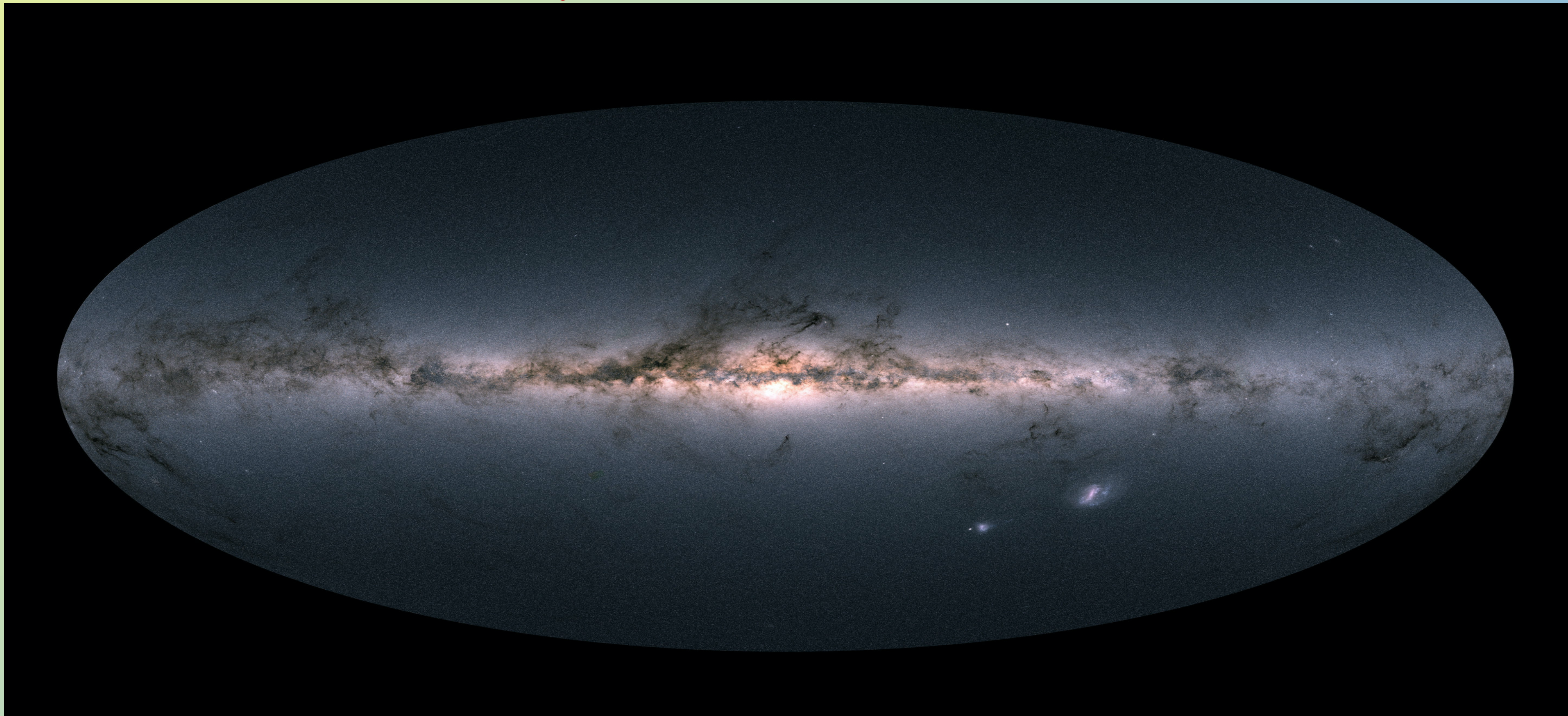
VVVX—Gaia Discovery of a Low Luminosity Globular Cluster in the Milky Way Disk

by E.R. Garro et al. 2020



Credit: Gaia Data Processing and Analysis Consortium (DPAC)

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VVVX Survey

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Abstract

Context. Milky Way globular clusters (GCs) are difficult to identify at low Galactic latitudes because of high differential extinction and heavy star crowding. The new deep near-IR images and photometry from the VISTA Variables in the Via Láctea Extended Survey (VVVX) allow us to chart previously unexplored regions.

Aims. Our long term aim is to complete the census of Milky Way GCs. The immediate goals are to estimate the astrophysical parameters for the newly discovered globular cluster candidates, measuring their reddenings, extinctions, distances, total luminosities, proper motions, sizes, metallicities and ages.

Methods. We use the near-IR VVVX survey database, in combination with Gaia DR2 optical photometry and proper motions (PMs), and with the Two Micron All Sky Survey (2MASS) photometry, to search and characterize new GCs within the Southern Galactic plane ($|b| < 5^{\circ}$).

Results. We report the detection of a heretofore unknown Galactic Globular Cluster, VVVX-GC-140900-653712 (hereafter Garro01 for short) at $RA = 14:09:00.0$; $DEC = -65:37:12$ (J2000) corresponding to $l = 310.828$ deg; $b = -3.944$ deg in galactic coordinates. We calculate a reddening of $E(J-Ks) = (0.3 \pm 0.03)$ mag and an extinction of $A_{Ks} = (0.15 \pm 0.01)$ mag for this new GC. Its distance modulus and corresponding distance were measured as $(m-M) = (15.93 \pm 0.03)$ mag and $D = (15.5 \pm 1.0)$ kpc, respectively. We also estimate the metallicity and age by comparison with known globular clusters and by fitting PARSEC and Dartmouth isochrones, finding $[Fe/H] = (-0.70 \pm 0.2)$ dex and $t = (11.0 \pm 1.0)$ Gyr. The mean GC proper motions (PMs) from Gaia DR2 are $\mu_{\alpha*} = (-4.68 \pm 0.47)$ mas/yr and $\mu_{\delta} = (-1.34 \pm 0.45)$ mas/yr. The total luminosity of our cluster is estimated to be $M_{Ks} = (-7.76 \pm 0.5)$ mag. The core and tidal radii from the radial density profile are $r_c \sim 2.1'$ (5.6 pc) and $r_t = 6.5'$ (14.6 pc) at the cluster distance.

Conclusions. We have found a new low-luminosity, old and metal-rich globular cluster, situated in the far side of the Galactic disk, at $R_G = 11.2$ kpc from the Galactic centre, and at $z = 1.0$ kpc below the plane. Interestingly, the location, metallicity and age of this globular cluster are coincident with the Monoceros Ring (MRi) structure.

Our work!

In this type of study, the main problems that an astronomer must overcome are reddening, and extinction. These are due to the dust bank, between us observers and the target, which absorbs the star light. The effect of the dust is mainly to redden your object. Another problem is the stellar crowding, because of high densities of stars in some regions of the Milky Way, as bulge and disk. All of those problems introduce uncertainties in your calculation. In order to reduce them, we used a combination of near-IR and optical data, obtained with the VVVX, the 2MASS, and Gaia DR2 surveys, with the purpose to derive the main parameters for Garro01. The main steps to characterize this globular cluster are summarized below.

1. Figure 1 shows the PM_RA as a function of PM_DEC. There is a clear over-density, inside the black circle, indicating the presence of stars with similar PMs. The mean GC PMs are: $\mu_{\alpha*} = (-4.68 \pm 0.47)$ $mas\ yr^{-1}$; $\mu_{\delta} = (-1.34 \pm 0.45)$ $mas\ yr^{-1}$. We select these stars in order to building-up a clean, decontaminated catalogue of highly-probable cluster members.

2. We use the red clump (RC) stars at $K_s = 14.48$ mag and $G = 17.70$ mag and reddening maps of Ruiz-Dern et al. (2018) in the near-IR and Schlafly & Finkbeiner (2011) in the optical to calculate:

- ✦ $A_{Ks} = (0.15 \pm 0.01)$ mag and $E(J - Ks) = (0.3 \pm 0.03)$ mag;
- ✦ $(m - M) = (15.93 \pm 0.03)$ mag, and therefore $D = (15.5 \pm 1.0)$ kpc;
- ✦ In Figures 2 and 3 are displayed the color-magnitude diagrams (CMDs) in near-IR (*Ks vs. J-Ks*), optical (*G vs. BP-RP*) and and respective matches (*Ks vs. G-Ks* and *G vs. G-Ks*). Red and yellow points are star members from VVVX and Gaia survey, while gray and black points are stars from the 2MASS catalogue. The cluster metallicity is derived following two different methods. Firstly, we compare Garro01 with the fiducial GC 47 Tuc (red lines in Figure 3). Secondly, we use the fitting-isochrone method, preferring both PARSEC (Marigo et al. 2017, black dotted lines in Figure 2) and Dartmouth (Dotter et al. 2008) isochrones. Both methods provide $[Fe/H] = (-0.70 \pm 0.2)$ dex and α-enhanced between 0 and +0.4 dex. The cluster appears to be slightly younger than 47 Tuc because we estimate an age $t = (11.0 \pm 1.0)$ Gyr.

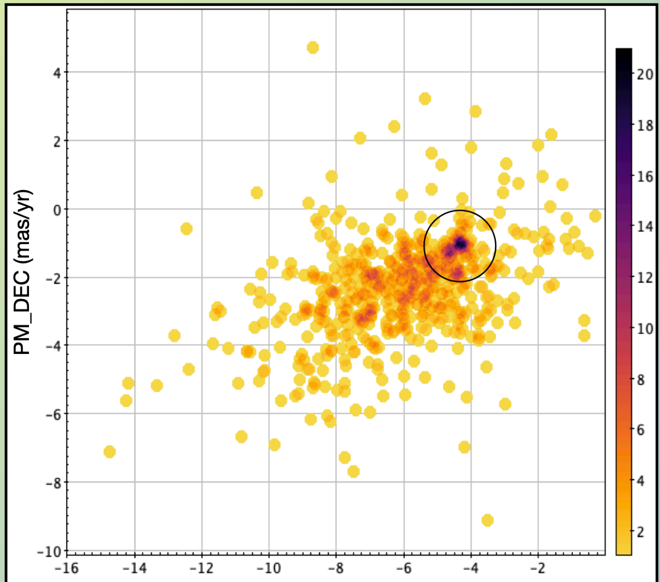

Figure 1

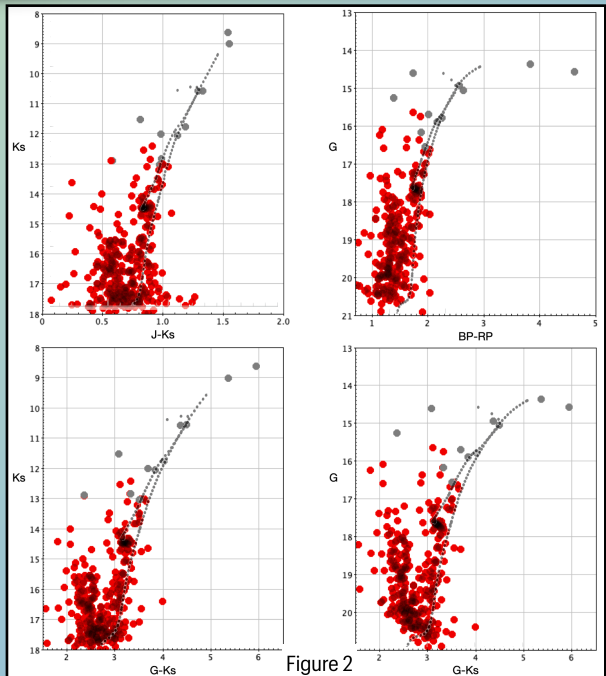

Figure 2

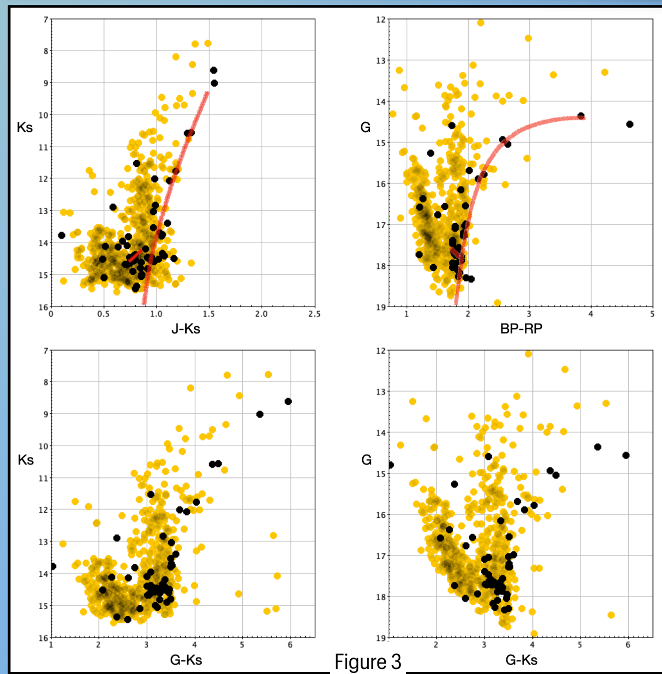

Figure 3

4. The integrated absolute magnitude is estimated coadding the RGB stars from the PM decontaminated diagrams. We find $M_{K_S} = (-7.76 \pm 0.5)$ mag, equivalent to $M_V = (-5.26 \pm 1.0)$mag for typical GC mean colours $V - K = (2.5 \pm 0.94)$ mag. This represents a lower limit since sub-giant branch and main-sequence stars are below the observational limit. Benefiting from strong resemblance 47 Tuc, we also estimated the total luminosity for Garro01, obtaining $M_V = -5.62$ mag, placing this GC on the low-luminosity tail of the MW GCLF, ~ 2 magnitudes fainter than the peak of the MW GCLF ($M_V = (-7.4 \pm 0.2)$ mag from Harris 1991; Ashman & Zepf 1998).

5. Its size is derived performing the radial density profile and using the King profile (King 1962), we obtain a core radius of $r_c = (2.1 \pm 1.47)$ arcmin is equivalent to a physical size $r_c = 4.6$ pc, and a tidal radius of $r_t = (6.5 \pm 11)$ arcmin, corresponding to 14.6 pc, consistent with the typical galactic GC sizes as listed in the 2010 Harris (1996) compilation .

6. As Figures 3 and 4 shown, another interesting implication is that the location and distance, but also the metallicity of this GC match those of the MRi structure, a potential accretion event recently identified in the Galactic plane (Newberg et al. 2002). This connections must still confirmed from follow-up spectroscopy.

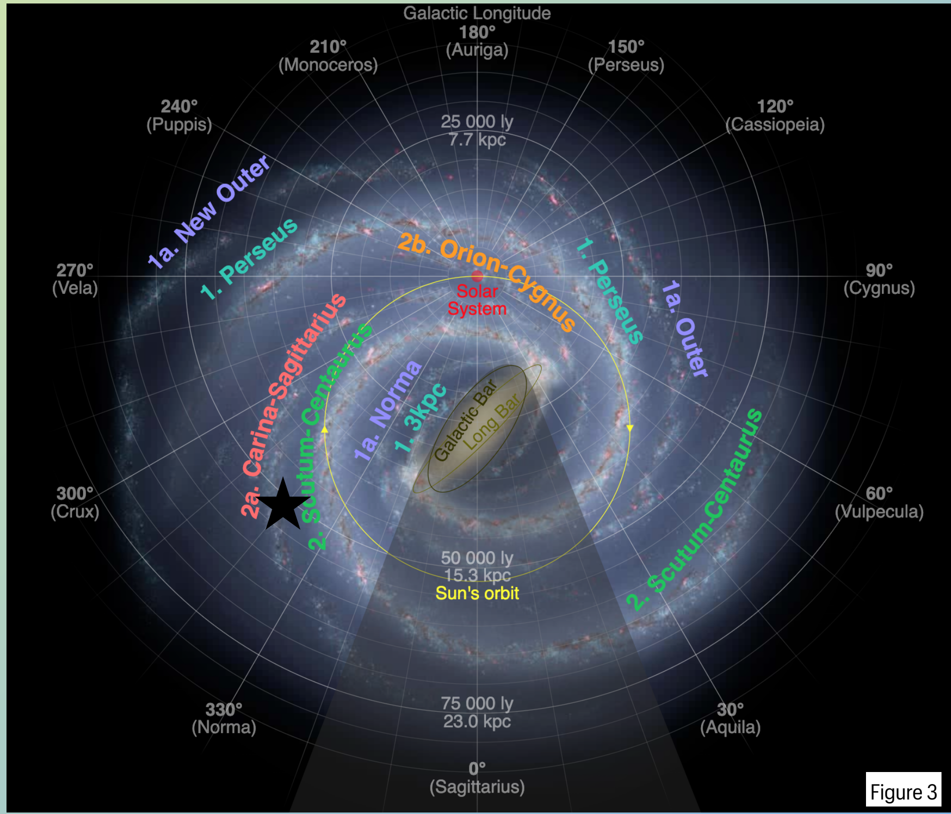

Figure 3

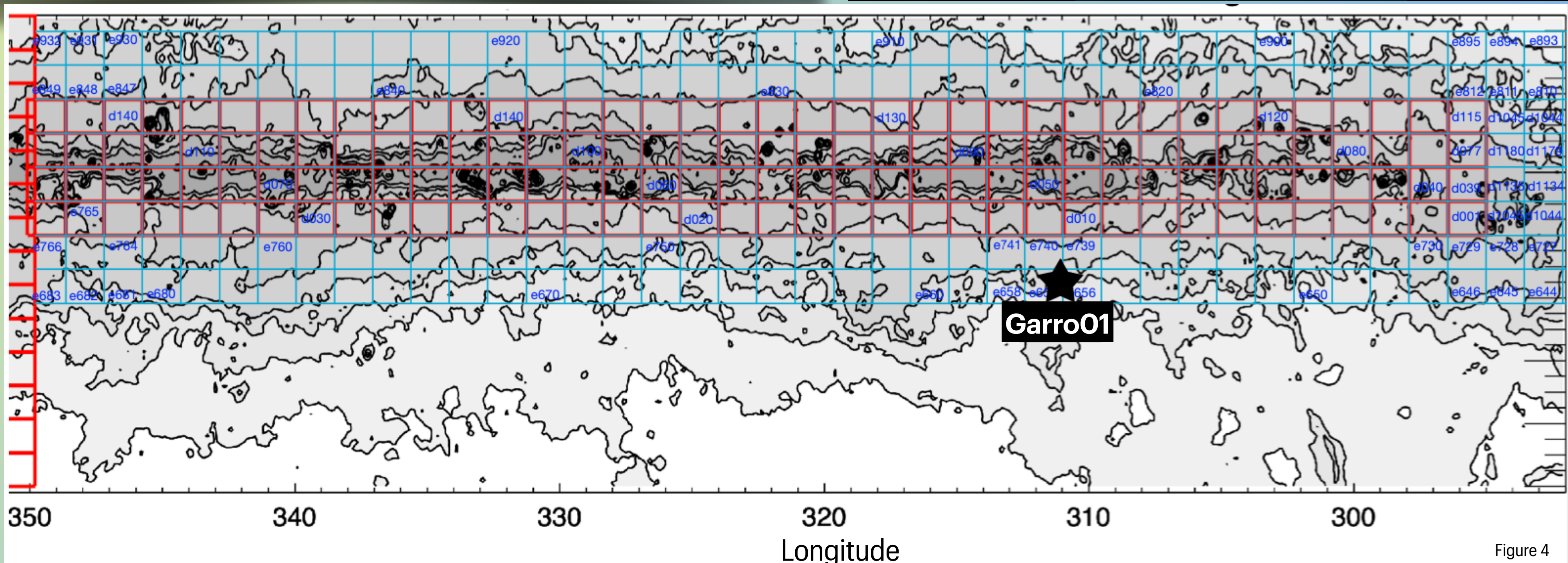

Figure 4