NGC 6738: Not a real open cluster

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Abstract. A 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 and associations: general – open clusters and associations: individual: NGC 6738

1. Introduction

NGC 6738 ($\alpha_{2000} = 19^h01^m4$, $\delta_{2000} = +11^\circ36'$, $l = 44^\circ4$, $b = +3^\circ1$) 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. (1963) 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 US 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 Fig. 1. In the first run the surveyed area was 11.4×11.4 arcmin² centered on the cluster position

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.

Date yymmdd	Exposures	Field ($\prime$)	Seeing ($\prime\prime$)
990720	short	11×11	2.0
990720	medium	11×11	2.0
990720	long	11×11	2.0
990721	short	11×11	1.8
990721	medium	11×11	1.8
990721	long	11×11	1.8
000729	medium	44×44	3.0

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 1024 $\times$ 1024 thinned, backside-illuminated CCD was used for the first epoch and a Tektronix/SITe 2048 $\times$ 2048 CCD for the second epoch, along with Johnson *UBV* and Kron–Cousins *RI* filters. Images were processed using IRAF, with nightly median sky flats and bias frames. 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

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Fig. 1. Finding chart of the stars brighter than $V = 13$ in the field of NGC 6738. Dots scale with magnitude. Stars spectroscopically observed are numbered.

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 ~ 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, Eqs. (2.9ff)) are:

$$V : -0.020 \pm 0.007 \quad (1)$$

$$B - V : 0.949 \pm 0.007 \quad (2)$$

$$U - B : 1.072 \pm 0.018 \quad (3)$$

$$V - R : 1.017 \pm 0.005 \quad (4)$$

$$R - I : 0.971 \pm 0.013. \quad (5)$$

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 form¹. The V , $(B - V)$ and $(U - B)$, $(B - V)$ diagrams for the stars observed are shown in Fig. 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 & 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 & 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 Fig. 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 Fig. 3 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 Fig. 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

¹ <ftp://ftp.nofs.navy.mil/pub/outgoing/aah/sequence/ngc6738.dat>

Fig. 2. V , $(B-V)$ diagrams (top) and $(U-B)$, $(B-V)$ diagrams (bottom) of the 44×44 arcmin² field (left) and 11.4×11.4 arcmin² field (right). The position of Blaauw ZAMS (dashed lines) for $m-M = 12.1$ and $E(B-V) = 0.6$ is marked.

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 44×44 arcmin² area centered on the cluster have been obtained with the B&C spectrograph at the 122 cm 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 literature together with colour excesses and corrected distance moduli obtained from our photometry. The stars observed appear to be distributed between 10 to 1600 pc with no clear clustering. This is confirmed by the intrinsic CMD shown in Fig. 4 where, disregarding the obvious late type dwarfs belonging to the field, no main sequence is present. We arrive at the same conclusion observing where the classified stars lie in the photometric diagrams of Fig. 2. From point (b) in the previous section, we must infer that all of our program

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.

star	TYC number	V	$B - V$	spectral type		E_{B-V}	$(B - V)_0$	$V_0 - M_V$
				this paper	literature			
1	HIP 93402	8.35	0.34	A4 V	A0	+0.23	+0.11	5.91
2	1048 00548 1	9.11	0.25	A1 III	A	+0.24	+0.01	8.18
3	1048 00812 1	9.08	0.36	F2 IV/V	F0	+0.01	+0.35	6.04
4	1048 00652 1	10.09	0.54	F7 IV/V	F5	+0.05	+0.49	7.08
5	1048 01244 1	10.10	0.52	F5 V	A7	+0.08	+0.44	6.34
6	1048 00663 1	10.53	0.19	A0 III	A0	+0.22	−0.03	9.84
7	1047 00340 1	11.01	0.59	G0 V		+0.01	+0.58	6.58
8	1048 00726 1	11.02	0.37	A3 III		+0.29	+0.08	9.61
9	1048 00898 1	11.19	0.51	F5 IV/V	F5	+0.07	+0.44	7.97:
10		11.28	0.62	F8 V		+0.10	+0.52	6.98
11		11.58	0.28	A2 V		+0.23	+0.05	9.56
12	1047 02770 1	11.84	0.27	A3 V		+0.19	+0.08	9.75
13	1047 02104 1	11.86	0.29	A0 III		+0.32	−0.03	10.86
14		11.95	0.28	A0 III		+0.31	−0.03	10.97
15	1048 00908 1	7.76	1.07	G6 IV	K0	+0.25	+0.82	3.82
16	1047 01117 1	9.23	0.96	G8 V	K0	+0.22	+0.74	3.05
17	1048 00949 1	9.30	1.73	K7 V	M0	+0.40	+1.33	−0.03
18	1047 01033 1	9.52	0.94	G8 V	K0	+0.20	+0.74	3.41
19	1048 00192 1	10.16	1.92	K7 V	M0	+0.59	+1.33	0.24
20	1047 01087 1	10.16	1.48	K4 III	K5	+0.10	+1.38	9.85
21	1047 00370 1	10.21	0.50	F3 V	A5	+0.12	+0.38	6.22
22	1047 00861 1	10.29	1.77	M1 III	M	+0.19	+1.58	10.20
23	1047 02069 1	10.77	0.25	A1 V	A0	+0.24	+0.01	9.03
24	1048 00104 1	10.77	2.28	K5 III:		+0.78:	+1.50:	8.55:
25	1047 02012 1	10.92	1.40	K3 V		+0.44	+0.96	2.92
26	1048 00660 1	10.96	0.50	A3 V	A0	+0.42	+0.08	8.16
27	1048 00360 1	11.05	1.49	K5		+0.34:	+1.15:	2.63:
28	1047 01773 1	11.38	0.74	G6 IV		−0.06:	+0.82	8.45:
29		11.75	0.69	F4 IV		+0.27	+0.42	8.38
30	1048 00582 1	11.89	0.53	A4 V		+0.42	+0.11	8.87

stars are field stars. This is also supported by the reddenings of the observed stars which span about 1 mag, suggesting once more that they do not lie at the same distance.

4. Proper motions

Using proper motions from Tycho-2, a vector point diagram (VPD) of the stars located inside a box of $1^\circ \times 1^\circ$ on the center of the cluster is given in Fig. 5. This diagram shows no concentration of cluster stars distinct from the distribution of field stars (cf. Lattanzi et al. 1991). From this characteristic, we can infer the absence along the line of sight to NGC 6738 of a localized group of stars sharing the same projected space motion.

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 20 000 resolving power over the 4550–8750 Å interval. Data reduction and analysis has been performed with IRAF. Table 3 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 s^{-1} . Stars #2 and #8 show large radial velocity variations that suggest a binary nature. As for the

Fig. 3. Apparent luminosity function for the 44×44 arcmin² (solid line) and for the 11.4×11.4 arcmin² (dot-dashed line).

Fig. 5. Vector point diagram (based on Tycho-2 data) of the stars located inside a $1^\circ \times 1^\circ$ area centered on NGC 6738. Error bars do not exceed the point size. Solid ones mark the stars spectroscopically observed.

Fig. 4. Intrinsic colour-magnitude diagram of observed stars, each of them labeled with its spectral classification.

preceding section, the large scatter of radial velocities does not support the presence of a real cluster. Three stars group around $RV = -35 \text{ km s}^{-1}$ and $9.5 \leq m-M \leq 10.0$ 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

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

star	$RV_\odot$ km s ⁻¹	JD (+2 451 000)
1	-7.6 ± 0.9	798.287
2	58.8 ± 1.8	773.375
	31.0 ± 1.6	798.379
	38.2 ± 2.2	799.373
3	-36.9 ± 1.3	773.333
	-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

surrounding field. Following Odenkirchen & 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 (Fig. 6) shows a stellar density distribution in agreement with Poissonian statistics (represented by dots with error bars) except for $V \leq 12$ mag stars of the inner circle (histogram on top of Fig. 6) and which we have spectroscopically observed and already found not to be physically related.

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.

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 image of the dust emission at $100\ \mu\text{m}$ measured by IRAS (cf. <http://irsa.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 spectro-photometric 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,

Fig. 7. Surface stellar density from 44×44 arcmin² field. Grey levels in steps of 0.25 stars/arcmin². It covers a range from 0.5 stars/arcmin² (lightest) to 2.3 stars/arcmin² (darkest).

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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References

- Blaauw, A. 1963, in *Stars and Stellar Systems. III. Basic Astronomical data*, ed. K. A. Strand (Univ. of Chicago Press), 383
- Burki, G., & Maeder, A. 1973, *A&A*, 25, 71
- Bertelli, G., Bressan, A., Chiosi, C., Ng, Y. K., & Ortolani, S. 1995, *A&A*, 301, 381
- Collinder, P. 1931, *Lund Ann.*, 2, 1
- Henden, A. A., & Kaitchuck, R. H. 1990, *Astronomical Photometry* (Richmond: Willmann-Bell)
- Landolt, A. U. 1983, *AJ*, 88, 439
- Landolt, A. U. 1992, *AJ*, 104, 340
- Lang, K. R. 1992, *Astrophysical Data: Planets and Stars*, (New York: Springer-Verlag)
- Lattanzi, M. G., Massone, G., & Munari, U. 1991, *AJ*, 102, 177
- Ng, Y., Bertelli, G., Bressan, A., & Chiosi, C. 1996, *A&A*, 310, 771
- Odenkirchen, M., & Soubiran, C. 2002, *A&A*, 383, 163
- Roslund, C. 1960, *PASP*, 72, 205
- Ruprecht, J. 1966, *Bull. Astron. Inst. Czech.*, 17, 33
- Sahade, J., & Beron-Davila, F. 1963, *Ann. Astroph.*, 26, 153
- Stetson, P. B. 1987, *PASP*, 99, 191
- Yamashita, Y., Nariai, K., & Norimoto, Y. 1977, *An Atlas of Representative Stellar Spectra* (University of Tokyo Press)
- Wallace, P. 1994, in *ASDASS III*, ed. D. R. Crabtree, R. J. Hanisch, & J. Barnes, *ASP Conf. Ser.*, 61, 481