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Internal and foreground reddening maps of the Magellanic Clouds

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Abstract. We present the internal and foreground reddening maps of the Large and Small Magellanic Clouds. These are estimated using the red clump stars identified from the OGLE III catalog. The foreground reddening is estimated from the shift of the peak in the red clump colour distribution and the internal reddening from the width of the colour distribution, after correcting for population effects. The foreground reddening in the LMC is found to be correlated with the location of the star forming regions. The reddening towards the LMC is found to be larger than that towards the SMC.

Keywords : Magellanic Clouds, Red clump stars

Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) are the nearest galaxy pair where one can resolve individual stars and study them. The MCs are known to host stars of all evolutionary phases, but with a lower metallicity. Since the metallicity of Magellanic Clouds (MCs) is less than that of our Galaxy, the dependence of various processes on metallicity can be understood by studying the stars in the MCs. One of the main hurdles in deriving the observed characteristics of stars is in estimating the reddening in the line of sight towards the stars studied. Thus a map of the reddening with sufficient spatial resolution is necessary. In the recent years, the MCs have been very thoroughly studied using various surveys, for example, Optical Gravitational Lensing Experiment (OGLE) II and III (Udalski et al. 2000; Udalski et al. 2008a, 2008b), Magellanic Clouds Photometric Survey (Zaritsky et al. 1997). These surveys can be easily used to map the reddening across the face of the

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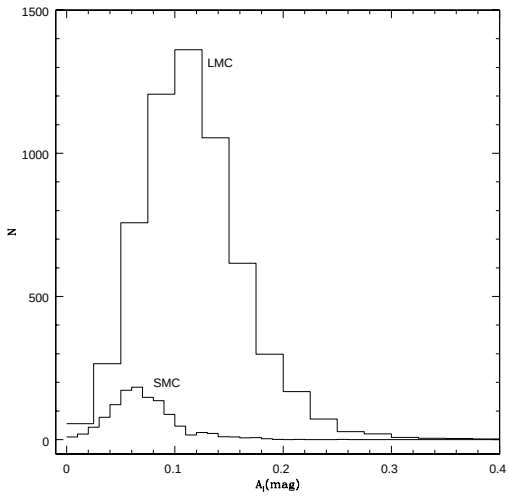

Figure 1. The histograms of the extinction, A_V towards the LMC & the SMC.

MCs. The reddening estimated using these catalogs will have good resolution and large coverage. Since the data from a survey catalogue is homogeneous, the systematic error in the reddening estimation will be minimum.

1. Data and Analysis

OGLE III survey presented VI photometry of 40 deg^2 of the LMC (Udalski et al. 2008a) and 14 deg^2 of the SMC (Udalski et al. 2008b) consisting of about 35 million stars and 6.2 million stars respectively. We divided the observed LMC region into 7416 regions (with a reasonable number of RC stars, 100 - 2000) with a bin size of 4.44 * 4.44 square arcmin. The observed SMC region is divided into 1280 regions (with a reasonable number of RC stars, 500 - 2000) with a bin size of 8.88 * 8.88 square arcmin. The average photometric error of red clump stars in I and V bands for both LMC & SMC data are around 0.05 mag. Data with errors less than 0.15 mag are considered. Red clump stars are identified in a box with boundaries 0.65 - 1.35 mag in (V−I) colour and 17.5 - 19.5 mag in I magnitude, in the (V−I) vs I CMDs. Red clump stars have a constant characteristic I band magnitude and (V−I) colour. Their number distribution profiles resemble a Gaussian. The peak of their colour distribution is used to estimate the foreground reddening and the width of their colour distribution is used to obtain the internal reddening. A nonlinear least-square method is used for fitting the distribution. The parameters obtained are the coefficients of each term in the function used to fit the profile, error in the estimation of each parameter, and reduced chi square value. The peak values

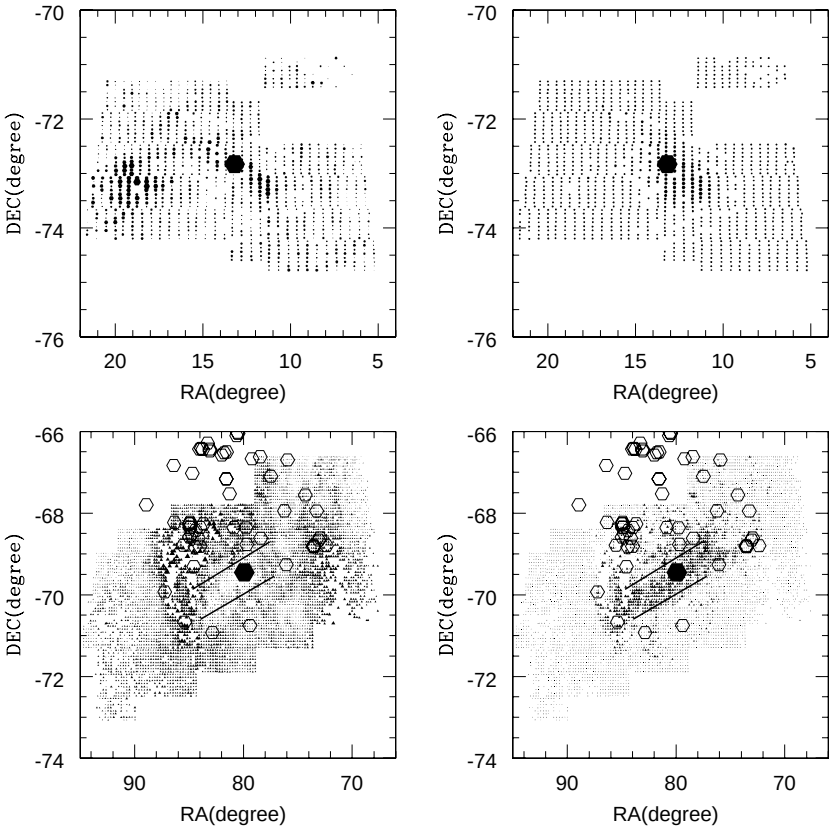

Figure 2. The upper left and right panels show the foreground and internal reddening maps of the SMC. The bottom left and right panels show the foreground and internal reddening maps of the LMC. The open hexagons in the bottom panels represent the HI shells. The black closed hexagon in all the plots represents the optical center of the galaxy. The point size in all the plots is proportional to the magnitude of the estimated reddening values.

of the colour, (V-I) mag at each location is used to estimate the foreground reddening. The foreground reddening is calculated using the relation E(V-I) = (V-I)obs-0.92 mag. The intrinsic color of the RC stars in the LMC is taken to be 0.92 mag (Olsen & Salyk 2002). Olsen & Salyk (2002) selected this value to produce the median reddening obtained towards LMC by Schlegel (1998). For SMC OGLE III data set we calculated the intinsic (V-I) colour of RC stars to produce the median reddening obtained by Schlegel (1998) towards SMC. The value turned out to be 0.89 mag. We used the realtion E(V-I) = (V-I)obs-0.89 mag to estimate the foreground reddening towards SMC. Regions with peak

errors greater than 0.01 mag and those with reduced chi square value greater than 2.0 are omitted from the analysis. Foreground reddening was derived for 5924 regions in the LMC and 1146 regions in the SMC. The width of the colour distribution of RC stars in each reagion is used to estimate the internal reddening. The width of the colour distribution, $\sigma^2_{\rm col} = \sigma^2_{\rm internalreddening} + \sigma^2_{\rm intrinsic} + \sigma^2_{\rm error}$. The intrinsic spread in the colour distribution of red clump stars is due to differences in age, metallicity, mass, star formation rate etc. Red clump stars are theoretically modelled and intrinsic spread in the distributions are predicted by Girardi & Salaris (2001), after incorporating the above effects. LMC intrinsic dispersion is 0.025 mag and for SMC 0.03. Regions with reduced chi square value less than 2 & also error associated with the width less than 0.01 mag are used for final analysis. Thus, the internal reddening was estimated for 5930 and 1181 regions in the LMC and the SMC respectively.

2. Results and discussion

The histogram of the foreground extinction, estimated using $A_V = 1.4E(V\text{-}I)$ is shown in figure 1. Most of the regions have A_V less than 0.2 mag in the LMC and 0.1 mag in the SMC. This shows that extinction towards the SMC is much smaller compared to the LMC. The internal and foreground reddening maps of MCs are presented in the Fig. 2. The internal reddening is found only near the SMC center, whereas a fair amount of foreground reddening is found near the wing of the SMC as well. In the case of the LMC, the internal reddening is found to be more near the bar region whereas the foreground reddening is found to be more near the locations of star formation. In both the Clouds, the internal reddening is found to be correlated with the stellar density distribution such that there is more internal reddening where there is large stellar density. This suggests that the reddening traced here is due to the stellar mass loss by AGB/RGB stars. The correlation of the foreground reddening with the location of HI shells in the LMC indicates that the dust has been expelled in these regions along with HI towards the line sight.

References

Girardi L., & Salaris M., 2001, MNRAS, 323, 109
Olsen K.A.G., & Salyk C., 2002, AJ, 124, 2045
Schlegel D. J., Finkbeiner D. P., & Davis M., 1998, ApJ, 500, 525
Udalski A., Szymanski M., Kubiak M., et al., 2000, Acta Astron., 50,307
Udalski A., Soszynski I., Szymanski M., et al., 2008a, Acta Astron., 58, 89
Udalski A., Soszynski I., Szymanski M., et al., 2008b, Acta Astron., 58, 329
Zaritsky D., Harris J., Thompson I. B., 1997, AJ, 114, 1002