

NTT V , I colour-magnitude diagrams of the bulge globular cluster Tonantzintla 2^{*}

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Received March 5; accepted April 9, 1996

Abstract. — Ton 2 is among the less-known Galactic globular clusters. We present for the first time colour magnitude diagrams in the V , I bands. We used the ESO NTT telescope under an excellent seeing of $0.6''$. The horizontal branch is red and close to the red giant branch, tilted by some differential reddening. The horizontal branch morphology and the red giant branch curvature suggest a metallicity similar to that of 47 Tucanae. We derive a reddening of $E(B - V) = 1.26$ and a distance $d_{\odot} = 6.4$ kpc. Therefore, Ton 2 is ≈ 2.0 kpc from the Galactic center, and it appears to belong to the bulge population, being however only moderately metal rich.

Key words: globular clusters: Ton 2 — HR diagram

1. Introduction

The globular cluster Tonantzintla 2 (Pismis 26) was discovered by Pismis (1959) on Schmidt plates taken at the Tonantzintla Observatory, Mexico. The cluster is also designated GCL B1732-3831, BH 236 and ESO 333-SC16. The $B=1950.0$ coordinates are $\alpha = 17^{\text{h}} 32^{\text{m}} 43.8^{\text{s}}$, $\delta = -38^{\circ} 31' 20''$. It is projected rather close to the Galactic center at $l = 350.796^{\circ}$ and $b = -3.423^{\circ}$.

By means of the bright giants method Webbink (1985) estimated that the horizontal branch (HB) is at $V_{\text{HB}} = 18.2$, with a reddening of $E(B - V) = 0.91$ from a modified cosecant law, deriving a distance from the Sun $d_{\odot} = 8.7$ kpc. No metallicity estimate is available, and no colour-magnitude diagram (CMD) has so far been published for the cluster.

The cluster structure is moderately loose, with a concentration parameter $c = 1.30$, and it does not have a post-core-collapse morphology (Trager et al. 1995).

In the present paper we analyse the CMDs of Ton 2 in the V and I bands. In Sect. 2 we describe the observations. In Sect. 3 the CMDs are presented, and in Sect. 4 the cluster parameters are measured. Finally, concluding remarks are given in Sect. 5.

2. V and I photometry

The observations were obtained at the European Southern Observatory (ESO), using the 3.55 m New Technology Telescope (NTT). We used the SUSI camera, with a 1024×1024 thinned Tektronix CCD at the Nasmyth focus B . The pixel size is $24 \mu\text{m}$ ($0.13''$ on the sky), and the frame size is $2.2' \times 2.2'$.

The data were collected under excellent seeing conditions ($0.6''$). We give the log-book of observations in Table 1. We show in Fig. 1 a V image of Ton 2; it is clear that Ton 2 is not compact.

We carried out the reductions with the DAOPHOT II package. The reduction procedure was described in detail in the study of Liller 1 (Ortolani et al. 1996a), which was observed in the same run. The main sources of error in the photometry are the zero point accuracy (± 0.03 mags), and in crowded regions the magnitude transfer from the cluster images to the standard stars which can amount to 0.05 mags. The photometric errors in the stellar extractions are approximately constant up to $I = 17.5$, which amount to 0.02 mags; at $I = 18.5$ the error increases to 0.07 mags.

3. Description of the colour-magnitude diagrams

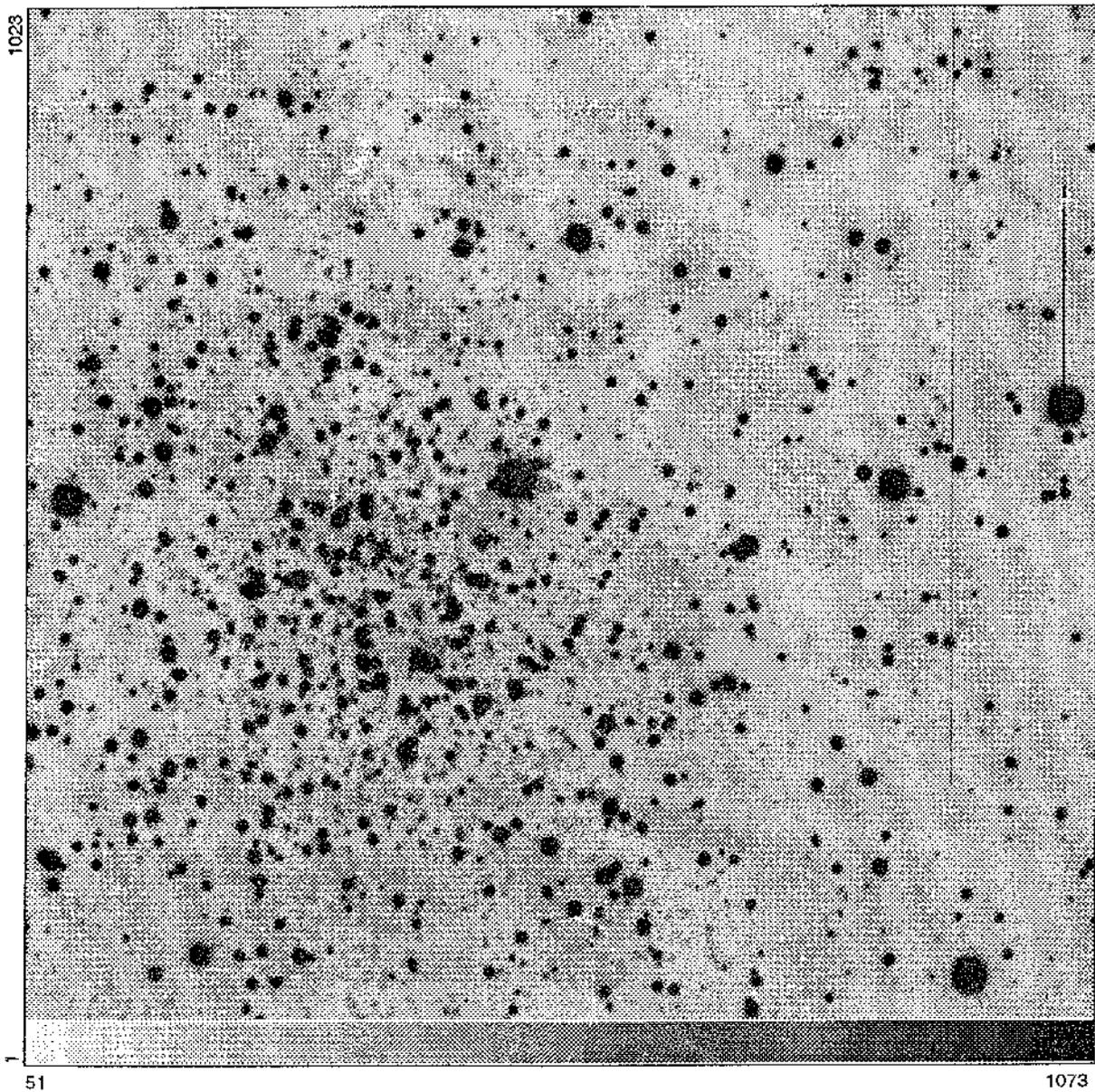
We show in Fig. 2 a V vs. $(V - I)$ diagram for the whole $2.2' \times 2.2'$ frame. The VI data are given in Table 2 available only in electronic form at the CDS. One notices a field blue disk main sequence (MS), and a wide red giant

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*Observations collected at the European Southern Observatory, La Silla, Chile; Table 2 is available only in electronic form at the CDS via anonymous ftp 130.79.128.5

Table 1. Log-book of observations

Target	Date	Equipment	Filter	Exp.(s)	Seeing(FWHM'')
Ton 2	16.05.1994	NTT + SUSI	I	60	0.6
"	"	"	I	300	0.6
"	"	"	V	60	0.6
"	"	"	V	300	0.6

**Fig. 1.** V image of Ton 2, obtained with a seeing of $0.6''$. Dimensions are $2.2' \times 2.2'$

branch (RGB), which corresponds to the superposition of the cluster and bulge field stars.

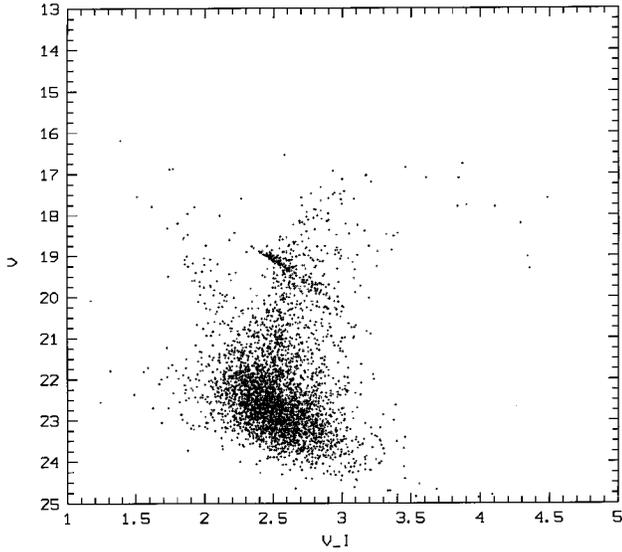


Fig. 2. V vs. $(V - I)$ CMD of Ton 2 for the whole frame

In Figs. 3a,b we plot the stars within a radius $r < 39''$, centred on the cluster, respectively for V vs. $(V - I)$ and I vs. $(V - I)$. In these figures the cluster sequences become clear. The horizontal branch (HB) is red, and it is partially superimposed on the RGB. The HB is tilted and extended, suggesting some differential reddening. The cluster RGB is curved in Figs. 3a,b, which can be used as metallicity criterion in the metal rich domain (Ortolani et al. 1991). The method consists in (a) locating the turn-over of the RGB point in the V vs. $(V - I)$ CMD, which is at $\Delta(V - I) \approx 0.9$ mag redder than the red HB center; (b) interpolating a straight line from this reference point up to the RGB tip in both V vs. $(V - I)$ and I vs. $(V - I)$ diagrams; (c) measuring the slope of this line. The method is independent of reddening; only a strong differential reddening might affect the results, which is not the case of Ton 2. We measured the slopes of the reddest part of the RGB, and obtained $\Delta V / \Delta(V - I) = 0.58 \pm 0.10$ and $\Delta I / \Delta(V - I) = -0.50$. Comparing these values to those given in Ortolani et al. (1991) and Ortolani et al. (1996b), we would assign a metallicity of $[\text{Fe}/\text{H}] \approx -0.9$ to Ton 2. On the other hand, by inspection of VI CMDs of NGC 6356 and 47 Tuc in Bica et al. (1994), we see that the HB red clump is closer to the RGB in Ton 2 than in 47 Tuc, which would indicate that it is slightly more metal-rich than 47 Tuc, more like NGC 6356. A compromise between these two indicators would be $[\text{Fe}/\text{H}] \approx -0.6$ for Ton 2.

The turn-off (TO) region has been reached, but the exact value of the magnitude difference between the HB and TO levels cannot be precisely derived with the present data. Recently, Ortolani et al. (1995) have studied with

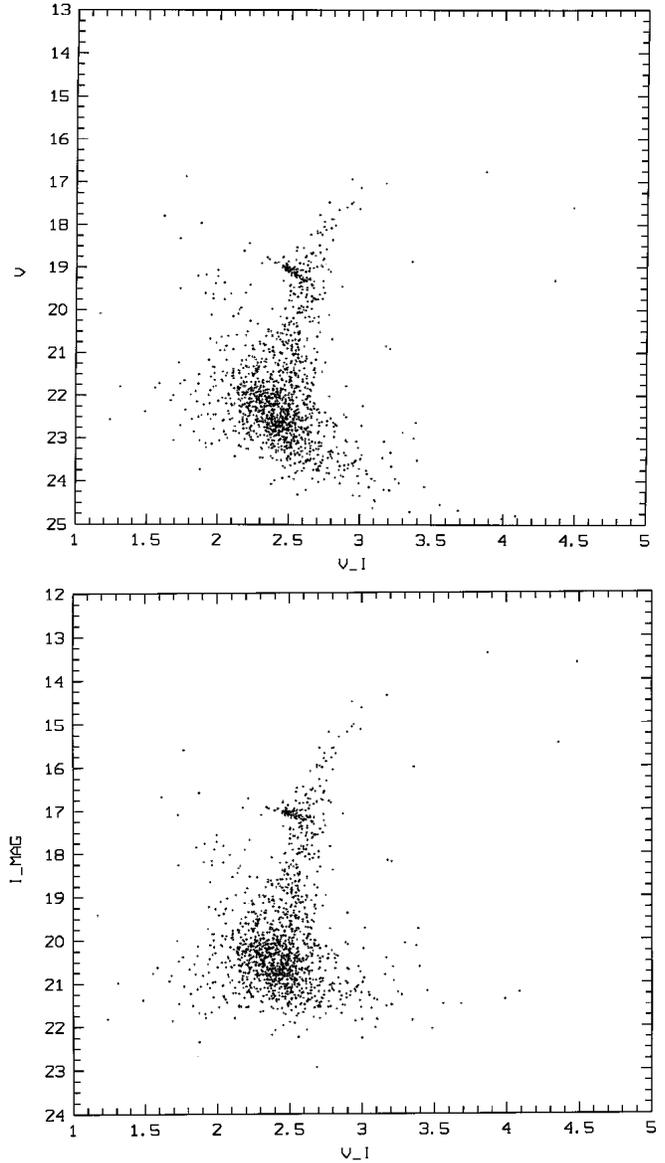


Fig. 3. CMDs of Ton 2 for an extraction of radius $r < 39''$ centred on the cluster: **a)** V vs. $(V - I)$, **b)** I vs. $(V - I)$

Hubble Space Telescope (HST) photometry the bulge globular clusters NGC 6528 and NGC 6553, and concluded that these nearly solar metallicity clusters are coeval with halo clusters. Since Ton 2 appears to belong to the bulge, and has a metallicity similar to that of 47 Tucanae (Sect. 4), it is a good candidate for age determinations with the HST.

4. Reddening and distance

We calculate the cluster reddening taking 47 Tucanae as a reference, since their metallicities are similar. The $(V - I)$ colour of the RGB at the HB level for Ton 2 is 2.61 ± 0.05 , while that of 47 Tucanae is $(V - I) = 0.99 \pm 0.03$, which

leads to $E(V - I) = 1.67$ and $E(B - V) = 1.26$ for Ton 2, assuming $E(B - V) = 0.04$ for 47 Tucanae (Zinn 1985), and $E(V - I)/E(B - V) = 1.33$ (Dean et al. 1978). Our value, directly derived from the CMD, is considerably higher than that reported in Webbink (1985).

The magnitude difference between the HB levels of Ton 2 and 47 Tucanae is $\Delta V = 5.05 \pm 0.15$. Using $A_V = 3.91$ for Ton 2 ($A_V/E(B - V) = 3.1$), and $(m - M)_0 = 12.89$ for 47 Tucanae (Zinn 1985), we obtain $(m - M)_0 = 14.03 \pm 0.2$ and a distance from the Sun $d_\odot = 6.4 \pm 0.6$ kpc for Ton 2, thus closer than Webbink's (1985) estimation.

Assuming a distance of the Sun to the Galaxy center of $R_\odot = 8.0$ kpc (Reid 1993), the Galactocentric coordinates are $X = 1.7$ ($X > 0$ refers to our side of the Galaxy), $Y = -1.0$ and $Z = -0.38$ kpc.

5. Conclusions

We observed Ton 2 in the V and I passbands, under excellent seeing conditions, and obtained deep CMDs. For the first time reliable cluster parameters are derived. A reddening of $E(B - V) = 1.26$ and a distance $d_\odot = 6.4$ kpc are found. This puts the cluster at ≈ 2 kpc from

the Galactic center, in the bulge. The horizontal branch morphology is red and the RGB has curvature effects, which leads to a metallicity estimation of $[\text{Fe}/\text{H}] \approx -0.6$. Due to the location of Ton 2 at about 2 kpc from the Galactic center, this could be a lower metallicity tail of the bulge population, or it might be another inner halo class of clusters such as 47 Tuc and NGC 6356.

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