Colour-Magnitude Diagrams of candidate age-gap filling LMC clusters

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Abstract. The LMC has a rich star cluster system spanning a wide range of ages and masses. One striking feature of the LMC cluster system is the existence of an age gap between 3-10 Gyrs. Four LMC clusters whose integrated colours are consistent with those of intermediate age simple stellar populations have been imaged with the Optical Imager (SOI) at the Southern Telescope for Astrophysical Research (SOAR). Their colour-magnitude diagrams (CMDs) reach V \sim 24. Isochrone fits, based on Padova evolutionary models, were carried out to these CMDs, after subtraction of field contamination. The preliminary results are as follows: KMK88-38 has an age of about 1.3 Gyr, assuming typical LMC metallicity and distance modulus, and a very low reddening. For OGLE-LMC0531, the best eye fits to isochrones yield an age \sim 1.6 Gyr and E(B-V)=0.03. BSDL917 is younger, \sim 150 Myrs, and subjected to larger extinction (E(B-V)=0.08). The remaining cluster is currently under analysis. Therefore, we conclude that these clusters are unlikely to fill in the LMC cluster age gap, even when fitting uncertainties in the parameters are considered.

Keywords. (galaxies:) Magellanic Clouds, galaxies: star clusters, (stars:) Hertzsprung-Russell diagram

1. Introduction

The LMC has a rich star cluster system spanning a wide range of ages and masses. One striking feature of the LMC cluster system is the existence of an age gap between 3-10 Gyrs. Four LMC clusters whose integrated colours are consistent with those of intermediate age simple stellar populations have been imaged with the Optical Imager (SOI) at the Southern Telescope for Astrophysical Research (SOAR).

2. Data

We have imaged 3 out of the 5 LMC clusters listed by Hunter et al (2003) as belonging to the age gap. Two of them have been fully reduced.

The images were taken in 2007 with SOAR/SOI telescope in the B, V, and I filters. A slow readout was used in order to minimise detector noise. A 2x2 pixel binning was adopted, yielding a spatial scale of 0.154 arcsec/pixel. Seeing was always around 0.8 arcsec.

The exposures were flatfielded, bias subtracted, mosaiced and latter combined. The photometry was carried out with standard point spread function (PSF) fitting. The DAOPHOT package (Stetson 1994) was used to detect sources (4 \sigma above sky background) and measure magnitudes. The PSF was modelled as a Moffat function with
β = 1.5. Photometric calibration was obtained from the standard fields in the Northeast arm of the SMC (Sharpee et al. 2002). A typical SOAR/SOI image section is shown in Figure 1.

CMDs for the fields of the two age gap candidates already reduced are shown in Figure 2. Their colour-magnitude diagrams (CMDs) reach $V \sim 23$. From left to right, we show the full SOI field CMD, the CMD in the cluster region and the field subtracted cluster CMD. Padova isochrones from Girardi et al. (2002) are superposed to these latter. Field subtraction was performed statistically, applying the method described in detail by Kerber et al. (2002).

Besides the age gap candidates, the SOI images also covered other LMC clusters listed in the catalogue by Bica et al. (2008). Figure 3 shows the field subtracted CMDs for them, again with isochrones overlaid.

Visual matching of the observed CMDs to the isochrone set has allowed us to estimate age, metallicity, distance modulus and reddening for each cluster. The resulting parameters are shown in Table 1.

3. Results and conclusions

The original targets, KMK88-38 and LMC0531, turn out to be the relatively old, as expected, with ages $\sim 1 - 2$ Gyrs. However, they are still younger than the lower age limit of the LMC gap. Interestingly, KMK88-39, LMC0214 and LMC0523, which lie in the same SOI fields (5.5arcmin x 5.5 arcmin in size), are much younger. LMC0523 final $V,(B-V)$ CMD has 3 stars in the Red Clump region. Even though they survived field subtraction, these stars have relatively low probabilities of actually belonging to the cluster, and they are, in fact, absent from the $V,(V-I)$ CMD. For LMC0214 we have only B and V images. The ages for this latter, as well as for KMK88-39 are upper limits, as their upper main sequence is close to the saturation limit. Finally, NGC 1878 is a richer and denser cluster. Field subtraction was not as efficient in this case, especially in $V,(B-V)$. We attribute that to crowding effects, which make photometric errors larger in the cluster region than in the field, jeopardising the statistical field subtraction. Still, its $V,(V-I)$ CMD indicates that NGC 1878 is also younger than 0.5 Gyr.
Figure 2. V (V-I) (top) and V (B-V) (bottom) CMDs for the fields around KMK88-38 (left) and LMC0531 (right) clusters. The panels from left to right show: the entire SOI field, the region around the cluster, the result of field subtraction. Padova isochrones are overlaid to the latter panels. Ages are shown as $\log(\tau_{\text{max}})$, $\log(\tau_{\text{min}})$, $\Delta \log \tau$. The adopted metallicity is also shown.

We thus conclude that the sample analysed so far does not contain any cluster located in the LMC age gap. We are currently reducing the field images of another age gap candidate: LMC0169. We are also reducing lower exposure time images of all clusters and perfecting the field subtraction algorithm; both are important steps towards improving our age and metallicity constraints on the clusters.
Figure 3. Field subtracted CMDs for the remaining clusters found in our SOAR/SOI images. The symbols are the same as in the corresponding panels of Figure 2.

| Name          | log(Age) | Z  | E(B – V) | (m – M)V |
|---------------|----------|----|----------|-----------|
| OGLE-LMC0214  | 8.4 ± 0.3 | 0.013 | 0.10    | 18.50     |
| OGLE-LMC0523  | 7.8 ± 0.3 | 0.013 | 0.20    | 18.40     |
| OGLE-LMC0531  | 9.2 ± 0.2 | 0.014 | 0.09    | 18.50     |
| KMK88-38      | 9.2 ± 0.2 | 0.006 | 0.01    | 18.65     |
| KMK88-39      | 8.5 ± 0.3 | 0.011 | 0.02    | 18.50     |
| NGC1878       | 8.4 ± 0.3 | 0.014 | 0.17    | 18.50     |

Table 1. The parameters found for our sample.

References

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