A Sequoia in the Garden: FSR 1758—Dwarf Galaxy or Giant Globular Cluster?[*]

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Received 2018 October 31; revised 2018 December 11; accepted 2018 December 12; published 2019 January 14

Abstract

We present the physical characterization of FSR 1758, a new large, massive object very recently discovered in the Galactic Bulge. The combination of optical data from the 2nd *Gaia* Data Release and the DECam Plane Survey and near-IR data from the VISTA Variables in the Vía Láctea Extended Survey led to a clean sample of likely members. Based on this integrated data set, position, distance, reddening, size, metallicity, absolute magnitude, and proper motion (PM) of this object are measured. We estimate the following parameters: $\alpha = 17{:}31{:}12$, $\delta = -39{:}48{:}30$ (J2000), $D = 11.5 \pm 1.0$ kpc, $E(J - Ks) = 0.20 \pm 0.03$ mag, $R_c = 10$ pc, $R_t = 150$ pc, $[\mathrm{Fe/H}] = -1.5 \pm 0.3$ dex, $M_i < -8.6 \pm 1.0$, $\mu_\alpha = -2.85$ mas yr^{-1}, and $\mu_\delta = 2.55$ mas yr^{-1}. The nature of this object is discussed. If FRS 1758 is a genuine globular cluster (GC), it is one of the largest in the Milky Way, with a size comparable or even larger than that of ω Cen, being also an extreme outlier in the size versus Galactocentric distance diagram. The presence of a concentration of long-period RR Lyrae variable stars and blue horizontal branch stars suggests that it is a typical metal-poor GC of Oosterhoff type II. Further exploration of a larger surrounding field reveals common PM stars, suggesting either tidal debris or that FRS 1758 is actually the central part of a larger extended structure such as a new dwarf galaxy, tentatively named Scorpius. In either case, this object is remarkable, and its discovery graphically illustrates the possibility of finding other large objects hidden in the Galactic Bulge using future surveys.

Key words: Galaxy: bulge – Galaxy: stellar content – globular clusters: individual (FSR 1758) – stars: kinematics and dynamics

1. Introduction

More than two dozen of new low-luminosity globular cluster (GC) candidates have been discovered in the past year to the direction of the Galactic Bulge (Minniti et al. 2017a, 2017b; Bica et al. 2018; Camargo 2018; T. Palma et al. 2019, in preparation; Ryu & Lee 2018). These objects are very difficult to detect, due to the heavy extinction and high field stellar density lying well inside the Bulge, and if proved to be genuine clusters, most are expected to be of low mass.

Very recently, Cantat-Gaudin et al. (2018), on the basis of the *Gaia* optical color–magnitude diagram (CMD), proposed another object, [FSR2007] 1758 (hereafter FSR 1758), to be a new GC located toward the Bulge. This serendipitous discovery was made while studying 1229 open clusters and noticing the striking proper motion (PM) separation from the field stellar population. They estimated a Galactocentric distance $R_G = 1600$ pc and a height below the plane $z = -470$ pc, which places it inside the Bulge itself. This object was listed as a diffuse open cluster in the catalogs of Froebrich et al. (2007) and Kharchenko et al. (2013), although we note that the position and physical properties in these initial studies are very preliminary.

In this Letter, we use combined data from 2nd *Gaia* Data Release (GDR2; Gaia Collaboration et al. 2018a), the DECam

Plane Survey (DECaPS; Schlafly et al. 2018), and the VISTA Variables in the Vía Láctea Extended (VVVX) Survey (Minniti 2018) to investigate the physical properties of this impressive object in much greater detail. We also use OGLE RR Lyrae stars to provide an external distance determination. Sections 2–4 describe the discovery, observations used, and derived CMDs, respectively. Then, based on our findings, we discuss its physical nature in Section 5 and summarize some conclusions in Section 6.

2. Independent Discovery of FSR 1758

One of us (R.B.) made the independent discovery of FSR 1758 serendipitously by visual inspection of the images from the DECaPS Survey of Schlafly et al. (2018). It stands out as a bright, diffuse glow in an otherwise patchy and generally high extinction zone, next to an extended dark cloud (Figure 1). A zoom-in reveals that the diffuse object is really a plethora of stars. A quick inspection of the GDR2 PMs in the region revealed that the cluster motion is very different from the field stars, as also noted by Cantat-Gaudin et al. (2018).

FSR 1758 appears to be quite large, perhaps rivaling in size the largest Galactic GCs, ω Cen and NGC 2419 (e.g., Harris 1996; Ripepi et al. 2007). The visible part seen in the DECaPS images (Figure 1) is probably just "the tip of the iceberg," being that much of its population is possibly hidden by field contamination and differential reddening. Part of the area has surprisingly low reddening, and it is this region that we

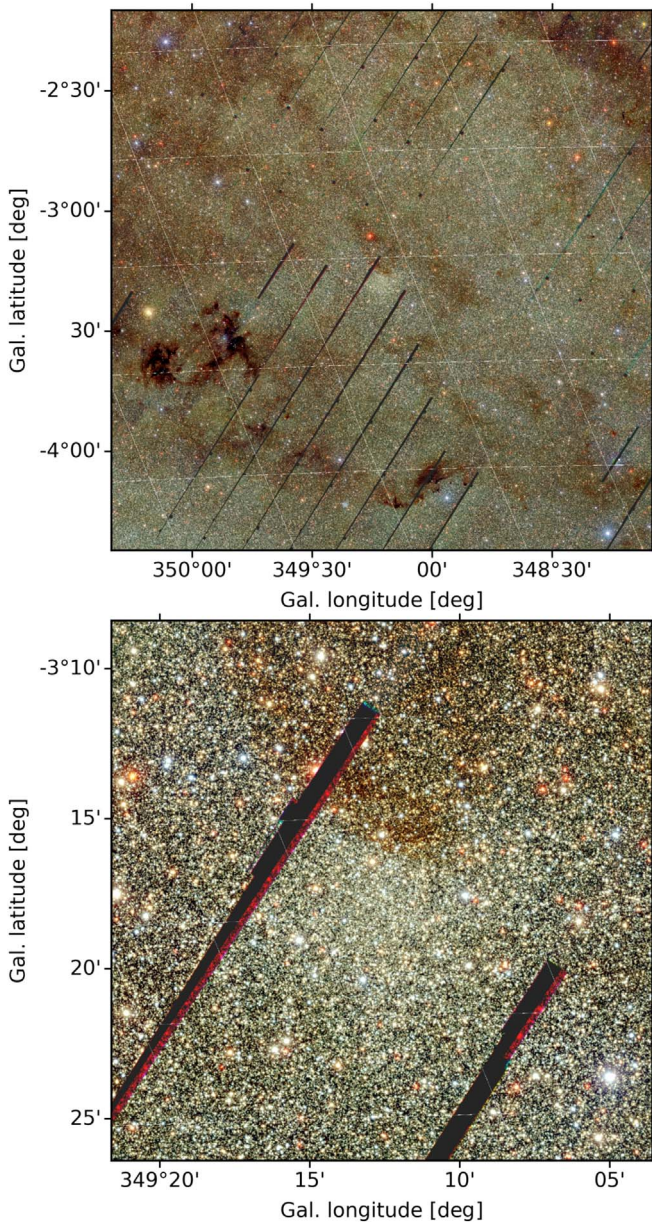**Figure 1.** Optical finding charts for the new GC from the DECaPS survey (Schlafly et al. 2018), showing a field of about $2°.25 \times 2°.25$ (top) and a zoomed-in region of about $18' \times 18'$ (bottom), both centered on the new globular cluster and in Galactic coordinates.

use to obtain the best cluster CMDs in order to determine its parameters. Nevertheless, approximately one-third of the object is heavily obscured by one or more interstellar clouds toward the plane. Thus, evidence suggests that the cluster may be more extended and/or have tidal tails, as discussed below.

3. GDR2, DECAPS, and VVVX Data

Because of the large non-uniform reddening in the bulge fields studied here (e.g., González et al. 2012; Alonso-García et al. 2015, 2018; Minniti et al. 2018; Schlafly et al. 2018), we also use the combination of optical GDR2 with near-IR VVVX data to help determine the parameters.

The GDR2 (Gaia Collaboration 2018) significantly improves the photometric and astrometric measurements of the first release and provides additional information on astrophysical parameters, variability, and median radial velocities for some sources. The GDR2 data have been processed by the *Gaia Data Processing and Analysis Consortium* (*DPAC*) and contain *G*-band magnitudes for over 1.6×10^9 sources with $G < 21$ mag and broadband colors G_{BP} covering (330–680 nm) and G_{RP} covering (630–1050 nm) for 1.4×10^9 sources. PM components in equatorial coordinates are available for 1.3×10^9 sources, with an accuracy of 0.06 mas yr^{-1}, 0.2 mas yr^{-1}, and 1.2 mas yr^{-1}, for sources with $G < 15$ mag, $G \sim 17$ mag, and $G \sim 20$ mag, respectively (Gaia Collaboration 2018).

DECaPS (Schlafly et al. 2018) is an optical multiband survey of the Southern Galactic Plane performed with the DECAM camera attached to the Victor Blanco 4 m telescope at Cerro Tololo Inter-American Observatory (Chile).

The VVVX survey (Minniti 2018) maps the Galactic Bulge and southern disk in the near-IR with the VISTA InfraRed CAMera (VIRCAM) at the 4.1 m wide-field Visible and Infrared Survey Telescope for Astronomy (VISTA; Emerson & Sutherland 2010) at ESO Paranal Observatory (Chile). In the Galactic Bulge, the VVVX Survey covers about 600 deg^2, using the J (1.25 μm), H (1.64 μm), and Ks (2.14 μm) near-IR passbands. The VVVX Survey data reduction and the archival merging were carried out at the Cambridge Astronomical Survey Unit (CASU; Irwin et al. 2004) and VISTA Science Archive at the Wide-Field Astronomy Unit, within the VISTA Data Flow System (Cross et al. 2012). In order to deal with the high crowding in this VVVX, we follow Alonso-García et al. (2018), extracting the point-spread function (PSF) photometry and obtaining a highly complete near-IR catalog.

4. Color–Magnitude Diagrams

Figure 2 (top panels) show the optical CMDs using the DECaPS photometry from Schlafly et al. (2018). The photometry is very deep, and the cluster red giant branch (RGB) is clearly seen, although heavily contaminated by foreground RGB stars. However, the most striking indication of the cluster is the presence of an extended blue horizontal branch (BHB), which is absent in the surrounding fields.

Figure 2 (bottom left panel) shows the near-IR CMD within $5'$ of the cluster center obtained from PSF photometry of the VVVX tile e682, following the procedure from Alonso-García et al. (2018). The cluster RGB and extended BHB are clearly seen, on top of the foreground disk and background Bulge stars. In particular, the cluster RGB is bluer than the Bulge RGB. A clump of stars located at $Ks = 13.4$, $J - Ks = 0.87$ can be identified; this feature is likely the red giant branch bump (RGBb). This interesting GC CMD feature is related to the evolution of the RGB stars during the first dredge-up, and it is sensitive to metallicity, helium content, and mixing efficiency (see Fu et al. 2018). The locus in a CMD of the RGBb depends on both age and metallicity. Once the cluster metallicity has been estimated, the location of the RGBb in a CMD helps to determine the age, and vice versa (Alves & Sarajedini 1999). The optical and near-IR CMDs exhibit a well-populated steep RGB, with no clear red clump, an indication of a metal-poor GC, in agreement with the presence of a prominent BHB.

Schlegel et al. (1998) and Schlafly & Finkbeiner (2011) determined the extinction in the area to be in the ranges $A_V = 3.35:2.89$ (Landolt filters), $A_I = 2.11:1.79$ (SDSS filters), and $A_K = 0.37:0.32$ (*UKIRT* filters). By comparing the near-IR CMD with known metal-poor clusters, we obtained
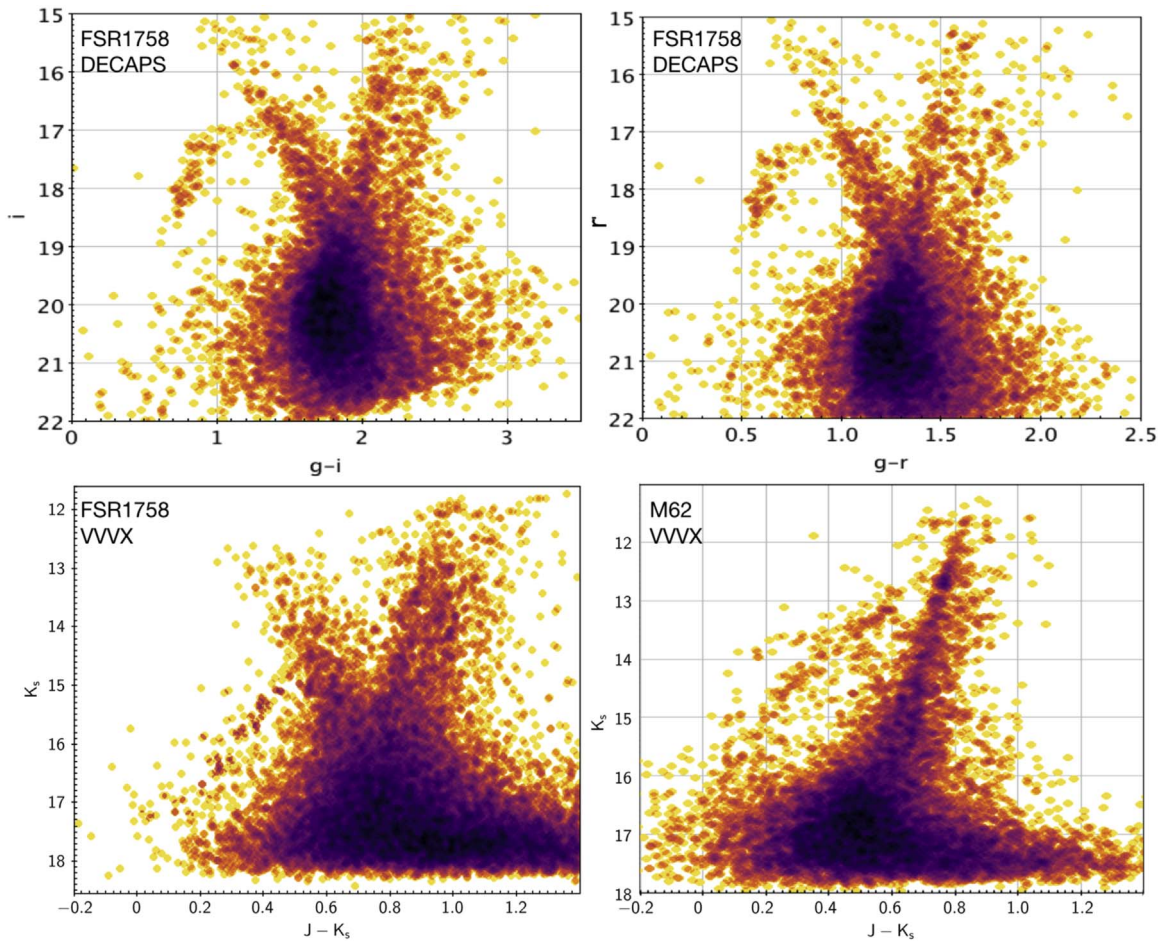
Figure 2. Left: DECaPS CMDs for the new GC region: r vs. $g - r$ (top right) and i vs. $g - i$ (top left). Right: VVVX CMD for the new GC region: Ks vs. $J - Ks$ (bottom left), compared with the known GC NGC 6266 (M62; bottom right).

$E(J - Ks) = 0.20 \pm 0.03$ mag, in agreement with the extinction values from Schlafly & Finkbeiner (2011)

Knowing the reddening, we can accurately measure the distance differentially with respect to the known Bulge GCs NGC 6642 and NGC 6266, using the VVVX near-IR CMDs. With respect to NGC 6642, we measured $\Delta(J - Ks) = 0.10$ mag and $\Delta Ks = 0.90$ mag. This yields a fainter distance modulus (by about 0.85 ± 0.1 mag) than the GC NGC 6642, whose distance and metallicity are $D = 8.1$ kpc and [Fe/H] $= -1.26$ dex, respectively. Our first estimate of the distance to FSR 1758 is then $D_1 = 12.0 \pm 0.5$ kpc. Similarly, with respect to NGC 6266, we measured $\Delta(J - Ks) = 0.10$ mag and $\Delta Ks = 0.95$ mag. This gives a fainter distance modulus than the GC NGC 6266, which has $D = 6.8$ kpc and [Fe/H] $= -1.18$ dex. Then, our second estimate is $D_2 = 11.0 \pm 0.5$ kpc. We can take the average of the former two values as the distance to FSR 1758, i.e., $D_{\mathrm{FSR1758}} = 11.5 \pm 1.0$ kpc. The error is estimated as the sum of the individual errors in order to include possible systematic differences. The alignment of the RGB and the BHB with these comparison GCs is remarkably good, which gives added confidence to this determination. We note that the GDR2 parallaxes in the distant and crowded cluster field would be unreliable.

We repeated the same procedure using the *Gaia* CMD and considering the clusters studied by Gaia Collaboration et al. (2018b) as references. Using this optical CMD we find a magnitude difference of 17.1 ± 0.1 mag and a reddening

$E(BP - RP) = 0.90 \pm 0.05$ mag. Using the extinction ratio from Andrae et al. (2018) yields $AG = 2.0\,E(BP - RP) = 1.8$ mag. This gives an absolute distance modulus of $(m - M)_0 = 15.30 \pm 0.10$ mag, equivalent to a distance $D = 11.5 \pm 0.5$ kpc. The *Gaia* CMD distance is then very consistent with the determination using the near-IR CMD. We note here that the fitting uncertainty of about 0.1 mag is quite optimistic because it does not consider the uncertainty in the reddening law. Therefore, as mentioned before, a distance error of the order of 1 kpc must be considered. As a conclusion, FSR 1758 is located on the far side beyond the Bulge. Its corresponding Galactocentric distance is $R_G = 3.7$ kpc, and its height below the plane is $z = -760$ pc.

Figure 3 (middle panel) shows the optical *Gaia* CMD, decontaminated using PM data. Again, the cluster RGB and extended BHB are clearly visible. The cluster RGBb is also well defined, located at $G = 16.9$, $BP - RP = 2.0$. The RGB tip is located at *Gaia* magnitude $G = 13.5$, bright enough for future spectroscopic follow-up. Figure 3 also shows the cluster PM (left panel), which is strikingly different from nearby field stars. This characteristic led Cantat-Gaudin et al. (2018) to claim the discovery of a new GC. The longitudinal component of the PM is close to zero, and indeed this cluster has a PM indicating it is plunging into the disk.

The wide wavelength coverage available allows us to constrain the cluster metallicity. Once the reddening is known, the metallicity can be readily estimated from the optical and
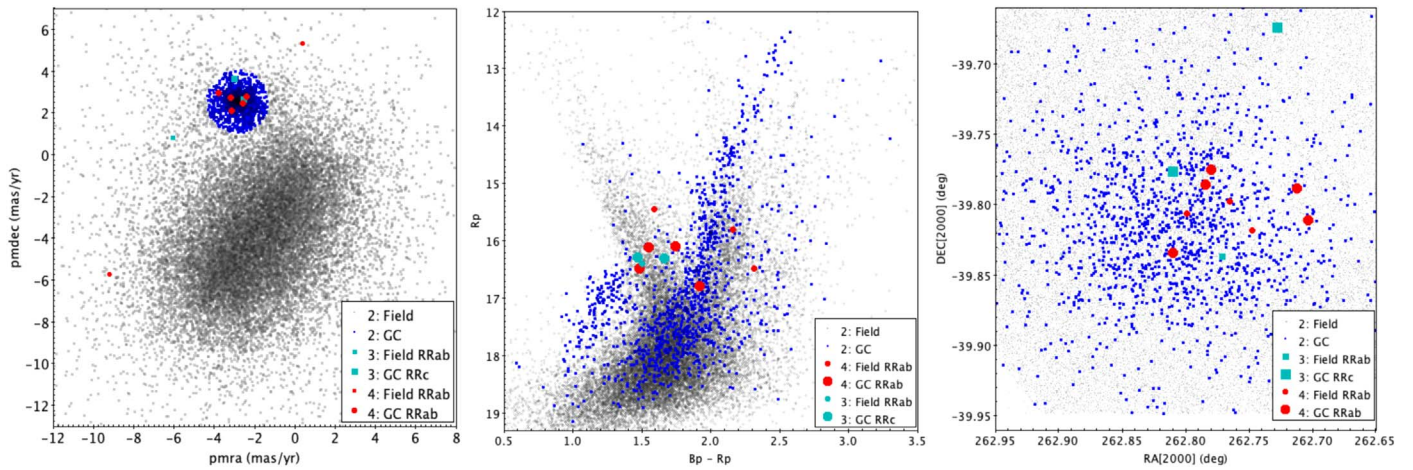
Figure 3. Left panel: *Gaia* PM diagram for the cluster region, with the selected stars around the $(\mu_\alpha, \mu_\delta) = (-2.85, 2.55)$ mas marked in blue. Center panel: *Gaia* CMD of all stars in the region (gray dots), compared with the PM selected GC members (blue dots). Right panel: spatial distribution of stars, probable members marked in blue. The RRLyr variable stars are also shown as red circles (type RRab) and cyan squares (type RRc). Large symbols are probable members of the cluster, while small symbols are stars belonging to the Bulge.

near-IR CMDs. Compared to other well-known GCs (e.g., Gaia Collaboration et al. 2018b), the *Gaia* CMD of FSR 1758 resembles those of M3 and M13, thus suggesting a metallicity close to [Fe/H] = −1.5 dex. Using the RGB location interpolated in the optical CMDs from Gaia Collaboration et al. (2018b) and the near-IR CMDs from Valenti et al. (2004), we estimated a value of [Fe/H] = −1.5 ± 0.3 dex for the metallicity of this cluster.

A concentration of RR Lyrae variables is also evident in the cluster region. From the OGLE catalog by Soszyński et al. (2014), we found eight fundamental RR Lyrae pulsators (RRab), plus three first overtone RR Lyrae pulsators (RRc) within 0°.15 (9′) from the cluster center. The centroid of the RR Lyrae distribution is located to the west of the centroid of the BHB distribution, probably due to a differential reddening effect. Table 1 lists the RRLyr stars including their OGLE IDs, types, periods, GDR2 equatorial coordinates and PMs (in J2000), OGLE mean *V*- and *I*-band and GDR2 magnitudes, extinctions A_I, distance from the cluster center, and probable cluster membership. We select the most likely cluster members based on the sky positions, PMs, and mean magnitudes and positions in the CMDs. The mean period for the five RRab members is $\langle P \rangle = 0.684$ day. As a consequence, we classify this cluster as an Oosterhoff type II, which is consistent with being metal-poor, like, for example, ω Cen (Clement & Rowe 2000).

RR Lyrae can be used to determine GCs distances even in deeply reddened cases (e.g., Alonso-García et al. 2015; Minniti et al. 2017b). We measured the distance to FSR 1758 differentially with respect to ω Cen following Braga et al. (2018), who relied on the period–luminosity-metallicity relations by Marconi et al. (2015). Considering all eight RRab listed in Table 1, we obtained a mean distance modulus of $\langle m - M_0 \rangle = 15.16 \pm 0.3$ mag, equivalent to a distance $D = 10.8 \pm 1.0$ kpc. On the other hand, using only the five RRab that are most probably cluster members we obtained $\langle m - M_0 \rangle = 15.02 \pm 0.3$ mag, equivalent to $D = 10.1 \pm 1.0$ kpc. Although the former estimate has a larger scatter due to the large individual reddening corrections, it is still in agreement with the distance determination based on the optical and near-IR CMDs.

5. The Nature of FSR 1758: A Giant GC or Dwarf Galaxy?

Figure 4 shows the radial profile and spatial extension of FSR 1758, obtained combining DECaPS and GDR2 data. We isolated stars with PMs similar to the cluster, within 1.2 mas from $\mu_\alpha = -2.85$ mas yr^{-1}, and $\mu_\delta = 2.55$ mas yr^{-1}, and parallaxes smaller than 0.3 mas, in order to avoid most of the foreground stars. The DECaPS star counts in *i*-band (shown in the left panel) indicates that the cluster stellar density joins the field at large radii from the center ($R > 15'$). The differential extinction in the field produces a structured radial profile. The fitting of a King profile (King 1962, 1966) gives a core radius $R_c = 0°.050 \pm 0°.004$ (about 10 ± 1 pc) and a tidal radius $R_t = 0°.78 \pm 0°.22$ (about 150 ± 45 pc). The derived value of $R_t = 150$ pc should be taken with caution due to the presence of strong differential reddening in the area. Although the structure of FSR 1758 determined from the star counts yields a concentrated radial profile typical of a GC, with a concentration index $c = 1.20^{+0.19}_{-0.13}$, it suggests an extended nature of the cluster. Figure 4 shows that this object is indeed very extended, possibly even larger than ω Cen, the most massive GC in the Milky Way (e.g., Meylan 1987; Harris 1996, 2010; Ferraro et al. 2006), with a tidal radius of $R_t = 45'$ (Trager et al. 1995) and a mass of 4×10^6 $M_\odot$ (D'Souza & Rix 2013). It is also a significantly flattened GC (White & Shawl 1987; Chen & Chen 2010). The appearance of FSR 1758 is also very flattened, like ω Cen, although this issue needs further investigation since the dark cloud located to the northeast of the cluster center could be significantly affecting this result. The total cluster luminosity is very difficult to estimate in the presence of the high background and heavy differential reddening. A lower crude estimate was obtained using the DECaPS photometry in the *i* band. Coadding up all stars within 0°.1 from the GC center (to avoid further field contamination), after accounting for the background taken in four different fields of similar area surrounding the cluster, assuming a distance of 11.5 ± 1.0 kpc, and an extinction of $A_i = 1.79$ mag from Schlafly & Finkbeiner (2011), we obtain a total *i*-band absolute magnitude brighter than $M_i < -8.6 \pm 1.0$ mag. This is a very bright GC indeed, and we emphasize that this total magnitude is only a lower limit because of incompleteness and

Table 1
RR Lyrae Pulsators in the Field of FSR 1758

ID	Type	P(days)	R.A.	Decl.	μ_α	μ_δ	V	I	G	B_P	R_P	A_I	$R('')$	PM	CMD	Notes
OGLE-BLG-RRLYR-00882	RRab	0.6396	262.70335	−39.81101	−3.195	2.721	18.771	16.735	17.877	18.710	16.787	1.68	267.5	Y	Y	GC
OGLE-BLG-RRLYR-00883	RRab	0.6606	262.71236	−39.78844	−2.411	2.777	18.540	16.735	17.918	⋯	⋯	1.73	252.7	Y	Y	GC
OGLE-BLG-RRLYR-00887	RRab	0.5183	262.74721	−39.81809	2.174	−21.062	18.093	15.816	16.988	17.966	15.803	1.63	150.0	N	N	Bulge
OGLE-BLG-RRLYR-00889	RRab	0.5762	262.76517	−39.79741	0.397	5.344	18.999	16.932	18.153	18.792	16.474	1.66	104.0	N	N	Unknown
OGLE-BLG-RRLYR-00891	RRab	0.5504	262.77940	−39.77487	−3.144	2.113	17.788	16.241	17.362	17.960	16.479	1.68	133.3	Y	Y	GC
OGLE-BLG-RRLYR-00893	RRab	0.7642	262.78404	−39.78579	−3.779	2.969	17.649	15.983	17.035	17.658	16.107	1.65	92.4	Y	Y	GC
OGLE-BLG-RRLYR-00894	RRab	0.7561	262.79889	−39.80606	−9.222	−5.744	17.237	16.013	16.879	17.047	15.456	1.65	8.7	N	N	Bulge
OGLE-BLG-RRLYR-00896	RRab	0.8062	262.80977	−39.83407	−2.597	2.440	17.572	16.046	17.157	17.834	16.091	1.57	96.5	Y	Y	GC
OGLE-BLG-RRLYR-00885	RRc	0.3480	262.72721	−39.67458	−2.981	3.610	18.049	16.389	17.531	17.960	16.297	2.05	522.0	Y	Y	GC
OGLE-BLG-RRLYR-00890	RRc	0.3214	262.77060	−39.83700	−6.044	0.811	18.046	16.434	17.403	17.908	16.407	1.77	131.3	N	Y	Unknown
OGLE-BLG-RRLYR-00895	RRc	0.3292	262.80971	−39.77662	−2.531	2.640	17.650	16.387	17.429	17.763	16.296	1.83	117.3	Y	Y	GC

Note. V, I values are from Soszyński et al. (2014). Positions; proper motions; and G, B_p, and R_p values are from GDR2. Typical OGLE photometric errors are $\sigma_V = 0.01$ mag and $\sigma_I = 0.01$ mag. Typical period errors are $\sigma_P = 0.00001$ days. Typical proper motion errors are $\mu_\alpha = 0.43$ mas and $\mu_\delta = 0.32$ mas. Extinction values A_I are from Schlafly & Finkbeiner (2011).
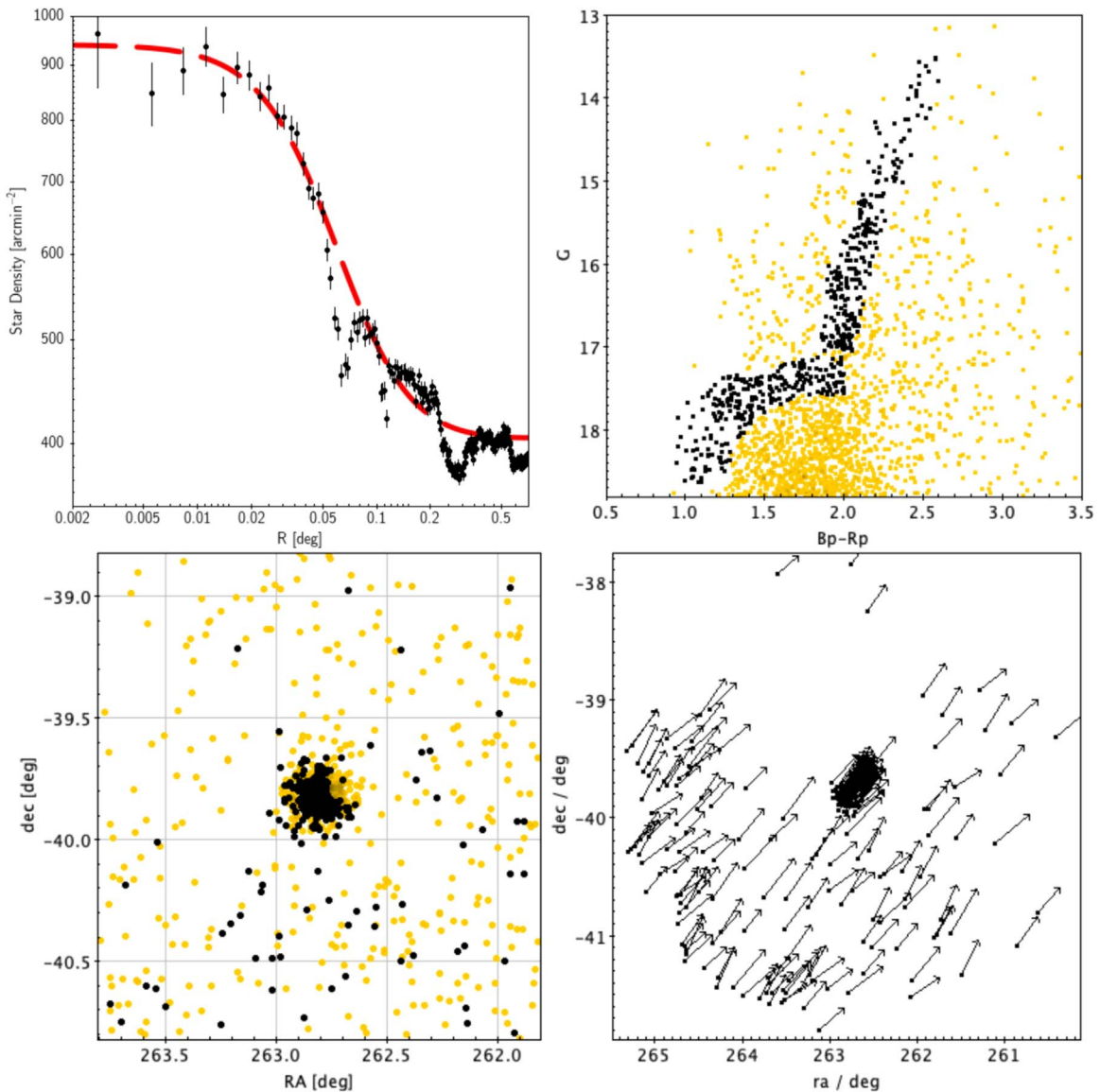
Figure 4. Top left panel: stellar radial density profile of stars using DECaPS *i*-band photometric data (black dots) and King's profile fitting (red line). This shows that the cluster size is extended beyond 0°.5. Top right panel: GDR2 CMD of selected (by PM and parallax) stars in the area of 2° radius, with BHB and RGB stars highlighted in black. Bottom left panel: spatial distribution of *Gaia* selected BHB and RGB stars over a 1° × 1° field. Note that some faint stars probably belonging to the cluster are missed due to the selection criteria applied to separate BHB and RGB stars from others. Bottom right panel: spatial distribution of common PM stars, showing a possible larger structure extended a few degrees to the southeast. The Galactic Plane is located toward the northwest.

differential reddening. A detailed study of reddening is needed in order to improve the values of astrophysical parameters allowing for a more robust comparison with ω Cen.

The large size of the cluster is confirmed using stellar tracers like BHB stars. Note that BHB stars are particularly sensitive to extinction, and therefore the empty patches just represent high extinction fields. Because there was no clear edge to the distribution of BHB stars, we decided to explore the spatial distribution of comoving stars using the GDR2 PMs. We then searched for associated streaming motions within two degrees of the cluster, using the same set of stars isolated from GDR2. Then, we selected the stars that lie in the main locus of the cluster RGB and BHB, with an additional constraint of $G < 18.8$. The result, shown in the right panel of Figure 4, reveals an asymmetric source distribution, with the potential comoving stars located preferentially to the southeast. This suggests that FSR 1758 may be the nucleus of a dwarf galaxy,

which we tentatively name as Scorpius dwarf galaxy, joining in this category with the GCs ω Cen (Meylan et al. 2001), M54 (Monaco et al. 2005), and M31-G1 (Gregg et al. 2015). In particular, some of the BHB stars in the outskirts of the field studied may belong to the body of this putative dwarf galaxy, in analogy with the BHB stars found by Monaco et al. (2003) in the field surrounding the GC M54, which is now known to be the nucleus of the Sgr dwarf galaxy. It could also be one of the putative primordial bulge building blocks such as Terzan 5 (Ferraro et al. 2009).

Also interesting in this regard is the fact that FSR 1758 appears not to fit to the well-defined size–metallicity and size–Galactocentric radius relations for the Galactic GCs (e.g., Vanderbeke et al. 2015), but to lie far above the mean correlations observed between these parameters. A thorough comparison of its properties with those of dwarf galaxies is beyond the scope of this Letter. For example, in the absence of

radial-velocity data, it is not possible to determine its mass-to-light ratio. Given its metallicity, if it was a dwarf galaxy, its stellar mass would be of the order of $10^7 M_\odot$, according to the mass–metallicity relation for dwarf galaxies (Kirby et al. 2013). This relation could remain valid even if the object is tidally stripped.

Since FSR 1758 is close in projection to two other GCs belonging to the Bulge, Ton 2 and NGC 6380, we explored the possibility of a real association with any of them. We found that they all share similar PMs; all three clusters might be plunging onto the Galactic disk.

With an angular separation of only $0^\circ.8$ and a probable physical separation of about 600 pc (perhaps even smaller considering the large errors in the distances), the association of FSR 1758 with NGC 6380 (Harris 1996, 2010) is strong. They might be a binary cluster or part of a larger structure like a dwarf galaxy. However, their compositions are different by 0.7 dex, with NGC 6380 being more metal-rich. The angular separation between Ton 2 and FSR 1758 is $1^\circ.4$. The distance to the former cluster is believed to be $D = 8.2$ kpc, although it is not well established, and its metallicity was determined to be [Fe/H] = −0.70 dex. Given the different metallicities, a putative association is not strongly supported. In addition, the radial velocities of Ton 2 and NGC 6380 are very different, −182 km s^{-1} and −4 km s^{-1}, respectively, so these clusters are definitely not associated with each other.

Spectroscopic data of a number of stellar members of FSR 1758 are essential, not only to compute the radial velocity, necessary to determine the orbital path of the object, but also to derive information about its origin and potential association with any of the known GCs and to obtain metallicity estimates. Combining the velocity dispersion and metallicities for various stars will allow us to definitively determine the nature of this object by estimating its dark matter content and whether or not it possesses a metallicity spread.

6. Conclusions

FSR 1758 is a new GC recently discovered serendipitously in the Milky Way Bulge. In this Letter, we used combined data from the *Gaia*, DECaPS, and VVVX surveys to determine the cluster physical parameters for the first time, including its position, distance, reddening, size, metallicity, and mean PM. The cluster is centered at equatorial coordinates $\alpha =$ 17:31:12, $\delta = -39$:48:30 (J2000), and Galactic coordinates $l = 349^\circ.217$, $b = -3^\circ.292$ degrees. A distance of $D = 11.5 \pm 0.5$ kpc was estimated using the optical and near-IR CMDs, and confirmed with OGLE RR Lyrae variable stars. From the CMDs, extinction values were also measured, resulting in $E(J - Ks) = 0.20 \pm 0.03$ mag, and $E(BP - RP) = 0.90 \pm 0.05$ mag. The metallicity of FSR 1758 was estimated to be [Fe/H] = -1.5 ± 0.3 dex, based on the appearance of the RGB in the optical and near-IR CMDs. Finally, its derived mean PM, $\mu_\alpha = -2.85$ mas yr^{-1} and $\mu_\delta = 2.55$ mas yr^{-1}, indicates that this cluster is plunging onto the Galactic plane. The acid test for this cluster will be to obtain spectra for a number of members. The measurement of radial velocities which, combined with the distance and PM information, will give us the orbital parameters for the individual stars, and the chemical information will allow us to search for any metallicity variation or the presence of multiple populations.

The stellar density distribution shows that FSR 1758 is a very large cluster, with a core radius $R_c = 10$ pc and a large tidal radius of about $R_t = 150$ pc, with a lower limit for the i-band luminosity of about $M_i < -8.6$. The inspection of a larger field of view of several degrees around the cluster led to the detection of extended streaming motions, i.e., a collection of stars with characteristics similar to the BHB and RGB stars of the cluster, with coherent PMs, and moving parallel to the cluster. This points to the hypothesis that this object is actually much larger, possibly the nucleus of a dwarf galaxy.

The census of Galactic GCs is not complete, and several low-luminosity GCs may still be missing in the Galactic Bulge (Bica et al. 2016; Minniti et al. 2017a; Camargo 2018; Ryu & Lee 2018). The discovery of FSR 1758 represents a paradigm shift, as it clearly shows that not only low-luminosity GCs may be missing in the Bulge, but also some quite luminous and massive ones. Future searches to be carried out with the Large Synoptic Survey Telescope (Ivezic et al. 2008) or with the Wide Field Infrared Survey Telescope (Spergel et al. 2015; Stauffer et al. 2018) might detect more GCs hidden in this region. Finally, the recently started multi-epoch observation campaign for the VVVX survey would significantly extend the areal coverage, allowing us to search for more RR Lyrae variable stars likely associated with this new large GC.

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