STAR CLUSTERS IN THE MAGELLANIC CLOUDS

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ABSTRACT. Star clusters in the Magellanic Clouds (MCs) differ from those in the Galaxy in a number of respects: (1) the Clouds contain a class of populous open clusters that has no Galactic counterpart; (2) Cloud clusters have systematically larger radii r_h than those in the Galaxy; (3) clusters of all ages in the Clouds are, on average, more flattened than those in the Galaxy. In the Large Magellanic Cloud (LMC) there appear to have been two distinct epochs of cluster formation. LMC globulars have ages of 12-15 Gyr, whereas most populous open clusters have ages <5 Gyr. No such dichotomy is observed for clusters in the Small Magellanic Cloud (SMC) The fact that the SMC exhibits no enhanced cluster formation at times of bursts of cluster formation in the LMC, militates against encounters between the Clouds as a cause for enhanced rates of star and cluster formation.

1. Introduction

1.1 POPULOUS CLUSTERS

In the Galaxy there exists a clear-cut distinction between open clusters and globular clusters. No such dichotomy is observed for star clusters in the MCs, which contain a class of populous clusters that have no Galactic counterpart. These objects are sometimes referred to as "blue globular clusters". This is an inappropriate terminology because:

a) some blue globular clusters are red;
b) the masses of these objects are an order of magnitude lower than those of typical globulars;
c) their ages are ~10 Gyr;
d) in the LMC, populous clusters are observed to have disk-like kinematics.

The fact that the Galaxy does not contain supergiant HII regions like 30 Doradus shows that the Milky Way systems presently do not form young clusters that are as rich as the populous clusters in the LMC.

1.2 CLUSTER RADII

Cluster radii r_h, which contain half of all cluster stars in projection remain relatively stable over periods as long as 10 relaxation times (Spitzer & Thuan 1972). Fig. 1 shows a comparison between the r_h values for clusters in the Galaxy and the MCs. On average, both open and globular clusters in the Clouds appear to be ~3x larger than those in the Galaxy. Furthermore, the radii r_h of clusters in both the Galaxy and in the LMC (Hodge 1962) increase with increasing Galactocentric distance. The most straightforward interpretation of this observation is that compact

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clusters form preferentially in dense regions of their parent galaxies. Such a relationship might also account for Cloud clusters' being, on average, larger than their Galactic counterparts.

1.3 CLUSTER ELLIPTICITIES

Clusters in the MCs are typically more highly flattened than those in the Galaxy. Such very elliptical clusters as NGC121 in the SMC and NGC1978 in the LMC have no Galactic analogues. Luminous clusters are, on average, more highly flattened than fainter clusters. Van den Bergh and Morbey (1984) have shown that Cloud clusters of all ages are flatter than their Galactic counterparts.

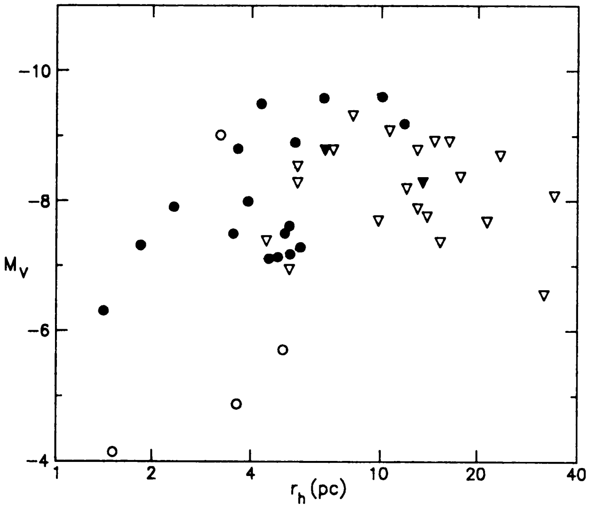

Figure 1. Radii r_h of clusters in the Galaxy, the LMC and the SMC.
● Galactic globulars (1/5 of all)
○ Galactic open clusters
▼ Cloud globulars
▽ Cloud open clusters.

2. Cluster distribution

2.1 THE LMC CLUSTER SYSTEM

The cluster system of the LMC has a major axis, a=15° (13 kpc) and b/a=0.7 (Olszewski *et al.* 1988). Half of the true globular clusters (which contain RR Lyrae stars) appear projected outside the main body of the LMC cluster system. Van den Bergh (1981) has shown that old clusters are smoothly distributed over the face of the LMC, but that young clusters exhibit some concentration to the Bar of the LMC. The fact that no novae have yet been discovered in the Bar of the LMC suggests that the absence of old clusters from the Bar may not be entirely due to selection effects.

2.2 THE SMC CLUSTER SYSTEM

Fig. 2 shows a plot of the locations of old (B-V > 0.5, U-B > 0.0) and young (B-V < 0.5, U-B < 0.0) clusters in the SMC. The figure shows that young clusters in the SMC are more concentrated

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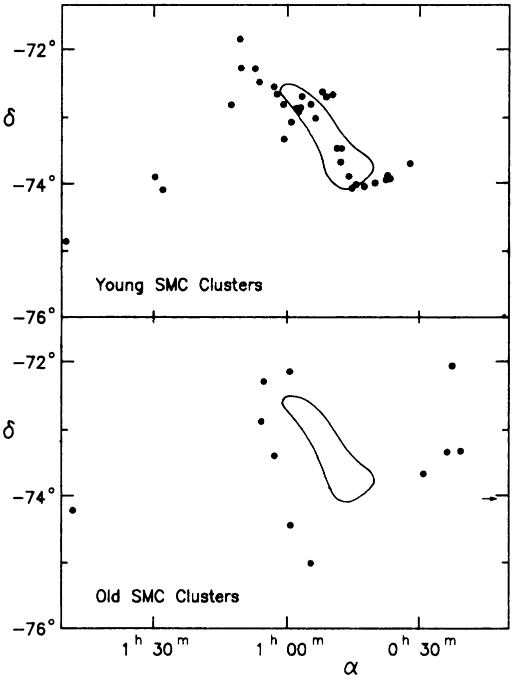

Figure 2. Distribution of old and young clusters in the SMC

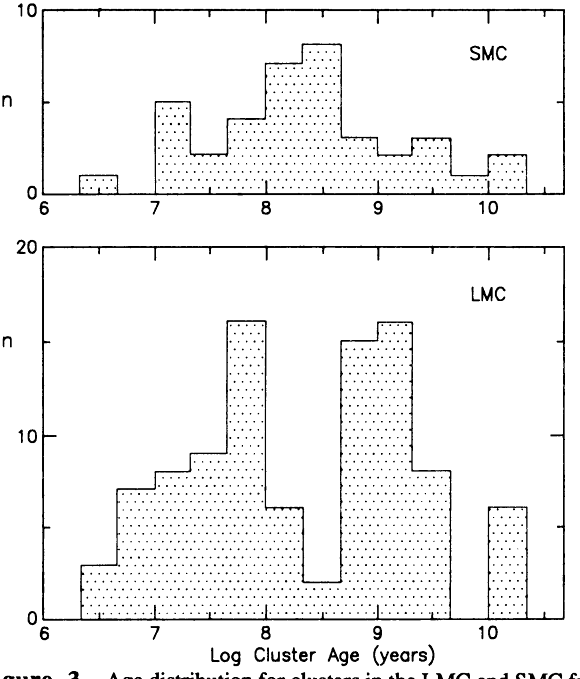

Figure 3. Age distribution for clusters in the LMC and SMC from data compiled by Sagar & Pandey (1989).

to the core of the SMC than the old clusters associated with this galaxy. This is consistent with the observation that the core of the SMC has bluer integrated colours than the outer region of the SMC.

3. Cluster ages

Sagar and Pandey (1989) have published a compilation of all age determinations for clusters in the MCs. Plotted in Fig. 3 are the distributions of the most recent age determinations for each of the clusters in the LMC and SMC. The figure suggests a rather smooth evolution of the rate of star and cluster formation in the SMC. On the other hand, the history of cluster formation in the LMC appears to have been punctuated by a number of major bursts. Note the apparent gaps in star formation between 4 Gyr and 10 Gyr, and the less pronounced gap between 0.2 Gyr and 0.5 Gyr. Since selection effects are probably similar in the LMC and SMC the apparent difference between their star-forming histories may be significant.

4. Cloud globular clusters

NGC 121 appears to be the only true globular cluster in the SMC. This cluster contains RR Lyrae stars, has a red horizontal branch and a relatively young age of ~12 Gyr. Six LMC clusters (NGC1466, 1786, 1835, 1841, 2210 and 2257) contain RR Lyrae stars and a seventh (Hodge 11) has a colour-magnitude diagram indicating that it has an age >10 Gyr. All seven genuine LMC globular clusters have blue horizontal branches (van den Bergh in prep). It appears likely that the Reticulum cluster (Gratton & Ortolani 1987), which contains 22 RR Lyrae variables (Demers & Kunkel 1976), is also a globular associated with the LMC.

The mean luminosity of the true globular clusters in the LMC is similar to that of globulars in the Galaxy and M31. It is truly remarkable that the globular clusters in giant ellipticals in the Virgo cluster (Harris *et al.* 1990), in the thick disk of the Galaxy (Armandroff 1989), in the halo of the Galaxy and in the LMC have similar luminosity functions. This contrasts with the situation for open clusters which have luminosities that extend up to much brighter levels (i.e. populous clusters) in the MCs than they do in the Galaxy.

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