ON THE BEHAVIOUR OF GLOBULAR CLUSTER RED GIANTS IN THE COLOR-MAGNITUDE DIAGRAM

(Abstract)

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In the last years it has become clear, that a knowledge of the infrared magnitudes of red giant stars in globular clusters is of great importance for the investigation of their behaviour on the color-luminosity diagram. Unfortunately, the data available at present are insufficient. Here we shall try to draw some preliminary conclusions based on available results.

On the basis of a wide-band infrared image-tube photometry ($\lambda_{\text{eff}} = 8460$ Å, $\Delta\lambda = 2050$ Å) of selected stars in four globular clusters (Russev, 1972, 1973), we pointed out the possibility of the existence of a special sequence PRG (Peak Red Giants) in the '$M_I - (B-I)_0$' diagram (Figure 1), whose stars are in a stage near to the helium flash. The sequence PRG is in fact the top-end of the giant branch and it begins from the break-point of this branch. This point could be easily determined on all of the diagrams constructed using infrared magnitudes.

Recently, Eggen (1972) published UBVRI electrophotometric observations of red giants in 10 globular clusters, as well as the old disk-population cluster M67 and pointed out the behaviour of stars in the '$M_{\text{bol}} - (R-I)$' diagram. In Figure 2, taken from his paper, it is obvious, that the break-points of red giant branches are placed at different values of $(R-I)$ with a dispersion of about $0\overset{m}{.}2$.

The diagrams 'color $(B-I)$-magnitude $I_J(8800$ Å$)$' for all 11 clusters were constructed (Russev, 1972, 1973) according to Eggen's observations. It seems that the color-index $(B-I)$ is the best effective temperature-index for red giant stars in globular clusters. There are several facts, which lead to this conclusion:

(i) The band of V magnitude includes a spectral region, where the low-temperature stars show a large number of TiO absorption bands. Therefore, as was convincingly proved by Eggen (1969), the color-index $(B-V)$ is not a simple function of the temperature of the red stars.

(ii) The band of $R_J(6800$ Å$)$ magnitude lies not far from the band I_J, so that even the presence of a small number of absorption lines and bands acts unfavourable on the color $(R-I)$ as a temperature index. On the other hand, the bands R_J and I_J lie near the continuum's maximum of the red stars, which leads to a slow change of the color $(R-I)$ with the star's temperature.

In this way, we can conclude, that color-index $(B-I)$ is a better criterion for temperature classification of red giant stars. In Figure 3 are shown two 'color-magnitude' arrays for stars in 47 Tuc by Eggen's observations (Eggen, 1972). To make the comparison easily observable we have plotted the infrared magnitude I as a function of

Tayler (ed.), Late Stages of Stellar Evolution, 240–243.

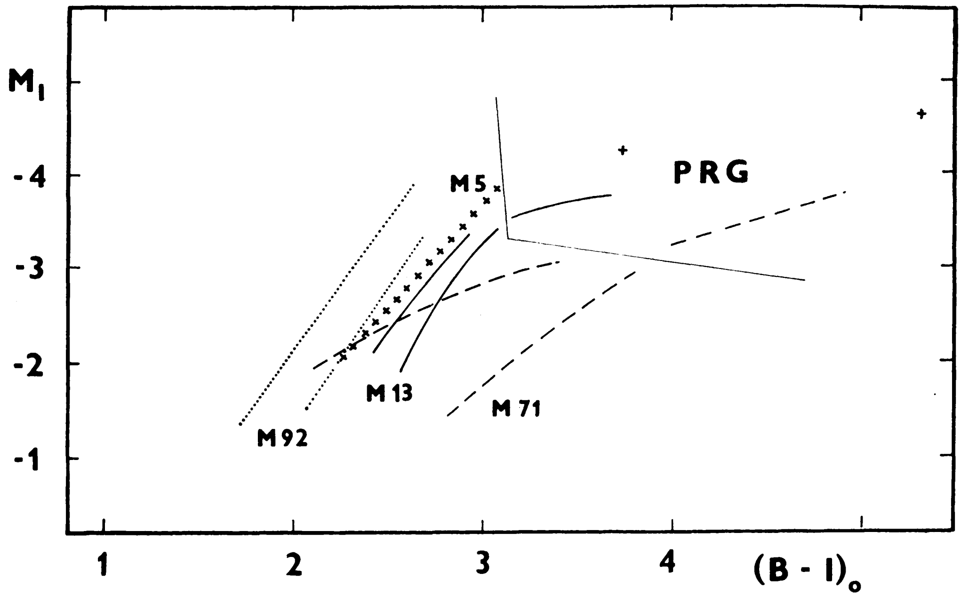

Fig. 1. Composite '$M_I - (B - I)_0$' diagram for globular clusters M5, M13, M71 and M92 (Russev, 1972, 1973). The region PRG of reddest stars is noted.

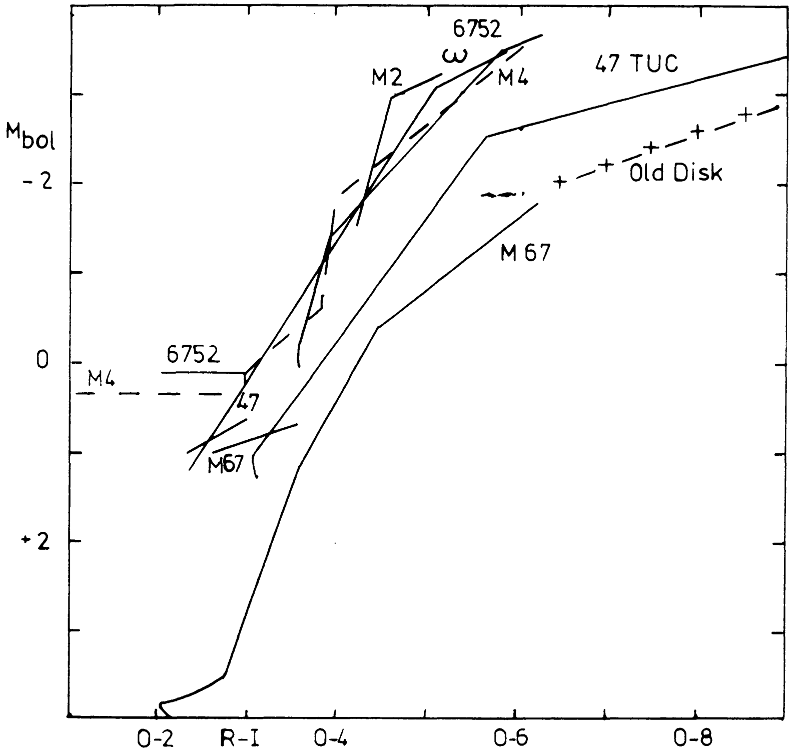

Fig. 2. Composite '$M_{bol} - (R - I)$'-relation from Eggen's paper (Eggen, 1972).

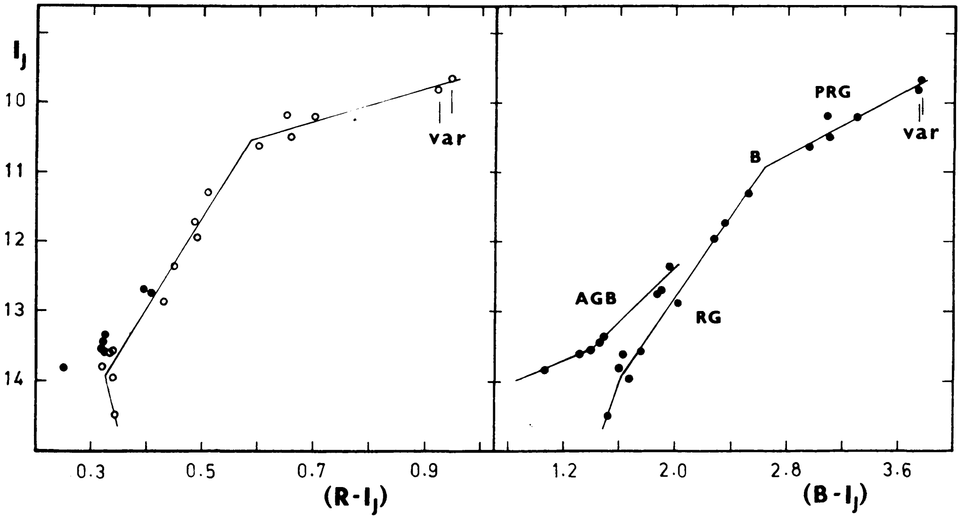

Fig. 3. The '$I-(R-I)$' and '$I-(B-I)$'-relations for red giants in 47 Tuc. According to Eggen (1972), on the left side diagram, the filled circles represent the asymptotic giant stars.

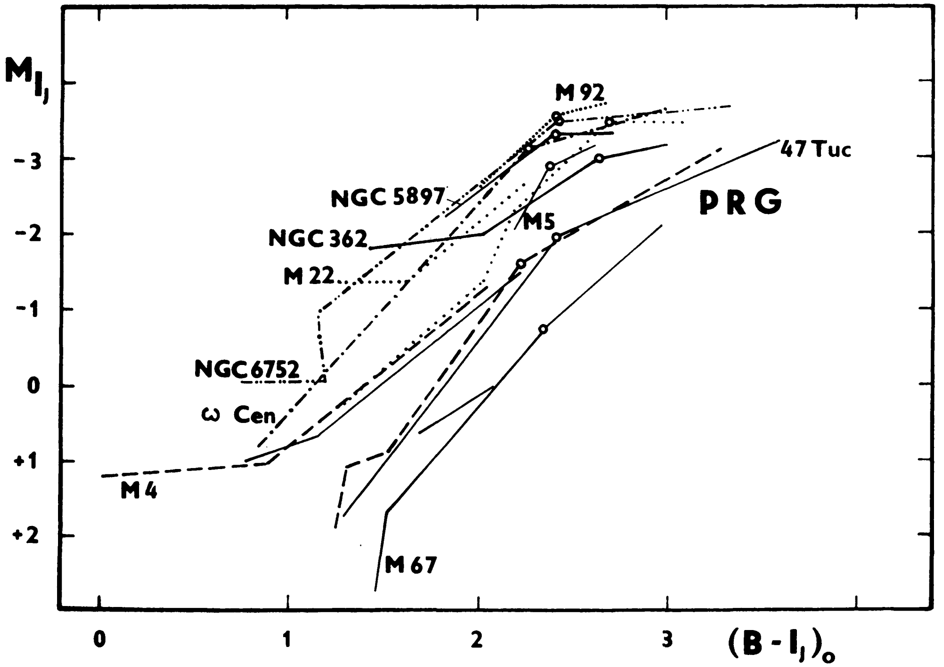

Fig. 4. Composite 'color-luminosity' diagram for ten clusters. The open circles are the break-points of red giant branches.

https://doi.org/10.1017/S0074180900018301 Published online by Cambridge University Press

the color $(R-I)$ (Figure 3 – left) and I as function of the color $(B-I)$ (same figure – right). Obviously it is much easier to draw the red giant branch (RG), the asymptotic branch (AGB) and the sequence PRG on the right-hand side diagram and there the break-point (B) can be defined with better accuracy. This applies to all of Eggen's clusters.

A composite 'M_I-$(B-I)_0$' diagram (Figure 4) was constructed by means of a homogeneous system of distance-moduli and color excesses by Kukarkin and Russev (1972). Only for M67 we adopted $\mathrm{Mod}^{\mathrm{C1}}_{I,0}=9\overset{m}{.}29$ and $E_{B-I}=2.5$. $E_{B-V}=0\overset{m}{.}15$ (Russev, 1972, 1973; Eggen and Sandage, 1964). With open circles we denote the break-points of the red giant branches. The dispersion of these points on the $(B-I)_0$ axis is $0\overset{m}{.}46$, which corresponds approximately to half of the dispersion on Figure 2. The average position of the red giant break-points is at $(B-I)_0=2.41\pm0.15$ or at effective temperature about 3800K. On Figure 4 the line for M2 was not drawn, as no stars situated in the PRG region have been observed.

Finally, we can characterize the red giant sequence PRG by the following:

(1) It has a smaller slope than the red giant branch. In general the brighter the absolute infrared luminosity of the breakpoint the smaller the slope.

(2) It is less populated with stars than the red giant branch, which indicates comparatively short time of evolution on this sequence.

Moreover, the blue boundary of PRG region on the '$M_I-(B-I)_0$' diagram probably disagrees with the red instability region.

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