INVESTIGACION EN LA REGION DEL CUMULO ABIERTO TR 14
INVESTIGATION IN THE REGION OF THE OPEN CLUSTER TR 14

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Abstract: CCD UBVRI imaging photometry was carried out in the area of Tr 14. For the first time, we can have an overall view of the lower main sequence of the cluster. It is fully confirmed the anomalous nature of the extinction law. The distance of Tr 14 is stated in d= 3100 pc while its age, derived by the fitting of isochrones is about $1 \cdot 10^6$ y. The HR diagram of the cluster shows some stars placed in locations where usually are found contracting stars. Our estimation indicates that an on-going star formation process is taken place with an age spread of $5 \cdot 10^6$.

Resumen: Se llevó a cabo fotometría CCD UBVRI en la región del cúmulo Tr 14. Por primera vez podemos tener una vista completa de la secuencia principal inferior de este cúmulo. Se confirma completamente que la ley de extinción es anómala. La distancia de Tr 14 es d= 3100 pc en tanto que su edad, a partir de ajuste de isocronas es de $1 \cdot 10^6$ años. Hay algunas estrellas en el diagrama HR de Tr 14 ubicadas en posiciones donde usualmente se encuentran las estrellas en fase de contracción. Nuestra estimación indica que el proceso de formación estelar es continuo y que la dispersión en la formación es alrededor de $5 \cdot 10^6$ años.

Introduction

This open cluster has historically been investigated together with the other very young cluster in the area of Carina, Tr 16 (Feinstein et al, 1973; Tapia et al, 1988 and references therein). Two main aspects remain unresolved: the true nature of the extinction law in the direction to Tr 14/16 (in the same route is the true distance subject) and the overall state of star cluster evolution and its interaction with the interstellar medium. The current investigation is intended to analyze the lower main sequence of Tr 14 and to clarify the evolutionary situation of faintest members.

Observations

Observations were made at the University of Toronto Southern Observatory, Las Campanas. The equippement was the 60 cm telescope and a PM 512 x 512 Photometrics chip UV coated. The longer exposure times were 800 sec in U, 500 sec in B, 480 sec in V and 100 sec in R and I bands. The reductions were made at La Plata Observatory and at Bonn Institute of Astronomy. The PSF fitting method using DAOPHOT (Stetson, 1987) was applied to get colors and magnitudes.

Results

Figure 1 shows the observed U-B vs B-V diagram. Differential reddening is clearly evident and limits are needed to state cluster memberships. By applying to Cudworth et al (1993) proper motion survey we state that cluster members are likely to be found between $0.38 \leq E(B-V) \leq 1.00$ mag. These limits compares fairly well to the adopted by Massey & Johnson (1993). To analyze the value of R = Av/E(B-V) we applied to three methods: a) the variable extinction diagram (Johnson, 1968), b) the E(V-I)/E(B-V) diagram (Herbst, 1976) and the color difference method (Johnson, 1968). All the three methods confirm that the extinction law in the direction to Tr 14 in anomalous. We adopted a mean value of R = 4.7 for the intracluster extinction, mainly based in method b) which is in resonable agreement with early values (Smith 1987, Thé 1994). After correcting by reddening and visual absorption through the expression given in Vázquez et al (1994) and Forte (1978) a plot of reddening across the cluster surface is presented in Figure 2. This figure confirms the general trend of absorption found by Feinstein et al (1973), Smith (1987) and Cox et al (1994). In fact, absorption increases from east to west and from south to north of the cluster. It then becomes clear from the figure that Tr 14 is an embedded open cluster (Lada & Lada, 1991) emerging from the dense cloud where it formed. Therefore, Tr 14 as a whole, is likely expanded and is not in state of virial equilibrium (Lada, 1984).

The superposition of the Schmidt-Kaler ZAMS (1982) to the dereddened color magnitude diagram of Figure 3 yields a distance of d = 3100 $\pm$ 300 pc (Vo-Mv = 12.50 $\pm$ 0.20, error from inspection).

Figure 4 depicts the HR diagram of Tr 14. Isochrones from Schaler et al (1992) are superposed along with the time-constant loci of Iben & Talbot (1967). There is some scatter among the most massive stars wich could be the result of undetected binaries, fast rotators or age spread. Anyway, the isochrone fitting indicates that Tr 14 is $1 \pm 0.5 \cdot 10^6$ y old.

Inspecting the lower main sequence, the most notorious aspect is the widdening of it at constant effective temperature. In fact several stars situated above the ZAMS have high membership probabilities according to Cudworth et al (1993) proper motion survey. If our membership assingation is well done and if memberships of Cudworth et al (1993) are realistic, then we are dealing with an open cluster containing stars in contracting phase. This migt not be surprising taking into account the youthness of the cluster and that, among its brightest and most massive stars, there are two of them aged $5 \cdot 10^5$. But, most important is that material from which stars

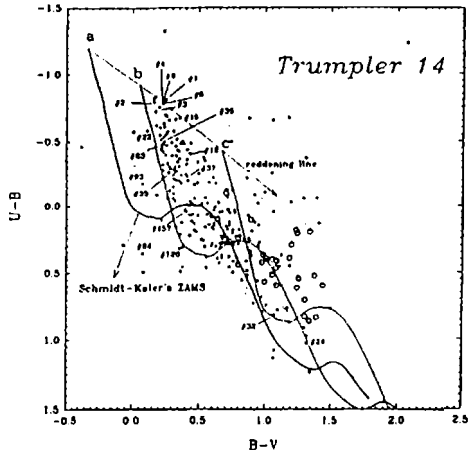

Figure 1: Color-color diagram. Symbols: filled circles, likely members; filled triangles, probable members; hollow circles, pre-main sequence stars?; hollow squares: non members. Solid lines depict diferent locations of the Schmidt-Kaler's ZAMS (1982) in its normal location (a), shifted to E(B-V) = 0.38 (b) and to E(B-V) = 1.00 (c). The path of the normal reddening line for an O-type star is also shown.

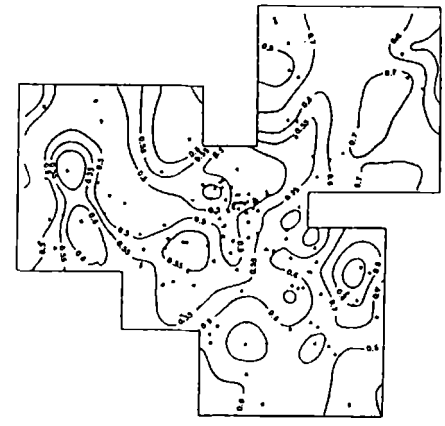

Figure 2: Reddening plot across the cluster surface. Asteriks indicate the cluster stars used in the determination of the constant reddening lines. Numbers are E(B-V) along every line. North is at top and East is at right.

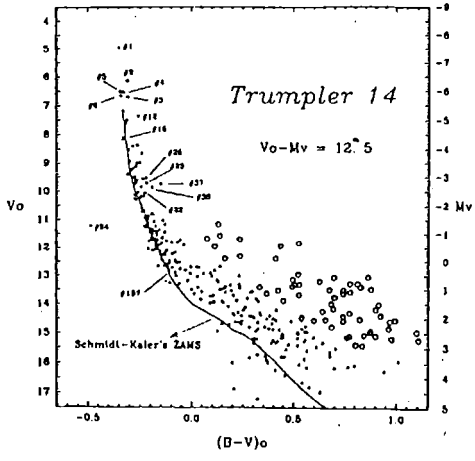

Figure 3: The Vo vs (B-V)o diagram for stars in Tr 14. Symbols as in fig. 1. The solid line is de Schmidt-Kaler's ZAMS (1982) fitted to a corrected distance modulus Vo-Mv = 12.5±0.2.

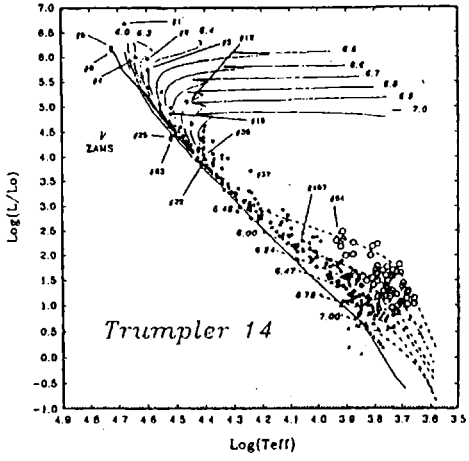

Figure 4: The HR diagram of Tr 14. Symbols as in fig 1. Solid lines are the isochrones and the theoretical ZAMS of Schaller et el (1992). Numbers at the end of lines indicate log(age[y]). Dashed lines are the time-constant loci of Iben & Talbot (1966). Numbers at their left end are the log(age[y]).

may form is still present in the area. In addition, Cox (1994) detected signs of recent star formation in Carina region. Turning to figure 4, the distribution of assumed contracting stars is step by step comparable to the found in NGC 2264 (Mendoza & Gómez, 1980) or in NGC 6530 (van den Ancker an Thé, 1993). The notorious age spread shown by all these stars reveals that an ongoing star formation process is taking place in the area of Tr 14. The time-constant loci by Iben & Talbot (1967) indicate that the age spread is about $5 \cdot 10^6$ y.

We compute stellar masses interpolating among Schaller et al (1992) stellar models and it yield a lower limit for the total cluster mass of around 2000 Mo and about 40% of it is concentrated in the compact cluster core. We obtained a value of x = 1.1 for the initial mass function slope. It fits within the errors with x = 1.35 derived by Salpeter (1955). However, a bit flat slope might be the result of an overcorrection by field stars.

Conclusions

For the first time the lower main sequence of Tr 14 is seen. It is well populated and goes down to V = 19 mag. The distance of the cluster is d = 3100 pc and its age is $1 \pm 0.5 \cdot 10^6$ y. The HR diagram of the cluster shows the presence of contracting stars. Comparing to the time-constant loci, the process of star formation shows an age spread of $5 \cdot 10^6$ y. A lower limit for the total cluster mass is around 2000 Mo and about 40% of it is in the cluster core.

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