STAR CLUSTERS IN THE MAGELLANIC CLOUDS

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I INTRODUCTION

The evolutionary history of the Magellanic Clouds has been very different from that of the Galaxy. As a result we presently observe major differences between both the stellar content and the cluster populations in the Galaxy and the Clouds.

Perhaps the most striking characteristic of Galactic clusters is the clear-cut dichotomy between massive old globulars and less massive younger open clusters in the galactic disc. No such dichotomy exists in the Clouds where "populous intermediate-age clusters" span the gap between old globulars such as NGC 121 in the SMC and NGC 2257 in the LMC and younger objects similar to Galactic open clusters. A second major difference is that some Cloud clusters, such as NGC 121 and NGC 1978 are quite flattened, whereas Galactic globulars are much more nearly spherical. Finally young clusters in the Clouds (especially those in the SMC) are metal-poor compared to their Galactic counterparts. This difference simply reflects the fact that the Galaxy is a highly evolved system in which the interstellar gas has been more strongly contaminated by stellar ejecta than is the case in the Magellanic Clouds.

II THE FLATTENING OF CLUSTERS

The flattenings of Large Cloud globulars have recently been measured by Geisler and Hodge (1980) and by Frenk and Fall (1982). These measurements show (van den Bergh 1982) that old LMC clusters are significantly more flattened than are galactic globulars. The strong flattening of NGC 121 suggests that the SMC clusters are similar to those in the LMC rather than to those in the Galaxy. The reason for this difference between the flattenings of Galactic and Cloud clusters remains a mystery. Norris (1983) has made the interesting suggestion that cluster flattening is related to the "second parameter phenomenon". He notes that all Galactic globulars with large ($\varepsilon \sim 0.15$)

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flattenings have blue horizontal branches, whereas Galactic globular clusters with red horizontal branches are almost spherical ($\epsilon \sim 0.0$). These systematics, if real, do not seem to apply to Cloud clusters. In the SMC NGC 121 is quite highly flattened but has a red horizontal branch (Tifft 1963, Gascoigne 1966). Casual inspection of the globulars in M31 indicates that they, like their Galactic counterparts, are nearly spherical. Of the Galactic globulars ω Cen ($\epsilon = 0.19$) has the largest intrinsic flattening. It is probably not coincidental that it is also the most luminous Galactic globular. It is of interest to note that four of the six most luminous globulars known in NGC 5128 (Hesser et al. 1984) are noticably flattened. Even in the Clouds cluster flattening seems to be a function of luminosity. Table 1 and Figure 1 show that the most luminous LMC clusters of all ages (van den Bergh 1981) are more flattened (Frenk and Fall 1982) than are less luminous LMC clusters. A Kolmogorov-Smirnov test shows that this difference is significant at the 99% confidence level.

The fact that some relatively young (Searle, Wilkinson and Bagnuolo 1980) luminous Cloud clusters are highly flattened, whereas young Galactic clusters are almost invariably spherical, suggests that differences between cluster formation in the Galaxy and the Clouds persist to the present day. This view is supported by the observation that a number of "populous star clusters" (which do not appear to have a Galactic counterpart) have been formed during the last 1×10^9 yr.

Finally it is noted that the absence of a population of old flattened clusters in the Galaxy implies that our Milky Way System was not formed by the coalescence of numerous Magellanic-type galaxies. Even the merger with a single LMC-like galaxy probably can be excluded by the absence of flattened old clusters.

Table 1
FLATTENING OF LMC CLUSTERS

V	⟨ε⟩	n_{cl}
9.00 - 9.99	0.19	4
10.00 - 10.99	0.14	16
11.00 - 11.99	0.11	15
12.00 - 12.99	0.08	15

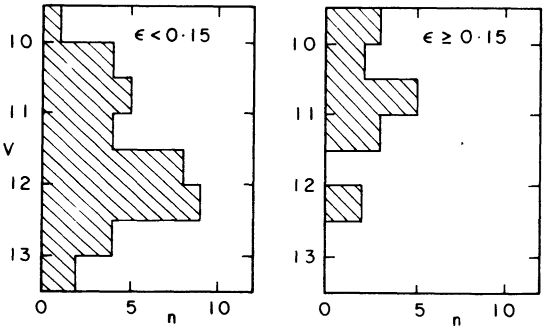

Fig. 1. The magnitude distribution of little-flattened and highly-flattened LMC globulars.

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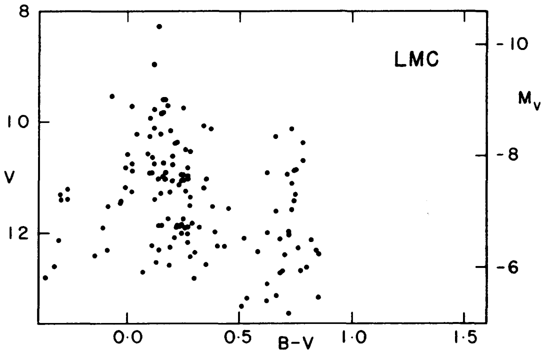

Fig. 2. Integrated C-M diagram of the LMC clusters

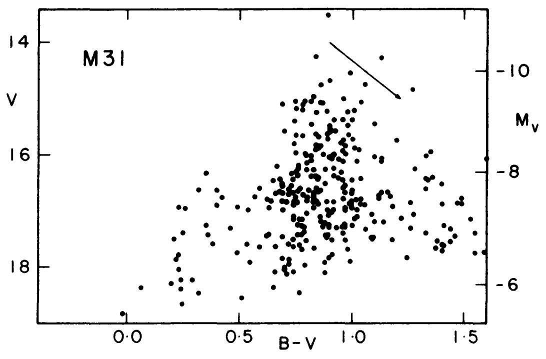

Fig. 3. Integrated CM diagram of M31 clusters

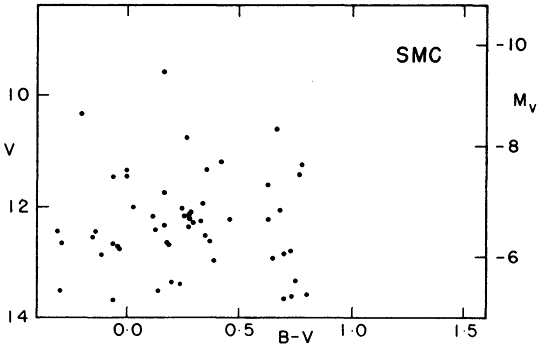

Fig. 4. Integrated Colour-Magnitude diagram for SMC clusters

III THE COLOURS OF CLOUD CLUSTERS

Fig. 2 shows an integrated colour-magnitude diagram (van den Bergh 1981) for all LMC clusters for which photoelectric UBV observations are presently available. The figure shows that (1) blue clusters outnumber red ones by a 5 to 1 margin and (2) the most luminous blue clusters are ~ 2 mag brighter than the most luminous red ones. In this respect the LMC differs drastically from the Andromeda Nebula (see Fig. 3) in which red clusters vastly outnumber blue clusters (Sharov and Lyuty 1982) and in which the most luminous red clusters are much brighter than the most luminous blue clusters. The reason for this striking difference is, no doubt, that the rate of cluster formation has declined drastically over the lifetime of M31, whereas it has remained much more nearly constant with time in the Large Cloud.

The colour-magnitude diagram for Small Cloud clusters (see Fig. 4) is basically similar to that of the Large Cloud except that the SMC contains fewer very luminous blue clusters than does the LMC. For $M_V < -8.0$, for which the photoelectric data should be reasonably complete, the LMC contains 25 blue clusters versus 3 such objects in the SMC. (If the LMC and SMC produced the same number of bright blue clusters per unit luminosity one would have expected to observe 5.7 such objects in the Small Cloud i.e. most of the observed difference is due to the fact that the SMC is intrinsically less luminous than the LMC.)

I hope that the results presented by other speakers at this symposium will throw more light on the origin of the puzzeling differences between Cloud clusters and Galactic clusters that have been discussed above.

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DISCUSSION

Fall: A natural explanation for the correlation between ellipticity and luminosity is in terms of the correlation between ellipticity and age. The LMC clusters appear to get rounder with age and they also get fainter with age; hence they appear flattest when brightest and rounder when faintest. Indeed, the correlation between ellipticity and luminosity might be interpreted as support for the correlation between ellipticity and age because the clusters certainly have faded with time.
van den Bergh: First it will have to be established that there is still an age-ellipticity relation after the luminosity-ellipticity relation is removed.
Fall: From measurements by Frenk and myself we find that the significance of the correlation between the ellipticity and the relative ages of populous clusters in the LMC is 97%. This is increased a bit when our large sample is supplemented by the small sample of Geyer and Richtler, which also shows a trend between ellipticity and age.
van den Bergh: I believe that your age versus ellipticity relation is a pseudo correlation that results from the fact that blue LMC clusters are, in the mean, brighter than the old red LMC clusters. A two component analysis will have to be made to see if any statistically significant age-ellipticity relationship remains after the ellipticity-luminosity relation is removed.
Mathewson: The observed flattening of LMC clusters may be due to their forming in the disk rather than in the halo as in the case of our galaxy (see Freeman, these proceedings).
van den Bergh: That does not explain why young clusters in the galaxy are round whereas young clusters in the Magellanic Clouds are flattened. Also bright clusters in the halo of NGC5128 appear to be flattened.
Alcaino: Considering that NGC5128 at a distance whose lower limit is estimated at, I believe, 3 Mpc, is it at all possible to appreciate within some degree of accuracy the flattening of a globular cluster candidate?
van den Bergh: Yes! On CTIO plates taken in good seeing it is possible to see that some of the brightest globulars associated with that galaxy are distinctly non-stellar.
Frogel: Since visual extinction of globulars is a strong function of galactic coordinates, how do you know that your correlation of ellipticity with extinction isn't really due to correlation with location in the Galaxy?
van den Bergh: Tests show that ellipticity of galactic globulars is more strongly correlated with extinction than it is with galacto-centric distance.
Demarque: The galactic globular cluster Omega Cen has the rare property of having a measurable ellipticity. It is also of course very old. Are you suggesting that Omega Cen might be an example of a cluster cannibalized by our Galaxy?
van den Bergh: I think that it is probably significant that Omega Cen is both the most luminous and the most flattened galactic globular cluster.