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A critical look at the scenario of merging to explain multi-populations GCs

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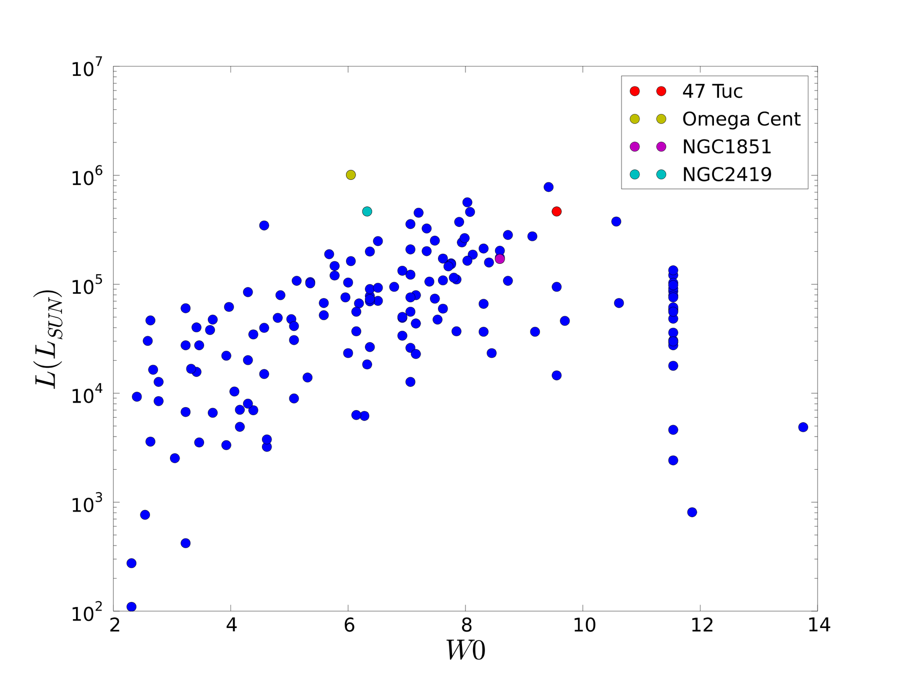
Introduction

The origin of multiple populations in globular clusters (GCs) is still an enigma. Different scenarios have been proposed but none of them explains all the observed features. In particular, it is not clear why the most metal poor population is the more centrally concentrated in some GCs (e.g.NGC 1851), while it is the less centrally concentrated in other GCs (e.g. Omega Cen). We will here revisit the hypothesis multi-populations GCs result from a merging between two progenitor clusters with different populations. This scenario has been recently investigated in Amaro-Seoane at al. (2013) too.

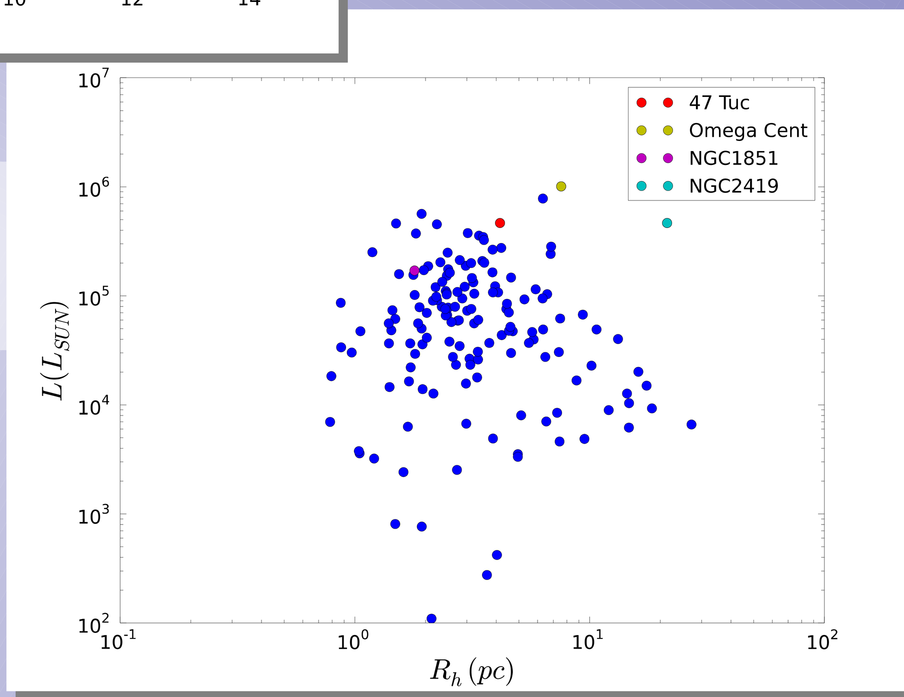
Numerical Methods

We performed new direct-summation N/body simulations of the merger between two star clusters, using the STARLAB software environment (Portegies Zwart et al. 2001).

The two stellar populations are distinguished only by means of the metallicity value, but this enters the analysis exclusively as an index flag: metallicity plays no role, except for setting the relative abundance of particles which belongs to progenitor GC1 or GC2.



Left: Luminosity versus King model central potential parameter.
Data from Harris (1996)

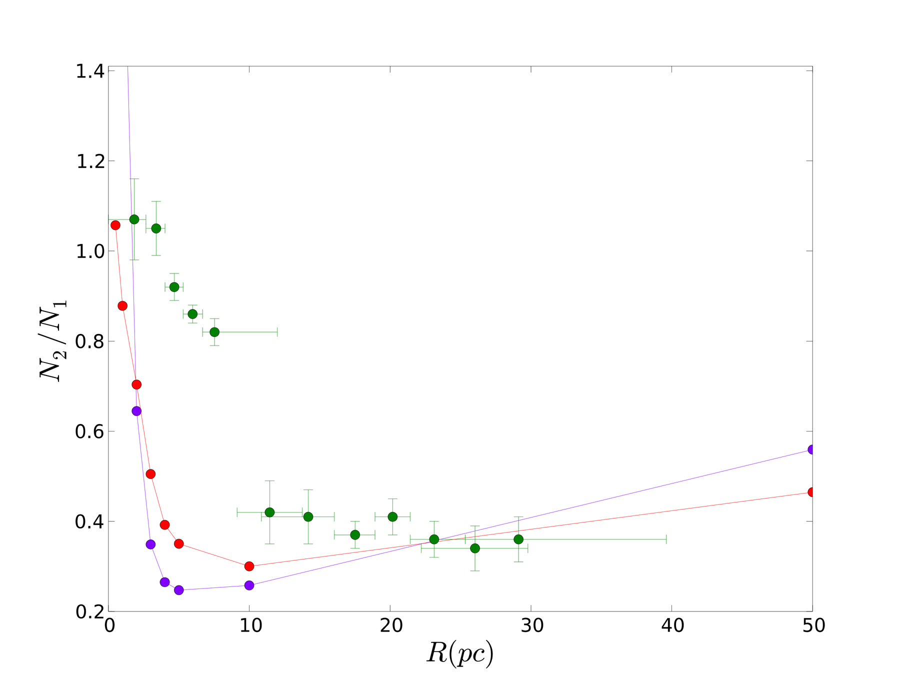


Right: Luminosity versus half-light radius.
Data from Harris (1996)

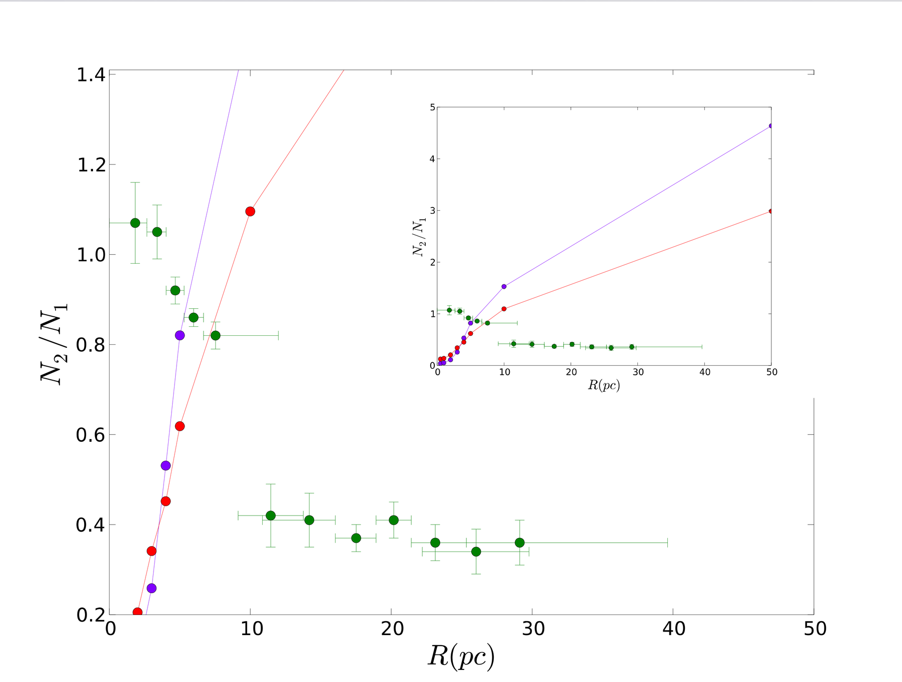
Simulations

- King models: input parameters concentration and initial cluster virial radius. Initial conditions selected on the basis of Harris catalogue of observed GCs
- The two merging GCs (GC1 and GC2) composed respectively of $4 \cdot 10^4$ and $2 \cdot 10^4$ particles. The ratio 2:1 was chosen on the estimates for metal rich (MR)/metal poor (MP) populations in Omega Cen and NGC1851
- Equal mass stellar particles. Total merged GC mass is ~ $3 \cdot 10^5 M_{SUN}$
- Parabolic merging: centers of mass distance=12pc – 24pc, pericenter = 0.5 pc. $V_{rel} = 0.25\ V_{parab}$

Case I

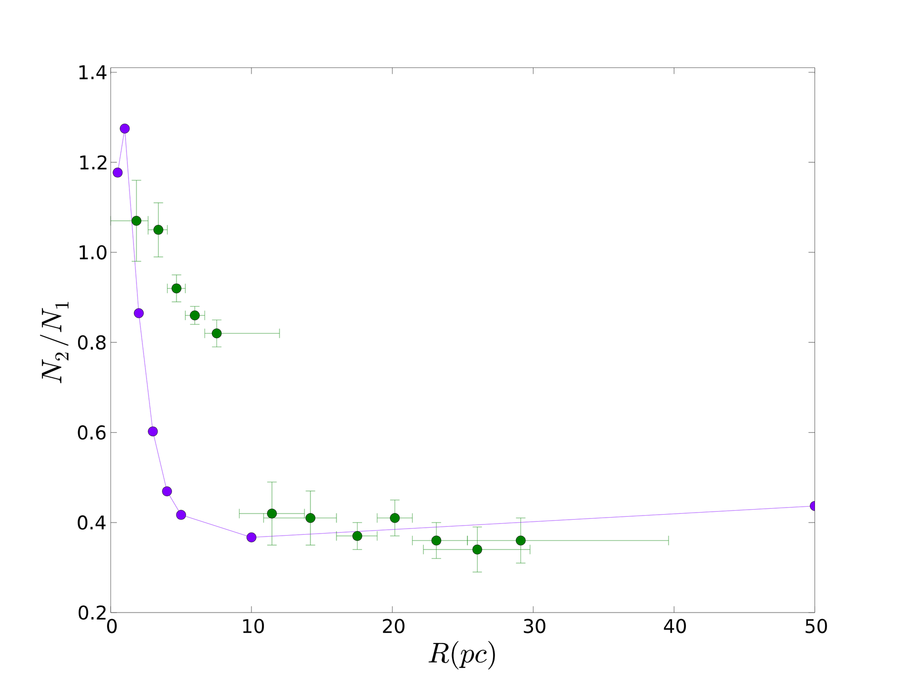


Case II

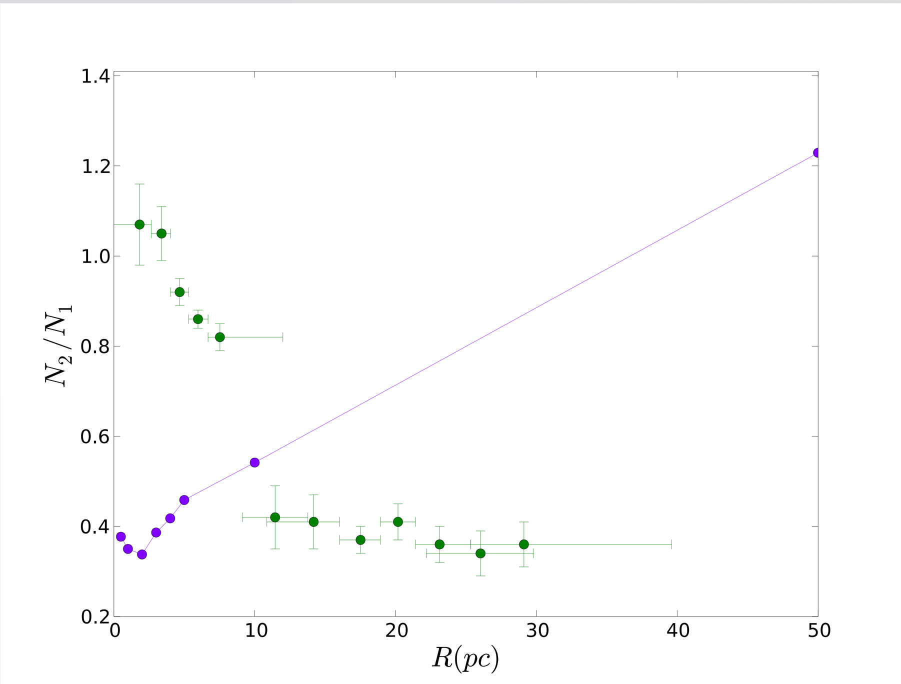


Population fraction profiles.
Red line: t ~t_{rlx}. Purple line: t ~ 0.1 t_{rlx}.
Green dots: observed data for Omega Cen (Bellini et al. 2009).

Case III



Case IV



Population fraction profiles.
Purple line: t ~ 0.1 t_{rlx}.
Green dots: observed data for Omega Cen (Bellini et al. 2009).

		W0	R_V(pc)
Case I	GC 1	5	6
	GC 2	9	3
Case II	GC 1	6	3
	GC 2	4	6
Case III	GC 1	6	10
	GC 2	7	7
Case IV	GC 1	7	4
	GC 2	8	4

Table: King model central potential parameter W0 and initial virial radius for every progenitor cluster

Discussion

The four panels show the resulting populations ratio for a GC originated through merging of star clusters. The choice of initial values for the concentration parameter and, even more, for the virial radius is fundamental: the smaller population (GC2) is more centrally concentrated whenever its initial dimensionless central potential W0 is higher than GC1's one and its initial virial radius is smaller than the other progenitor's one. This are the cases I and III, in which the simulations follow the same trend as observed in Omega Cen trend. Two body relaxation leads to a gradual mixing of the two populations.

In the other two situations the GC2 turns out to be more extended, even for high values of W0. The key factor is the initial size of the cluster: a high total density value is needed in order to have the smaller population highly concentrated at the center, hence to consider the merger a sensible mechanism to explain GCs bimodality.

Whether it is reasonable to systematically expect smaller star clusters to have higher densities seems unlikely on the basis of current observational data.

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Fundamental References:
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