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THE DISTORTIONS IN THE DENSITY PROFILES IN LMC CLUSTERS NGC 1850, NGC 2214 AND BSDL 103

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Г. Николов, В. Голев, М. Контизас, А. Даперголас, Е. Контизас, Я. Беллас-Велидис. ДИСТОРСИИ НА ПРОФИЛИТЕ НА ПЛЪТНОСТТА В КУПОВЕТЕ ОТ ГОЛЕМИЯ МАГЕЛАНОВ ОБЛАК NGC 1850, NGC 2214 И BSDL 103

Известно е, че Магелановите облаци имат голямо разнообразие от купове с различни възрасти и морфология. За разлика от Млечния път Магелановите облаци са претърпели силни гравитационни взаимодействия помежду си и с нашата Галактика за времето на техния живот. По време на тези епизоди на взаимодействия се появява взривно звездообразуване и образуване на купове. По тази причина голям брой от звездните купове там са в процес на незавършено образуване, намирайки се във все още силно дистурбирана среда, често по двойки. Тук представяме профилите на плътността на такива кандидати за двойни купове на основата на архивни наблюдения с космическия телескоп „Хъбъл" и дискутираме дисторсиите на тези профили.

G. Nikolov, V. Golev, M. Kontizas, A. Dapergolas, E. Kontizas, I. Bellas-Velidis. THE DISTORTIONS IN THE DENSITY PROFILES IN LMC CLUSTERS NGC 1850, NGC 2214 AND BSDL 103

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 gravi-

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tational interactions among themselves and our Galaxy through their lifetime. During those episodes of interactions, bursts of star and cluster formation has occurred. For this reason a large number of star clusters are in the process of forming, still embedded in very disturbed environments and often are found in pairs. Here we present the density profiles of such binary cluster candidates based on archival HST observations and the distortions in the profiles are discussed.

Keywords: Magellanic Clouds: clusters, individual: NGC 1850, NGC 2214, BSDL 103; density profiles

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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 in order to resolve the central regions. The centers of the populated clusters are too crowded and saturated, and as a consequence no photometry or star count could be done there.

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 RDPs are more likely to be found in multiple clusters, rather than in an isolated globular cluster. That is why we have selected as much as possible of such binary clusters in LMC.

In this study we present several multiple cluster candidates: NGC 2214, NGC 1850 and NGC 1850b and, also, the small cluster BSDL 103 located at 3 arcmin away from the prominent cluster NGC 1711 in the LMC. These clusters appear in the LMC extended catalogue [3] and are listed as a multiple cluster candidates [see 4].

2. OBSERVATIONS AND DATA REDUCTION

We use archival data from Hubble Space Telescope (HST), downloaded from the HST Data Archive Center through the MAST service, which have been reduced according to the standard HST pipeline using the latest calibrations available. The observations of the cluster BSDL 103 are from HST proposal 5904, imaged in 1997. We use five images in the visual part of the spectrum (F555W) and five in the infrared (F814W), 300 s exposure each. For the cluster NGC 1850 we use observations from the HST proposal 5475, im-

aged in 2002. This is a snapshot program and there are only two images – one in F555W and one in the F450W filter. The observations of the cluster NGC 2214 are from the HST proposal 8134 and there are long (350 s) and short (10 s) exposures, which allow doing photometry on bright and faint stars. The list of the observations used is presented in Table 1.

For the photometric measurements and for identifying stars we use the HSTphot package PSF fitting procedures. The photometry done with HSTphot is corrected for the geometric distortion [7], the filter-dependent plate scale changes (determined empirically by Dolphin) [5] and the 34th row error [1,10]. The radial density profiles (RDPs) are constructed by counting the number of stars in rings around the cluster. We are using a radial step of 0.1 arcmin to construct the profiles and each ring is 0.1 arcsec wide. The profiles we present are corrected for the background density of the stars, determined at 1.2–1.7 arcmin away from the center of the cluster. The selection of the bright and faint stars depends on the magnitude range of the stars in the cluster.

Table 1. List of observations

Cluster name	Dataset	Filter	Exposure [s]	Dataset	Filter	Exposure [s]
BSDL 103	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
NGC 1850	U26M1E02T	F555W	20	U26M1E01T	F455W	40
NGC 2214	U5AY1101R	F555W	350	U5AY1104R	F814W	350
	U5AY1102R	F555W	350	U5AY1105R	F814W	350
	U5AY1109R	F555W	350	U5AY1107R	F814W	350
	U5AY110AR	F555W	350	U5AY1108R	F814W	350
	U5AY1103R	F555W	10	U5AY1106R	F814W	10

3. RADIAL DENSITY PROFILES

3.1. BSDL 103

We have constructed the radial density profiles of the cluster BSDL 103, presented in Fig. 1 density profiles for the bright stars and for the faint stars of the cluster BSDL 103.

It is expected that the profiles follow a smooth King-like profile [6, 8] but in the case of this pair of clusters the profiles of the cluster are distorted. In the

RDP of the bright stars we see that they are concentrated mainly in the cluster BSDL 103. Their density goes down to about the half of the central value when we are outside the cluster. The RDP for the faint stars is distorted and after log $r = -0.5$ the stellar density has a constant value.

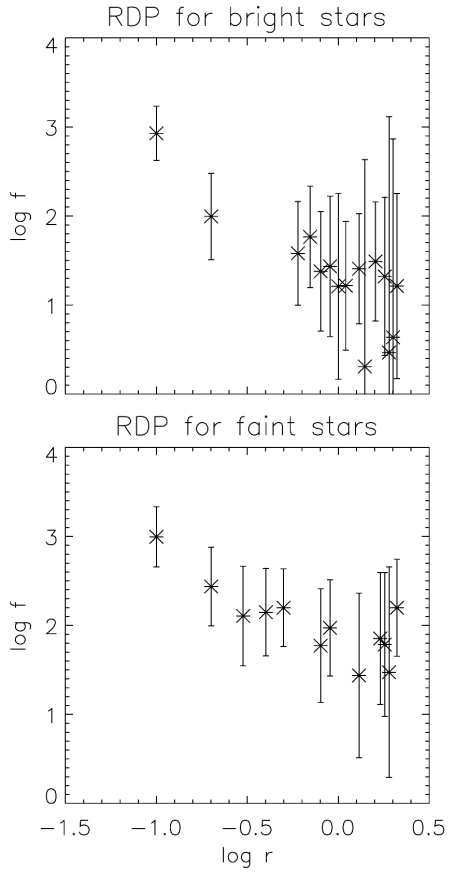

Fig. 1. The radial density profiles for the cluster BSDL 103 for the bright stars (19^m<V<23^m) and for the faint stars (23^m<V<27^m). The abscissa is the logarithm of the distance from the centre of the cluster in units of 0.1 arcmin (log *r*), and the y-axis is the logarithm of the density of stars (log *f*)

3.2. NGC 1850

The cluster NGC 1850 is one of the bright and populous star clusters in the LMC. The companion cluster NGC 1850b is small and young, containing mainly blue bright stars. It is located at a distance of about 1 arcmin to the main cluster companion NGC 1850. It is not clear whether NGC 1850b is physically

associated with NGC 1850 or not – it may be a chance of superposition of two clusters along the same line of sight. Probably they are a physical pair because they both are embedded and surrounded by a gas cloud, imaged in F656N narrow Hα filter. Fig. 2 shows the radial density profiles for the cluster NGC 1850. In this pair we do not see a distortion in the profile of the fainter stars, because NGC 1850b is not very populous and not so massive and could not distort the shape of NGC 1850. Instead, we see that there is a slight distortion, like a bump, in the profile of the bright stars. It is a result of the presence of the secondary cluster NGC 1850b, which contains mainly bright blue stars.

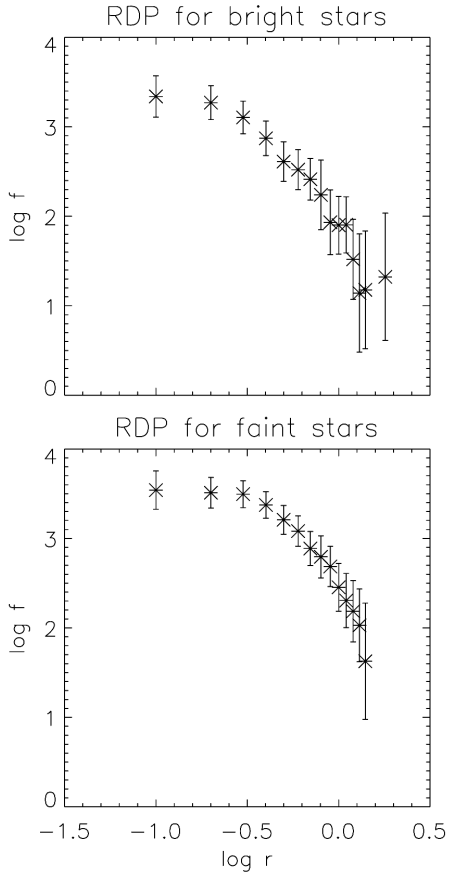

Fig. 2. The radial density profiles for the cluster NGC 1850 for the bright stars (14^m<V<19^m) and for the faint stars (19^m<V<25^m). The axes are as in Fig. 1

3.3. NGC 2214

NGC 2214 is a populous binary cluster in LMC with significant population of the blue stars. It has been reported [2] as a merger, where the secondary component appears to be still clearly visible in images from ground based observations.

It is evident (see the RDP of the cluster in Fig. 3) that the slope of the RDP for bright stars is steeper than the RDP for the faint ones, indicating that the bright stars are more concentrated to the center of the cluster while the faint stars are more spread. This suggests that a mass-segregation is taking place in NGC 2214. After a dynamical interaction in the cluster the massive stars transfer part of their energy to the less massive stars, causing the massive ones to orbit closer to the cluster's center. Correspondingly, the less massive stars get larger velocities during encounters, causing some of them to escape from the cluster.

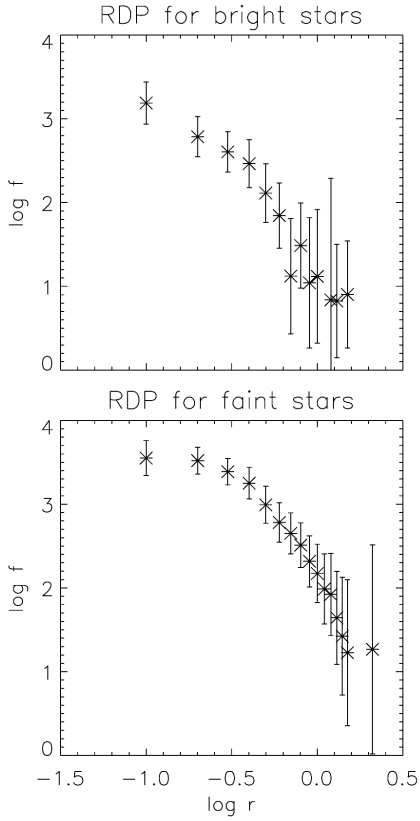

Fig. 3. The radial density profiles for the cluster NGC 2214 for the bright stars (14^m<V<19^m) and for the faint stars (19^m<V<25^m). The axes are as in Fig. 1.

4. DISCUSSION

We have constructed the RDPs for the LMC clusters BSDL 103, NGC 1850 and NGC 2214. The density profile of BSDL 103 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 quite concentrated within the cluster. For the binary cluster NGC 1850/NGC 1850b the second one, being composed of bright stars mainly, produces a slight bump in the profile of the bright stars. The RDPs of NGC 2214 indicate a mass-segregation in the cluster, which might be triggered by a possible recent merging of this cluster with another one.

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