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UVBY–β PHOTOMETRY OF THE OPEN CLUSTERS NGC 1662 AND NGC 2129 [1]

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RESUMEN

Se presentan resultados obtenidos mediante fotometría *uvby*-β de dos cúmulos abiertos.

ABSTRACT

Analysis of two open clusters is carried out through *uvby*-β photometry.

Key words: **OPEN CLUSTERS AND ASSOCIATIONS: INDIVIDUAL (NGC 1662, NGC 2129) — TECHNIQUES: PHOTOMETRIC**

1. INTRODUCTION

This paper is part of a series which has the purpose of examining the nature of the stars belonging to open usters. The aim of this series is, among other things:

1) To study short period pulsating stars, mainly of the Delta Scuti type. 2) To determine the incidence of ıe Be and Ap phenomena. 3) To study blue stragglers in open clusters.

In order to study the previous points we must first:

1) Study stars in open clusters of different ages and chemical compositions. 2) Determine the membership f each star in the cluster.

In the present study, an analysis of the open clusters NGC 1662 and NGC 2129 is presented. These clusters 'ere selected because they seem to have a relatively large number of young stars.

2. OBSERVATIONS

The observations were carried out at the National Astronomical Observatory (OAN) of the UNAM in)ctober, 1989. For the acquisition of the photometric data, the 1.5-m telescope at the OAN was utilized with multichannel spectrophotometer that allows the acquisition of data simultaneously in the *uvby* filters and in he narrow and wide filters that define β.

A total of 42 stars in the direction of NGC 1662 cluster and 20 in the direction of NGC 2129 were observed.

3. DISCUSSION

Since the aim of the present paper is to establish physical and geometrical characteristics of the cluster tars, the first step was to determine membership of the observed stars in each of the clusters.

We first defined which stars were main-sequence stars and the broad spectral regions to which they belonged y constructing a $[m_1] - [c_1]$ plane which defines three main spectral regions: 1) Early type stars of classes B nd early A; 2) A and F stars; 3) later than F-type stars.

The distance for each group was calculated separately.

[1] Based on observations collected at the San Pedro Mártir Observatory, OAN, México.

The calibration of the A and F stars follows a procedure proposed by Nissen (1988) which is based on Crawford's (1975, 1979) calibrations. For the B and early A type stars, a method for the determination of the reddening proposed by Shobbrook (1984) was utilized.

The method proposed by Balona & Shobbrook (1984) was employed for the determination of the absolute magnitude. The distance modulii were evaluated in the customary ways. Histograms of the distances in parsecs for each cluster were constructed for each group of stars for which the distances were determined, i.e., B and early A; A and F type stars, as well as for the whole sample.

A membership probability was defined from this histogram by adjusting a gaussian distribution to it.

To separate binaries from single stars a $\beta - M_V$ diagram of the data presented was constructed for each cluster.

In order to determine the membership of the cool stars to the cluster, a $(b-y)-V$ diagram was constructed utilizing only those B, A and F type stars for which a high probability of membership was established. Then, all the cool stars were located in this diagram and those stars that lay from the extension of the previously defined MS into the cooler zone were regarded as stars with a high probability of membership.

To estimate the age of the cluster the following procedures were undertaken: First, an estimation of the turn-off point was carried out by determining the temperature and gravity of the member stars and plotting them in the $m1_0 - c1_0$ theoretical grids of Relyea & Kurucz (1978). Second, their log $L/L_\odot$ were determined from the M_V values reported and the bolometric corrections taken from Lang (1991). With these values and an average metallicity value characteristic of these clusters, [Fe/H] = 0.0, a direct comparison with the theoretical models of VandenBerg (1985), Maeder (1990), or Meynet et al. (1990) was made.

An alternative procedure for verifying the temperature of the B stars was done from the calibration between $[u-b]$ and θ_e. We have followed Pérez et al. (1989) who utilized the calibrations of Philip & Newell (1975). The same results were obtained with both methods.

The determination of the Ap abundance was carried out through *uvby-β* photometry since it is well-known that the Ap stars lie in a specifically defined zone in the $[m_1] - [c_1]$ diagram. In these zones the Ap Sr-Cr-Eu and Sr-Cr stars are clearly marked.

4. RESULTS

4.1. NGC 1662

The $[m_1] - [c_1]$ diagram gave the following number of stars that belong to each range of spectral types: 15 B and early A, 11 A and 2 F stars. The distance was determined for each star and an histogram constructed. It can be immediately seen that there is a conspicuous clustering of early type stars and that the cluster must lie in the distance range between 250 to 550 pc with a mean value of 391 ± 83 pc. The probability of membership was evaluated considering these limits. The histogram of the apparent magnitude indicates that, in order to reach the stars of later spectral types, stars fainter than magnitude 13 should be observed.

The binaries have been determined from the $\beta - M_V$ diagram and four have been found, although only two are cluster members.

Five cool stars are assumed to belong to the cluster and two are of the giant class.

The temperatures were derived from the $m_{10} - c_{10}$ diagram of Relyea & Kurucz (1978). Accurate numerical values were obtained from the $[u-b] - \theta_e$ calibration described by Pérez et al. (1989). Both methods yield equal star temperatures. The estimated age is 4.9×10^8 yr in agreement with that reported by Lang (1991).

The number of Ap stars in the direction of NGC 1662 is high, six, all of which are cluster members.

4.2. NGC 2129

Although a fair number of bright stars were observed in the direction of NGC 2129 and the $[m_1] - [c_1]$ diagram shows that there are several early type stars as well as several late type MS stars, the determined distance represented in a histogram does not show the presence of a clustering of stars, raising doubts on its existence. No further analysis was carried out, except that one Ap star was found in its direction.

5. CONCLUSIONS

We have presented the results obtained for two young open clusters for which high quality intermediate

nd photometry was obtained for a fair number of stars. The most important results have been presented and veral conclusions can be drawn:

1. Proof of Existence. The apparent richness of the cluster varies. Although roughly the same number of ars have been observed in each one, the number of member stars varies enormously, from the highest number : NGC 1662 to the lowest possible number, zero, for NGC 2129. With respect to NGC 2129 not much could be id about its existence unless much fainter stars were observed. However, from the distance histogram obtained e could easily question its existence. Emphasis should be made on the results of Schmidt-Kaler (1982) who ınd high dispersion in the absolute magnitude. Equally, high dispersion is found when an inspection of the o-color diagram by Hoag et al. (1961) is carried out. All these results support the findings of the present alysis.

2. Ap stars. Young & Martin (1973) and Hartoog (1976) found a ratio of 0.051 for the frequency of Ap ars in clusters and of 0.070 for field stars. From the results obtained in the present paper, a higher value is termined for NGC 1662, which gives values of 0.20 and 0.17 for cluster and field, respectively.

3. Blue Stragglers. Mermilliod (1982) has compiled an exhaustive list of blue stragglers in young open ısters. She has found 39 stars lying to the left of the MS of 75 open clusters younger than the Hyades and ncludes that the blue stragglers appear to be a feature common to all open clusters whatever their age may , and that their number increases with the age of the clusters. In the present work, no blue straggler was und in NGC 1662.

4. Metallicity. In his work Nissen (1988) established a prescription to determine the [Fe/H] index for F pe stars. This technique has been followed here. Unfortunately, as has been previously stated, only NGC 1662 s enough F type stars belonging to the cluster to evaluate this index. The determined value, [Fe/H] = 0.22 characteristic of clusters of its age and distance.

6. FUTURE WORK

We will try to carry out and will encourage the following:

Differential photoelectric photometry to detect small amplitude, fast light changes as those encountered in e Delta Scuti or B type stars, for cluster members that are within the spectral limits of such variables.

Spectroscopic studies in the B type stars to detect any anomalies, such as those presented by the Be stars. lso, spectroscopic confirmation of the Ap stars identified here is desirable.

) Absolute multicolor photometry to delineate the lower region of the MS for those clusters of which only the per part of the MS has been observed.

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DISCUSSION

Herbig: There has been some interest in the possibility that δ Sct stars exist in very young clusters, becaus the instability strip crosses the pre-main sequence tracks of stars of intermediate mass. I do not know if or would expect such stars to pulsate, as do post-main sequence objects. But I recall that M. Breger did find few δ Sct variables in NGC 2264. Do you have any comment on this matter?

Peña: We have carried out studies of known δ Scuti stars in other clusters like the Pleiades and Praesep They are always, as Breger has found, of smaller amplitude and shorter periods than field stars. We have als monitored some stars to detect variability as in NGC 1342 or NGC 7062.

Crawford: I see you use both m_0 and $[m_1]$, I suggest that you use only m_0, as it has a natural physic meaning: intrinsic "star" (that is, the index corrected for interstellar reddening). It also is better than $[m_1]$ (any Q values) as it is still valid (and unique) in view of my differences in interstellar reddening laws (or slopes

Peña: Thank you.

Michel: In your studies of galactic clusters, have you found any B or Be variable stars?

Peña: We have observed only all the stars once or twice at the most, hence it is impossible to detect ar variability. However, once we know which early type stars belong to the cluster it would be desirable to monit them continuously to detect short time scale variabilities .

Garrison: In your schematic diagram for NGC 1662, I notice that the boundaries for peculiar stars are ver close to the line for normal stars, which means that normal observational errors may put normal stars into th peculiar-stars boxes.

Peña: We think that the detection of the stars should be confirmed by spectroscopic studies. This is in ou plans for the extension of the project.

Costero: Is the interstellar reddening large enough in the direction of the observed clusters and, if so, did yo use it as an extra parameter to establish cluster membership of individual stars?

Peña: Yes, we use it as an extra parameter. Actually in another cluster, which we have found to be two cluster $E(b-y)$ varies noticeably between them. Our values in general, agree with those reported in the literature f the rest of the clusters.

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