

The Age Distributions of Clusters and Field Stars in the Small Magellanic Cloud — Implications for Star Formation Histories

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Abstract. Differences between the inferred star formation histories (SFHs) of star clusters and field stars seem to suggest distinct star formation processes for the two. The Small Magellanic Cloud (SMC) is an example of a galaxy where such a discrepancy is observed. We model the observed age distributions of the SMC clusters and field stars using a new population synthesis code, SPACE, that includes stellar evolution, infant mortality and cluster dissolution. We find that the two observed age distributions can be explained by a single SFH, thus eliminating the need to assume two separate mechanisms for star formation.

1. Introduction

We consider the relation between age distributions of clusters and field stars. It has been suggested that separate formation mechanisms for clusters and field stars exist in galaxies (e.g., Meurer et al. 1995; Chandar et al. 2005), implying different formation histories for the two. However, this appears to contradict theory and observations, as most stars are supposed to be formed in clusters.

Observations of the Small Magellanic Cloud (SMC) show a significant difference between the age distributions of clusters and field stars (Hodge 1987; Harris & Zaritsky 2004). The SMC therefore provides an ideal opportunity to investigate whether the observed distributions can be reproduced by one star formation history (SFH) if all stars were formed in clusters.

2. Model Ingredients

To reproduce the SMC cluster and field star age distributions, we first adopt the global SFH for the SMC derived from color-magnitude diagrams by Harris & Zaritsky (2004). Secondly, clusters are assumed to be initially distributed according to a cluster initial mass function (CIMF) represented by a power law with index -2 . Of these clusters, a mass-independent fraction f_{IMR} (infant mortality rate) does not survive its first 10 Myr due to residual gas expulsion by supernovae and the consequent removal of binding energy. The surviving clusters gradually dissolve due to the tidal field and external perturbations. The loss of stars due to these effects is described by an analytical model (Lamers et al. 2005; Kruijssen & Lamers 2008). Dynamical cluster mass loss follows an exponential decrease on an instantaneous dissolution timescale related to present cluster mass as $\tau_{\text{dis}} = t_0 M_{\text{cl}}^{\text{tot}\gamma}$ with $\gamma = 0.62$ and t_0 a parameter describing the speed of dissolution. We monitor the transition of stars from clusters into the field.

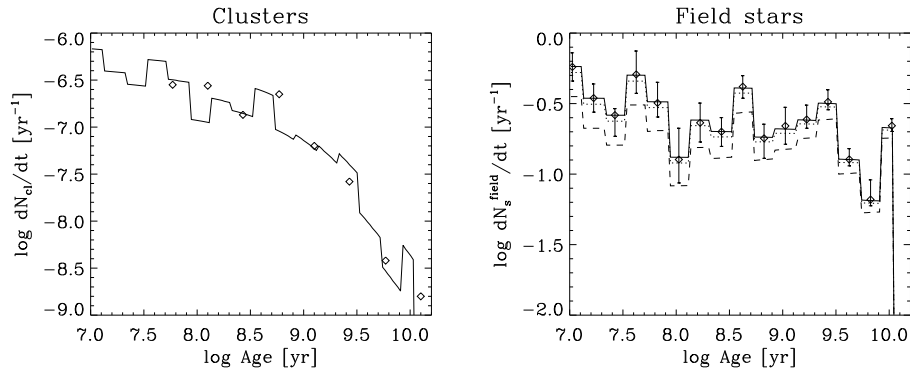


Figure 1. Age distributions of SMC clusters (left panel) and field stars (right panel). Diamonds denote observed values (left panel: Hodge 1987, right panel: Harris & Zaritsky 2004), while our model predictions are shown for infant mortality rates of $f_{\text{IMR}} = \{0.6, 0.9, 0.995\}$ as dashed, dotted and solid lines, respectively. Error bars represent 2σ error margins.

3. Age Distributions and Implications for Star Formation Histories

The observed age distributions and the fit from the cluster population synthesis model SPACE (Kruijssen et al., in preparation) are shown in Fig. 1. Assuming the SFH from Harris & Zaritsky (2004), we see that the shape of the cluster age distribution is accurately described by adopting a dissolution timescale of $t_0 = 30$ Myr, implying a total disruption time of ~ 8.5 Gyr for a $10^4 M_\odot$ cluster. This agrees with the recent analysis of the SMC clusters by Gieles et al. (2007).

In principle, one could derive the infant mortality rate f_{IMR} from the ratio of the number of clusters and field stars. However, only part of the SMC is covered in the cluster sample from Hodge (1987). Therefore, only an upper limit for f_{IMR} can be derived: we find $f_{\text{IMR}} \leq 0.995$. Figure 1 shows that the field star age distribution is still well-fitted by a more reasonable value of $f_{\text{IMR}} = 0.9$. This implies that it is not significantly affected by the partial SMC cluster coverage. We conclude: (1) *The overpopulation of field stars relative to clusters at old ages is due to cluster dissolution.* (2) *No such process as separate field star formation is required to explain the age distributions of field stars and clusters in the SMC.*

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