NGC 6738: not a real open cluster

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Abstract. An abstract should be given

Photometric, astrometric and spectroscopic investigation of the poorly studied open cluster NGC 6738 has been performed in order to ascertain its real nature. NGC 6738 is definitely not a physical stellar ensemble: photometry does not show a defined mean sequence, proper motions and radial velocities are randomly distributed, spectro-photometric parallaxes range between 10 and 1600 pc, and the apparent luminosity function is identical to that of the surrounding field. NGC 6738 therefore appears to be an apparent concentration of a few bright stars projected on patchy background absorption.

Key words. Open Clusters: general – Open Clusters: individual (NGC 6738)

1. Introduction

NGC 6738 (α²⁰⁰⁰ = 19h01m4, δ²⁰⁰⁰ = +11°36′, l = 44°A, b = +3°.1) shows up as a group of bright stars on a fairly crowded background located a few degrees from the galactic equator in Aquila. It is classified as IV₂p meaning that the object is poorly populated and separated from the surrounding field and spans a moderate range in brightness (Ruprecht 1966). No modern data exist for this object. Collinder (1931) found a distance of 1190 pc and Roslund (1960) reported, by means of objective prism spectral classification, that the stars down to 12 mag in the region of the cluster are dwarfs but they do not appear to define a main sequence, thus already challenging the reality of the object. In another study, Sahade et al. (1983) listed the eclipsing variable V888 Aql as a possible cluster member. In this paper we report on UBVRI photometry, radial velocities, spectral classifications and Tycho-2 proper motions of stars in the field of the cluster, in order to ascertain its true nature. As a matter of fact, looking at the Palomar Atlas maps, the cluster region seems to show up more like a window of low absorption in a larger region of high obscuration than as a physical grouping of stars.

2. Photometry

Photometric observations were made with the 1.0-m Ritchey-Chrétien telescope of the U. S. Naval Observatory, Flagstaff Station, in two successive runs on 1999 and 2000. The journal of observations is given in Table 1 and a finding chart for the brighter stars is presented in Figure 2. In the first run the surveyed area was 11.4 × 11.4 arcmin² centered on the cluster position and with a limiting magnitude of V = 20.0, whereas in the second run a larger area of 44 × 44 arcmin² was imaged down to V=17.0 in order to have a larger scale sampling of the field surrounding the cluster.

A Tektronix/SITe 1024x1024 thinned, backside-illuminated CCD was used for the first epoch and a Tektronix/SITe 2048x2048 CCD for the second epoch, along with Johnson UBV and Kron–Cousins RI filters. Images were processed using IRAF, with nightly me-

| Date | Exposures | Field | Seeing |
|------|-----------|-------|--------|
| ymmdd |           | (r)   | (θ)   |
| 990720 | short | 11x11 | 2.0    |
| 990720 | medium | 11x11 | 1.8    |
| 990721 | short | 11x11 | 2.0    |
| 990721 | medium | 11x11 | 1.8    |
| 990721 | long  | 11x11 | 3.0    |
| 000729 | medium | 44x44 | 1.8    |

Table 1. Journal of observations. Seeing is the FWHM of stellar images as measured on the CCD frames. Short exposures are a few seconds; medium exposures are around a minute; and long exposures are several minutes in duration.

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Aperture photometry was performed with routines similar to those in DAOPHOT (Stetson 1987). Astrometry was performed using SLALIB (Wallace 1994) linear plate transformation routines in conjunction with the USNO–A2.0 reference catalog. Errors in coordinates were typically under 0.1 arcsec in both coordinates, referred to the mean coordinate zero point of the reference stars in each field. The telescope scale is 0.6763 arcsec/pixel. Typical seeing was $\sim 2$ arcsec. A 9 arcsec extraction aperture with concentric sky annulus was commonly used. The reported photometry only uses data collected under photometric conditions (transformation errors under 0.02 mag). Cluster observations were interspersed with observations of Landolt (1983, 1992) standard fields, selected for wide colour and airmass range. The mean transformation coefficients (cf. Henden & Kaitchuck 1990 eqns. 2.9ff) are:

- $V$: $-0.020 \pm 0.007$
- $B - V$: $0.949 \pm 0.007$
- $U - B$: $1.072 \pm 0.018$
- $V - R$: $1.017 \pm 0.005$
- $R - I$: $0.971 \pm 0.013$

Second order extinction was negligible except for B-V, where a coefficient of $-0.03$ was used. The resulting UBVRI magnitudes and position of the observed stars are available in electronic form. The $V,(B-V)$ and $(U-B),(B-V)$ diagrams for the stars observed are shown in Figure 2. Assuming a slope of 0.72 for the reddening line in the colour-colour $(U-B),(B-V)$ diagrams and a Blaauw (1963) ZAMS in both colour-colour and colour-magnitude $V,(B-V)$ diagrams (hereafter CMD), we tentatively fit at the same time all the main sequences, obtaining a mean reddening of $E(B-V)=0.6$ and a distance modulus of $(m - M) = 12.1$. But the apparent pattern of a main sequence must not deceive us. In fact, as shown by Burki and Maeder (1973), a main sequence is not proof of the presence of an open cluster: field stars can trace a fictitious main sequence. In order to discriminate field stars from cluster stars, Burki and Maeder suggest:

(a) observing the lower limiting envelope of the main sequence in CMDs (field star fictitious sequences are steeper than those of real clusters).

(b) observing the position of the stars in CMDs and colour-colour diagrams (field stars have no coherent positions).

(c) observing the luminosity function (unlike cluster stars, the field star apparent luminosity function always reaches its maximum at the limiting magnitude).

Looking at point (a), at the top of Figure 2 we see that the lower limiting envelope of the main sequences differs from the Blaauw’s ZAMS at the fainter magnitudes. But
if an open cluster should exist, it could be hidden by the field stars, so this argument is not decisive. Point (c) is tested in Figure 2 where the apparent luminosity functions of both fields decrease abruptly at their magnitude limit: this is a typical feature of field stars. In the case of a cluster, the luminosity function should show a secondary peak at brighter magnitudes, which is not present in our data. Comparing the diagrams of both fields in Figure 2, the contamination due to main sequence and red giant stars lying on the galactic disk is apparent. The structure of the CMDs is reminiscent of a pattern composed of different stellar populations, at different distances and different reddenings along the line of sight, as for example reported by Ng et al. (1996) and Bertelli et al. (1995) in their investigation of the galactic structure towards the galactic centre.

3. Spectroscopy

For classification purposes, spectroscopic observations of 30 stars in a $44 \times 44$ arcmin$^2$ area centered on the cluster have been obtained with the B&C spectrograph at the 122cm telescope of the Asiago Observatory. A 600 gr/mm grating has been used providing a dispersion of 2 Å/pix (74 Å/mm) in the 3900–4900 Å interval and the observations were reduced using IRAF. Table 2 shows our spectral classifications (obtained against an internal atlas of re-observed MK standards from the list of Yamashita et al. 1977) compared to the scanty data found in the lit-
Table 2. Spectroscopic data. Column from left to right: star number, Tycho (or Hipparcos) identification, V magnitude, B-V colour, our spectral types and those from literature (if available), E(B-V), (B-V)$_0$ and distance moduli. Colour excesses and distance moduli have been computed using Lang’s (1992) tables. Colon indicates uncertainties in the intrinsic colours and/or absolute magnitudes.

The “negative” reddening shown by star #28 could trace an undetected binary.

Table 3. Radial velocities from Echelle spectra. The listed errors are errors of the mean.

| star | RV $_\odot$ | JD (+2451000) |
|------|------------|----------------|
| 1    | -7.6±0.9   | 798.287        |
| 2    | 58.8±1.8   | 773.375        |
|      | 31.0±1.6   | 798.379        |
|      | 38.2±2.2   | 799.375        |
| 3    | -36.9±1.3  | 773.335        |
|      | 34.7±1.0   | 773.440        |
| 4    | -56.3±0.1  | 773.354        |
| 5    | -5.3±0.7   | 799.458        |
| 6    | 36.1±0.5   | 798.359        |
| 8    | -34.1±1.8  | 773.391        |
|      | -41.8±1.0  | 798.399        |
|      | 20.8±1.0   | 799.430        |
| 11   | -35.7±0.4  | 798.420        |
| 22   | -58.9±0.4  | 773.419        |
5. Radial velocities

Some of the brightest stars in the field of the cluster have been observed with the Echelle spectrograph mounted at the 182 cm telescope operated by Osservatorio Astronomico di Padova at Mount Ekar (Asiago, Italy). The set up used provided a 20000 resolving power over the 4550 - 8750 Å interval. Data reduction and analysis has been performed with IRAF. Table lists the heliocentric radial velocities of program stars together with their errors as estimated from the comparison of the results obtained from the various echelle orders. The errors cluster around 1 km sec$^{-1}$. Stars #2 and #8 show large radial velocity variations that suggest a binary nature. As for the preceding section, the large scatter of radial velocities does not support the presence of a real cluster. Three stars group around RV = −35 km sec$^{-1}$ and 9.5 ≤ m-M ≤ 10.0 mag (stars #6, #8 and #11). Star #3 shows the same radial velocity but it lies at a closer distance.

6. Stellar counts

In order to test the physical reality of an open cluster, it is common to analyse its radial density distribution. In real clusters the density should decrease outwardly, eventually merging with the surrounding field. Following Odenkirchen and Soubiran (2002), we have measured the stellar density in 0.5 arcmin$^2$ wide annuli centered at the nominal position of NGC 6738 for three different magnitude ranges. The result (Figure 6) shows a stellar density distribution in agreement with Poissonian statistics (represented by dots with error bars) except for V ≤12 mag stars of the inner circle (histogram on top of Figure 6) and which we have spectroscopically observed and already found not to be physically related. Figure 7 shows the integrated stellar density distribution in the field of NGC 6738. The highest density is off-centered with respect to the cluster position, and the overall pattern is very patchy. The pattern is the mirror
Fig. 6. Histogram of the surface density of the stars in the 11.4×11.4 arcmin² field of NGC 6738 in three different magnitude ranges. Bins show the stellar density in 0.5 arcmin² wide annuli. Dots indicate the expected mean with 1σ errorbars provided by Poissonian statistics.

image of the dust emission at 100 μm measured by IRAS (cf. http://iras.ipac.caltech.edu/applications/ISSA/); the emission concentrates towards the areas of lowest stellar counts. This fact is indicative of an extremely non homogeneous distribution of interstellar material over the field of view. Coupled with a chance grouping of a few bright foreground stars, this concentration could erroneously lead to a cluster detection.

7. Conclusions

Our purpose was to perform an investigation as complete as possible to verify the existence of the open cluster NGC 6738. Tycho-2 proper motions have been combined with our new deep and wide-field UBVRI photometry, radial velocities and spectral classification. We have not found evidence supporting the existence of a real cluster; the colour-magnitude and colour-colour diagrams do not show a reliable cluster main sequence; the spectrophotometric parallaxes of the 30 brightest stars show no concentration in distance.; the apparent luminosity function is one of field stars; proper motions and radial velocities do not support a common space motion of the program stars; the stellar density distribution in the field of NGC 6738 does not have a peak in the supposed location of the cluster, nor a negative gradient moving away from it, as expected if a real cluster were present, but instead it reveals the patchy structure of the interstellar absorption confirmed by the IRAS data. Finally, the concentration of stars brighter than V=12 mag toward the center of the field, from which one may infer the presence of a cluster and certainly drove the earlier investigators to pick up this object, has been shown to be a chance grouping. Concluding, it appears safe to conclude that NGC 6738 is not a real open cluster.

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