New Metal-poor Globular Clusters in the Galactic Bulge: The Elephant Graveyard*

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1. Search for Metal-poor Globular Cluster Candidates in the Bulge Using RR Lyrae

Usually new GC candidates are identified in images of the field using visual inspection or automatic detection algorithms. However, in the direction of the Galactic bulge there is a very high stellar density, due to the foreground and background stars along the line of sight. This means that a GC does not necessarily have a significant over density above the background. However, we can use tracers like RR Lyrae (RRL) and Type 2 Cepheid (T2C) variable stars to find metal-poor GCs. Carballo-Bello et al. (2016), and Minniti et al. (2017a) used this method to confirm two new GCs in the Galactic plane (FSR 1735, and VVV-GC-005 = FSR 1716, respectively). Here we apply this same method to identify RRL overdensities that might trace unknown metal-poor GCs in the bulge.

RRL and T2Cs variable stars are old and metal-poor, representatives of Population II. They are often found in metal-poor GCs, aside from the Galactic halo and bulge. It is reasonable to think that some of the field RRL come from ancient GCs that have been disrupted by dynamical processes like evaporation, dynamical friction, tidal disruption, disk or bulge shocking, etc. Most of these processes are expected to be intensified in the inner regions of the Milky Way, deep in the potential well where the Galactic tides are larger. It is then reasonable to think that the bulge is the "elephant graveyard," the place where most of the disrupted Galactic GCs would end up. Since the dynamical processes are continuous, this is also the place where one would find the doomed GCs, those that are being destroyed or in the verge of disruption.

We select metal-poor GC candidates because of the presence of RRL and T2C variable stars, using the catalogs of Pietrukowicz et al. (2015), Gran et al. (2016), and R. Contreras Ramos et al. (2017, in preparation), building density maps and looking for local overdensities. These are in general tight groups composed of a couple or more RRL and/or T2Cs within a radius of 2 arcmin. Also, at least two of these objects should have magnitude consistent with similar distances. We find 38 new GC candidates in total, designated Minniti 23 to 60 (Minni for short since they are small cluster candidates of low-luminosity). Note that Minniti 22 was already listed as a candidate by Minniti et al. (2017b). Table 1 lists their positions R.A. and decl. (J2000) in degrees, number of RRL/T2Cs within 2 arcmin radius, and mean field reddenings from Gonzalez et al. (2012).

Table 1. New Candidate Globular Clusters

ID	R.A. (deg)	Decl. (deg)	NRR+T2C	A_{Ks} (mag)
Minni 22	267.2140	−33.0620	3RRL	0.325
Minni 23	268.5595	−36.1524	3RRL	0.109
Minni 24	270.4500	−28.3602	6RRL	0.169
Minni 25	265.9887	−33.9416	3RRL	0.324
Minni 26	266.1200	−34.8055	3RRL	0.263
Minni 27	267.9595	−33.8665	5RRL	0.286
Minni 28	268.1345	−33.4998	2RRL	0.201
Minni 29	268.0991	−32.2987	3RRL	0.303
Minni 30	268.5145	−31.3104	4RRL	0.259
Minni 31	269.6533	−27.6393	4RRL	0.250
Minni 32	271.6033	−29.3081	5RRL	0.138
Minni 33	267.4658	−30.7368	4RRL	0.429
Minni 34	268.5408	−28.4309	7RRL	0.355
Minni 35	268.0333	−28.4206	6RRL	0.415
Minni 36	268.9833	−29.9706	4RRL	0.243
Minni 37	269.0145	−29.5806	5RRL	0.227
Minni 38	268.4354	−30.0209	6RRL	0.234
Minni 39	268.0979	−29.2945	4RRL	0.417
Minni 40	267.6770	−29.6068	8RRL	0.462
Minni 41	261.6104	−28.7406	3RRL	0.278
Minni 42	264.1562	−29.0379	5RRL	0.406
Minni 43	263.4937	−27.0084	4RRL	0.392
Minni 44	265.5895	−26.5479	4RRL	0.451

ID	R.A. (deg)	Decl. (deg)	NRR+T2C	*A* (mag)
Minni 45	265.1187	−27.1276	6RRL	0.411
Minni 46	265.5895	−27.5601	9RRL	0.478
Minni 47	265.1770	−27.8248	3RRL	0.451
Minni 48	263.3645	−28.0298	4RRL	0.370
Minni 49	265.3145	−25.8456	4RRL	0.385
Minni 50	268.0395	−29.9065	3RRL+1T2C	0.343
Minni 51	270.1770	−27.1718	2RRL+1T2C	0.262
Minni 52	269.6479	−28.4898	2RRL+1T2C	0.230
Minni 53	268.2562	−30.6004	4RRL+1T2C	0.323
Minni 54	264.8203	−28.3330	6RRL	0.418
Minni 55	266.0128	−27.3757	4RRL	0.579
Minni 56	267.7326	−29.6107	3RRL	0.463
Minni 57	267.6547	−28.7673	2RRL	0.817
Minni 58	265.8062	−28.4729	2RRL	1.096
Minni 59	267.8284	−29.8230	2RRL	0.435
Minni 60	265.8229	−27.7065	3RRL	0.570

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We also used the VVV survey near-IR data (Minniti et al. 2010; Saito et al. 2012) to inspect the targets, in particular the PSF photometric catalogs (Alonso-García et al. 2015). The near-IR color–magnitude diagrams (CMDs) of the new GC candidates listed in Table 1 revealed well defined red giant branches, including a red clump in some cases. In general the known GCs in the bulge can be directly seen in the images from the optical and near-IR surveys like Glimpse, *Wise*, 2MASS, VVV and DSS2. However, images centered on the coordinates adopted in this work do not show the clusters clearly. This suggests that our targets may be low-luminosity GCs. The present new GC candidates need to be confirmed with follow-up observations. We suggest the following methods: (1) Optical or near-IR CMDs to detect the features and sequences that are typical of GCs (RGB, TO, HB or RC), and to fit theoretical isochrones. Also, because of the severe background contamination, it is important to use a decontamination method, like the statistical subtraction of the background (Bonatto et al. 2007; Palma et al. 2016). (2) Kinematically using proper motions or radial velocities to select cluster members. These measurements can clean the CMDs in order to confirm the typical GC features (Contreras Ramos et al. 2017). (3) Spectroscopically measuring individual element abundances that yield a typical GC chemical footprint. (4) Obtain accurate distances using the updated *Gaia* period–luminosity relations for RRL and T2Cs.

To summarize, we have used the catalogs of bulge RRL variable stars to search for GCs that have been concealed toward the Galactic bulge. We found 38 new metal-poor candidate GCs that contain RRL and/or T2C variable stars, augmenting significantly the sample of new candidate GCs of Minniti et al. (2017b).

Footnotes

* Based on observations collected under ESO programmes 179.B-2002 and 298.D-5048.

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