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Primordial or Dynamical Mass Segregation in Young LMC Clusters?

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Abstract. We present the detailed analysis of *Hubble Space Telescope* observations of the spatial distributions of different stellar species in two young compact star clusters in the Large Magellanic Cloud, NGC 1805 and NGC 1818. Based on a comparison of the characteristic relaxation times in their cores and at their half-mass radii with the observed degree of mass segregation, it is most likely that significant primordial mass segregation was present in both clusters, particularly in NGC 1805. Both clusters were likely formed with very similar initial mass functions.

1. Strong mass segregation on short time-scales

One of the major uncertainties in modern astrophysics is the issue of whether the stellar initial mass function (IMF) is universal or, alternatively, determined by environmental effects. Galactic globular clusters and rich, compact Magellanic Cloud star clusters are ideal laboratories for providing strong constraints on the universality of the IMF, in particular because they are essentially single age, single metallicity systems for which statistically significant samples of individual stars over a range of masses can easily be resolved.

Although the standard picture, in which stars in dense clusters evolve rapidly towards a state of energy equipartition through stellar encounters – with the corresponding mass segregation – is generally accepted, observations of various degrees of mass segregation in very young star clusters (e.g., de Grijs et al. 2002a,b and references therein) suggest that at least some of this effect is related to the process of star and star cluster formation itself. Quantifying the degree of actual mass segregation is thus crucial for the interpretation of observational luminosity and mass functions (LFs/MFs) in terms of the IMF, even for very young star clusters.

Therefore, we obtained F555W and F814W *Hubble Space Telescope/WFPC2* imaging observations of two young compact LMC clusters, NGC 1805 ($\sim$ 10 Myr) and NGC 1818 ($\sim$ 25 Myr), covering a large range of radii (see de Grijs et al. 2002a for observational details).

The radial dependence of the LF and MF slopes indicate clear mass segregation in both clusters at radii $r \lesssim 3-6R_{\rm core}$ (de Grijs et al. 2002a,b). Within the

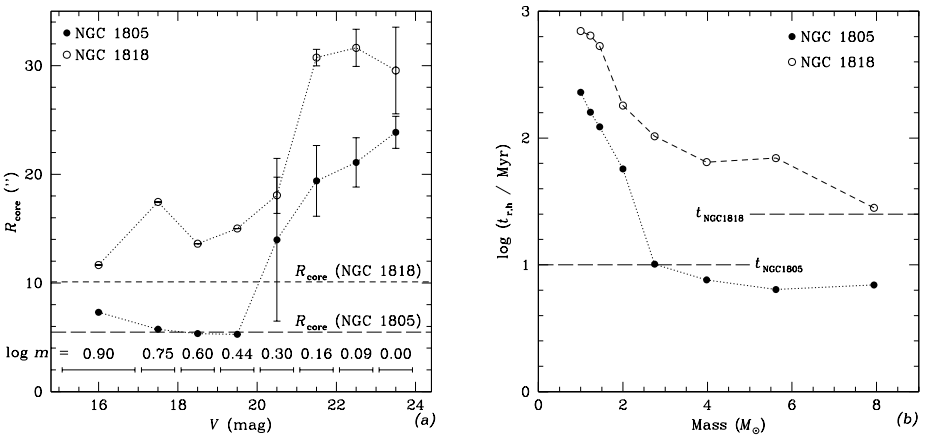

Figure 1. *(a)* – Core radii as a function of magnitude (mass) for both clusters. The error bars are driven by uncertainties in the background subtraction; fitting ranges are indicated at the bottom of the panel. The horizontal dashed lines represent the overall core radii from the clusters' surface brightness profiles. *(b)* – Half-mass relaxation time as a function of mass for NGC 1805 and NGC 1818. The best age estimates for both clusters are indicated by horizontal dashed lines.

uncertainties, we cannot claim that the slopes of the outer MFs in NGC 1805 and NGC 1818 are significantly different, which therefore implies that these clusters must have had very similar IMFs.

In Fig. 1a we show the dependence of the cluster core radius on the adopted magnitude (mass) range. For both clusters we clearly detect the effects of mass segregation for stars with masses $\log(m/M_\odot) \gtrsim 0.2$ ($m \gtrsim 1.6 M_\odot$). It is also clear that stars with masses $\log(m/M_\odot) \gtrsim 0.4$ ($m \gtrsim 2.5 M_\odot$) show a similar concentration, while a trend of increasing core radius with decreasing mass (increasing magnitude) is apparent for lower masses.

We estimate that the NGC 1818 cluster core is between $\sim 5-30$ crossing times old, so that dynamical mass segregation in its core should be well under way. By applying scaling laws to NGC 1805, we conclude that its core is likely $\lesssim 3-4$ crossing times old. However, since strong mass segregation is observed out to $\sim 6 R_{\rm core}$ and $\sim 3 R_{\rm core}$ in NGC 1805 and NGC 1818, respectively, for stellar masses in excess of $\sim 2.5 M_\odot$, it is most likely that significant primordial mass segregation was present in both clusters, particularly in NGC 1805 (cf. Fig. 1b).

References

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