

**The Optical Gravitational Lensing Experiment.  
OGLE-III Photometric Maps of the Galactic Disk Fields.<sup>1</sup>**

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ABSTRACT

We present OGLE-III Photometric Maps of the Galactic disk fields observed during the OGLE-III campaigns for low luminosity transiting objects that led to the discovery of the first transiting exoplanets.

The maps contain precise, calibrated *VI* photometry of about 9 million stars from 21 OGLE-III fields in the Galactic disk observed in the years 2002–2009 and covering more than 7 square degrees in the sky. Precise astrometry of these objects is also provided.

We discuss quality of the data and present a few color–magnitude diagrams of the observed fields.

All photometric data are available to the astronomical community from the OGLE Internet archive.

**Key words:** *Galaxy: disk – Surveys – Catalogs – Techniques: photometric*

**1. Introduction**

Photometry of millions of stars collected during the regular long term monitoring of the targets of the Optical Gravitational Lensing Experiment (OGLE) is a unique observational material that can be used for many astrophysical applications. Since the second phase, OGLE-II, the OGLE group has regularly released the OGLE Photometric Maps of Dense Stellar Regions containing calibrated *BVI* or *VI* photometry and precise astrometry of millions of stars from the observed

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<sup>1</sup>Based on observations obtained with the 1.3 m Warsaw telescope at the Las Campanas Observatory of the Carnegie Institution of Washington.

fields. They included astrophysically important objects like the Large and Small Magellanic Clouds and the Galactic Center.

The most recent version of the OGLE Maps comes from the third phase of the OGLE project – OGLE-III. OGLE-III observations covered an area of the sky larger by an order of magnitude as compared to the original OGLE-II maps, and contain photometry of about ten times more stars. So far OGLE-III Maps of the Large and Small Magellanic Clouds were released (Udalski *et al.* 2008ab).

OGLE-III maps have already been widely used by astronomers to many projects (*e.g.*, Subramanian and Subramanian 2010, Szczygieł *et al.* 2010). They are also widely used as a huge set of secondary photometric standards for calibrating photometry.

The OGLE-III target list included a set of fields from the Galactic disk. These fields located in dense stellar regions at low Galactic latitude and longitudes between  $280^\circ$  and  $310^\circ$  were extensively monitored with high cadence (order of 15 minutes) for low luminosity object and planetary transits leading to the discovery of the first transiting exoplanets (Udalski *et al.* 2002, Bouchy *et al.* 2004).

Precise photometry of the Galactic disk fields can be a very useful tool for studying the Galactic structure. Large area of the sky around the Galactic equator has been currently monitored by the OGLE-IV survey in the optical, *VI*, domain, as well as in the near infrared by the VVV project conducted on the VISTA telescope at ESO Paranal Observatory, Chile. OGLE-III photometry of selected Galactic disk fields can be then a good anchoring point for these larger scale surveys of the Galactic disk.

This paper is the next in the OGLE-III Map series. We present here OGLE-III photometric maps of the Galactic disk fields covering about 7 square degrees in the sky and containing photometry and astrometry of about 9 million stars. The maps are available to the astrophysical community from the OGLE Internet archive.

## 2. Observational Data

The photometric data presented in this paper were collected during the OGLE-III phase between February 2002 and May 2009 with the 1.3-m Warsaw Telescope at Las Campanas Observatory, Chile, operated by the Carnegie Institution of Washington. The telescope was equipped with the eight chip mosaic camera (Udalski 2003) covering approximately  $35 \times 35$  arcmin in the sky with the scale of 0.26 arcsec/pixel.

Observations were carried out in *V*- and *I*-band filters closely resembling the standard bands. One should be however aware, that the OGLE glass *I*-band filter approximates well the standard one for  $V - I < 3$  mag colors. For very red objects the transformation to the standard band is less precise. The vast majority of observations were obtained through the *I*-band filter. Typically up to  $\sim 2700$  images for each field were collected in this band and just a few in the *V*-band. The exposure time was 180 s or 120 s for the *I*-band and 240 s for the *V*-band.

Observations were conducted only in good seeing (less than  $1''.8$ ) and transparency conditions. The median seeing of the  $I$ -band images is equal to  $1''.2$ .

The Galactic disk fields observed during OGLE-III phase as well as the equatorial and galactic coordinates of their centers and number of stars detected in the  $I$ -band are listed in Table 1. The area of the sky covered by OGLE-III observations of these fields exceeds 7 square degrees.

Table 1  
OGLE-III Galactic Disk Fields

Field	RA (2000)	DEC (2000)	$l_{II}$	$b_{II}$	$N_{\text{Stars}}$
CAR100	11 <sup>h</sup> 07 <sup>m</sup> 00 <sup>s</sup>	-61°06'30"	290°6544	-0°7510	382528
CAR104	10 <sup>h</sup> 57 <sup>m</sup> 30 <sup>s</sup>	-61°40'00"	289°8439	-1°7249	475893
CAR105	10 <sup>h</sup> 52 <sup>m</sup> 20 <sup>s</sup>	-61°40'00"	289°2911	-1°9906	459781
CAR106	11 <sup>h</sup> 03 <sup>m</sup> 00 <sup>s</sup>	-61°50'00"	290°5054	-1°6063	401528
CAR107	10 <sup>h</sup> 47 <sup>m</sup> 15 <sup>s</sup>	-62°00'25"	288°9089	-2°5647	318932
CAR108	10 <sup>h</sup> 47 <sup>m</sup> 15 <sup>s</sup>	-61°24'35"	288°6343	-2°0343	379610
CAR109	10 <sup>h</sup> 42 <sup>m</sup> 10 <sup>s</sup>	-62°10'25"	288°4607	-2°9904	307029
CAR110	10 <sup>h</sup> 42 <sup>m</sup> 15 <sup>s</sup>	-61°34'35"	288°1846	-2°4606	371079
CAR111	10 <sup>h</sup> 47 <sup>m</sup> 15 <sup>s</sup>	-60°48'45"	288°3599	-1°5037	334938
CAR112	10 <sup>h</sup> 52 <sup>m</sup> 20 <sup>s</sup>	-61°04'15"	289°0276	-1°4562	370525
CAR113	10 <sup>h</sup> 57 <sup>m</sup> 20 <sup>s</sup>	-61°04'08"	289°5717	-1°1922	369094
CAR114	10 <sup>h</sup> 57 <sup>m</sup> 20 <sup>s</sup>	-60°28'18"	289°3178	-0°6516	344169
CAR115	10 <sup>h</sup> 40 <sup>m</sup> 30 <sup>s</sup>	-62°09'00"	288°2783	-3°0629	349173
CAR116	10 <sup>h</sup> 37 <sup>m</sup> 00 <sup>s</sup>	-62°45'00"	288°2176	-3°7841	299996
CAR117	10 <sup>h</sup> 42 <sup>m</sup> 05 <sup>s</sup>	-62°45'00"	288°7274	-3°5017	316077
CAR118	10 <sup>h</sup> 38 <sup>m</sup> 30 <sup>s</sup>	-63°20'50"	288°6602	-4°2207	261809
CEN106	11 <sup>h</sup> 32 <sup>m</sup> 30 <sup>s</sup>	-60°50'00"	293°4598	0°5784	500453
CEN107	11 <sup>h</sup> 54 <sup>m</sup> 00 <sup>s</sup>	-62°00'00"	296°2458	0°1238	557251
CEN108	13 <sup>h</sup> 33 <sup>m</sup> 00 <sup>s</sup>	-64°15'00"	307°4281	-1°7417	845638
MUS100	13 <sup>h</sup> 15 <sup>m</sup> 00 <sup>s</sup>	-64°51'00"	305°4335	-2°0928	735652
MUS101	13 <sup>h</sup> 25 <sup>m</sup> 00 <sup>s</sup>	-64°58'00"	306°4749	-2°3261	766910

### 3. Photometric Maps of the Galactic Disk Fields

The construction of the OGLE-III maps was presented in detail in Udalski *et al.* (2008a). We followed this procedure for the Galactic disk fields as well.

The OGLE-III maps contain the mean photometry of all detected stellar objects. The mean photometry was obtained for all objects with minimum of 6 observations in the  $I$ -band by averaging all observations after removing  $5\sigma$  outliers. Because of small number of  $V$ -band epochs for some of the fields even a single  $V$ -band observation entered the database. In the case of more  $V$ -band data points they were also averaged with the  $5\sigma$  outliers rejection.

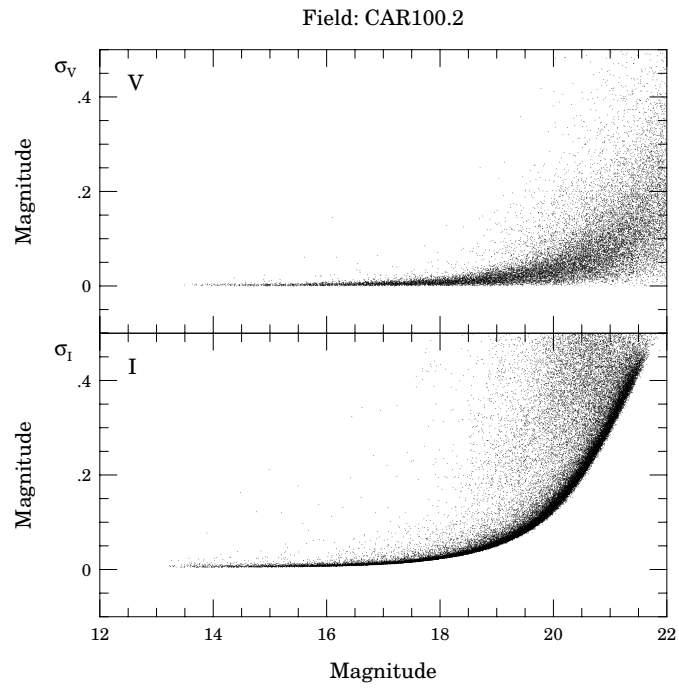


Fig. 1. Standard deviation of magnitudes as a function of magnitude for the field CAR100.2.

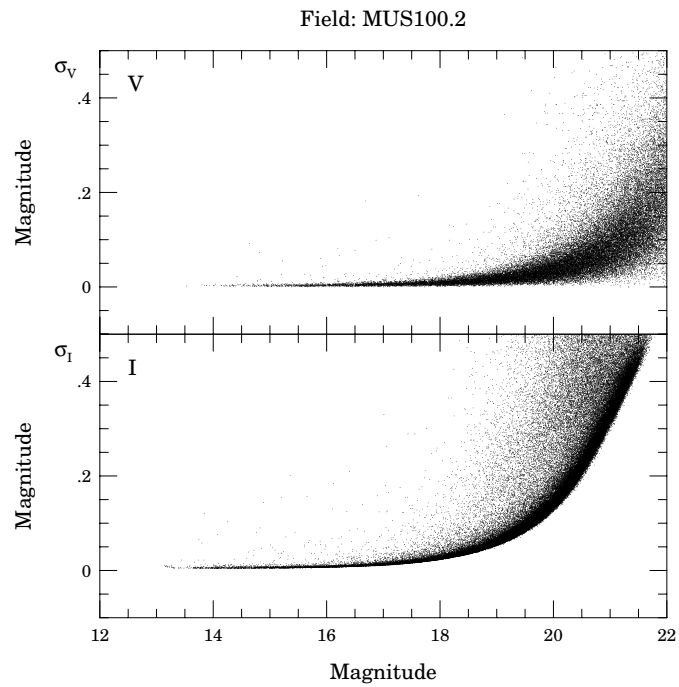


Fig. 2. Standard deviation of magnitudes as a function of magnitude for the field MUS100.2.

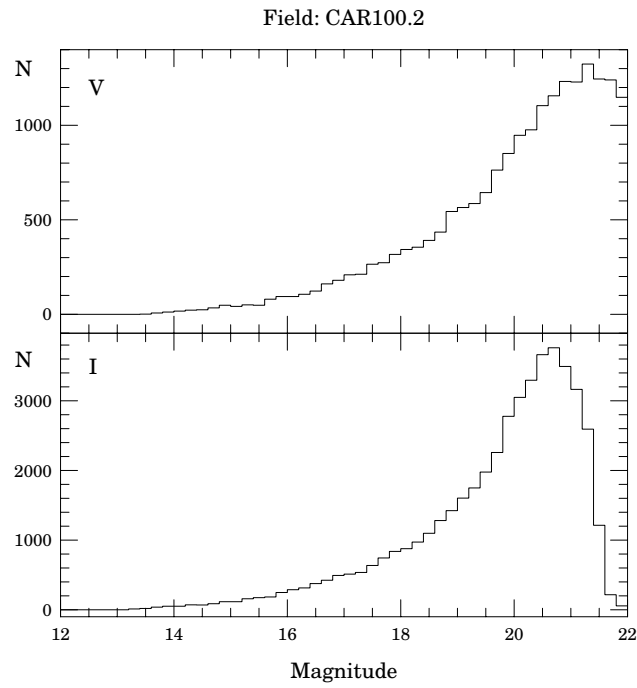


Fig. 3. Histogram of stellar magnitudes in the Galactic disk field CAR100.2.

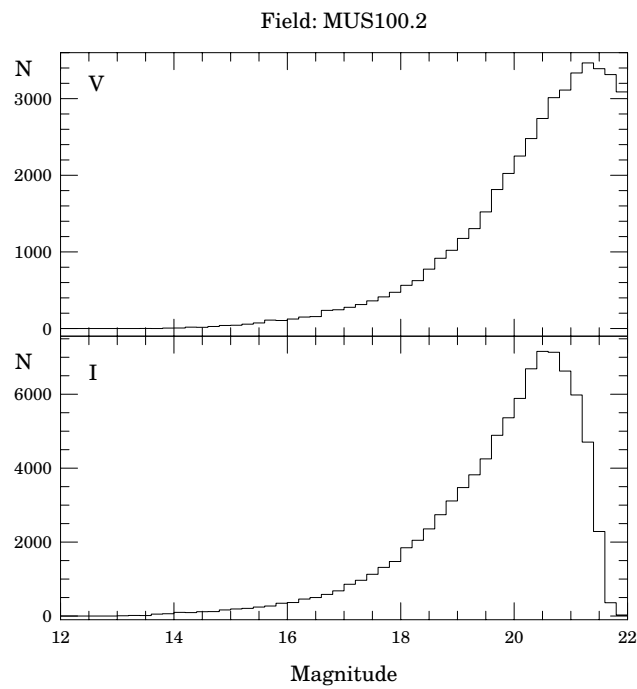


Fig. 4. Same as in Fig. 5 for the field MUS100.2.

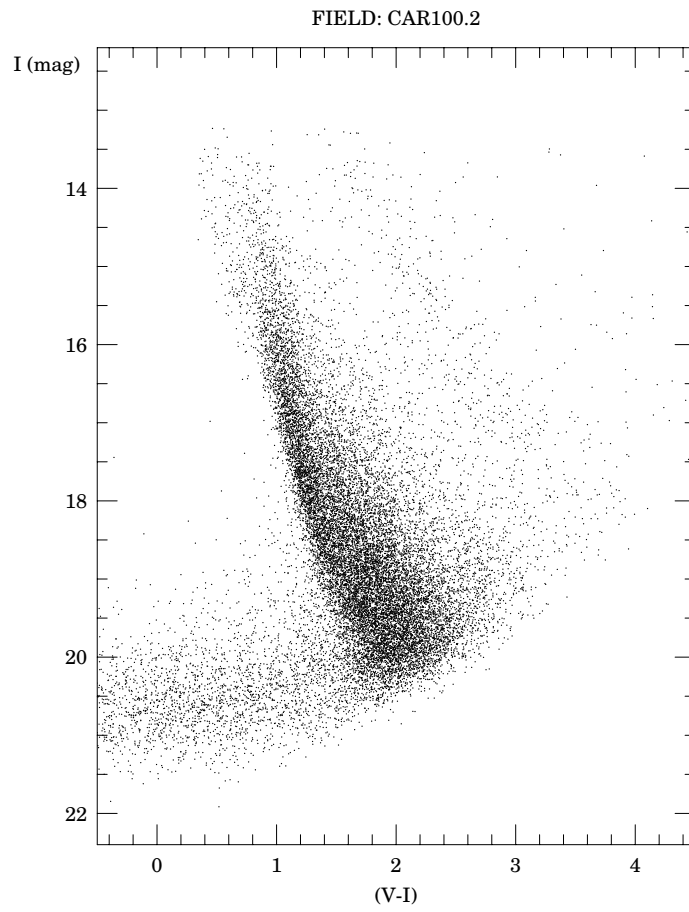


Fig. 5. Color-magnitude diagram of the Galactic disk field CAR100.2.

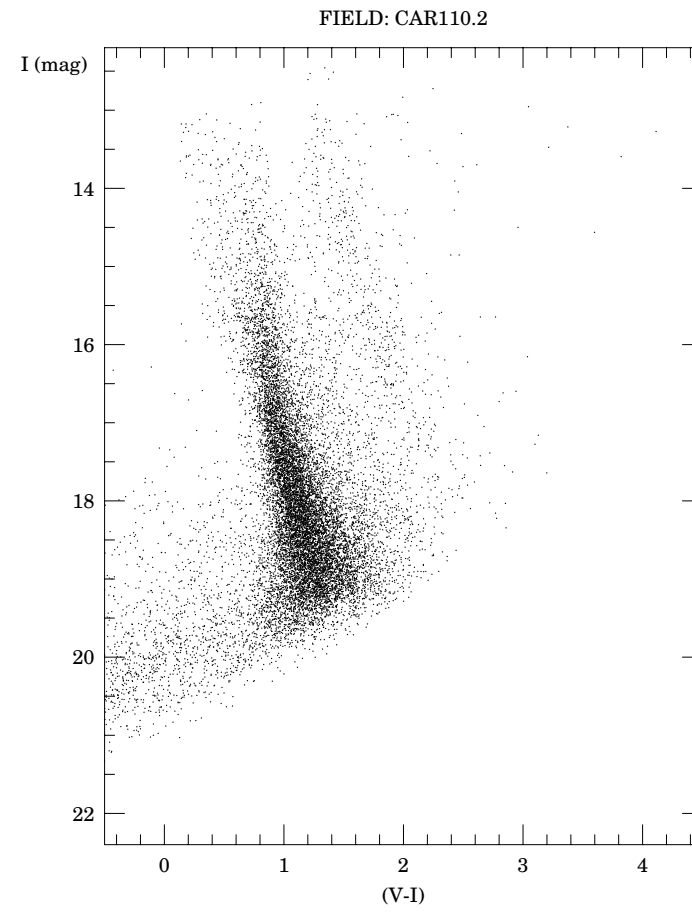


Fig. 6. Color-magnitude diagram of the Galactic disk field CAR110.2.

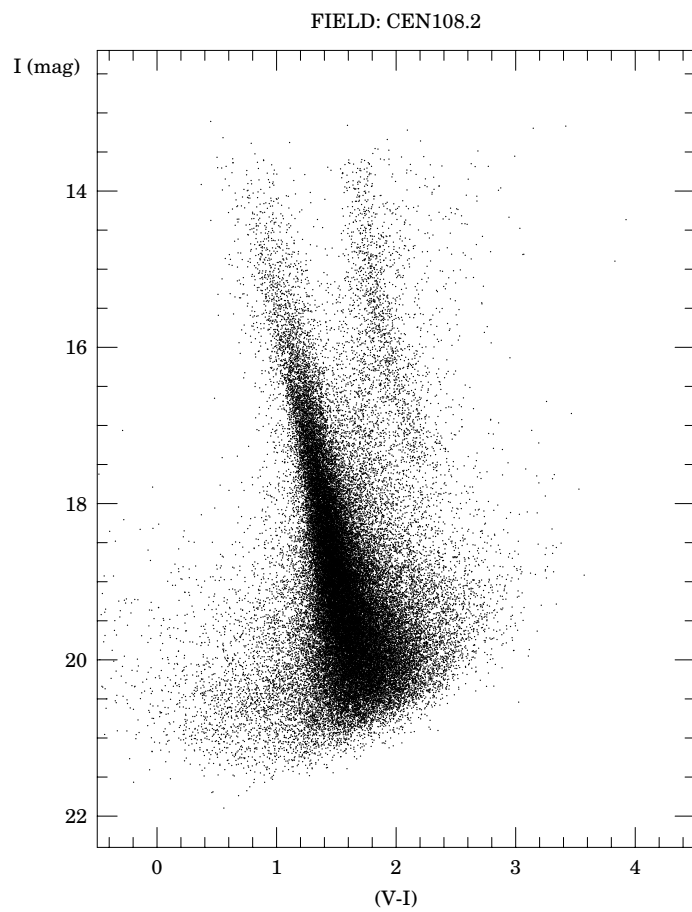


Fig. 7. Color-magnitude diagram of the Galactic disk field CEN108.2.

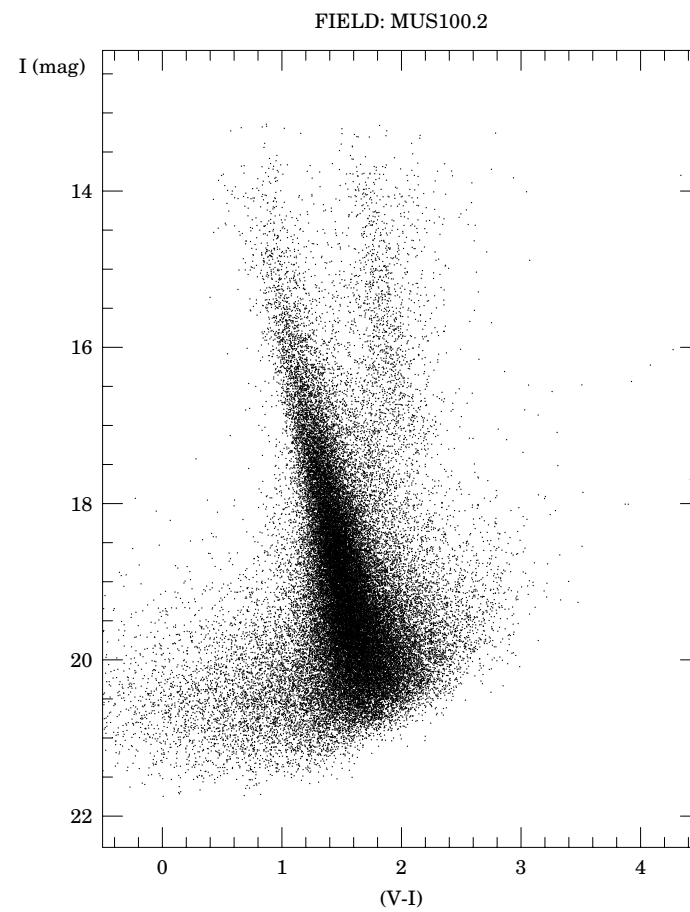


Fig. 8. Color-magnitude diagram of the Galactic disk field MUS100.2.

Table 2

OGLE-III Photometric Map of the CAR100.2 field (sample)

ID	RA (2000)	DEC (2000)	$X$	$Y$	$V$	$V-I$	$I$	$N_V$	$N_V^{\text{bad}}$	$\sigma_V$	$N_I$	$N_I^{\text{bad}}$	$\sigma_I$
1	11 <sup>h</sup> 07 <sup>m</sup> 04 <sup>s</sup> :50	-61°13'44"5	456.05	53.37	15.624	1.631	13.993	3	0	0.001	1749	0	0.008
2	11 <sup>h</sup> 07 <sup>m</sup> 06 <sup>s</sup> :55	-61°13'43"3	460.44	110.06	14.076	0.507	13.568	3	0	0.001	2533	10	0.009
3	11 <sup>h</sup> 07 <sup>m</sup> 07 <sup>s</sup> :11	-61°15'00"8	162.74	123.92	18.553	4.137	14.416	3	0	0.022	2547	1	0.015
4	11 <sup>h</sup> 07 <sup>m</sup> 08 <sup>s</sup> :69	-61°13'25"4	528.71	169.98	14.647	0.842	13.805	3	0	0.003	2667	12	0.011
5	11 <sup>h</sup> 07 <sup>m</sup> 10 <sup>s</sup> :78	-61°13'26"0	525.92	227.89	14.392	9.999	99.999	3	0	0.003	0	0	9.999
6	11 <sup>h</sup> 07 <sup>m</sup> 12 <sup>s</sup> :68	-61°14'47"5	213.08	278.48	16.273	2.599	13.674	3	0	0.007	2684	0	0.010
7	11 <sup>h</sup> 07 <sup>m</sup> 13 <sup>s</sup> :88	-61°14'17"0	329.61	312.49	14.197	0.420	13.777	3	0	0.003	2682	2	0.006
8	11 <sup>h</sup> 07 <sup>m</sup> 15 <sup>s</sup> :27	-61°15'09"3	129.01	349.62	15.406	1.741	13.665	3	0	0.002	2514	2	0.005
9	11 <sup>h</sup> 07 <sup>m</sup> 16 <sup>s</sup> :33	-61°15'27"8	57.57	378.53	14.735	9.999	99.999	3	0	0.004	0	0	9.999
10	11 <sup>h</sup> 07 <sup>m</sup> 06 <sup>s</sup> :24	-61°15'01"8	159.36	99.77	15.930	1.116	14.814	3	0	0.004	2371	3	0.007
11	11 <sup>h</sup> 07 <sup>m</sup> 06 <sup>s</sup> :73	-61°13'47"6	443.65	115.12	16.710	1.101	15.609	3	0	0.009	2561	6	0.007
12	11 <sup>h</sup> 07 <sup>m</sup> 10 <sup>s</sup> :87	-61°14'07"8	365.50	229.39	16.291	0.826	15.465	3	0	0.008	2681	3	0.006
13	11 <sup>h</sup> 07 <sup>m</sup> 11 <sup>s</sup> :11	-61°13'57"4	405.35	236.04	16.061	0.980	15.081	3	0	0.005	2684	0	0.005
14	11 <sup>h</sup> 07 <sup>m</sup> 11 <sup>s</sup> :69	-61°13'56"7	408.00	252.21	16.296	1.001	15.296	3	0	0.004	2674	10	0.009
15	11 <sup>h</sup> 07 <sup>m</sup> 14 <sup>s</sup> :18	-61°15'20"2	87.43	318.99	17.938	2.442	15.496	3	0	0.002	2010	0	0.177
16	11 <sup>h</sup> 07 <sup>m</sup> 15 <sup>s</sup> :33	-61°15'02"8	153.89	351.27	16.080	0.960	15.120	3	0	0.003	2603	0	0.006
17	11 <sup>h</sup> 07 <sup>m</sup> 15 <sup>s</sup> :37	-61°13'27"2	520.71	354.97	15.932	0.926	15.006	3	0	0.005	2683	1	0.007
18	11 <sup>h</sup> 07 <sup>m</sup> 17 <sup>s</sup> :08	-61°14'20"9	314.19	400.92	17.147	1.461	15.686	3	0	0.002	2683	1	0.007
19	11 <sup>h</sup> 07 <sup>m</sup> 19 <sup>s</sup> :14	-61°15'13"8	111.06	456.46	16.629	1.004	15.625	3	0	0.004	2388	4	0.008
20	11 <sup>h</sup> 07 <sup>m</sup> 20 <sup>s</sup> :06	-61°13'53"3	419.50	484.11	16.996	1.524	15.472	3	0	0.006	2682	2	0.006
21	11 <sup>h</sup> 07 <sup>m</sup> 20 <sup>s</sup> :39	-61°13'36"2	485.25	493.84	16.486	0.898	15.587	3	0	0.002	2683	0	0.007
22	11 <sup>h</sup> 07 <sup>m</sup> 20 <sup>s</sup> :54	-61°14'57"2	174.38	495.87	16.584	1.164	15.420	3	0	0.005	2653	1	0.008
23	11 <sup>h</sup> 07 <sup>m</sup> 21 <sup>s</sup> :10	-61°14'19"4	319.17	512.36	16.438	0.844	15.593	3	0	0.005	2681	3	0.008
24	11 <sup>h</sup> 07 <sup>m</sup> 04 <sup>s</sup> :20	-61°15'24"0	74.40	42.86	16.865	9.999	99.999	3	0	0.007	0	0	9.999
25	11 <sup>h</sup> 07 <sup>m</sup> 04 <sup>s</sup> :22	-61°14'05"1	377.10	45.19	17.009	1.081	15.928	3	0	0.009	1589	0	0.009



In Table 2 we present a sample of the data – the first 25 entries from the map of the CAR100.2 subfield. The columns contain: (1) ID number; (2,3) equatorial coordinates J2000.0; (4,5)  $X, Y$  pixel coordinates in the  $I$ -band reference image; (6,7,8) photometry:  $V, V - I, I$ ; (9,10,11) number of points for average magnitude, number of  $5\sigma$  removed points,  $\sigma$  of magnitude for  $V$ -band; (12,13,14) same as (9,10,11) for the  $I$ -band. 9.999 or 99.999 markers mean “no data”. Value of  $-1$  in column (9) indicates multiple  $V$ -band cross-identification (when the  $V$ -band counterpart was detected in more than one field in overlapping areas; the average magnitude is the mean of the merged datasets).

The full set of the OGLE-III Photometric Maps of the Galactic Disk Fields is available from the OGLE Internet archive (see Section 5).

#### 4. Discussion

The OGLE-III Photometric Maps of the Galactic Disk Fields contain entries for about 9 million stars located in 21 OGLE-III fields. Figs. 1 and 2 show the typical accuracy of the OGLE-III Photometric Maps of these targets: standard deviation of magnitudes as a function of magnitude in the  $V$ - and  $I$ -band for the field CAR100.2 and denser MUS100.2.

The completeness of the photometry can be assessed from the histograms presented in Fig. 3 and 4 for the same fields as in Figs. 1 and 2. It reaches  $I \approx 20.5$  mag and  $V \approx 21$  mag.

Figs. 5–8 present color–magnitude diagrams (CMDs) constructed for a few selected subfields from different Galactic disk fields observed by OGLE-III survey.

#### 5. Data Availability

The OGLE-III Photometric Maps of the SMC are available to the astronomical community from the OGLE Internet Archive:

*<http://ogle.astrouw.edu.pl>  
<ftp://ftp.astrouw.edu.pl/ogle3/maps/gd/>*

The archives include, besides the tables with photometric data and astrometry for each of the subfields, also the  $I$ -band reference images. Usage of the data is allowed under the proper acknowledgment to the OGLE project.

We also plan to build an on-line, interactive access to the photometric maps database, allowing to search for objects fulfilling user-defined set of criteria. The availability of such an access will be announced on the OGLE project WWW page.

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