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Open clusters in the log Age vs. M_V plane

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Abstract. In the log Age vs. integrated absolute magnitude (M_V) plane, the open clusters of the Milky Way form a well-defined band parallel to theoretical sequences decribing the passive evolution of Simple Stellar Populations and display a pretty sharp upper threshold in mass ($M \sim 2 \times 10^4\ M_\odot$) over a 4 dex range of ages.

Key words. Galaxy: open clusters – Galaxy: globular clusters

1. Introduction

The evolution of integrated spectro-photometric properties of a Simple Stellar Population (SSP, i.e. an idealized population of stars having the same chemical composition and the same age, Renzini & Fusi Pecci 1988) is one key prediction of stellar theoretical models (see, for example Buzzoni 1989; Maraston 1998, and references therein). In particular, it is well known that the total luminosity of a SSP must decrease with time as massive stars progressively exhaust their nuclear fuel and conclude their evolutionary lifetime, thus ceasing to contribute to the luminosity of the SSP.

In Fig. 1 we show various theoretical evolutionary sequences describing the fading with age of SPSSs (from Maraston 1998, 2005), in the plane of the logarithm of the SSP age versus its integrated absolute V magnitude (M_V), hereafter A-M_V diagram, for brevity (see Gieles et al. 2007; Withmore et al. 2007, and references therein, for the application of this or similar diagrams to the study of star clusters in different environments). It can be appreciated that (i) for ages $> 10^7$ yr the evolutionary sequences are essentially linear ($M_V \propto 1.8 \times \log Age_{[yr]}$, with $a \simeq 1.8$), and, (ii) the sequences depends quite weakly on the assumed metallicity and/or Initial Mass Function (IMF) of the SSP. Once a metallicity and a form of the IMF are assumed, each sequence directly correspond to a total stellar mass; thus the mass of *real* SSPs can be compared in this plane independently of their respective age. Moreover, the past and future evolution of such SSPs can be directly read on this diagram. Given the weak dependence on age and IMF, in the following we will adopt a grid of solar metallicity / Salpeter-IMF sequences. These define a total-stellar-mass scale whose zero point may be uncertain up to a factor of a few, while *mass differences* should be pretty reliable and *homogeneous*.

Star clusters are the best approximation of SSPs available in nature. Classical Globular Clusters (GC) are all very old and should lie in a narrow slice of the A-M_V diagram. Here, for simplicity, we adopt Age = 12 Gyr (Gratton et al. 1997) for all the Galactic GCs, for which we took M_V from Harris (1996). On

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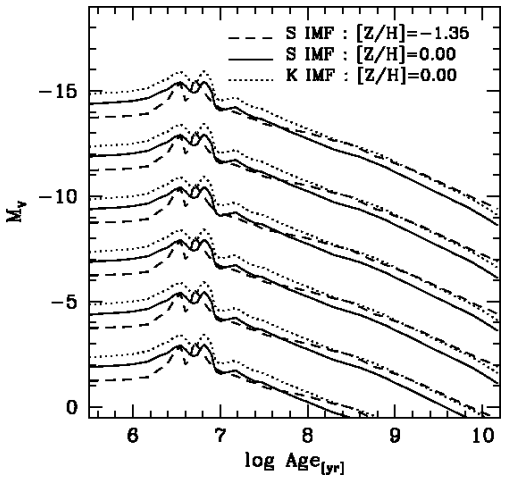

Fig. 1. Passive evolutionary sequences for SSPs of different metallicities ([Z/H]) and IMFs (S = Salpeter; K = Kroupa, see Kroupa 2001), from Maraston (1998, 2005). Each bundle of three sequences correspond to a given total mass.

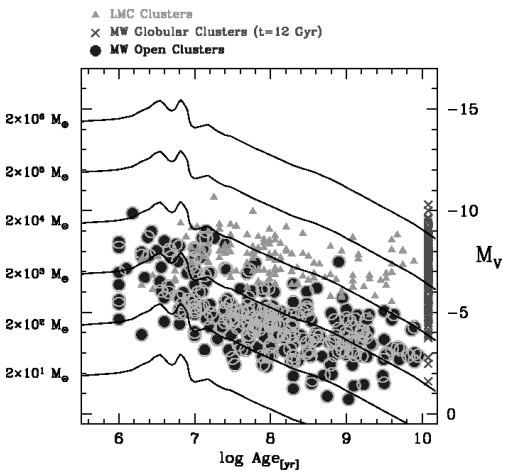

Fig. 2. Galactic GCs and OCs and LMC clusters in the A-M_V plane. The passive-evolution sequences are for solar metallicity and Salpeter's IMF (from Maraston 1998, 2005). The only OC clearly exceeding the 2×10^4 $M_\odot$ threshold is Tombaugh 2, around log Age ∼ 9.

the other hand, Galactic Open Clusters (OC) are known to span a large range in ages (from millions to billions years). For their sparse nature, it is quite hard to obtain reliable integrated

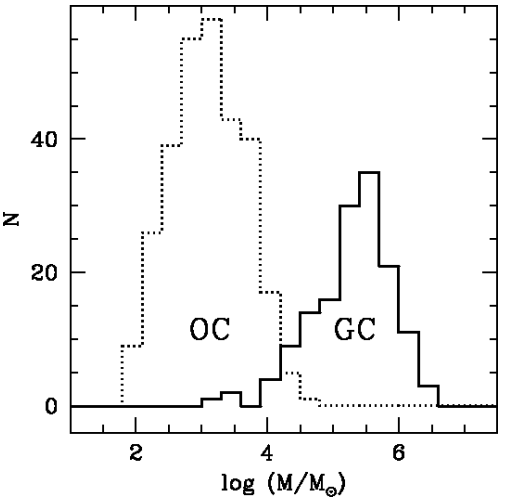

Fig. 3. Mass distribution of Galactic OCs and GCs, from interpolation on the theoretical grid of Fig. 2.

properties of OCs; nevertheless the WEBDA database[1] collects also OC M_V from many different sources and, in general, the agreement between independent estimates is reassuringly good. We extracted, from WEBDA, ages and M_V for 293 OCs, taking the M_V estimates from Lata (2002), Battinelli et al. (1994), Spassova et al. (1985), Pandey et al. (1989), and Sagar et al. (1983), in order of preference. In Fig. 2 Galactic OCs are compared to GCs and to stars cluster of the Large Magellanic Cloud (data from van den Bergh (1981), treated as in Fusi Pecci et al. (2005)), in the A-M_V diagram. It is interesting to note that OCs form a well defined band, parallel to the evolutionary sequences and approximately comprised between $M \simeq 5 \times 10^1$ $M_\odot$ and $M \simeq 2 \times 10^4$ $M_\odot$. The different distribution of LMC clusters demonstrate that the occurrence of a mass threshold is not universal, but it is likely associated with the particular environment in which clusters formed. A thorough discussion of the mechanisms that shape the distribution of cluster populations in this plane can be found in Withmore et al. (2007, see also references therein).

Fig. 2 also recalls that OCs and GCs have two well separated mass distributions; while

[1] www.univie.ac.at/webda/

the difference in mean mass is obviously not a surprise, the bimodality of the mass distribution of Galactic star clusters as a whole (OC+GC) is far from trivial (see Fig. 3, and van den Bergh & Lafontaine 1984). Finally, it is interesting to note that, at the dawn of the Galactic era, the progenitors of GCs had luminosities typical of dwarf galaxies ($-10 \leq M_V \leq -15$, approximately).

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References

Battinelli, P., Brandimarti, A., & Capuzzo-Dolcetta, R. 1994, A&AS, 104, 379
Buzzoni, A. 1989, ApJS, 71, 817
Fusi Pecci, F., Bellazzini, M., Buzzoni, A., De Simone, E., Federici, L., & Galleti, S. 2005, AJ, 130, 544
Gratton, R.G., Fusi Pecci, F., Carretta, E., Clementini, G., Corsi, C.E., & Lattanzi, M. 1997, ApJ, 491, 749
Gieles, M., Lamers, H.G.L.M., Protegies Zwart, S.F., 2007, ApJ, 668, 268
Harris, W.E. 1996, AJ, 112, 1487
Kroupa, P. 2001, MNRAS, 322, 231
Lata, S., Pandey, A.K., Sagar, R., & Mohan, V. 2002, A&A, 388, 158
Maraston, C. 1998, MNRAS, 300, 872
Maraston, C. 2005, MNRAS, 362, 799
Pandey, A.K., Bhatt, B.C., Mahra, H.S., & Sagar, R. 1989, MNRAS, 236, 263
Renzini, A., & Fusi Pecci, F. 1988, ARA&A, 26, 199
Sagar, R., Joshi, U.C., & Sinvhal, S.D. 1983, Bull. Astron. Soc. India 11, 44
Spassova, N.M., & Beav P.V. 1985, Ap&SS, 112, 111
van den Bergh, S. 1981, A&AS, 46, 79
van den Bergh, S., & Lafontaine, A. 1984, AJ, 89, 1822
Whitmore, B.C., Chandar, R., & Fall, S.M. 2007, AJ, 133, 1067