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# NGC 6522: an intermediate metallicity globular cluster projected on the Baade Window*

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**Abstract.** We studied NGC 6522 colour magnitude diagrams using CCD photometry with BV filters. We have carefully estimated the reddening, which is critical for Baade Window studies, obtaining E(B-V) = 0.55. We derive for this intermediate metallicity cluster, a distance of 6.2 kpc, slightly foreground to the bulk of the metal-rich bulge population. The CMD properties of the cluster core show an enhanced and extended blue horizontal branch, a characteristic in common with many other core collapsed globular clusters.

**Key words:** globular clusters: NGC 6522 – Galaxy: center – Galaxy: abundances – HR diagram

## 1. Introduction

NGC 6522 = GCL-82 = ESO456-SC43 is projected on the Baade Window (BW) at l=1.03°, b=-3.93° ($\alpha_{1950}$=$18^h00^m23^s$, $\delta_{1950}$=-30°02.2'). The cluster is very concentrated with c = 2 (Peterson & Cameron Reed 1987). It appears to be a post collapse cluster (Djorgovski & King 1986). Integrated light studies, both with photometry and spectroscopy, provide metallicities in the range $-1.44 < [Fe/H] < -1.05$ and reddening $0.51 < E(B\text{-}V) < 0.60$ (Zinn 1980; Bica & Pastoriza 1983; Zinn & West 1984). This intermediate metallicity suggests that NGC 6522 is not associated to BW bulge stellar population. On the other hand, the other globular cluster projected on the BW, NGC 6528 is as metal-rich and appears to be at similar distance as the bulk of the bulge stellar population (Ortolani et al 1992).

Several V vs (B-V) Colour Magnitude Diagrams (CMD) have been published for NGC 6522 (Arp 1965; van den Bergh 1971; Blanco & Blanco 1985; Walker & Mack 1986, hereafter WM86). They provide $0.45 < E(B\text{-}V) < 0.56$ and the horizontal branch (HB) level varies from $16.0 < V_{HB} < 16.97$. The latter uncertainty is probably due to the fact that the photometries are not deep enough to clearly define the HB properties. In the present study we provide deep CCD photometry in Johnson-Cousins BVI bands, and employ modern reduction techniques for photometry in crowded fields to derive the cluster main properties.

The CCD observations and reductions are presented in Sect. 2. In Sect. 3 the CMDs are shown, and the cluster CMD morphology is analysed. The cluster parameters are derived in Sect. 4. The main conclusions drawn in this work are summarized in Sect. 5.

## 2. Observations and reductions

NGC 6522 was observed with the Danish 1.5m ESO telescope at La Silla, Chile, in June 1992 (Fig. 1). The thinned RCA CCD ESO #5 of 512 × 320 pixels was used. The pixel size is $30 \times 30\mu$ giving a sky projected size of $0.47'' \times 0.47''$. As described in Table 1, a set of Johnson-Cousins B, V and I images was secured in fairly good seeing conditions. During that night, however, the sky conditions were only marginally photometric and no absolute zero point for the photometry could be determined.

The calibration was then obtained using the stars measured by van den Bergh (1971) numbers 67, 129, 196, 132 and M which are sufficiently far from our saturation limit, well distributed in our field around the cluster and free from nearby companions. These stars are in the range $13 < V < 15$, where more recent measurements (WM86) show that the agreement with modern CCD photometry is, on the average, very good. If Blanco & Blanco (1984) stars are used, the colour is shifted by 0.03 mag. to the blue. Colour term corrections were taken from Landolt (1973) standard stars observed during photometric nights ($K_B$ = 0.13 and $K_V$ = 0.04), following our standard procedure described in detail in Ortolani et al (1993). The comparison of our instrumental magnitudes with van den Bergh's photometry gives standard errors of $\sigma V = 0.05$ and $\sigma(B\text{-}V) = 0.06$ without any systematic trend indication. No calibration is available for the I colour.

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* Observations collected at the European Southern Observatory, La Silla, Chile

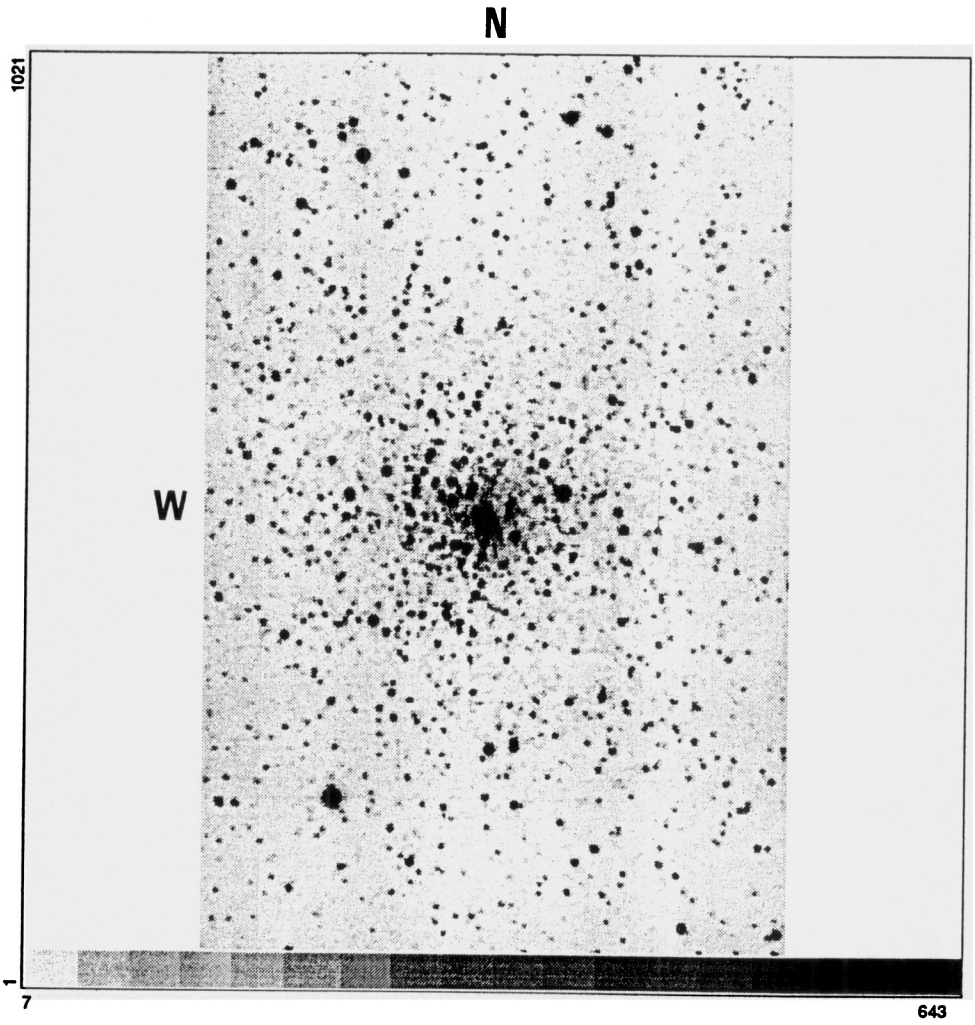


**Fig. 1.** V frame of NGC 6522 of size 2.5′ × 4.5′. Axes are in pixels

**Table 1.** Log-book of the observations

| Filter | Date | UT | Exp.time(s) | Seeing |
|---|---|---|---|---|
| *V* | 24.05.92 | $6^H01^M$ | 60 | 1.3″ |
| *V* | ” | $6^H06^M$ | 480 | 1.3″ |
| *V* | ” | $6^H20^M$ | 480 | 1.3″ |
| *I* | ” | $6^H29^M$ | 20 | 1.2″ |
| *I* | ” | $6^H37^M$ | 300 | 1.2″ |
| *I* | ” | $6^H46^M$ | 300 | 1.2″ |
| *B* | ” | $7^H48^M$ | 1200 | 1.4″ |
| *I* | ” | $7^H55^M$ | 300 | 1.3″ |

The reductions of the original CCD frames (flatfield and instrumental magnitude measurements) was carried out at the computer center of the Department of Astronomy in Padova using Midas and Daophot II code.

## 3. The CMD analysis

Figure 2 presents the V vs (B-V) CMD for a ring of 7″ < r < 56″ centered on the core, intended to measure the cluster properties outside the very center.

In Fig. 3 we show stars for r > 75″, intended to measure mostly the field background.

Two shifted sequences appear in both CMDs: one from NGC 6522 and the other from the field, which corresponds to the BW population. The bulge field stars are mostly in the red part of the diagram: the metal-rich HB is seen at V ≈ 17.0, (B-V) ≈ 1.75; the red giant branch (RGB) shows no tip, which is expected in metal-rich populations, since the tip stars are fainter and bluer, mixing with the ascending RGB, like in the high metallicity clusters NGC 6553, NGC 6528 and Terzan 1 (Ortolani et al 1990, 1992, 1993).

The cluster CMD appears more evident in Fig. 2. The extended blue HB nature of this cluster is evident. As discussed by Djorgovski & King (1986), NGC 6522 has evidence of core collapse. This effect of enhanced blue HB was also observed in NGC 6752 (Aurière & Ortolani 1989). Therefore NGC 6522 is

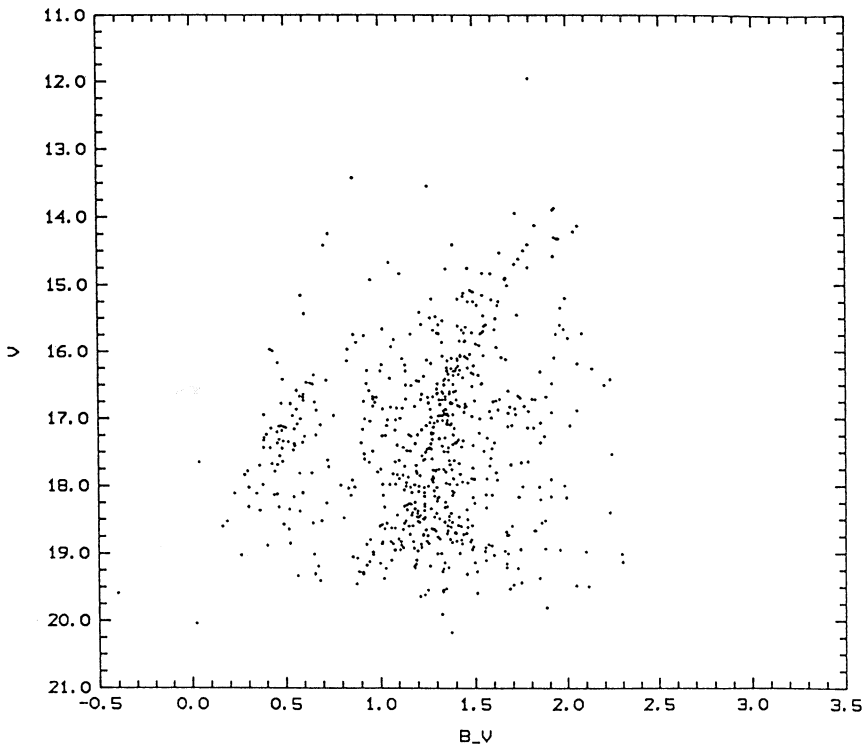


**Fig. 2.** V vs (B-V) CMD for spatial extraction of stars in $7'' < r < 56''$ representing the cluster outside the core

another cluster with core CMD properties in common with many other core collapsed clusters (Fusi Pecci et al 1993). Recently we also found the same CMD effect in the globular cluster NGC 6540 (Bica et al 1993).

The cluster CMD is also crossed by a young disk main sequence (MS), intersecting the HB in the area of the RR Lyrae gap. This young MS is clearly seen in Fig. 3. The shape of the cluster CMD is very similar to that of NGC 6752, in particular the extended blue HB (Aurière & Ortolani 1989). Superimposing the CMD of NGC 6522 to that of the central part of NGC 6752, we derive a shift $\Delta$(B-V) $\approx$ 0.5$\pm$0.05 mag, and then the HB at the RR Lyrae gap level can be clearly recognized at V $\approx$ 16.2. The fit with NGC 6752 is quite good, except that the red giant branch (RGB) of NGC 6522 seems slightly more tilted than that of NGC 6752, possibly due to a small metallicity difference. A similar behaviour is seen in WM86. There are a few stars in the red HB zone, however it is hard to judge their membership to the cluster because of field contamination.

## 4. Cluster parameters

The accurate reddening determination for NGC 6522 is of great importance because of its projection close to the BW center, which is a reference field for the studies of the Galactic bulge population. The reddening is fundamental for the derivation of temperatures of cool stars, with important implications on the abundance scale of the BW population.

From the colour shift relative to NGC 6752 (Sect. 3), and the latter cluster reddening of E(B-V) = 0.04 (Webbink 1985), we deduce a total reddening for NGC 6522 of E(B-V) $\approx$ 0.54$\pm$0.05, if the metallicity of the two clusters is comparable. An independent check is obtained from the blue edge of the RR Lyrae gap, following Blanco & Blanco (1985). The measured value is (B-V) = 0.70$\pm$0.07 to be compared with an intrinsic one of (B-V) $\approx$ 0.15, giving E(B-V) = 0.55. These values are in good agreement with E(B-V) = 0.51, 0.56 and 0.60 derived by Zinn (1980), WM86 and Bica & Pastoriza (1983) respectively. For the neighbouring cluster NGC 6528, (Ortolani et al 1992) obtained E(B-V) = 0.55. All these values are somewhat higher than that discussed by Terndrup (1988) in his analysis of the BW field population (E(B-V) $\approx$ 0.45).

Adopting E(B-V) = 0.55, the distance of NGC 6522 can be derived from the HB level, assuming an absolute magnitude of $M_V$ = 0.6 (Buonanno et al 1989). From $V_{HB}$ = 16.2, we get $(m-M)_o$ = 13.95 or a distance of $d_\odot \approx$ 6.2 kpc from the Sun. This places the cluster slightly in the foreground of the bulk of the BW stellar population. As the cluster appears to be closer than the BW, it should possibly be preferable to adopt, for the BW a reddening E(B-V) $\geq$ 0.55, since an inspection of sky survey plates suggests that the cluster is in one of the less reddened zones of the BW.

WM86 obtained for NGC 6522 a distance of 8.3 kpc using a reddening similar to ours, but assuming that the four RR Lyrae close to NGC 6522, with V = 16.97, belong to the cluster. This value seems however too low according to our CMD. Adopting a distance for the Galactic center of 8.0 kpc (Feast 1987), our $d_\odot$ = 6.2 kpc results in Galactocentric coordinates X = 1.8, Y = 0.1 and Z = $-$0.4 kpc.

The metallicity of NGC 6522 is extensively discussed in the literature. A summary is presented in WM86. From integrated light Zinn & West (1984) found [Fe/H] = -1.44, similar to that

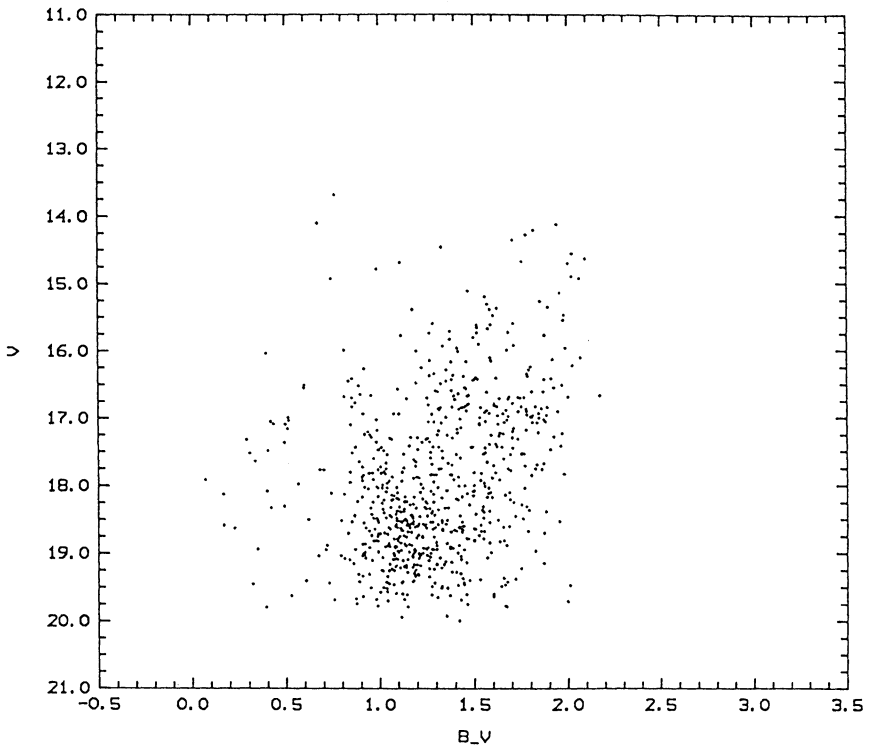


**Fig. 3.** Same as Fig. 2 for r > 75″, representing mostly field stars

of NGC 6752. The blue extended HB of NGC 6522 and the relatively steep RGB make this cluster resembling more intermediate metallicity clusters such as NGC 6752 (Aurière & Ortolani 1989) than 47 Tuc (Hesser et al 1987; Aurière & Ortolani 1988) which shows a quite different CMD morphology. However, as discussed in Sect. 3, the slightly flatter RGB of NGC 6522 with respect to that of NGC 6752, could be due to a somewhat higher metallicity. Preliminary studies of low-resolution spectra of 2 stars in NGC 6522 by Castro et al (1993) indicate rather [Fe/H] $\approx$ -1.0. Regarding the extended blue HB, R. Buonanno (private communication) recently proposed that the second parameter, establishing the HB morphology in globular clusters, could be the cluster concentration. In that case, core collapse clusters like NGC 6522 are expected to show a blue tail.

## 5. Conclusions

From CCD BV photometry, we find that the CMD morphology of NGC 6522 is that of an intermediate metallicity cluster. It has an extended blue HB, which appears to be enhanced at the central parts, which sets this cluster as another case of core collapse with such characteristic.

We derive the following cluster parameters: E(B-V) $\approx$ 0.55, $d_{\odot} \approx$ 6.2 kpc. This projected cluster on the Baade Window is consequently slightly foreground to the metal-rich bulge population. The cluster reddening should be a lower limit to be adopted in Baade Window studies, since NGC 6522 is apparently located in one of its less reddened zones.

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