Stellar systems in the Local group: Large Magellanic Cloud star clusters

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The Large Magellanic Cloud (LMC) provides a unique opportunity to study populous star clusters of various ages resolved in stars by the Hubble Space Telescope instruments. The dynamical models of star clusters predict that after the cluster is formed, the less massive stars are given additional kinetic energy from the massive stars via two-body encounters (Meylan and Heggie 1997). Eventually some of them overcome the cluster's gravitational potential and escape. The massive stars, on the other hand, in time tend to sink towards the cluster's centre, and the most massive stars form the core of the cluster. This process leads to the segregation of stars by stellar mass in the clusters. An alternative explanation of the stellar segregation observed in clusters is that it has a primordial origin, i.e. the massive stars are born inside the cluster's core at an early cluster formation epoch. Observationally, when mass-segregation is present, the spatial distribution of massive stars shows a central concentration with a core-radius being smaller than that of the less massive stars.

From the HST/WFPC2 observations archive we selected a sample of LMC star clusters to investigate them by means of their radial stellar density profiles. The high spatial resolution of the WFPC2 allows us to determine the radial distribution of groups of stars of various magnitudes in a cluster. Since the brighter stars are more massive than the fainter stars, the structural parameters of the profiles can be used to trace mass segregation in star clusters. In the Dissertation we fit the observed radial density profiles with theoretical models by Elson, Fall & Freeman 1987 and King 1962 to determine the cluster core-radius per magnitude of the stars. We investigate segregation of masses in the following LMC clusters: NGC 1711, NGC 1754, NGC 1984, NGC 1898, NGC 2004, NGC 2005, NGC 2011, NGC 2019, NGC 2031, and NGC 2214. Such comparative analysis of the structural parameters from the radial-density profiles modelling of groups of stars of various magnitudes is applied for the first time for estimating the dynamical evolutionary state and stellar mass segregation in the studied clusters.

Colour-magnitude diagrams are constructed for the clusters BSDL 103, BSDL 101, NGC 2031, and NGC 2031, their ages estimated from modern theoretical isochrones fitting. For NGC 2004 and NGC 2031 also a comparison with synthetic cluster simulation is presented.

The key points and results of the study are presented in the last chapter of the Dissertation, and summarized below:

– a detailed study of the dynamical evolutionary state of the Large Magellanic Cloud star clusters NGC 1711, NGC 1754, NGC 1984, NGC 1898,

NGC 2004, NGC 2005, NGC 2011, NGC 2019, NGC 2031, and NGC 2214 is presented
- radial density profiles for various magnitudes of the stars in the studied clusters are constructed, and the variation of the core-radii vs. magnitude is used as a method to assess mass segregation
- Elson model is fitted to the profiles of the young LMC clusters NGC 1711, NGC 1984, NGC 2004, NGC 2011, NGC 2031, NGC 2214 and their structural parameters are determined
- King model is fitted to the old LMC star clusters NGC 1754, NGC 1898, NGC 2005, NGC 2019 and their structural parameters are determined
- mass segregation in NGC 1711 and NGC 2004 is confirmed
- evidence of mass segregation in the clusters NGC 2011, NGC 2031, and NGC 2214 is observed, unlike NGC 1984 and NGC 2019
- indication of stellar mass segregation, possibly of dynamical origin, is observed in the old star clusters NGC 1754, NGC 1898 and NGC 2005
- isochrones fitting for the CMDs of BSDL 103 and BSDL 101 implies that the two clusters are the same age, $(6 \pm 1) \times 10^8$ years, and much younger than the field stars. We argue that the similarity of BSDL 103 and BSDL 101 colour-magnitude diagrams suggests that both clusters are coeval and most probably are a physical pair
- the object, categorized as cluster KMHK 156 is actually two bright stars of Gaia magnitudes G=13.08 and G=13.74 with a small separation of 4.1 arcsec on the sky
- we demonstrate how an eMSTO effect can be achieved only through the sky determination during photometry of multiple-CCD cameras (Nikolov 2018). In the presented case of NGC 2031, on the cluster CMD the stars from WF3 CCD are shifted in colour with respect to the other CCDs
- using synthetic cluster simulations and isochrone fitting, we estimate that the stellar population of NGC 2031 has an age of 227 ± 3 Myr and metallicity $Z = 0.0058 \pm 0.0002$, with reddening estimated to $E(V-I) = 0.17$ towards the cluster
- for cluster NGC 2004 an age estimation of 16 ± 4 Myr is obtained using single stellar population isochrone fitting and a synthetic cluster simulation. The reddening towards the cluster is estimated to be $E(V-I) = 0.3$

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