Reddening Maps of the Large and Small Magellanic Cloud based on OGLE-IV Red Clump Stars

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Here we present the most extensive and detailed reddening maps of the Magellanic Clouds inferred from the color properties of Red Clump stars. The analysis is based on the deep photometric maps from the fourth phase of the Optical Gravitational Lensing Experiment (OGLE-IV). We refined methods of calculating the RC color to obtain the highest possible accuracy of reddening maps based on RC stars. Using spectroscopy of red giants, we found the metallicity gradient in both Magellanic Clouds, which causes a slight decrease of the intrinsic RC color with a distance from the galaxy center of about 0.002 mag/deg in the LMC and between 0.003 and 0.009 mag/deg in the SMC.

1 Introduction

Knowing the reddening is essential in practically all astrophysical studies that involve calculating the distance to an object. In particular, reddening in the Magellanic Clouds (MCs) is especially important due to the great role of the MCs in modern astronomy, as they serve as a local laboratory for numerous research areas.

The widely used reddening maps that were available until now cover only a small central area of the Magellanic Clouds, and are based on OGLE-III data (Haschke et al. 2011, recently recalibrated by Górski et al. 2020). Here we use data gathered by OGLE-IV which covers a much larger area around the MCs, to create reddening maps based on Red Clump (RC) stars. Fig. 1 shows a comparison of the OGLE-III and OGLE-IV footprints.

2 Data

The OGLE-IV telescope is located at the Las Campanas Observatory in Chile and is observing the Magellanic System with a cadence of $1-4$ days. Data used in this study were gathered between 2010 and 2019 in the V- and I-bands. For details on the OGLE telescope and data see Udalski et al. (2015).

The RC is a prominent feature in the color-magnitude diagram (CMD). Fig. 2 shows two examples of CMDs from the LMC (left) and the SMC (right). The effect of reddening on the RC, in the case where the dust cloud is located between the LMC/SMC and the observer is schematically shown in Fig. 3. In the case when the obscuring dust is within the LMC/SMC, we observe smearing of the RC in the direction of the reddening vector, which is called the differential reddening.

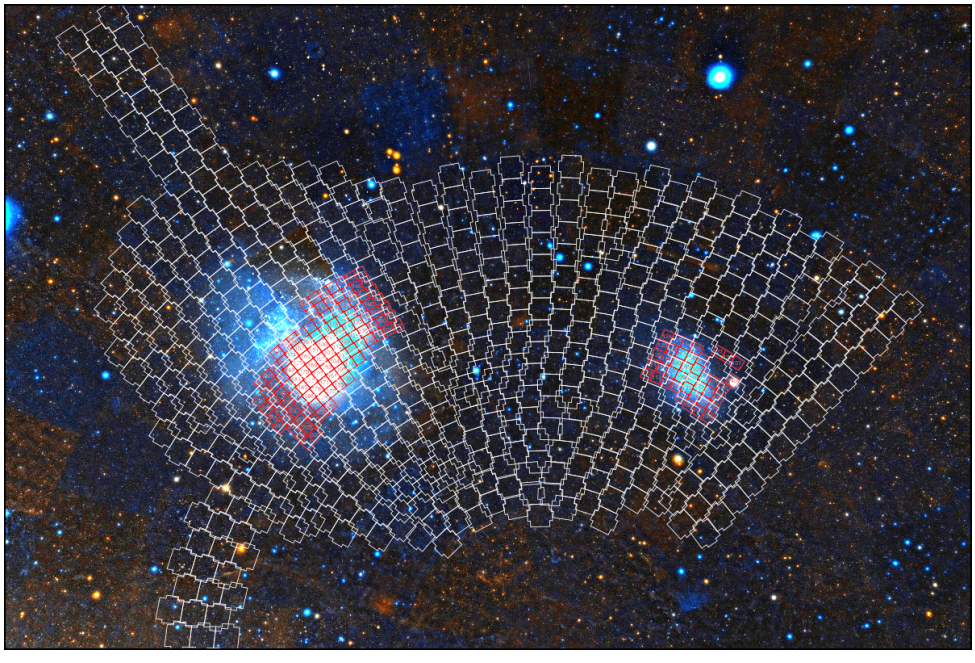

Fig. 1: The OGLE-III footprint, on which the previous reddening maps were based (Haschke et al. 2011, Górski et al. 2020) is shown with red rectangles, while the OGLE-IV footprint, on which the current study is based (Skowron et al., 2021), is shown with white polygons.

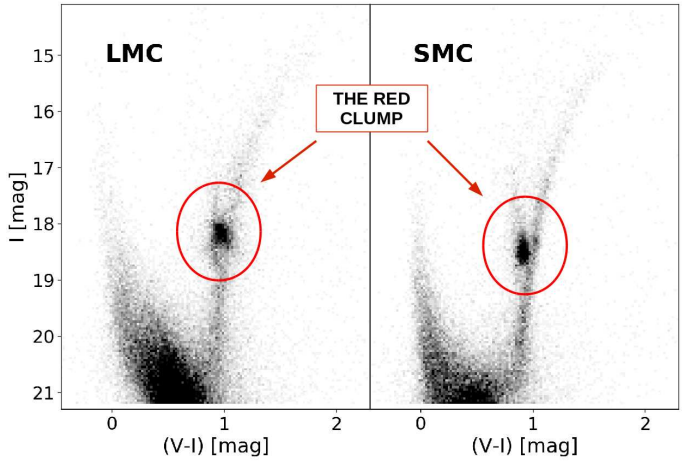

Fig. 2: CMD of an observing field in the LMC (*left*) and the SMC (*right*) based on OGLE-IV data in the *V*- and *I*-bands. The location of the RC is marked with red ellipses.

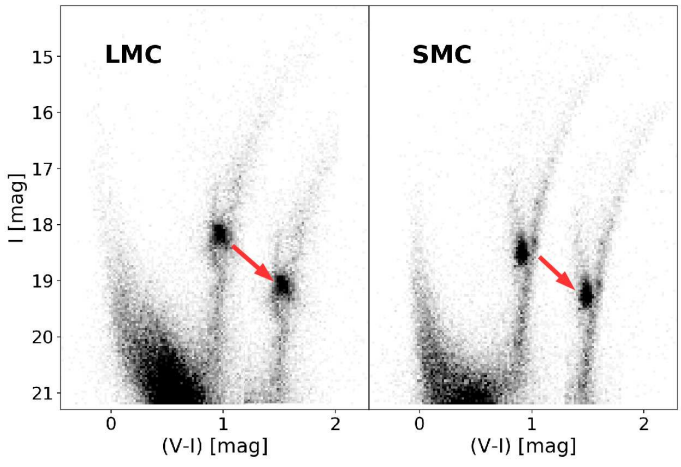

Fig. 3: Same as Fig. 2, but the effect of reddening on the RC is schematically presented, with a reddening vector (red). Reddening causes the RC look dimmer and redder.

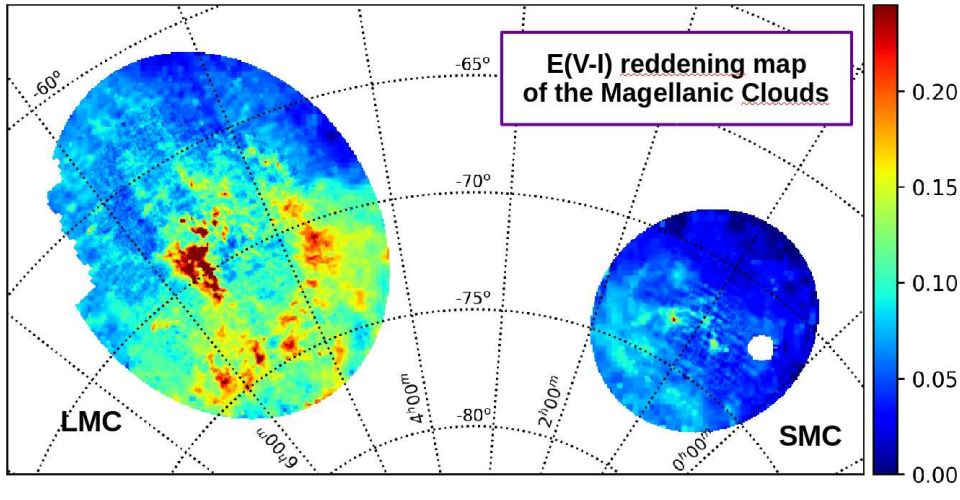

Fig. 4: The $E(V-I)$ reddening map of the Magellanic Clouds. The color corresponds to the value of $E(V-I)$ – blue is for low and red is for high reddening, respectively.

3 Reddening from the Red Clump

The reddening $E(V-I)$ is calculated as the difference between the observed RC color $(V-I)$ and the intrinsic RC color $(V-I)_0$,

$$E(V-I) = (V-I) - (V-I)_0.$$

The biggest difficulty in obtaining $E(V-I)$ is the proper estimation of $(V-I)$. We established a new method of calculating both $(V-I)$ and $(V-I)_0$, which is described in great detail in Skowron et al. (2021), to which we refer the reader, since

the discussion of the method is beyond the scope of these short proceedings. We also found that there is a metallicity gradient in both Magellanic Clouds that influences the value of $(V-I)_0$, such that the intrinsic color decreases with the distance from the center of the LMC/SMC. In the case of the LMC the change is 0.002 mag/deg, and in the SMC between 0.003 and 0.009 mag/deg. This effect was accounted for in estimating the reddening value. The final $E(V-I)$ reddening map of the LMC and SMC is shown in Fig. 4, where the LMC is on the left, SMC on the right, and the reddening value is color-coded.

The presented reddening maps are available here: http://ogle.astrouw.edu.pl/cgi-ogle/get_ms_ext.py both in the form of a multidimensional fits file and as friendly on-line interface.

References

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