m26\overset{s}{.}94$	$-29°55'51\overset{''}{.}3$	16.528	1.024	lt
V089	MM5B	$17^h47^m08\overset{s}{.}47$	$-35°03'27\overset{''}{.}4$	16.569	1.591	lt
V090	BWC	$18^h03^m03\overset{s}{.}12$	$-30°04'20\overset{''}{.}3$	16.712	1.844	lv
V091	BW2	$18^h01^m53\overset{s}{.}94$	$-30°19'41\overset{''}{.}9$	16.737	1.813	lv
V092	BW10	$18^h01^m07\overset{s}{.}71$	$-29°56'58\overset{''}{.}4$	16.767	1.966	lv
V093	BW6	$18^h02^m57\overset{s}{.}27$	$-30°12'12\overset{''}{.}2$	16.825	2.050	lt
V094	GB1	$17^h55^m01\overset{s}{.}67$	$-29°50'23\overset{''}{.}7$	16.853	2.702	lv
V095	MM3	$18^h07^m44\overset{s}{.}64$	$-29°00'23\overset{''}{.}2$	16.868	1.733	lv
V096	BW6	$18^h02^m55\overset{s}{.}58$	$-30°21'27\overset{''}{.}4$	16.881	2.098	lv
V097	MM7B	$18^h12^m00\overset{s}{.}88$	$-25°58'44\overset{''}{.}4$	16.928	2.175	lt
V098	MM1A	$18^h07^m15\overset{s}{.}71$	$-26°43'35\overset{''}{.}0$	16.954	2.130	lt
V099	MM3	$18^h08^m13\overset{s}{.}41$	$-29°05'58\overset{''}{.}2$	16.965	1.853	lv
V100	BW11	$18^h00^m22\overset{s}{.}38$	$-30°15'57\overset{''}{.}8$	16.990	2.189	lt
V101	MM7A	$18^h10^m32\overset{s}{.}86$	$-25°49'42\overset{''}{.}3$	17.131	2.281	lv
V102	BW11	$18^h00^m57\overset{s}{.}93$	$-30°19'34\overset{''}{.}4$	17.156	1.666	lt
V103	BW9	$18^h00^m50\overset{s}{.}91$	$-29°55'26\overset{''}{.}5$	17.163	2.030	lv
V104	BWC	$18^h03^m40\overset{s}{.}32$	$-30°03'44\overset{''}{.}8$	17.210	2.105	lt
V105	BW9	$18^h00^m42\overset{s}{.}42$	$-29°50'42\overset{''}{.}9$	17.224	1.814	lt
V106	MM7A	$18^h11^m08\overset{s}{.}89$	$-25°50'49\overset{''}{.}3$	17.248	2.058	lv
V107	BW1	$18^h01^m53\overset{s}{.}48$	$-29°49'32\overset{''}{.}7$	17.306	1.868	lv
V108	MM1A	$18^h06^m51\overset{s}{.}46$	$-26°44'19\overset{''}{.}3$	17.399	2.050	lv,p
V109	MM1B	$18^h06^m33\overset{s}{.}31$	$-26°57'09\overset{''}{.}8$	17.429	2.326	lv
V110	BW7	$18^h03^m53\overset{s}{.}83$	$-29°56'09\overset{''}{.}3$	17.449	1.881	lv
V111	BW2	$18^h01^m49\overset{s}{.}30$	$-30°14'04\overset{''}{.}2$	17.494	1.899	lv
V112	MM5A	$17^h47^m52\overset{s}{.}01$	$-34°52'24\overset{''}{.}4$	17.596	1.847	lt
V113	BW2	$18^h02^m22\overset{s}{.}79$	$-30°21'54\overset{''}{.}5$	17.689	1.827	lt
V114	BW1	$18^h01^m49\overset{s}{.}03$	$-29°48'59\overset{''}{.}8$	17.729	1.875	lt
V115	MM5A	$17^h47^m40\overset{s}{.}77$	$-34°41'30\overset{''}{.}0$	17.752	1.624	lv
V116	BW10	$18^h00^m42\overset{s}{.}34$	$-30°06'18\overset{''}{.}7$	17.799	2.789	lh

So far many searches have been performed with OGLE-I data and it is very likely that most of variable stars underwent detection. Next phase of the OGLE project, called – OGLE-II (Udalski, Kubiak and Szymański 1997) with about 30 times larger data throughput will provide much better data for search for long term variables, due to better time coverage and larger dynamical range of photometry. In particular bright stars saturated in the OGLE-I data will be easily detectable (*cf.* Fig. 9 Udalski, Kubiak and Szymański 1997).

The photometric data of all selected variable stars can be retrieved from the OGLE Internet archive: *ftp://sirius.astrouw.edu.pl/ogle/long_term*.

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REFERENCES

Lasker, B.M., *et al.* 1988, *Astrophys. J. Suppl. Ser.*, **88**, 1.
Paczyński, B. 1986, *Astrophys. J.*, **304**, 1.
Szymański, M. and Udalski, A. 1993, *Acta Astron.*, **43**, 91.
Udalski, A., Szymański, M., Kałużny, J., Kubiak, M., and Mateo, M. 1992, *Acta Astron.*, **42**, 253.
Udalski, A., Szymański, M., Kałużny, J., Kubiak, M., and Mateo, M. 1993, *Acta Astron.*, **43**, 69.
Udalski, A., Szymański, M., Kałużny, J., Kubiak, M., Mateo, M., and Krzemiński, W. 1994a, *Acta Astron.*, **44**, 1.
Udalski, A., Szymański, M., Stanek, K.Z., Kałużny, J., Kubiak, M., Mateo, M., Krzemiński, W., Paczyński, B., and Venkat, R. 1994b, *Acta Astron.*, **44**, 165.
Udalski, A., Szymański, M., Kałużny, J., Kubiak, M., Mateo, M., and Krzemiński, W. 1995, *Acta Astron.*, **45**, 237.
Udalski, A., Olech, A., Szymański, M., Kałużny, J., Kubiak, M., Mateo, M., Krzemiński, W., and Stanek, K.Z. 1997a, *Acta Astron.*, **47**, 1.
Udalski, A., Szymański, M., Kałużny, J., Kubiak, M., Mateo, M., Krzemiński, W., and Stanek, K.Z. 1997b, *Acta Astron.*, **47**, 169.
Udalski, A., Kubiak, M., Szymański, M. 1997c, *Acta Astron.*, **47**, 319.
Woźniak, P. and Szymański, M. 1998, *Acta Astron.*, **48**, 269.