Dynamical Evolution of Dense Stellar Systems
Proceedings IAU Symposium No. 246, 2007
E. Vesperini, M. Giersz & A. Sills, eds.

doi:10.1017/S1743921308015330

On the Origin of Complex Stellar Populations in Star Clusters

J. Pflamm-Altenburg[1,2] and P. Kroupa[1,2]

[1]Argelander Institut für Astronomie (AIfA), Auf dem Hügel 71, D-53121 Bonn, Germany
email: jpflamm@astro.uni-bonn.de, pavel@astro.uni-bonn.de

[2]Rhine Stellar Dynamics Network (RSDN)

Abstract. The existence of complex stellar populations in some star clusters challenges the understanding of star formation. E.g. the ONC or the sigma Orionis cluster host much older stars than the main bulk of the young stars. Massive star clusters (ω Cen, G1, M54) show metallicity spreads corresponding to different stellar populations with large age gaps. We show that (i) during star cluster formation field stars can be captured and (ii) very massive globular clusters can accrete gas from a long-term embedding inter stellar medium and restart star formation.

Keywords. stars: formation, globular clusters: general

1. Field star capture

The collapsing cloud is described by a Plummer potential with a fixed total gas mass and a time-dependent Plummer parameter, infinite at the beginning and decreasing within the collapse time-scale. The field stars are simulated by test particles which are initially uniformly distributed in a sphere and have a Gaussian velocity distribution.

1.1. *ONC*

Palla *et al.* (2005) found 4 stars out of 84 low mass stars in the ONC being 10 Myr older than the main bulk of stars and followed that star formation is prolonged. Extrapolating, $\approx$ 53 such older stars are expected in the whole ONC (Pflamm-Altenburg & Kroupa 2007b). The number of simulated captured stars within a radius of 2.5 pc of the centre of the ONC is plotted in Fig. 1 (left) for different collapse time-scales and initial background velocity dispersions. Age spreads in young star clusters may therefore not be due to prolonged star formation but can be explained by stellar capture.

1.2. *R136*

Brandl *et al.* (1996) found 110 faint red sources in a field of $3{\times}3$ pc^2 of the centre of R136 in the LMC of unknown physical nature and excluded that they can be red giants as their required age would be larger than 350 Myr. As membership probabilities can not be determined for stars in R136 all stars within the central sphere with a radius of 1.7 pc are calculated after the collapse with a time-scale of 10 Myr has stopped (Pflamm-Altenburg & Kroupa 2007a, *in preparation*). The faint red sources can indeed be captured old red giants.

2. Gas accretion

Globular clusters more massive than $\approx 10^6$ $M_\odot$ such as ω Cen, G1 and M54 show a spread in metallicity corresponding to different stellar population with age gaps of

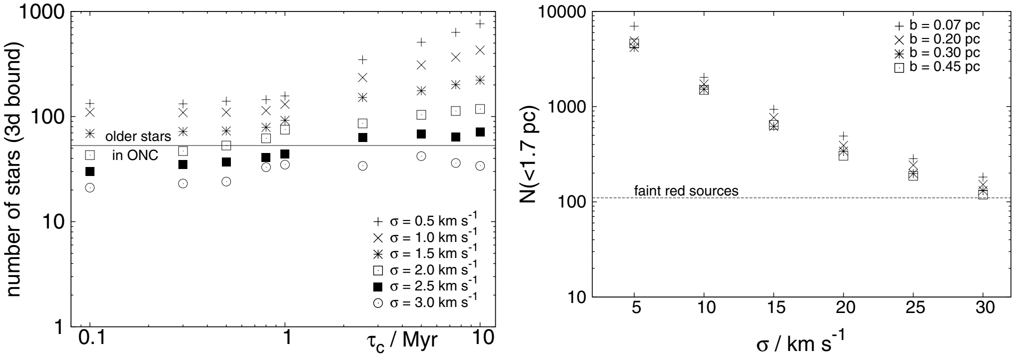

Figure 1. *Left*: Captured stars in the ONC within a radius of 2.5 pc for different velocity dispersions, σ, and collapse time-scales, τ_c, (Pflamm-Altenburg & Kroupa 2007b). *Right*: Field stars in the central sphere of 1.7 pc radius in R136 for different velocity dispersions and final Plummer parameters, b, (Pflamm-Altenburg & Kroupa 2007a, *in preparation*).

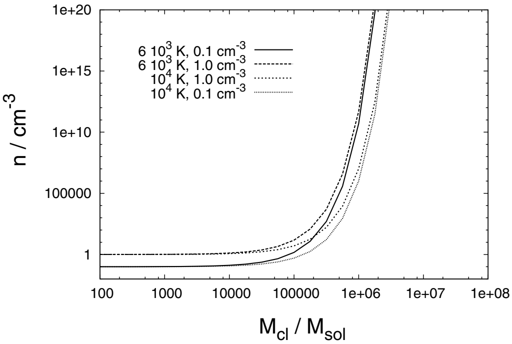

Figure 2. Particle density of the ISM at the origin of the cluster potential as a function of the total cluster mass (Pflamm-Altenburg & Kroupa 2007c, *in preparation*). Note the instability near 10^6 $M_\odot$.

several hundred Myr or a few Gyr. M54 and ω Cen are confirmed and supposed, respectively, to have been embedded in the ISM of a dwarf galaxy. To explore the effect of the cluster potential on a long-term embedding co-moving ISM we calculate the hydrostatic solution of an isothermal non-self-gravitating gas with an additional Plummer potential (Pflamm-Altenburg & Kroupa 2007c, *in preparation*). The central particle density in the cluster potential is plotted in Fig. 2 for different temperatures and densities of the warm component of the ambient ISM. Star clusters more massive than $\approx 10^6$ $M_\odot$ may cause an instability of the ISM, start gas accretion and form stars. Gas accretion can explain multiple stellar populations in massive star clusters and the change of the mass-radius relation at cluster masses of $\approx 10^6$ $M_\odot$.

References

Brandl B., Sams B. J., Bertoldi F., Eckart A., Genzel R., Drapatz S., Hofmann R., Loewe M., & Quirrenbach A. 1996, *ApJ* 466, 254

Palla F., Randich S., Flaccomio E., & Pallavicini R. 2005, *ApJL* 626, L49

Pflamm-Altenburg J., & Kroupa P. 2007b, *MNRAS* 375, 855

https://doi.org/10.1017/S1743921308015330 Published online by Cambridge University Press