Density Profiles of Star Clusters in the Magellanic Clouds

G. Nikolov,[1,2] A. Dapergolas,[3] M. Kontizas,[2] V. Golev,[1] and
M. Belcheva[2]

[1]*Department of Astronomy, Faculty of Physics, Sofia University, Sofia 1000,
Bulgaria*

[2]*Department of Astrophysics, Astronomy & Mechanics, Faculty of Physics,
University of Athens, GR15783 Athens, Greece*

[3]*IAA, National Observatory of Athens, GR118 10 Athens, Greece*

Abstract. The Large Magellanic Cloud (LMC) and the Small Magellanic Cloud
(SMC) provide the unique opportunity to study young and populous star clusters, some
of them elliptical in shape, or members of a multiple system, which are almost absent in
the Milky Way. We have selected a sample of Magellanic Clouds' star clusters, some of
them candidates for being components of a multiple system, with the purpose of investi-
gating by means of their number density profiles. This approach allows us to determine
the radial distribution of the stars of different magnitude. Since the brighter stars have
larger masses than the fainter stars, the profiles can be used to trace mass-segregation
in the clusters. We have fitted a theoretical model by Elson, Fall & Freeman (Elson,
Fall & Freeman 1987) to determine the core radius and the concentration of the stars
for each magnitude range. We present the density profiles and the derived structural pa-
rameters for the selected cluster sample. Some of the clusters show indication of mass
segregation.

1. Observations and data reduction

In this work we use archival observations from Hubble Space Telescope WFPC2 cam-
era. We use observations from the following HST programs: HST project 5904 for
cluster NGC 1711; HST project 5475 for cluster NGC 1850; HST project 5916 for
cluster NGC 1898; HST project 8134 for clusters NGC 1984 and NGC 2011 and NGC
2214. We use calibrated images that were reduced according to the standard HST
pipeline, using the latest available calibrations, including bias subtraction and flat-field
correction.

The photometric reduction was done using HSTphot (Dolphin 2000) - a photom-
etry package especially designed for a point-spread function (PSF) fitting of WFPC2
point sources. For each image the bad and hot pixels were removed, and the cosmic
rays cleaned. The images with the same pointing and rotation were combined in order
to obtain a better signal to noise ratio and then were used for PSF photometry with a
local determination of the background near the star. In this way we minimize the result-

ing error in the magnitude determination. The magnitude errors from the photometry are typically larger than 0.1^m only for the stars fainter than $V > 25^m$.

2. Number density profiles

We construct the profiles by counting the number of stars in concentric rings from the center of the cluster. The number of stars in each ring is corrected for the incompleteness of the photometry. That number is then divided by the area of the ring to determine the stellar density.

To derive structural parameters from the clusters' density profiles we fit the Elson, Fall & Freeman (1987) theoretical profile, which represents well the young LMC clusters with no tidal truncation in the form of:

$$f(r) = f_0 \left(1 + \frac{r^2}{a^2}\right)^{-\gamma/2} \tag{1}$$

where f_0 is the central density, γ is the power-law slope, and a is a scale radius, connected to the cluster's core radius as $r_c = a\sqrt{2^{(\gamma/2)} - 1}$.
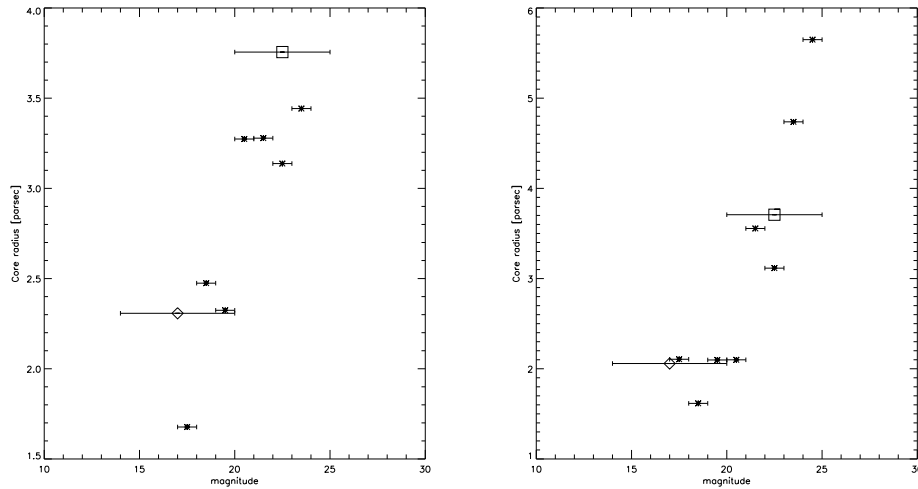

Figure 1.: Core-radius derived from the best-fit EFF model for each magnitude in the clusters NGC 1711 (left) and NGC 2214 (right) with its magnitude range indicated with horizontal bars. The diamond corresponds to the r_c of the bright stars ($V \leq 20$) while the square is the core-radius derived for the fainter stars ($V \geq 20$)

3. Discussion

The LMC cluster NGC 1711 is known to be mass-segregated (Subramaniam, Sagar, & Bhatt 1993) and here (Fig. 1 left) we confirm that there is an evident trend for our
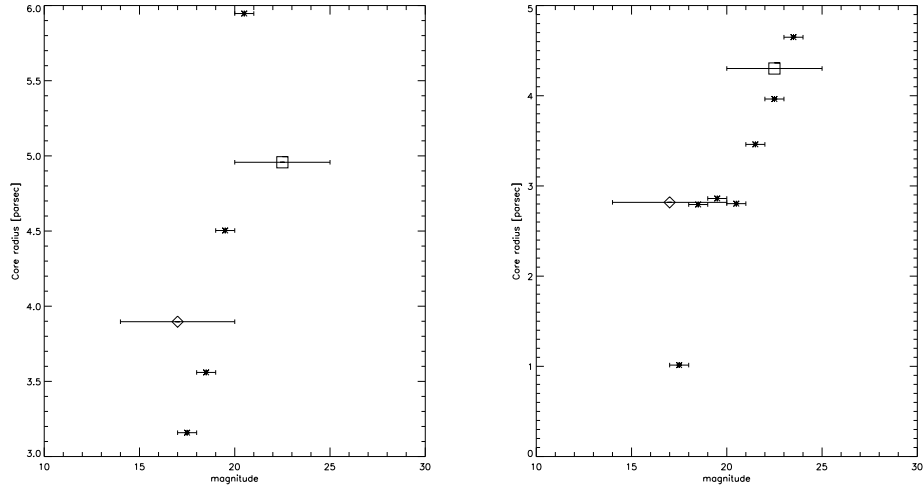
Figure 2.: Core-radius derived from the best-fit EFF model for each magnitude in the clusters NGC 1850 (left) and NGC 1898 (right) with its magnitude range indicated with horizontal bars. The diamond corresponds to the r_c of the bright stars ($V \leq 20$) while the square is the core-radius derived for the fainter stars ($V \geq 20$)
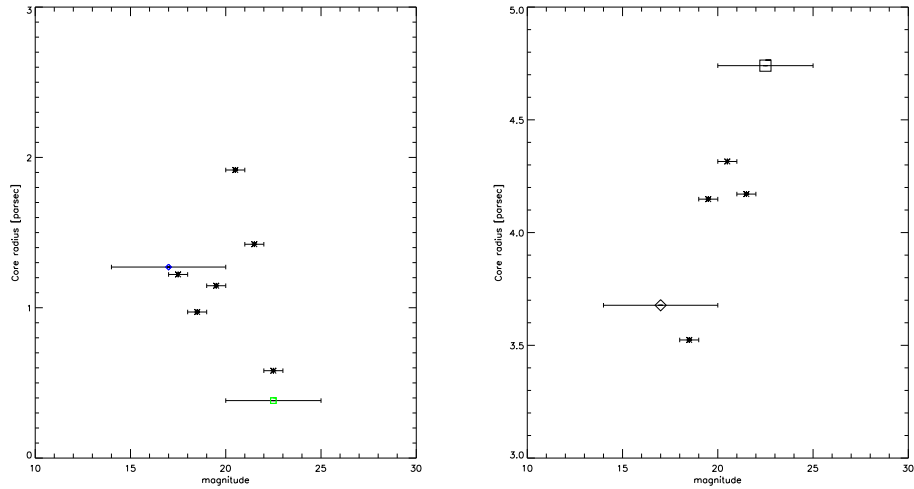

Figure 3.: Core-radius derived from the best-fit EFF model for each magnitude in the clusters NGC 1984 (left) and NGC 2011 (right) with its magnitude range indicated with horizontal bars. The diamond corresponds to the r_c of the bright stars ($V \leq 20$) while the square is the core-radius derived for the fainter stars ($V \geq 20$)

best-fit core-radius to increase with magnitude the faint stars are more wide spread than the cluster's bright stars. NGC 1850 is a well-known binary cluster candidate of LMC. The main cluster is very populous while the companion is a small bright clump of ~50 blue stars. In our RDP the contribution of the small companion is not evident, because of averaging the number of stars in each concentric ring. Figure 2 (left) shows

the derived core-radius vs. magnitude for the main cluster. The core-radius for NGC 1898 follows the same trend as NGC 1711 – the bright stars are more concentrated and the fainter stars are more wide spread (Fig. 2 right). The cluster NGC 1984 is located in a very dense star field in a LMC star forming region. The field stars probably influence our density profiles for the stars fainter fainter than 20^m (Fig. 3 left). NGC 2011 is a young LMC cluster located in the OB association region LH 75.This cluster also shows an indication of stellar stratification (Fig. 3 right). NGC 2214 is a young LMC cluster, possibly in a process of merging (Bhatia & MacGillivray 1988). On Figure 1 (right) we show the derived core-radius from fitting the profile for each magnitude bin, indicated by horizontal bars. It can be seen that the derived core-radius tends to become larger with increasing magnitude.

From the above investigation we can conclude that the core-radius at various magnitudes may be used as an indication for stellar stratification in star clusters.

References

Bhatia, R. K. & MacGillivray, H. T. 1988, A&A, 203, L5
Dolphin, A. E. 2000, PASP, 112, 1383
Elson, R. A. W., Fall, S. M., & Freeman, K. C. 1987, ApJ, 323, 54
Subramaniam, A., Sagar, R., & Bhatt, H. C. 1993, A&A, 273, 100