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# A Catalog of Accurate Equatorial Coordinates for Variable Stars in Globular Clusters

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**ABSTRACT.** We have compiled a catalog of equatorial coordinates for 3398 variable stars in those 103 globular clusters that, according to the most recent update of the Catalogue of Variable Stars in Globular Clusters (CVSGC) available in 2008 June (essentially that of 2002, with some more recent additions), had known variable stars. Our catalog is in the electronic attachment to this article. We found that 216 stars are also contained in the General Catalogue of Variable Stars (GCVS) or in the New Catalogue of Suspected Variable Stars (with Supplement); most of these identifications were not previously recognized. We also detected a number of previously unknown cross-identifications among stars of the CVSGC. Our results allow us to initiate compilation of name lists in order to add to the GCVS those stars from the CVSGC that satisfy GCVS naming criteria.

*Online material:* machine readable table

## 1. INTRODUCTION

For reasons of tradition, most known variable stars in globular clusters remain outside the General Catalogue of Variable Stars (GCVS; cf. Kholopov et al. 1985). The origin of this tradition is not quite clear: in principle, the GCVS should include all reliably identified variable stars of our Galaxy. Globular-cluster variable stars were not included in the catalogs that preceded the GCVS, namely the variable star catalogs published by the "Astronomische Gesellschaft" (see Prager 1926, Schneller 1942); apparently the rule was introduced when membership of globular clusters in the Galaxy had not yet been established beyond doubt.

The need in catalogs of variable stars in the Galaxy's globular clusters is obvious, and the total number of variable stars in globular clusters exceeded 1000 as early as in the first half of the twentieth century. Thus, specialized catalogs appeared. Three editions of the Catalogue of Variable Stars in Globular Clusters (CVSGC) were compiled and published in Canada (Sawyer 1939, 1955; Sawyer Hogg 1973). This work was continued by Helen Sawyer Hogg's successors who are now keeping the catalog as an Internet resource (Clement et al. 2001).

The presentation of information on star positions in the CVSGC differs from that in the GCVS. All the printed CVSGC editions contain rectangular coordinates of different precision (as a rule, formally to $1''$ in both coordinates) for variable stars in each globular cluster. The catalog presents low-accuracy equatorial coordinates of globular-cluster centers (to $0.1^{\mathrm{m}}$ in right ascension and $1'$ in declination, or even worse in some cases).

In all the CVSGC printed editions, the coordinates of globular-cluster centers are given for the equinox 1950.0. There is no information on the equinox of the rectangular coordinates of variables, but they are often directly taken from original papers, possibly from several papers for the same cluster, including papers published as early as by the end of the nineteenth century. Thus, the equinox of the rectangular coordinates is not exactly fixed. Obviously, a system of rectangular coordinates with axes along right ascension and declination for a certain equinox will be aligned incorrectly for a different equinox. In many cases, the precision of published rectangular coordinates, reproduced in the CVSGC, was no better than $3''$ or even worse. This can lead to ambiguous identifications in the crowded central regions, and identification charts are a valuable resource.

Table 1

GLOBULAR-CLUSTER VARIABLE STARS IN THE GCVS AND NSV CATALOGUES

| GC | Var | GCVS, NSV | GC | Var | GCVS, NSV | GC | Var | GCVS, NSV | GC | Var | GCVS, NSV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 104 ..... | V12 | CO Tuc | 6304 ..... | V1 | V2167 Oph | 6441 ..... | V49 | V1169 Sco | 6638 ..... | V56 | NSV 24475 |
| | V1 | Z Col | | V2 | V2161 Oph | | V50 | V1167 Sco | | V57 | V4054 Sgr |
| | V2 | Y Col | | V3 | V2171 Oph | | V68 | V1166 Sco | | V58 | NSV 24476 |
| 3201 ..... | V15 | NSV 04813 | | V4 | NSV 21164 | 6522 ..... | V7 | V3900 Sgr | | V59 | NSV 24478 |
| | V65 | KP Vel | | V5 | V2173 Oph | | V8 | V1437 Sgr | | V60 | NSV 24481 |
| | V68 | NSV 04810 | | V6 | NSV 21193 | | V9 | V1438 Sgr | | V61 | V3845 Sgr |
| Rup 106 ..... | V2 | V887 Cen | | V7 | V2166 Oph | 6535 ..... | V1 | MO Ser | | V62 | NSV 24485 |
| 4590 ..... | V27 | FI Hya | | V8 | V2177 Oph | | V2 | MP Ser | | V63 | IL Sgr, |
| | V32 | EN Hya | | V9 | V2181 Oph | 6541 ..... | V1 | SS CrA | | | V4056 Sgr |
| 4833 ..... | V1 | RY Mus | | V10 | V2155 Oph | 6553 ..... | Nova | V1148 Sgr | 6642 ..... | V1 | V2578 Sgr |
| | *V2 | RZ Mus | | V11 | V2159 Oph | 6558 ..... | V5 | V4301 Sgr | 6637 ..... | V2 | V3484 Sgr |
| | V11 | FQ Mus | | V12 | V2160 Oph | | V8 | V4601 Sgr | | V4 | V1894 Sgr |
| 5139 ..... | V1 | NSV 06235 | | V13 | NSV 08349 | | V9 | V4595 Sgr | 6652 ..... | V7 | V3616 Sgr |
| | V2 | V825 Cen | | V14 | V2163 Oph | 6569 ..... | V4 | V2711 Sgr | | V9 | V3641 Sgr |
| | V56 | V833 Cen | | V15 | NSV 08361 | | V6 | NSV 10364 | 6656 ..... | V14 | V1311 Sgr |
| | V65 | V813 Cen | | V16 | V2169 Oph | | V15 | V2698 Sgr | | V17 | V4068 Sgr |
| | V78 | V814 Cen | | V17 | NSV 08377 | 6584 ..... | V15 | PX Tel | | V22 | V3853 Sgr |
| | V129 | V826 Cen | | V18 | V2180 Oph | | V24 | PU Tel | | V26 | V2007 Sgr |
| | V133 | V594 Cen | | V19 | NSV 08367 | | V27 | PT Tel | | V28 | V2367 Sgr |
| | V168 | V832 Cen | | V20 | NSV 08369 | | V39 | PS Tel | | V29 | NSV 11080 |
| | V269 | V791 Cen | | V21 | NSV 08385 | 6626 ..... | V7 | V4137 Sgr | | V30 | NSV 11084 |
| | V283 | V1045 Cen | 6341 ..... | V14 | V798 Her | | V15 | V4128 Sgr | | V31 | V3855 Sgr |
| 5272 ..... | V113 | XX CVn | 6333 ..... | V3 | V1864 Oph | | V16 | V4130 Sgr | | V32 | V4067 Sgr |
| | *V141 | RV CVn | | V7 | V1845 Oph | | V17 | V2342 Sgr | | V33 | V4069 Sgr |
| | V205 | WY CVn | | V12 | V1840 Oph | | V24 | V4129 Sgr | 6681 ..... | V2 | V4082 Sgr |
| | V206 | WZ CVn | | V13 | V2208 Oph | 6638 ..... | V1 | NSV 10895 | | V5 | V4081 Sgr |
| 5286 ..... | V1 | GI Cen | 6356 | V5 | V2009 Oph | | V2 | NSV 10896 | 6712 ..... | V1 | MP Sct |
| 5466 ..... | V19 | BL Boo | | V6 | V1995 Oph | | V3 | V4051 Sgr | | *V2 | AP Sct |
| IC 4499 ..... | V173 | PQ Aps | 6352 ..... | V6 | V819 Ara | | V4 | NSV 10908 | | *V7 | CH Sct |
| 6093 ..... | V6 | S Sco | HP 1 ..... | V1 | NSV 08984 | | V5 | NSV 10913 | | V8 | MR Sct |
| | V7 | R Sco | | V2 | NSV 08989 | | V6 | NSV 10914 | | V15 | MW Sct |
| | *Nova | T Sco | | V3 | NSV 08973 | | V7 | NSV 10916 | | V16 | LZ Sct |
| 6101 ..... | V12 | NSV 20592 | | V4 | NSV 09002 | | V8 | NSV 10918 | | V21 | MN Sct |
| | V13 | NSV 20587 | | V5 | NSV 09011 | | V9 | NSV 10921 | 6723 ..... | V30 | NSV 24641 |
| | V14 | NSV 20591 | | V6 | NSV 09016 | | V10 | NSV 10928 | 6752 ..... | V4 | V394 Pav |
| | V15 | NSV 20604 | | V7 | NSV 08967 | | V11 | NSV 10930 | | V5 | V395 Pav |
| 6144 ..... | V1 | BP Sco | | V8 | NSV 08978 | | V12 | V4052 Sgr | | V6 | V396 Pav |
| | V2 | BO Sco | | V9 | NSV 08983 | | V13 | V1673 Sgr, | | V8 | V397 Pav |

Table 1 (*Continued*)

| GC | Var | GCVS, NSV | GC | Var | GCVS, NSV | GC | Var | GCVS, NSV | GC | Var | GCVS, NSV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6171 ..... | *V1 | V720 Oph | | V10 | NSV 08988 | | | V4053 Sgr | | V11 | V398 Pav |
| 6235 ..... | V3 | V2249 Oph | | V11 | NSV 08997 | | V14 | NSV 10942 | 6779 ..... | V7 | V487 Lyr |
| | V4 | V2250 Oph | | V12 | NSV 09007 | | V15 | V4055 Sgr | | V8 | V485 Lyr |
| 6266 ..... | V29 | PU Oph | | V13 | NSV 09012 | | V16 | NSV 10948 | | V9 | V486 Lyr |
| | V70 | OU Oph | | V14 | NSV 09021 | | V17 | NSV 10951 | | V10 | V483 Lyr |
| 6273 ..... | *V2 | FK Oph | | V15 | NSV 09023 | | V18 | NSV 10952 | | V11 | V484 Lyr |
| | V6 | NSV 20887 | Ter 1 ..... | V4 | NSV 22828 | | V19 | NSV 10956 | Pal 10 ..... | V2 | MV Sge |
| | V7 | V2135 Oph | 6388 ..... | V4 | MU Sco | | V46 | NSV 24458 | | V3 | MZ Sge |
| 6284 ..... | V10 | V2121 Oph | | V29 | V1164 Sco | | V47 | NSV 24460 | 6838 ..... | *V1 | Z Sge |
| | V11 | V2123 Oph | 6401 ..... | V1 | NSV 09335 | | V48 | NSV 24459 | | V3 | QU Sge |
| | V12 | GM Oph | 6397 ..... | V1 | V639 Ara | | V49 | NSV 24461 | | V4 | NSV 24932 |
| 6293 ..... | V2 | V2137 Oph | | V2 | V825 Ara | | V50 | NSV 24463 | | V6 | V345 Sge |
| | V7 | V2145 Oph | | V3 | V826 Ara | | V51 | NSV 24462 | 6934 ..... | V75 | OP Del |
| 6293, continued | V9 | NSV 21001 | 6426 ..... | *V11 | V979 Oph | 6638, continued | V52 | NSV 24465 | 6934, continued | V76 | OO Del |
| | V10 | V2136 Oph | 6441 ..... | V36 | V1165 Sco | | V53 | NSV 24466 | 7099 | V4 | NSV 25717 |
| | V11 | V2102 Oph | | V47 | V1168 Sco | | V54 | NSV 24472 | | | |
| | V12 | IW Oph | | V48 | V1170 Sco | | V55 | NSV 24471 | | | |

Table 2

A Fragment of the Catalogue of Accurate Equatorial Coordinates for Variable Stars in Globular Clusters

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NGC 1261 ..... | | | ! | | | | | |
| NGC 1261 ..... | V | 1 | | 03 12 12.51 −55 13 25.5 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 2 | | 03 12 11.28 −55 12 22.0 | | X,Y | | |
| NGC 1261 ..... | V | 3 | | 03 12 21.78 −55 13 50.7 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 4 | | 03 12 18.56 −55 13 28.4 | | X,Y | | |
| NGC 1261 ..... | V | 5 | | 03 12 11.93 −55 13 01.9 | | X,Y | | |
| NGC 1261 ..... | V | 6 | | 03 12 25.05 −55 13 08.6 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 7 | | 03 11 58.44 −55 10 37.3 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 8 | | 03 12 00.44 −55 15 16.4 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 9 | | 03 12 20.40 −55 13 35.3 | | X,Y | | |
| NGC 1261 ..... | V | 10 | | 03 12 21.99 −55 11 45.9 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 11 | | 03 12 05.50 −55 11 27.7 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 12 | | 03 12 26.15 −55 12 45.8 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 13 | | 03 12 07.01 −55 14 33.1 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 14 | | 03 12 09.75 −55 14 07.6 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 15 | | 03 12 02.50 −55 10 48.1 | 1999.821 | 2MASS | | Wrong X,Y in CVSGC |
| NGC 1261 ..... | V | 16 | | 03 12 13.90 −55 13 12.9 | | X,Y | | |
| NGC 1261 ..... | V | 17 | | 03 12 15.48 −55 12 36.6 | | X,Y | | |
| NGC 1261 ..... | V | 18 | | 03 12 13.80 −55 12 40.6 | 1999.821 | 2MASS | | |
| NGC 1261 ..... | V | 19 | | 03 12 18.19 −55 12 44.7 | | X,Y | | |
| NGC 1261 ..... | V | 20 | | 03 12 19.31 −55 13 00.4 | | X,Y | | |
| NGC 1261 ..... | V | 21 | | 03 12 14.47 −55 12 31.3 | | X,Y | | |
| NGC 1851 ..... | | | ! | | | | | |
| NGC 1851 ..... | V | 1 | | 05 14 28.93 −40 02 56.5 | 1998.997 | 2MASS | Z Col | |
| NGC 1851 ..... | V | 2 | | 05 14 02.75 −40 02 24.4 | 1998.997 | 2MASS | Y Col | |
| NGC 1851 ..... | V | 3 | | 05 14 02.44 −40 01 20.6 | 1998.997 | 2MASS ? | | |
| NGC 1851 ..... | V | 4 | | 05 14 08.53 −40 02 17.0 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 5 | | 05 14 09.89 −40 02 11.8 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 6 | | 05 14 00.01 −40 03 04.2 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 7 | | 05 14 07.06 −40 04 42.9 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 8 | | 05 14 08.90 −40 02 26.9 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 9 | | 05 14 01.33 −40 02 05.8 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 10 | | 05 14 10.95 −40 06 08.9 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 11 | | 05 14 12.64 −40 05 07.6 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 12 | | 05 13 59.84 −40 03 41.8 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 13 | | 05 14 06.73 −40 02 07.4 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 14 | | 05 14 12.85 −40 02 34.8 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 15 | | 05 14 09.07 −40 02 01.1 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 16 | | 05 14 12.27 −40 02 51.9 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 17 | | 05 14 02.90 −40 03 50.2 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 18 | | 05 14 09.91 −40 00 13.5 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 19 | | 05 14 08.76 −40 03 25.2 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 20 | | 05 14 05.57 −40 03 16.8 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 21 | | 05 14 01.14 −40 01 53.6 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 22 | | 05 14 17.50 −40 01 00.8 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 23 | | 05 14 16.15 −40 03 47.5 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 24 | | 05 14 19.34 −40 04 23.9 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 25 | | 05 13 55.80 −40 07 31.8 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 26 | | 05 13 55.35 −40 01 10.9 | 1998.997 | 2MASS | | |
| NGC 1851 ..... | V | 27 | | 05 14 03.70 −40 03 05.8 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 28 | | 05 14 09.75 −40 03 10.4 | 1994.0 | GCVS | | |
| NGC 1851 ..... | V | 29 | | 05 14 05.52 −40 02 20.8 | 1994.0 | GCVS | | |

Table 2 (*Continued*)

| | | | | | |
|---|---|---|---|---|---|
| NGC 1851 ..... | V | 30 | 05 14 07.53 −40 02 59.2 | 1994.0 | GCVS |
| NGC 1851 ..... | V | 31 | 05 14 08.73 −40 03 07.9 | 1994.0 | GCVS |
| NGC 1851 ..... | V | 32 | 05 14 04.65 −40 02 15.7 | 1994.0 | GCVS |
| NGC 1851 ..... | V | 33 | 05 14 07.91 −40 03 13.9 | 1994.0 | GCVS |

NOTE.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. Table 2 is published in its entirety in the electronic edition of the *PASP*. A portion is shown here for guidance regarding its form and content.

The use of rectangular rather than equatorial coordinates surely had its historical reasons. It is easy to point a telescope at a globular cluster even if the telescope setting is off by as much as a minute of arc. Until recently, studies of clusters were mostly photographic and were undertaken with relatively wide field cameras. The way the investigators identified the variables was to label them on photographic prints, and the rectangular coordinates provided a useful guide for locating a star on the identification chart. Another convenience of the rectangular coordinate system was that one could easily get a sense of how far the star was from the cluster center, just by reading the table.

In the "online" Internet catalog of variable stars in globular clusters, for some clusters, the rectangular coordinates were replaced with equatorial coordinates, for the equinox B1950.0 or J2000.0. The sources of the equatorial coordinates were heterogeneous and, as we will describe, not always reliable. However, the online CVSGC contained, until recently, rectangular coordinates for most stars, often unchanged as compared to the printed editions.

The SIMBAD database provides equatorial coordinates for some objects of the CVSGC, but the majority of globular-cluster variables are not contained there.

In the twenty-first century, it is more advantageous to list accurate equatorial coordinates of globular-cluster variables for several reasons. First, they allow one to point the telescope immediately at the right star. Second, it becomes possible to cross correlate the catalog with other catalogs, and check possible cross-correlations for variables in the same cluster. For some stars, it is possible to find observations in the public domain of the Internet and thus to improve the CVSGC information (see § 3).

When working on the GCVS, its authors often thought about adding all reliable and sufficiently well-studied globular-cluster variable stars to the GCVS, their omission being in contradiction with the declared purpose of the catalog. (If these plans are fulfilled, the specialized catalogs of variable stars in globular clusters will still remain important, as they present needed information in a form handy for those studying individual clusters.) However, we were not able to start implementing such plans until the solution was found to the problem of finding equatorial coordinates for all variable stars in the CVSGC.

We decided to compile a catalog of equatorial coordinates of globular-cluster variable stars, containing as close to all the CVSGC objects as possible.

## 2. COMPILATION OF THE CATALOGUE

For the list of objects, we downloaded the most recent update of the Catalogue of Variable Stars in Globular Clusters (CVSGC) available in 2008 June. This was essentially the version of 2002, with more recent additions for a small number of clusters. Note that this version is no longer accessible; currently (2009 September), a new revision is partially posted.

The CVSGC lists 147 globular clusters of our Galaxy. The number of variable stars strongly varies from one cluster to another. No variable stars were detected in many clusters, despite searches. The CVSGC contains a total of 103 globular clusters with known variable stars, from a single star in NGC 6380 and in NGC 6717, to almost 300 in NGC 5139 ($\omega$ Cen) and NGC 5272 (M3).

It is possible to find in the literature one or more photographic finding charts of variable stars for most clusters. In several clusters, we were able to use earlier studies aimed at identification of variables or their astrometry. The key references, not including papers with few stars, are the following. NGC 104: Geffert et al. (1997); NGC 288: Kaluzny (1996); NGC 2808, NGC 5024: Evstigneeva et al. (1997); NGC 4147: Stetson et al. (2005); NGC 5139: Shokin & Samus (1996a), Kaluzny et al. (2004); NGC 5272: Evstigneeva et al. (1994), Bakos et al. (2000); Pal 5: Vivas et al. (2004); NGC 5897, NGC 6712: B. Skiff, (private communication to the CVSGC compilers); NGC 5904: Evstigneeva et al. (1995); NGC 6121: Shokin & Samus (1996b), Kaluzny et al. (1997); NGC 6341: Tucholke et al. (1996); NGC 6362: Mazur et al. (1999); NGC 6397: Kaluzny (1997); NGC 6584: Samus et al. (1995); NGC 6656: Kravtsov et al. (1994); NGC 6752: Thompson et al. (1999); NGC 6809: Olech et al. (1999), Pych et al. (2001); NGC 6838: Park & Nemec (2000); NGC 6934: Kaluzny et al. (2001). If necessary, we checked the coordinates from these papers using finding charts, and improved them as needed using position catalogs or performing special measurements.

It should be noted that all the equatorial coordinates presented for 37 variables in the globular cluster NGC 6638 in

Rutily & Terzan (1977) are quite wrong (Samus et al. 2008). The errors are from 13 to 49 *minutes* of arc (exceeding half a degree in 18 cases). We have an impression that Rutily and Terzan calculated their equatorial coordinates from rectangular coordinates measured with respect to a reference point in several arcminutes to the northeast of the cluster center and used a wrong scale factor in these calculations. The very wrong coordinates in this article led to the result that two of the variable stars in the region of NGC 6638 have two GCVS identifications each (V13 = V1673 Sgr = V4053 Sgr; V63 = IL Sgr = V4056 Sgr).

For most clusters, the CVSGC contained no equatorial coordinates of their variable stars. In each of such clusters, we usually proceeded in the following way.

1. A search for all finding charts. For this purpose, we used not only the online version of the CVSGC but also the earlier CVSGC editions (Sawyer 1955; Sawyer Hogg 1973) and, in some cases, other sources of bibliography, selecting the best charts, checking agreement of the identifications suggested for the same stars.

2. Identifying the finding charts with position catalogs using the Aladin interactive atlas (the Strasbourg Center of Astronomical Data). Only two CVSGC stars could be identified with the Tycho-2 Catalogue (Høg et al. 2000), which also provided their proper motions.

In the cases of Tycho-2 identifications not available, we identified variable stars with the following catalogs, in the order of our preferences.

2MASS: Two Micron All Sky Survey (Cutri et al. 2003).

GSC2.3: Guide Star Catalog, version 2.3 (Lasker et al. 2008).

B1.0: Whole-Sky USNO-B1.0 Catalog of 1,045,913,669 sources (Monet et al. 2003).

Images from the 2MASS survey provided by the Aladin atlas often were also the most suitable for our purposes, the central cluster areas being, as a rule, not overexposed.

3. Measurements of photographic and CCD images of globular-cluster fields with variable stars using astrometric calibration from stars of the catalogs cited above. This approach was applied to stars missing in the position catalogs, as well as to double and multiple stars if the position of the variable component looked biased compared to the coordinates given for the whole blend in the position catalog.

4. Reductions of rectangular coordinates to equatorial coordinates. Such an approach was effective if there were sufficiently accurate rectangular coordinates in the same system for variables of a given cluster in the literature. It can be used to determine equatorial coordinates for stars with no other sources of information or to check identifications. Especially helpful were the precise catalogs of stars in the globular clusters NGC 5272 (Küstner 1922); NGC 5904 and NGC 6218 (Küstner 1933); NGC 6205 (Ludendorff 1905); NGC 6779 (Küstner 1920); NGC 7078 (Küstner 1921).

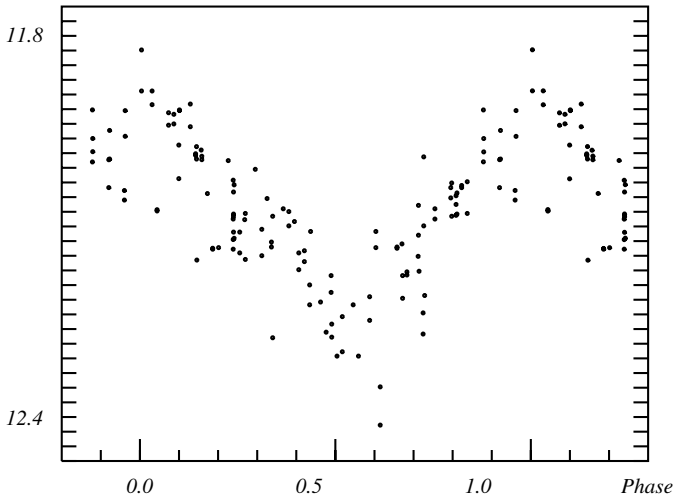


FIG. 1.—Phased light curve of V2 (NGC 6366) from NSVS data (maximum JD $= 2,451,373 + 72E$.

5. A check of the derived coordinates for possible matching of the CVSGC stars with objects of the GCVS or of the New Catalogue of Suspected Variable Stars (the NSV catalog, Kukarkin et al. 1982) and its Supplement (Kazarovets et al. 1998).

We found that 146 CVSGC stars are already contained in the GCVS (as noted, two of them, in the globular cluster NGC 6638, have two GCVS names each). GCVS names were given in the CVSGC only for nine stars. Designations from the NSV catalog (with Supplement) are available for 70 stars, with none of these identifications mentioned in the GVSGC. The identifications we found are collected in Table 1. The cluster numbers with no prefix in its first column are from the NGC. The column "Var" presents CVSGC designations; asterisks mark those with the GCVS identification given in the CVSGC.

The referee, Professor C. M. Clement, turned our attention to two problem identification cases in the globular cluster NGC 7078 (M15). We made our identifications without using the new paper, Corwin et al. (2008), that contains, among other results including discoveries of new variables, accurate equatorial coordinates for many previously known variable stars. The agreement with the coordinates in our catalog is generally very good. The referee found, however, several discrepant cases. In most of them, we agree that the identification in Corwin et al. (2008) is correct (it is often confirmed with reliable period determinations by Corwin et al.), so we have introduced necessary corrections in our catalog. Two problem cases, however, should be discussed here.

The star called V106 in Corwin et al. (2008) is Küstner 421 (Küstner 1921), while the star originally announced as V106 (Rosino 1969) is Kü 438. The angular distance between the two stars is only 5″. In the catalog, we decided to call Kü 438, V106a and Kü 421, V106b.

The variable V114, first announced by Kadla et al. (1984), is definitely not Kü 537 but rather is Kü 579. Thus, the real V114 is the star called NV3 in Corwin et al. (2008), and their "V114" is a new variable.

## 3. THE CATALOG

The catalog is available in electronic form in the online Table 2 of this article. The structure of the file is the following.

The first catalog line for each cluster contains the cluster name, with an exclamation mark in the sixteenth position. An asterisk in the fifteenth position means that there is a remark to the cluster as a whole in column (5) of the table. Then, lines for variable stars in the cluster follow.

Column 1. CVSGC name of the variable.

Column 2. Equatorial coordinates for equinox 2000.0, to $0.01^{\rm s}$ in right ascension and $0.1''$ in declination. For 218 stars, the coordinates are less precise.

Column 3. Epoch and source of the coordinates. Some of the symbols in this column will be explained below.

Column 4. GCVS and NSV identifications of the variable, if any. An asterisk after the GCVS or NSV identification means that the identification was mentioned in the CVSGC.

Column 5. Note. For supplemental information as needed. For example, a note was added for several clusters where we detected mutual identifications of CVSGC stars not recognized earlier. Notes can describe identification problems or present other additional information.

The catalog contains a total of 3398 variable stars in 103 globular clusters (15 stars entered in the CVSGC twice under different names have been counted once in the total; V106 in NGC 7078, the star with two identifications, has also been counted once).

The coordinates of 2184 stars (64%) were taken from the 2MASS catalog. All other sources of coordinates were used much less frequently. For 332 stars, the coordinates were measured by the authors using images, with respect to reference stars. For such stars, the column identifying the source of data contains the abbreviation GCVS. We took the coordinates of 403 stars directly from sources in the literature (indicated by the code Lit.; most of these sources are cited in the previous section). The equatorial coordinates of 229 stars in our catalog are based on reductions of rectangular coordinates of different precision (marked X,Y). Notes for 85 stars indicate doubtful identifications or low accuracy of their coordinates. Uncertain identifications and/or coordinates are designated with question marks after the column with the source of the coordinates.

New prospects from this catalog of equatorial coordinates for globular-cluster variable stars can be illustrated using, as an example, the following three CVSGC stars, which have quite insufficient information in the CVSGC but can now be studied using public-domain data of automatic photometric sky surveys. So far, such possibilities exist only for brightest cluster stars, mostly red variables.

*V68 (NGC 3201).* Identified with NSV 4810. The CVSGC gives the type "long", even without a variation range indicated. The star is very bright in the infrared ($K_S = 3.49^{\rm m}$ in the 2MASS catalog). It can be found in the ASAS-3 catalog of variable stars (Pojmanski 2002) as the star ASAS 101711–4610.8, of unidentified type (the ASAS-3 type MISC–miscellaneous), with the period of $71.8^{\rm d}$. The excellent ASAS-3 light curve shows brightness variations between $11.9^{\rm m}$ and $13.3^{\rm m}$ $V$. From 580 ASAS-3 observations, we can classify the variable as LB in the GCVS system.

*V2 (NGC 6366).* The CVSGC mentions the star's red color and that it is possibly a field star. Its photographic variability range ($15.7^{\rm m} - 16.8^{\rm m}$) is also given. There is no information on the variability type or period. The star is too faint for the ASAS-3 survey, which contains only a few observations scattered near the photometric limit, but its 123 red-light observations can be found in the ROTSE-I/NSVS survey (Woźniak et al. 2004). From these data, the star is a semiregular (SR) variable with a probable period about $72^{\rm d}$. Its red-light variation range is $11.9^{\rm m} - 12.4^{\rm m}$. Figure 1 shows its phased light curve.

*V3 (NGC 6752).* No type or variability range in the CVSGC, with only the star's red color indicated. The star does not enter the ASAS-3 variable star catalog, but the photometric catalog of the same survey nevertheless provides more than 580 observations revealing LB variations approximately between $11.2^{\rm m}$ and $11.5^{\rm m}$ $V$.

## 4. CONCLUSIONS

We compiled a catalog of accurate equatorial coordinates for 3398 variable stars in 103 globular clusters. These coordinates made it possible to perform the first maximally complete identification of the Catalogue of Variable Stars in Globular Clusters with the General Catalogue of Variable Stars and with the New Catalogue of Suspected Variable Stars (plus Supplement). 146 CVSGC stars were found to be contained in the GCVS and 70 stars, in the NSV Catalogue (with Supplement). Only 9 of these identifications were already indicated in the CVSGC.

The complete conversion of the CVSGC to equatorial coordinates makes it much easier to identify globular-cluster variable stars in the sky, permitting automatic pointing of ground-based and space-borne telescopes as well as studies of bright variables using available data of automatic photometric surveys. It becomes possible to add to the GCVS those globular-cluster variable stars that satisfy the rather strict GCVS naming criteria.

In future, we are planning a more detailed comparison of our results to the SIMBAD data, in contact with SIMBAD astronomers. Currently, coordinates of globular-cluster variables in SIMBAD are sparse, and the SIMBAD sources of identification are not always clear. In the course of our study, we noted some cases of agreement as well as of disagreement of our identifications with those in SIMBAD.

We continue our work in close contact with the CVSGC team to improve information on variable stars in globular clusters provided to the users. Our catalog of equatorial coordinates for globular-cluster variable stars is available electronically.

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