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THE DISTORTIONS IN THE DENSITY PROFILES OF STAR CLUSTERS OF THE MAGELLANIC CLOUDS

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Abstract. The Magellanic Clouds are known to have a large variety of star clusters of various ages and morphology. Unlike the Milky Way, the Magellanic Clouds have suffered strong interactions among themselves and our galaxy through their lifetime. During those episodes, bursts of star and cluster formation has occurred, so a large number of star clusters are in the process of forming, still embedded in very disturbed environments and often are found in pairs.

A study of the imprints of such interaction is presented for the pair of clusters BSDL101 / BSDL103 in order to show the distortions in the density profiles. These clusters are the first targets of an ongoing study of binary clusters in the Magellanic Clouds.

1. INTRODUCTION

Most of the studies of the dynamics of star clusters in the nearby galaxies are made before the 1990's, when photographic plates and ground-based telescopes were used. These observations cover mostly the outer regions of the clusters, because the spatial resolution was not good enough for the central regions to be resolved. The centers of the populated clusters are saturated, and in such crowded fields no photometry or star count can be done.

Now with the use of the Hubble space telescope we can resolve the central parts of these clusters and to study them in unprecedented details.

Any distortions in the profile are more likely to be found in multiple clusters, than in an isolated globular cluster. This is the reason why we have selected a number of such binary clusters. In this study we present the multiple cluster candidates BSDL100, BSDL101 and BSDL103, which are near the cluster NGC1711 in the LMC. These clusters appear in the LMC extended catalog (Bica et al. 1999) and are not well studied yet.

2. OBSERVATIONS AND DATA REDUCTION

This work is based on archival data from Hubble Space Telescope (HST), which have been reduced according to the standard HST pipeline. The observations we use are from 1997 – five images in the visual part of the spectrum (F555W) and five in the infrared (F814W), 300s exposure each. The cluster was observed on the night of 18/19 October 1997. The list of the observations used is presented in Table 1.

We used the HSTphot package PSF fitting procedures for the photometric measurements and for identifying stars. The photometry done with HSTphot is corrected for the geometric distortion (Holtzman et al., 1995), the filter-dependent plate scale changes (determined empirically) (Dolphin, 2000) and the 34th row error (Shaklan et al., 1995; Anderson and King, 1999).

Table 1. List of observations for BSDL 103.

Dataset	Filter	Exposure [s]	Dataset	Filter	Exposure [s]
U2Y8050JR	F555W	300	U2Y8050ER	F814W	300
U2Y8050KR	F555W	300	U2Y8050FR	F814W	300
U2Y8050LR	F555W	300	U2Y8050GR	F814W	300
U2Y8050HR	F555W	300	U2Y8050MR	F814W	300
U2Y8050IR	F555W	300	U2Y8050NR	F814W	290

3. COLOR-MAGNITUDE DIAGRAMS

In order to investigate if the two clusters BSDL101 and BSDL103 are from common origin we have constructed their color-magnitude diagrams (CMDs). On the Figure 1 the left is the CMD of the cluster BSDL103, and the right is the CMD of the cluster BSDL101.

The isochrones that are shown are taken from Marigo et al. (2008) for log t = 8.7 and 8.8, corresponding to age 5.01 10^8 and 6.31 10^8 years, respectively. We apply a distance modulus of 18.5^m to the Large Magellanic Cloud. In the figure 1a the isochrone of log t = 9.8 (6.3 10^9 years) is shown and it well represents the field stars. We made an investigation of the spatial distribution of the stars with V-I > 0.75 and V < 22^m and found out, that they are uniformly distributed in the field.

The similarity of the CMDs of the two clusters suggest that they are about the same age and probably were born together from the same gas complex.

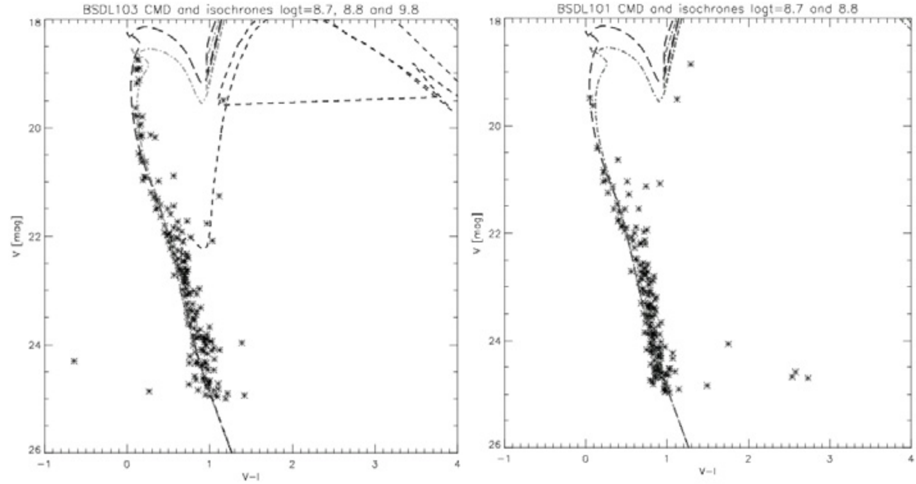

Figure 1: a) Left: CMD for the cluster BSDL103. The isochrone of log t = 8.7 (long-dashed line) and log t = 8.8 (dot-lined) well represent the cluster, while the one for log t = 9.8 (short-dashed line) represents the field stars; b) Right: CMD for the cluster BSDL101. The same isochrones for log t = 8.7 and 8.8 as for the Figure 1a.

3. RADIAL DENSITY PROFILES

The stellar density maps can be used to trace the cluster's ellipticity and structures like bridges between the clusters. Such features can disturb the stellar density profile of the cluster.

In Figure 2 we investigate the stellar density distribution by counting the stars in square bins of 0.8 pc wide or 64 Planetary Camera pixels. The derived density map illustrates that both clusters are small and seem embedded in the same larger structure, in which the stellar density is higher than the background away from the clusters. If we assume that they are coeval, then this map represents their original concentration from where they are born.

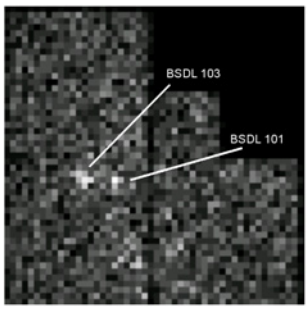

Figure 2: The stellar density map in and around the two clusters. One bin of the map is 64 Planetary Camera pixels wide.

We have constructed the radial density profiles (RDPs) of the cluster BSDL103 by counting the number of stars in rings around the cluster. Each ring is 0.1 arcsec wide. In the Figure 3 are presented the density profiles for the bright stars and for the faint stars of the cluster BSDL103.

It is expected that the profiles follow a smooth King-like profile (King, 1962; Elson, 1988). But in the case of this pair of clusters the profiles of the cluster are distorted. In the profile of the bright stars (Figure 3a) we see that they are concentrated mainly in the cluster BSDL103. Their density goes down to about the half of the central value when we are outside the cluster. The profile for the faint stars (Figure 3b) is distorted and after log R = –0.4 the stellar density has a constant value.

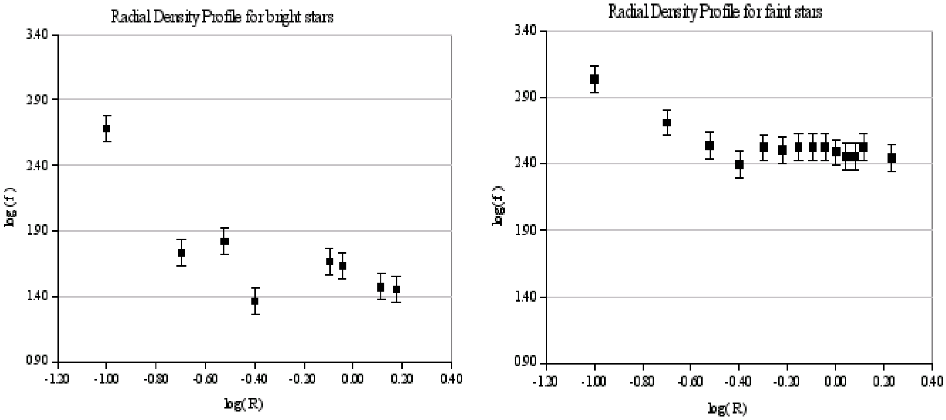

Figure 3: a) the radial-density profile for the bright stars ($17^m < V < 21^m$). The x-axis is the logarithm of the distance from the centre of the cluster (log R), and the y-axis is the logarithm of the density of stars (log f); b) the radial density profile for the faint stars ($21^m < V < 25^m$).

KMHK 156

In the frames we used we found out, that the object, categorized as a cluster KMHK156 by Kontizas et al. (1990) is actually two bright stars with a small separation, so that they cannot be resolved by the ground-based observations. On the WFPC2 images they are resolved.

6. CONCLUSIONS

We have constructed the RDPs for the cluster BSDL103 and density map of the surrounding field to investigate the stellar density. We find out that BSDL103 is a small cluster composed of bright main-sequence stars. The density profile of BSDL103 is distorted, especially for the faint stars, which are less massive and any interactions between the clusters affects them more than the massive ones. The bright stars are concentrated within the cluster. An isochrones fitting for the

CMDs of BSDL103 and BSDL101 implies that the two clusters are the same age, $(6\pm1)10^8$ years, and much younger than the field stars, which have an age of billions of years. The similarities of the CMDs suggest that the two clusters BSDL103 and BSDL101 are coeval and most probably are a physical pair, embedded in the region where they are born.

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