STATISTICAL ANALYSIS OF THE RED GIANT DISTRIBUTIONS OF OLD OPEN CLUSTERS

G. Barbaro and L. Pigatto
Istituto di Astronomia, Università di Padova
Osservatorio Astronomico, Padova

In order to verify the agreement with the theory of the observed HR diagram as a whole, 38 open clusters with $(B-V)_{o,t} \geq 0.10$ at the turnoff, have been analyzed with particular regard to the RGB luminosity function.

Theoretical isochrones derived from Ciardullo and Demarque (1977) and evolutionary tracks for central He-burning calculated by Sweigart and Gross (1976) have been used, adopting chemical composition X=0.700 and Z=0.001, 0.004, 0.01.
The RGB of isochrones have been corrected for a mixing length parameter $\alpha=1.5$ (Ciardullo and Demarque (1979)). The conversion tables in the M_V, (B-V) plane by Morton (1969), Morton and Adams (1968) for the V class and by Johnson (1966) and Lee (1970) for the III and I classes of luminosity have been adopted.
The analysis has been performed in two steps:

- comparison of the HR diagram with isochrones
- statistical check of the fit between the observed luminosity distributions of red giant stars and the theoretical ones by means of the Kolmogoroff test.

Two different behaviours come out when the theoretical luminosity functions of the RGB are compared with observed ones:
- clusters with $(B-V)_{o,t} > 0.35$ (Group I) fit well both the MS parameters M_V, $(B-V)_o$ at the turnoff point and the RGB luminosity functions,
- clusters with $(B-V)_{o,t} \leq 0.35$ (Group II) never agree with the RGB luminosity functions here considered. (Table 1 reports $(B-V)_{o,t}$ and metal abundance from literature of the clusters). This behaviour is brought into evidence in Fig. 1, where the magnitude of the weakest red stars of the base of the RGB is plotted against $(B-V)_{o,t}$ both for theoretical isochrones of metal abundance z=0.01, 0.001 and for the clusters of the two groups. In Fig. 2 the observed hystogram of the red giant stars distribution of NGC 7789, one of the most populous cluster of Group II, (the other clusters of the group have very similar distributions), compared with the theoretical distribution (RGB and He-burning phases) for the age and metal abundance compatible with the cluster ones, clearly shows the disagreement consisting in a evident lack of stars at the base of RGB.
It is obvious that Group II does not agree with the classical evolution

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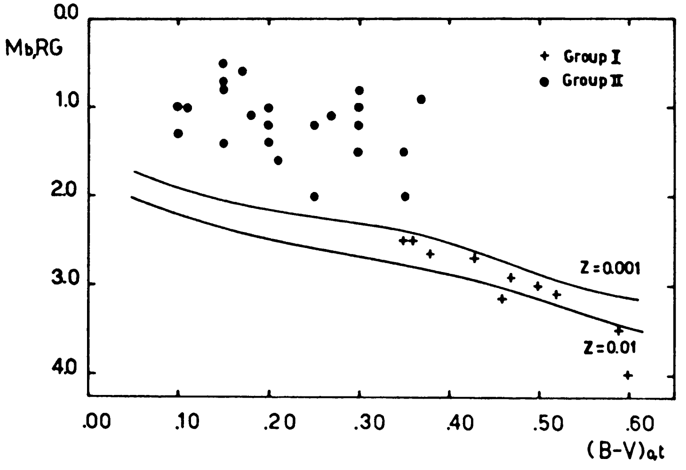

Figure 1 - Magnitude of the faintest red giant stars ($M_{b,RG}$) versus (B-V)o at turnoff of the clusters. The solid lines represent values for the isochrones of metal abundance z=0.01 and z=0.001.

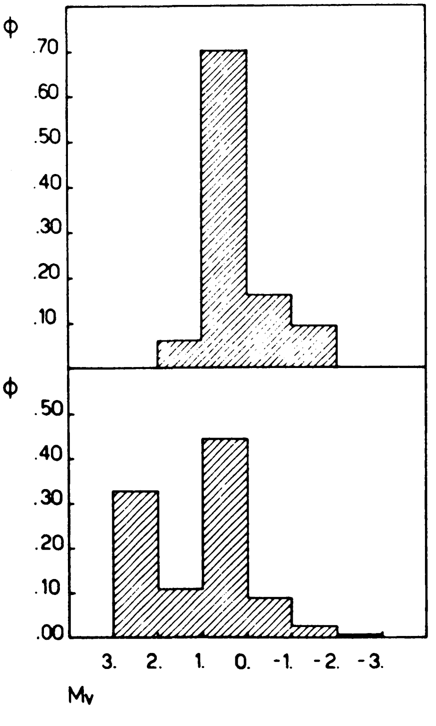

Figure 2 - Luminosity function of RGB of NGC 7789 (top) and for the theoretical isochrone (t=2 Gyrs, z=0.01) (bottom).

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TABLE 1

GROUP I			GROUP II					
NGC	(B-V)o,t	z_{obs}	NGC	(B-V)o,t	z_{obs}	NGC	(B-V)o,t	z_{obs}
188	0.60	0.013	IC166	0.35	--	3960	0.21	0.008
2141	0.50	0.006	752	0.35	0.010	5822	0.11	0.020
2158	0.35	0.005	1245	0.20	0.023	IC465	0.37	0.013
2204	0.36	0.008	1342	0.17	0.008	6633	0.10	0.010
2243	0.47	0.008	IC361	0.25	--	IC4756	0.20	0.015
2420	0.50	0.005	Hyades	0.10	0.025	6811	0.15	--
2506	0.38	0.007	1817	0.15	0.021	6819	0.30	0.019
2682	0.46	0.010	2236	0.18	--	6939	0.30	--
3680	0.38	0.012	2360	0.30	0.012	6940	0.25	0.022
6791	0.59	--	2477	0.20	0.016	7039	0.10	--
7142	0.43	0.005	Praesepe	0.15	0.024	7062	0.20	--
MEL66	0.52	0.004	2660	0.27	0.019	7762	0.30	--
			2818	0.15	--	7789	0.30	0.010

scheme, according to which the clusters should exhibit extended red giant branches as a consequence of the electron degeneracy developed during the shell H-burning phase, but their behaviour is rather reminiscent of that of younger clusters, whose evolved stars have a mass $M > 2.2\ M_\odot$ and ignite helium quietly in a non-degenerate core.

The hypothesis we make is that models in which the overshoot of the convective core is taken into account, could explain this discrepancy. In fact, as shown by Maeder (1975, 1976), the effect of overshoot for low mass stars, is to increase the mass of the convective core before and during the shell H-burning phase. It could happen that for a mass $1.5 < M \lesssim 2.2\ M_\odot$, i.e. in the mass range we are concerned, the mass fraction q_{core} becomes larger than the Schönberg-Chandrasekhar limit q_{S-C} before the core becomes degenerate: in this case the core begins to contract and evolves in the region of non degeneracy, giving rise to a quiet onset of He-burning.

Preliminary results of a model of $1.8\ M_\odot$, X=0.700, Z=0.02, by Bertelli and Bressan (paper in progress) show that, for a conservative overshooting parameter $\lambda = l/H_p = 1$, the core behaves as described above and the evolutionary path of the model is qualitatively similar to that of a $3\ M_\odot$.

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DISCUSSION

Mermilliod: The different trends in the two age groups may result from the different morphology of the giant region. In the younger age group, most giants are in the clump phase, while in the older one, there is a full giant branch. Thus, the faintest giant in both groups does not correspond to the same evolutionary state.

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