EL CUMULO ABIERTO NGC 5662 Y SU CEFEIDA VECINA V CENTAURI

THE OPEN CLUSTER NGC 5662 AND ITS NEIGHBOURING CEPHEID V CENTAURI

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RESUMEN: Sobre la base de nuevos datos fotométricos y cinemáticos se examina la composición estelar y estructura del cúmulo abierto NGC 5662. Se detecta la presencia de enrojecimiento diferencial y se examina la estabilidad del agregado. A partir de datos fotométricos y espectroscópicos se determina la función de luminosidad, distancia, edad, y composición química del cúmulo. Sobre la base de los nuevos parámetros astrofísicos derivados, se concluye que la Cefeida V Cen (P = 5.5 días) es muy probablemente miembro del cúmulo. Las observaciones UBV, DDO y CMT1T2 y los resultados detallados obtenidos en este trabajo han sido recientemente publicados por Clariá et al. (1991).

ABSTRACT: Based on new photometric and kinematical data the structure and stellar composition of the open cluster NGC 5662 is examined. The presence of differential reddening across the cluster field is

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detected and the cluster stability examined. The luminosity function, distance, age, and chemical composition of NGC 5662 are determined from photometric and spectroscopic data. The new astrophysical parameters derived support the conclusion that the Cepheid V Cen (P = 5.5 days) is very likely a cluster member. The UBV, DDO, CMT1T2 observations and the detailed results obtained in this work have been recently published by Clariá et al. (1991).

1. INTRODUCTION

NGC 5662 is a loose concentration of late B and A-type stars lying in the Centaurus section of the Milky Way. There seems to be a reasonably possibility that the bright Cepheid V Cen (p = 5.494 day), situated 35 arcmin southwest of the cluster center, is an outlying cluster member. A detailed study of NGC 5662 is therefore of some interest, particularly in view of the importance of cluster Cepheids for the calibration of the cepheid period-luminosity relation.

Relative proper motions of 188 stars in the cluster area were determined by King (1980) and the probability P of cluster membership for individual stars has also been derived. The lack of photoelectric UBV data for a good number of stars with P > 50% made the present study desirable.

2. CLUSTER MEMBERSHIP, INTERSTELLAR REDDENING AND DISTANCE.

New photoelectric data of 237 stars in the cluster field were obtained at CTIO and Las Campanas Observatory during 1985. The corresponding UBV diagrams (Figs. 1-3) reveal a relatively wide main sequence

consisting of B, A and F stars that extends over a V range of about 8-14 mag.

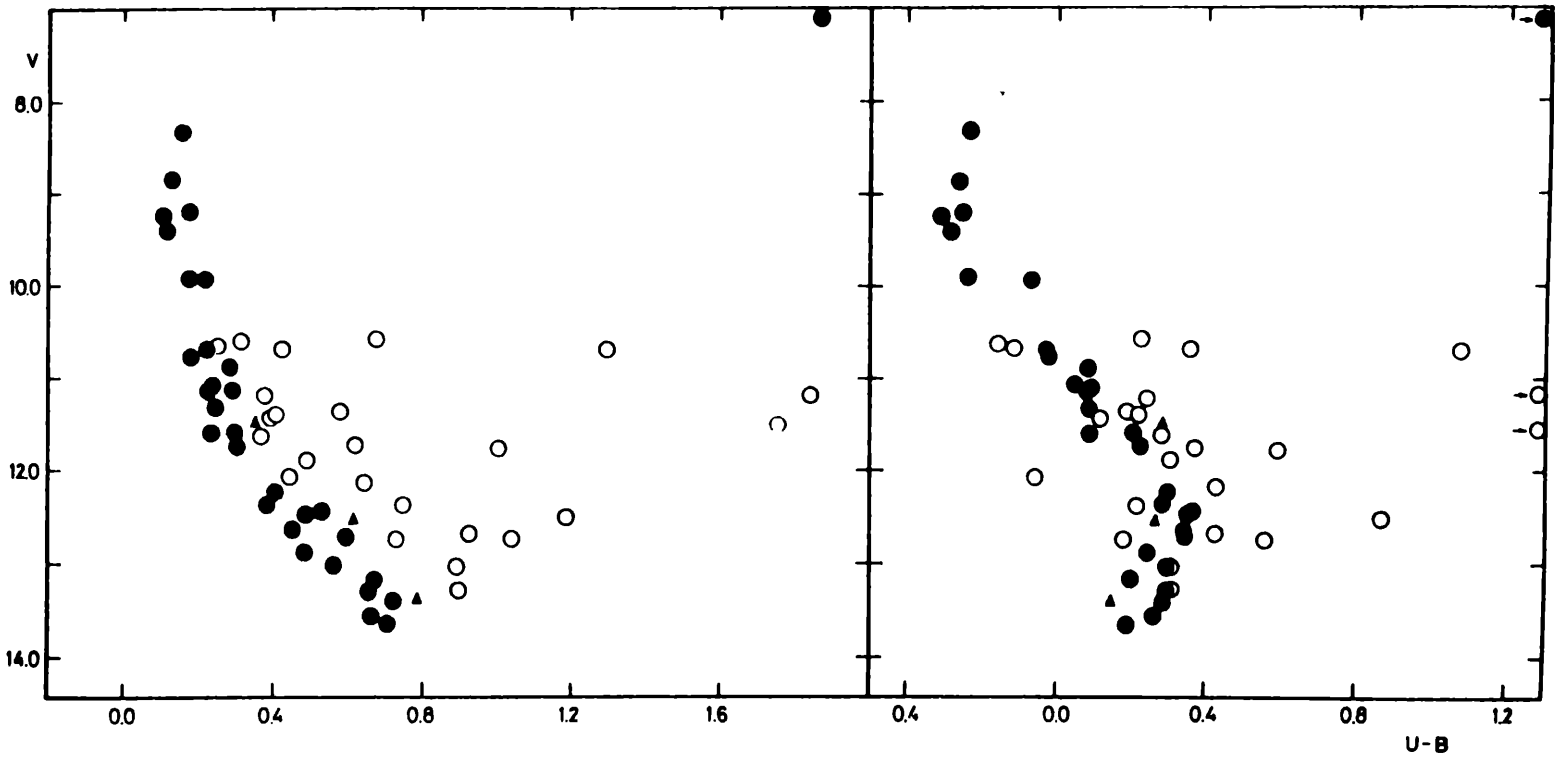


Figure 1: C-M diagrams for the inner region of NGC 5662. Stars with photometric membership classes 1, 2, and 3 are represented by filled circles, triangles, and open circles, respectively.

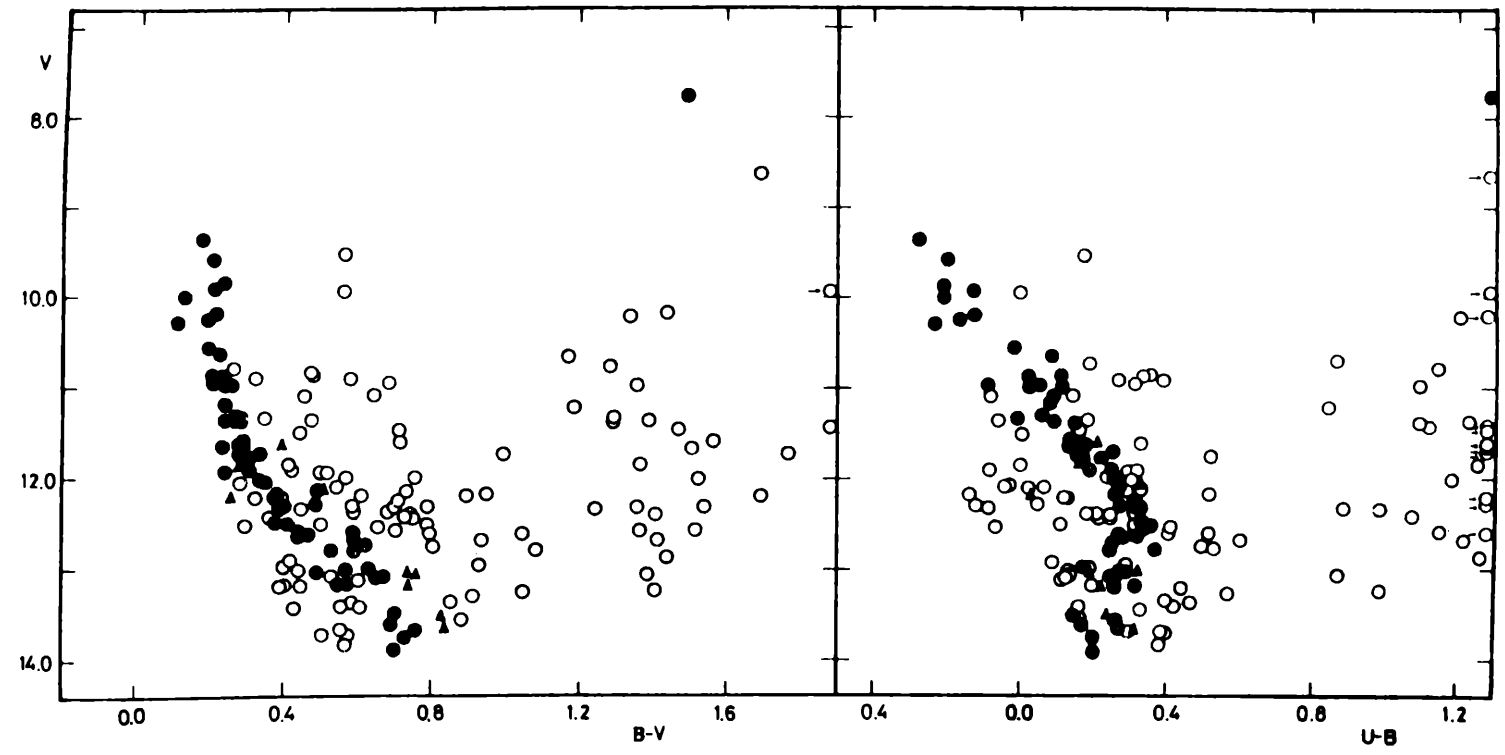


Figure 2: C-M diagrams for the outer region of NGC 5662.

Photometric membership classes 1, 2 and 3 were assigned to the observed stars according to the criteria proposed by Clariá and Lapasset (1986). We thus find that 60% of the stars in the central part of the cluster are very likely members (class 1), while in the outer part this percentage corresponds to the field stars. In Fig. 4 King's (1980) probabilities of membership, based on relative proper motions, are plotted as a function of the observed V magnitude. Filled circles, triangles, and open circles, represent photometric membership classes 1, 2, and 3, respectively. It can be seen that 88% of the stars with class 3 have P < 50%. We then conclude that, in general, the kinematic and photometric membership criteria yield results in reasonable good agreement.

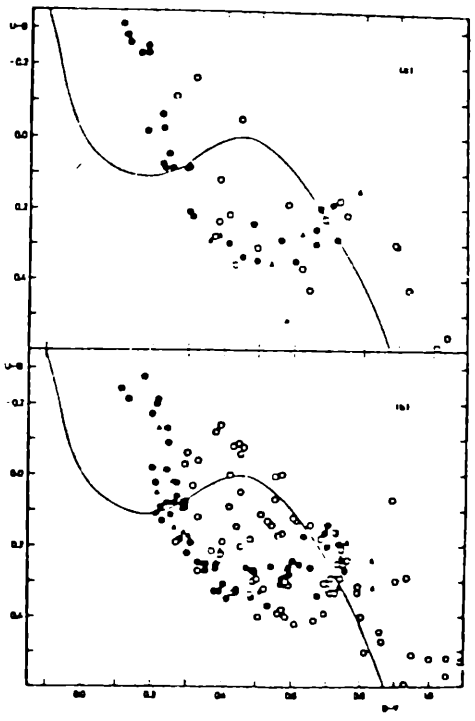


Figure 3: Two-colour diagram of NGC 5662 for stars in the inner a) and outer (b) regions. The full line is the standard relation of Schmidt-Kaler (1982) for main sequence stars. Symbols are as in Fig. 1.

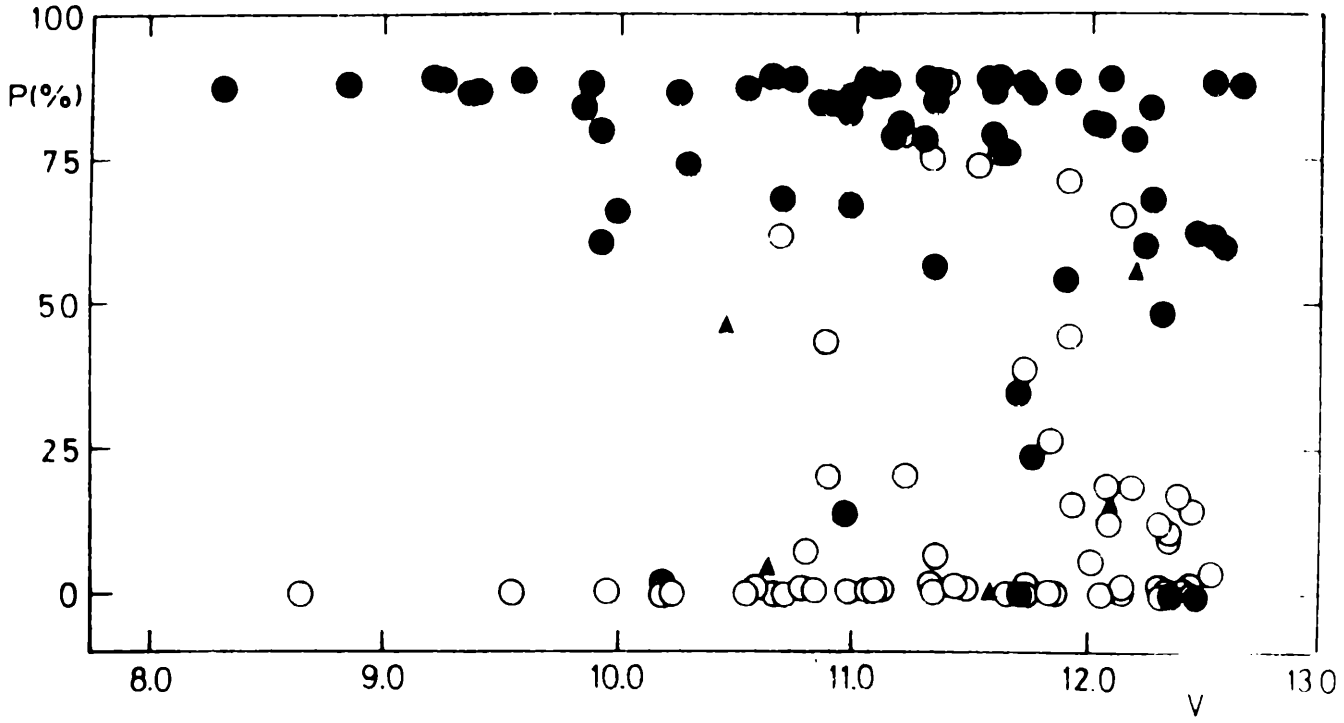


Figure 4: King's (1980) probabilities of membership, based on relative proper motions, plotted as a function of the observed V magnitude. Filled circles, triangles, and open circles represent photometric membership classes 1, 2, and 3, respectively. Probable red giants have not been plotted.

The scatter in Fig. 5 is clearly larger than the photometric errors for the colour indices, which indicates that the reddening does vary across the cluster. For this reason, individual colour excesses were computed from the equations given by García et al. (1988). The measured full width of the observed two-colour diagram for stars with B-V $\leq$ 0.30 is Δ E(B-V) = $E(B-V)_{max}$-$E(B-V)_{min}$ = 0.14 mag, i.e., larger than the lower limit of 0.11 mag estimated by Burki (1975) for clusters with differential reddening. The mean reddening from 41 early-type members is E(B-V) = 0.31 $\pm$ 0.05, while from 19 early-type members with

spectral types we derive E(B-V)MK = 0.28 ± 0.05, so that we have adopted E(B-V) = 0.31 ± 0.04.

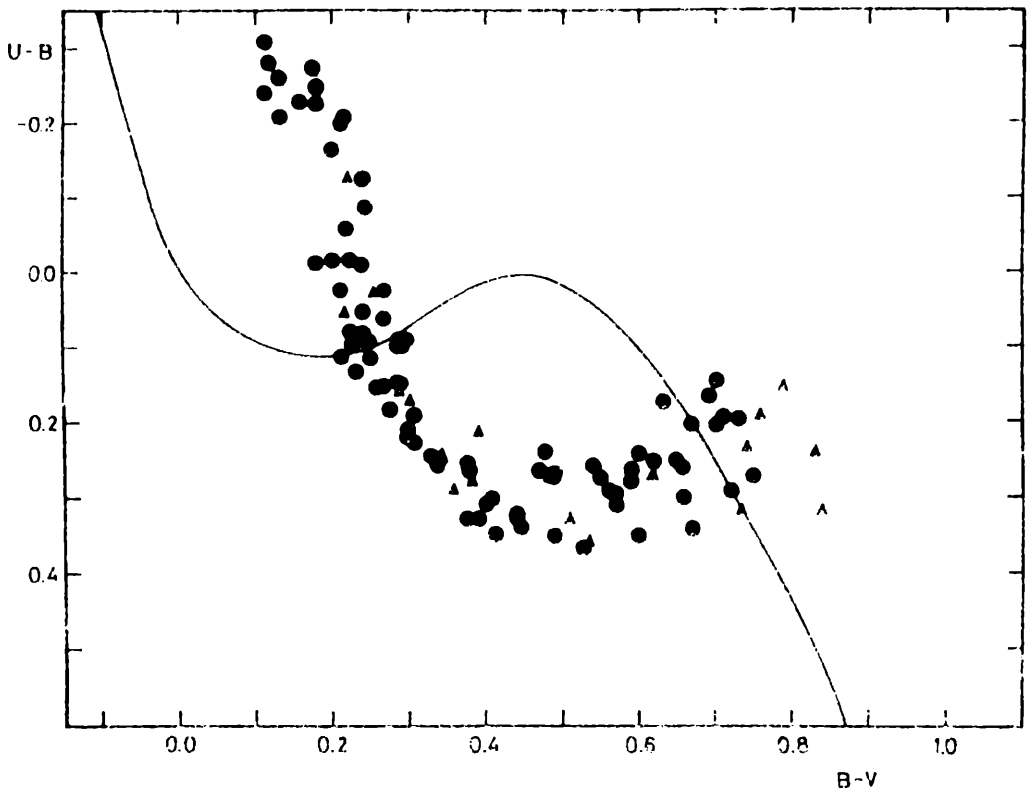


Figure 5: Colour-colour diagram for all the stars considered to be members (filled circles) or probable members (triangles) of NGC 5662.

A spatial correlation of reddening with position is observed in Fig. 6, in which all blue members have been plotted. It appears that stars with larger reddening tend to lie towards the southern part of the cluster. This result is consistent with an apparent decrease in the field star density across the cluster from north to south-east.

Figure 7 shows the reddening-free C-M diagram. The scatter here clearly decreasses for the stars with individually determined reddening values (represented by crosses). A fit of the cluster sequence to the ZAMS of Schmidt-Kaler (1982) leads to V_O-M_V = 9.64 ± 0.15. The mean distance modulus of 19 members with MK spectral types turned out to be $\langle V_O-M_V \rangle$ = 9.35 ± 0.40. Averaging

the two estimates we obtain a distance of (750 ± 50) pc.

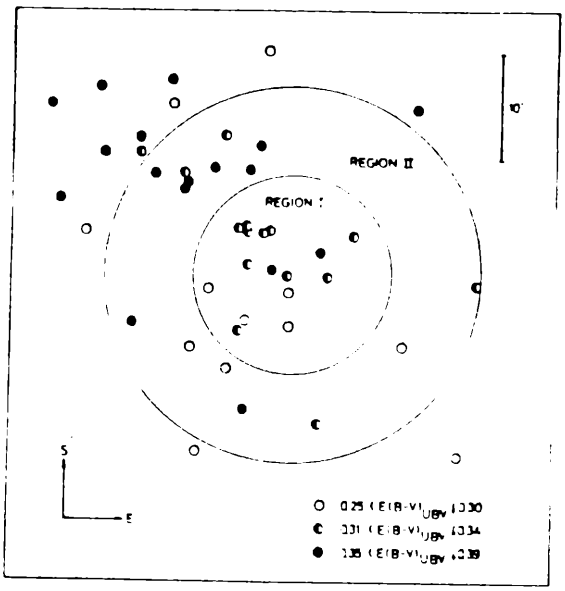
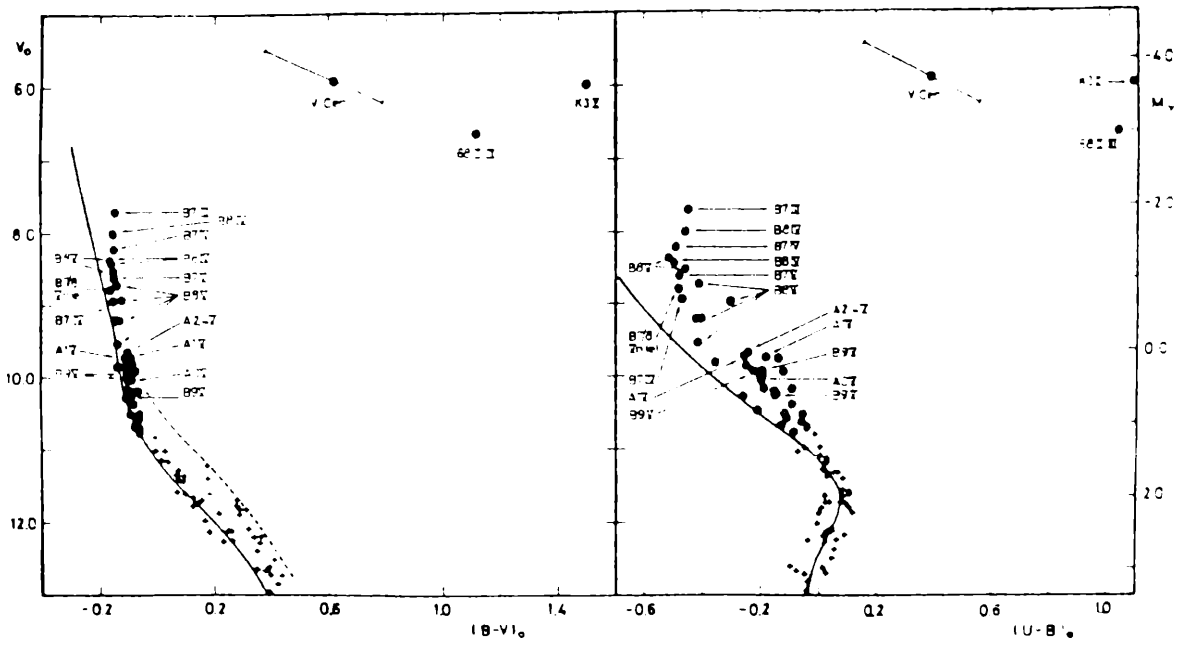


Figure 6: E(B-V) colour excesses of blue cluster members with (B-V)≤ 0.30 plotted spatially. Inner (I) and outer (II) regions are identified.



gure 7: The unreddened C-M diagram constructed with all the stars believed to be members. The full curve in both diagrams is the ZAMS of Schmidt-Kaler (1982), whereas the dashed curve is the 0.75 brightened ZAMS. Stars individually corrected for differential reddening are represented by circles, whereas crosses indicate stars corrected by reddening using the mean value E(B-V) = 0.31. The extremes of variability for V Cen are indicated.

3. CLUSTER DIAMETER AND METAL CONTENT

Star counts in concentric circles around the adopted cluster center have been made (Fig.8). The following conclusions may be drawn from the star counts: (1) The brighter stars (V < 12) are clearly concentrated in the central region within a radius of about 15 arcmin, adopted for NGC 5662. (2) The star distribution down to V = 14 and to V = 17 seems to be much more uniform with a slight central concentration. (3) The adopted angular radius leads to a linear diameter of 6.9 pc, so that the minimum stellar density amounts to 0.50 stars/pc^3.

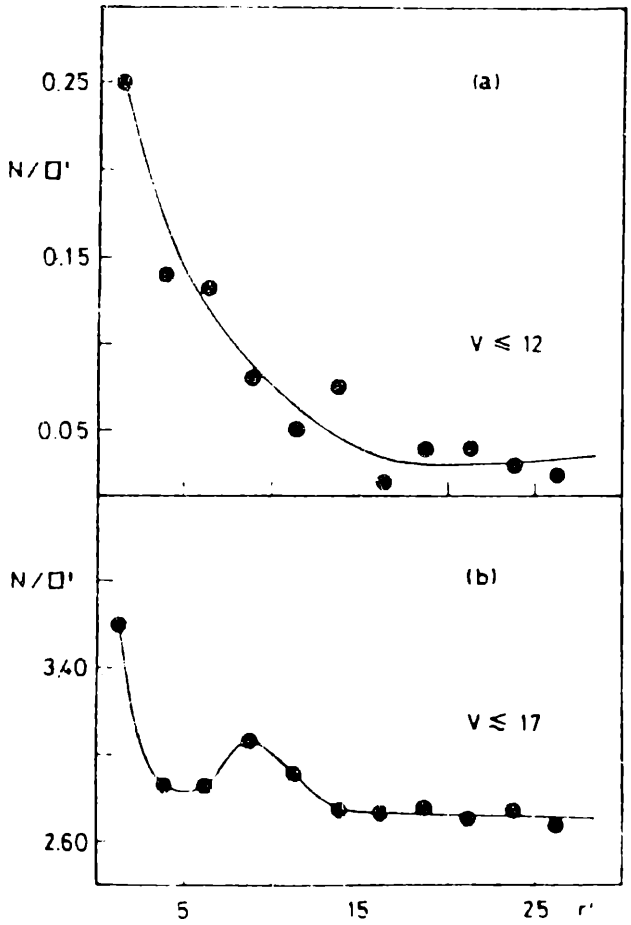


Figure 8: Star number density as a function of distance from the center of NGC 5662: (a) V < 12.0, (b) V < 17.

Three probable red giants were observed in the DDO and Washington systems at CTIO. Two of them are very likely members from both the photometric (Clariá 1985, Clariá and Lapasset 1983) and kinematic data. The DDO metallicity index δCN and the Washington line-blanketing indices Δ (M-T1) and Δ (C-M) yield [Fe/H] = -0.03 ± 0.13 for NGC 5662.

4. AGE AND STABILITY OF THE CLUSTER

The bluest $(U-B)_o$ and earliest MK spectral type are -0.52 and B7V, which imply ages of about 7.1×10^7 yr and 8.7×10^7 yr, respectively. The resulting mean age is then 7.9×10^7, i.e., identical to that of the Pleiades age group. This result is consistent with the fact that both the main sequence shape and the location of the two red giants for NGC 5662 are nearly similar to those for a cluster belonging to the Pleiades age group. The resulting total mass for NGC 5662 is ~ 256 $M_\odot$, which implies a lower limit of the space density of 1.5 $M_\odot/pc^3$. This value greatly exceeds the limit of 0.1 $M_\odot/pc^3$ (Mineur 1939) beyond which a cluster is generally considered to be stable.

5. LUMINOSITY FUNCTION OF THE BRIGHT MEMBERS

The resulting LF for the bright cluster members is plotted as a full histogram in Fig. 9. For comparison, the normalized LF of the Pleiades cluster and that obtained by Taff (1974) averaged over 62 open clusters, are also shown in the figure. Two main features should be noticed: (1) the number of stars per unit magnitude interval in NGC 5662 reaches its maximum and begins to decrease near Mv = 2.0. This apparent turnover in the distribution for Mv > 2.0 probably

results from observational selection effects; (2) the slope of the LF in NGC 5662 appears to be steeper than those in the other two functions. This is perhaps not what would be expected since NGC 5662 and the Pleiades cluster belong to the same age group.

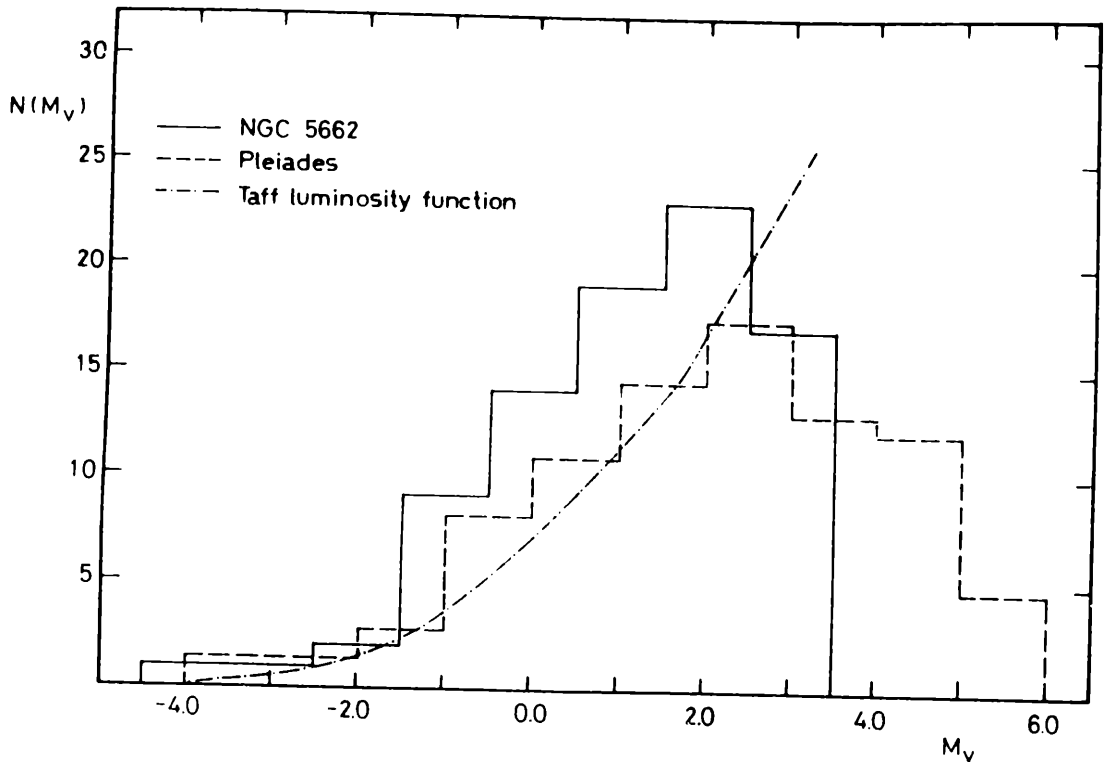


Figure 9: Luminosity function of NGC 5662 (full histogram) compared to the normalized LF of the Pleiades cluster and that averaged over 62 open clusters given by Taff (1974).

6. THE CEPHEID V CENTAURI

V Centauri lies at a distance slightly larger than two cluster radii from the center of NGC 5662. Its E(B-V) colour excess has been determined by different methods yielding values between 0.26 and 0.36. Since the absorption across the cluster is not uniform, any E(B-V) value for V Cen within the above interval should be considered consistent with cluster reddening. We have adopted <V> = 6.82 (Shaltenbrand and Tammann 1971) and

E(B-V) = 0.30. The latter value was derived by Pel (1978) from Walraven phothometry and transformed to the UBV system. The resulting luminosity of V Cen from Fig. 7, i.e. Mv= -3.72 appears to be somewhat hight if compared with that of -3.3 predicted by van den Bergh (1977) for Cepheids of this period. However, if we use our mean distance modulus, the derived luminosity of V Cen is Mv = -3.58, in closer agreement with the expected value. The age of V Cen, according to the results obtained by Kippenhahn and Smith (1982) is about 6×10^7 yr. The good agreement with the cluster age, however, is taken as an argument of lower weight due to the well known discrepancy between "evolution" and "pulsation" ages in cluster Cepheids (Cox 1980, Romeo et al. 1989). We conclude that, although situated nearly two radii far from the cluster center, V Cen is very likely a cluster member.

Table 1 summarizes the main results here obtained. The individual UBV, DDO and CMT1T2 observations as well as the detailed results obtained in the present study have been recently published by Clariá et al. (1991).

TABLE 1

Summary of main results obtained for NGC 5662

istance.....	V–Mv : apparent distance modulus.....	= 10.49
	E(B–V) : selective absorption.....	= 0.31 ± 0.04
	Av : visual absorption (variable).....	= 0.93
	V_o–Mv : true distance modulus.....	= 9.50 ± 0.15
	d : distance from the sun.....	= (790 ± 55)p
	z : distance below the galactic plane.....	= 48 pc

Table I (continued)

Dimensions	D	angular diameter	= 30′
	δ	linear diameter	= 6.9 pc
Membership	N(m)	number of members	> 87
	N(pm)	number of probable members[a]	= 20
	N(RG)	number of red giants	= 2
	N(v)	number of variables[a]	= 3
Chemical composition	[Fe/H]	metallicity	= −0.03 ±
Structure of main sequence	$(B-V)_o$	bluest $(B-V)_o$ colour index	= −0.17
	$(U-B)_o$	bluest $(U-B)_o$ colour index	= −0.52
	MK	earliest spectral type	= B7V
	τ	age	= 7.9 x 10
Luminosity function		slope somewhat steeper than that of the Pleiades cluster	
Integrated parameters	Mv	integrated visual absolute magnitude	= −5.03
	$(B-V)_o$	integrated intrinsic (B−V) colour	= 0.294
	$(U-B)_o$	integrated intrinsic (U−B) colour	= −0.206
	V_o	integrated visual magnitude	= 4.552
	$M/M_\odot$	total mass	≥ 256 $M_\odot$
	n	stellar density (stars/pc³)	= 0.50
	ρ	mean space density ($M_\odot$/pc³)	= 1.5

a: the Cepheid V Cen has been included

Acknowledgments

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