Abstract

The Magellanic Clouds (MCs) consist of a pair of galaxies, the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC), which are located at a distance of $\sim$ 50 kpc and 60 kpc, with stellar masses of $\sim 10^{10}$ $M_{\odot}$ and 10^{9} $M_{\odot}$, respectively. Morphologically they are categorized as irregular type galaxies. The MCs are gas rich and metal poor (Z=0.008 for LMC, and 0.004 for SMC) as compared to the Milky Way (MW), and have active star-forming regions. Their proximity and location at high galactic latitude enable us to resolve their individual populations as well as detect faint stellar populations. It is well known that the MCs are interacting with each other, as well as with the MW. The interaction is supported by the presence of the Magellanic Bridge and the Magellanic Stream.

The evolved stellar populations in the MCs help us to understand their evolution and interaction process. The MCs host both Population I as well as Population II stars. This extended range of star formation is a valuable source of information to understand the formation and evolution of galaxies in general, and the MCs in particular. Evolved stellar population means the stars that have evolved off the main sequence and the giants, such as red giants (RGs), red clump stars, and asymptotic giant branch stars. There is a dominant population of evolved stars present in the MCs, in star clusters as well as in the field.

The aim of the thesis is to study the evolved stellar populations for one of the component of the MCs, the LMC. The study is primarily divided into two parts. (1) *Study of sparse star clusters in the LMC:* To increase our understanding of sparse star clusters in the LMC, with well estimated parameters, using deep Washington photometric data for 45 LMC clusters. (2) *To estimate a metallicity map of LMC:* In order to understand the metallicity variation across the galaxy. This is done by creating a high spatial resolution metallicity map of the LMC, using

red giant branch (RGB) stars, with the help of photometric data and calibrated using spectroscopic studies of RGs in field and star clusters.

The introduction to the thesis study along with the aim are described in **Chapter 1** of the thesis.

The three sets of photometric data used for this study are described in **Chapter 2**. The data sets are: CT_1 Washington photometric data for 45 star clusters within the LMC, the VI photometric data from the Optical Gravitational Lensing Experiment Phase-III survey (OGLE III), and the Magellanic Cloud Photometric Survey (MCPS).

Study of sparse star clusters in the LMC: A systematic study is performed to analyse the 45 cluster candidates, to estimate their parameters (radius, reddening, and age) using the main-sequence turn-off (MSTO), as well as the evolved portion of the colour–magnitude diagram (CMD). The basic parameters were estimated for 33 genuine clusters, whereas the other 12 cluster candidates have been classified as possible clusters/asterisms.

The study of 33 star clusters are presented in **Chapter 3**. These clusters are categorized as genuine star clusters based on their strong density enhancement and cluster features with respect to their surrounding field regions. Out of the 33 clusters, 23 are identified as single clusters and 10 are found to be members of double clusters. Detailed discussions of all the individual clusters are presented. The estimated parameters for the single and double clusters are listed in two different tables. About 50% of the clusters are in the age range $\sim$ 100–300 Myr, the rest of them being older or younger. Comparison with previous age estimates shows some agreement as well as some deviation.

The remaining 12 clusters which could not be categorized as genuine star clusters are studied in **Chapter 4**. These clusters have poor (/suspicious) density enhancement and cluster features when compared to their surrounding fields. It is important to study such cluster candidates, as these objects probe the lower limit of the cluster mass function. Detailed discussion on these individual objects are presented and their estimated parameters are tabulated in this chapter. A detailed discussion based on the study of all the 45 inconspicuous clusters is presented in this chapter, including the estimated sizes (radii $\sim$ 2–10 pc), reddening with respect to field, and location in the LMC. The mass limit estimated for genuine clusters is found to be $\sim$ 1000 $M_\odot$, whereas for possible clusters/asterisms it is $\sim$ few 100 $M_\odot$, using synthetic CMDs.

The study of sparse clusters enlarged the number of objects confirmed as genuine star clusters (33) and estimated their fundamental parameters. The study emphasizes that the sizes and masses of the studied sample are found to be similar to that of open clusters in the MW. Thus, this study adds to the lower end of cluster mass distribution in the LMC, suggesting that the LMC, apart from hosting rich clusters, also has formed small, less massive open clusters in the 100–300 Myr age range. The 12 cases of possible clusters/asterisms are worthy of attention, in the sense that they can throw light on the survival time of such objects in the LMC.

Photometric metallicity map of the LMC using RGB stars: A metallicity map of the LMC is estimated using OGLE III and MCPS photometric data. This is a first of its kind map of metallicity up to a radius of 4–5 degrees, derived using photometric data and calibrated using spectroscopic data of RGB stars. The RGB is identified in the V, (V−I) CMDs of small areal subregions of varying sizes in both data sets. The slope of the RGB is used as an indicator of the average metallicity of a subregion, and this RGB slope is calibrated to metallicity using spectroscopic data for field and cluster RGs in selected subregions.

The metallicity map estimated using OGLE III photometric data is presented in **Chapter 5**. A method to identify the RGB of small subregions within the LMC and estimate its slope by using a consistent and automated method was developed. The technique is robust and independent of reddening and extinction. The details of calibrating the RGB slopes to metallicities, using previous spectroscopic results of RGs in field and star clusters are presented. The OGLE III metallicity maps are presented, based on four cut-off criteria to separate regions with good fits. The OGLE III map has substantial coverage of the bar, the eastern and western LMC, but does not cover the northern and southern regions. The OGLE III metallicity map shows the bar region to be metal rich whereas the eastern and western regions to be relatively metal poor. The mean metallicity is estimated for three different regions within the LMC. For the complete LMC the mean [Fe/H] is $= -0.39$ dex (σ[Fe/H] $= 0.10$); for the bar region it is $= -0.35$ dex (σ[Fe/H] $= 0.9$); and for the outer LMC it is $= -0.46$ dex (σ[Fe/H] $= 0.11$). The metallicity histogram for these different regions are also estimated. A radial metallicity gradient is estimated in the de-projected plane of the LMC. The metallicity gradient is seen to remain almost constant in the bar region (till a radius of $\sim$ 2.5 kpc) and has a shallow gradient of -0.066 ± 0.006 dex kpc^{-1} beyond that till $\sim$ 4 kpc.

In **Chapter 6** the metallicity map based on MCPS photometric data is estimated. The MCPS data covers more of the northern and southern LMC (less of eastern and western regions) and is important to be analysed in order to reveal the metallicity trend of the overall disk. The systematic differences between the filter systems of MCPS and OGLE III are corrected, and the MCPS slopes are then calibrated using the OGLE III slope–metallicity relation. The MCPS metallicity maps are presented, based on four cut-off criteria to separate regions with good fits. The bar region is found to be metal rich as was found using OGLE III data, whereas the northern and southern regions are marginally metal poor. The mean metallicity estimated for the complete LMC is $= -0.37$ dex (σ[Fe/H] $= 0.12$); and for the outer LMC it is $= -0.41$ dex (σ[Fe/H] $= 0.11$). The metallicity histogram for these different regions are estimated and compared with the OGLE III distribution. The metallicity range of the complete LMC is found to be almost similar for both data sets. The metallicity distribution within the bar has a narrow range as found using both data sets. The slight difference between mean metallicity of outer

LMC for the two data sets is attributed to their coverage. We suggest that the northern and southern regions of the LMC could be marginally more metal rich than the eastern and western regions. The metallicity gradient of the LMC disk, estimated from MCPS data is found to be shallow -0.049 ± 0.002 dex kpc^{-1} till about 4 kpc.

We also constructed a metallicity map of outliers using both OGLE III and MCPS data, and identified subregions where the mean metallicity differs from the surrounding areas. We suggest further spectroscopic studies in order to assess their physical significance.

The detailed conclusion of the thesis and future work are presented in **Chapter 7**. From the study of sparse star clusters in the LMC, it is concluded that LMC has open cluster like star cluster systems. It is important to include them to understand the cluster formation history (CFH) and their survival time scale. Presently, our understanding of the CFH is dominated by rich clusters. The bar of the LMC is found to be the most metal rich region, and the LMC metallicity gradient though shallow, resembles the gradient seen in spiral galaxies. The gradient is also similar to that found in our Galaxy. The higher metallicity in the bar region might indicate an active bar in the past.