Advances in Hellenic Astronomy during the IYA09
ASP Conference Series, Vol. 424, 2010
K. Tsinganos, D. Hatzidimitriou, and T. Matsakos, eds.

Modeling the Distribution of Various Objects in the Magellanic Clouds for Gaia

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Abstract. Gaia is an ESA mission expected to chart a three-dimensional map of our Milky Way galaxy, in the process revealing the composition, formation and evolution of the Galaxy. Gaia will also observe nearby galaxies resolved in stars. The main goal of our project is to obtain the spatial distribution of different stellar components in these galaxies. The Magellanic Clouds, being the nearest neighbours of our Galaxy, are the most important targets with a large number of observed stars. In order to obtain their spatial distribution already existing catalogues are used, which are homogeneous, have a good coverage of the galaxies, and are deep enough, such as The Magellanic Clouds Photometric Survey, 2MASS, SuperCosmos Sky Survey, etc. The spatial distribution of different Magellanic Clouds' populations is studied using isopleth maps and radial density profiles. Preliminary results are now available. Exponential disk and King profiles seem to fit the spatial distribution of the various stellar populations very well.

1. Introduction

Gaia is an ESA cornerstone mission. It is primarily an astrometric mission, whose goal it is to create the largest and most precise three dimensional chart of our Galaxy by providing unprecedented positional and radial velocity measurements for about one billion stars in our Galaxy and throughout the Local Group (Perryman et al. 2001). Gaia will be scanning the entire sky and its observations are not only limited to stars. It is expected to detect point-like sources like quasars, solar system objects, supernovae, unresolved galaxies, and more.

ELSA (European Leadership in Space Astrometry) is a Marie Curie Research Training Network (RTN) supported by the European Comissions Sixth Framework Programme (Lindegren et al. 2008). The overall objectives of ELSA are to develop the theoretical understanding and practical analysis tools of importance for the Gaia mission and to foster the development of a new generation of researchers in the area of space astrometry and other subjects, such as astrophysical and instrument modeling, numerical analysis, data processing. his project is part of the scientific preparations for the Gaia mission, and therefore strongly linked to the Gaia Data Processing and Analysis Consortium.

The main objective of our project within ELSA is to investigate the spatial distribution of stellar components in nearby galaxies, that are resolved in stars by Gaia, such as galaxies from the Local Group. The Magellanic Clouds are our main targets, because of their proximity and large number of observable stars.

For this we are using archive data - both all-sky surveys such as 2MASS, and dedicated catalogues such as the Magellanic Clouds Photometric Survey (Zaritsky et al. 2002, 2004). We also use the SuperCosmos sky survey for comparison, but only the outer parts of the galaxies because areas at the centers are greatly affected by crowding. We are also interested in the distribution of more specific objects, such as carbon stars, or extended objects like star clusters, associations or emission nebulae.

The results of our investigation will be used to improve the Gaia Universe Model. The Universe Model is a set of algorithms used by the data generators of the Gaia simulators - GASS, GIBIS and GOG - to generate simulated data in the framework of Gaia data reduction preparation. It generates astronomical objects and their observable characteristics. The distribution of these objects and statistics of observables should be as realistic as possible allowing for simulation to be used for estimating telemetry, testing software, simulating images, etc.

2. Results

In this paper we present the preliminary results based on data obtained from the Magellanic Clouds Photometric Survey (MCPS) and the catalogues of carbon stars in the Magellanic Clouds from Rebeirot et al. (1993), Morgan et al. (1995) and Kontizas et al. (2001). From the MCPS we selected the main sequence stars with $B-V< -0.3$ and are also investigating the spatial distribution of both galaxies as a whole, using stars brighter than 20 mag.

In order to determine approximately the extent and the sizes of the galaxies we perform star counts (in a rectangular grig) and produce isopleth contour maps - the contours in these maps trace areas with equal stellar density. They show the overall shape of the galaxies and give an initial insight for its spatial distribution. In Figure 1 we show the isopleth maps of the Magellanic Clouds' carbon stars.

We also use radial density profiles (RDP) to obtain the actual distribution of the galaxies. The RDPs correspond to the projected radial number-density of objects contained in concentric rings around the LMC and SMC centroids. The underlying assumption for this kind of analysis is that the structures should present an important degree of radial symmetry. This is not always the case of the Magellanic Clouds, but RDPs can still be used as probes of the radial distribution of the various objects averaged over all azimuthal directions and, therefore, of the large-scale structure, as can be seen in Figures 2, 3 and 4.

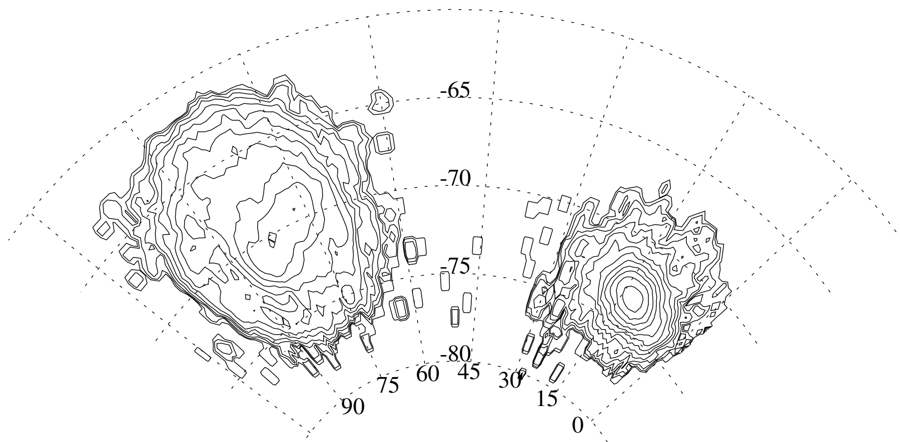

Figure 1.: Isopleth contour maps of the Magellanic Clouds carbon stars. Left: LMC, right: SMC.

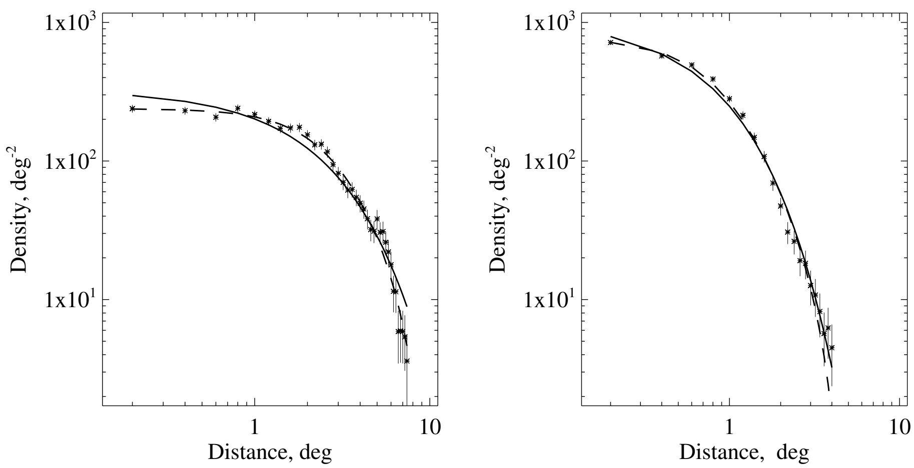

Figure 2.: Radial density profiles for the carbon stars, fitted with exponential-disk (solid line) and King profiles (dashed line). Left: LMC, right: SMC.

As a first approach to describe the spatial distribution of various stellar populations in the Magellanic Clouds from the RDPs, we use an exponential-disk profile

$$\sigma(R) = \sigma_{0D} \times e^{-\frac{R}{R_D}}$$

where R_D and σ_{0D} are the scale length and the central density of objects respectively. We also use a King-like profile based on the King law (King 1962), which is usually used to describe the distribution of globular clusters, but also applies to Galactic clusters and dwarf spheroidal galaxies,

$$\sigma(R) = \sigma_{0K} \left(\frac{1}{\sqrt{1 + \frac{R^2}{{R_c}^2}}} + \frac{1}{\sqrt{1 + \frac{{R_t}^2}{{R_c}^2}}} \right)^2$$

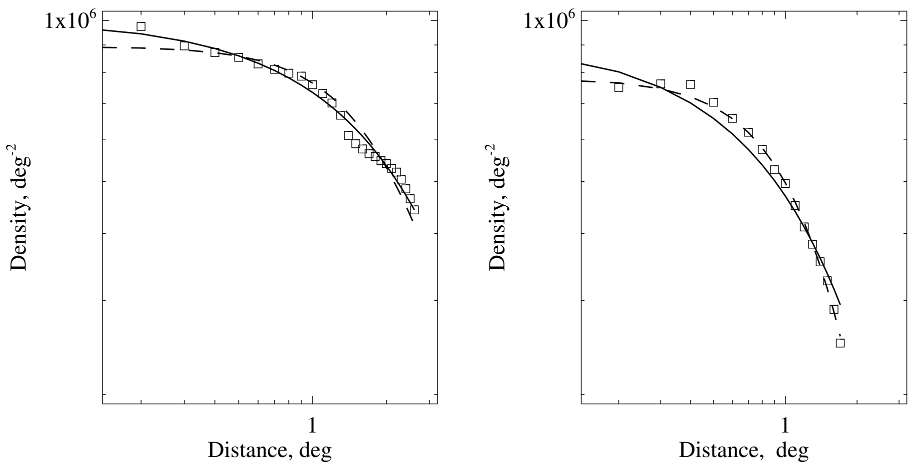

Figure 3.: Radial density profiles for all stars brighter than 20 mag from the MCPS, fitted with exponential-disk (solid line) and King profiles (dashed line). Left: LMC, right: SMC. Error bars are comparabe to or smaller than the symbols.

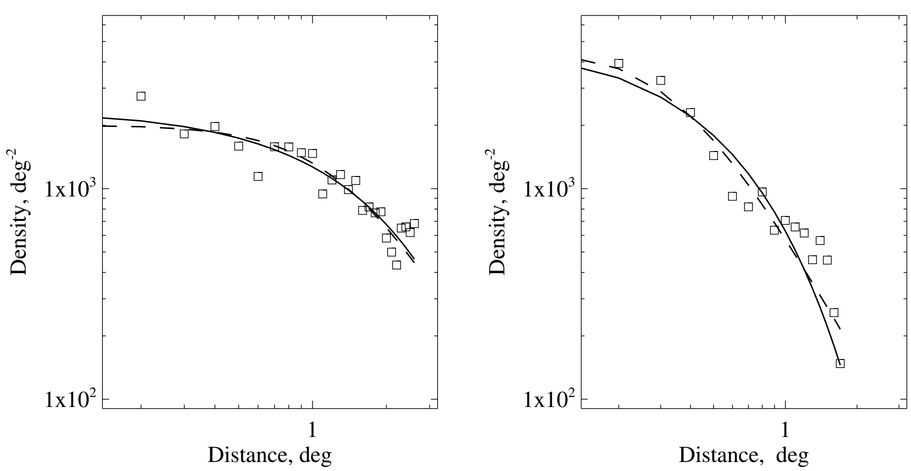

Figure 4.: Radial density profiles for main sequence stars from the MCPS, fitted with exponential-disk (solid line) and King profiles (dashed line). Left: LMC, right: SMC. Error bars are comparabe to or smaller than the symbols.

where R_t and R_c are the core and tidal radii respectively, and σ_{0K} is the central density of objects.

In some cases we did not use the inner $1\deg$ of the LMC, because of asymmetries (e.g. the LMC bar) which distort the radial profiles (see Figure 2 and Figure 4). For the carbon stars both the King and the exponential laws seem to fit, although the exponential-disk model seems to be slightly better in the case of SMC. The Magellanic Clouds' main sequence stars also seem to follow the same trend. The only difference is that the King profile seems better. The average radial density distribution of all stars, however, is closer to the King-like profile, while the exponential-disk model obviously fails. All the structural parameters measured can be found in Table 1.

Table 1.: Structural parameters of the carbon stars (CS), main sequence stars (MS), and all stars brighter than 20 mag. measured from the RDPs with the exponential-disk and King profiles (Fig. 2, 3, 4). The last column contains the concentration parameter $c_p = \log(R_c/R_t)$.

RDP	σ_{0D} [Obj. deg^{-2}]	R_D [deg]	σ_{0K} [Obj. deg^{-2}]	R_c [deg]	R_t [deg]	c_p
LMC all	$(1.4 \pm 0.1) \times 10^6$	1.48 ± 0.10	$(7.5 \pm 1.2) \times 10^6$	5.8 ± 0.4	6.5 ± 0.08	0.04
SMC all	$(1.4 \pm 0.3) \times 10^6$	0.71 ± 0.08	$(7.8 \pm 1.3) \times 10^6$	2.9 ± 0.2	3.2 ± 0.04	0.03
LMC MS	$(1.8 \pm 0.2) \times 10^4$	1.02 ± 0.05	$(1.6 \pm 0.1) \times 10^4$	2.3 ± 0.4	6.6 ± 0.2	0.45
SMC MS	$(2.1 \pm 0.2) \times 10^4$	0.48 ± 0.03	$(2.5 \pm 0.2) \times 10^4$	0.9 ± 0.1	2.8 ± 0.10	0.50
LMC CS	$(4.2 \pm 0.2) \times 10^2$	1.75 ± 0.06	$(3.9 \pm 0.2) \times 10^2$	2.7 ± 0.1	10.5 ± 0.4	0.60
SMC CS	$(10.7 \pm 0.5) \times 10^2$	0.70 ± 0.02	$(10.9 \pm 0.4) \times 10^2$	0.9 ± 0.04	5.4 ± 0.2	0.80

Acknowledgments. M. Belcheva acknowledges financial support from EC FP6 RTN ELSA. G. Nikolov acknowledges the support of the Bulgarian National Science Research Fund through grant DO-02-85/2008.

References

King, I. 1962, AJ, 67, 471

Kontizas, E.,Dapergolas, A., Morgan, D. H. & Kontizas, M. 2001, A&A, 369, 932

Lindegren, L., Bijaoui, A., Brown, A. G. A., Drimmel, R., Eyer, L., Jordan, S., Kontizas, M., van Leeuwen, F., Muinonen, K., Pourbaix, D., Torra, J., Turon, C., de Vries & J. Zwitter, T. 2008, IAUS, 248, 529

Morgan, D. H. & Hatzidimitriou, D. 1995, A&AS, 113, 539

Perryman, M. A. C., de Boer, K. S., Gilmore, G., Høg, E., Lattanzi, M. G., Lindegren, L., Luri, X., Mignard, F., Pace, O. & de Zeeuw, P. T. 2001, A&A, 369, 339

Rebeirot, E., Azzopardi, M. & Westerlund, B. E. 1993, A&AS, 97, 603

Zaritsky, D., Harris, J., Thompson, I. B. & Grebel, E. K. 2004, AJ, 128, 1606

Zaritsky, D., Harris, J., Thompson, I. B., Grebel, E. K. & Massey, P. 2002, AJ, 123, 855