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ISIMA report on "Star clusters in galaxy cores"

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ABSTRACT

The distinction between globular clusters and dwarf galaxies has progressively blurred with the recent discoveries of several outer halo extended star clusters, whose size and luminosity are comparable to the one of faint Milky Way satellites. In order to explain the sparse structure of extended clusters, it has been suggested that they formed in dwarf galaxy satellites that later accreted onto the Milky Way. Using N-body simulation we test the possibility that a cluster originally formed as compact in the center of a dwarf galaxy could undergo a significant expansion during the accretion process, due to the change of the tidal potential. We show that the cluster gains energy during its early evolution, because of the compressive tidal environment provided by the core region of the dwarf galaxy. When the cluster stops feeling the compressive tides, it experiences an expansion. However, we demonstrate that the imprinted expansion is not enough to explain the observed extended structure, since the outcome of this process are always systems more compact than corresponding clusters evolved completely in isolation. We conclude that an accreted origin of extended globular clusters is unlikely to explain their large spatial extent.

Key words: globular clusters:general

1 INTRODUCTION

In recent years the study of globular cluster systems around galaxies has brought to the discoveries of a number of low luminosity stellar systems populating the transition region between low-luminosity dwarf spheroidal galaxies (dSphs) and globular clusters (GCs) in the luminosity-size parameter space. In the Milky Way (MW) the known objects are Pal 4, Pal 14, AM 1, NGC 2419 (Mackey & van den Bergh 2005; Harris 2010), and several other in M31 (Huxor et al. 2005, 2008, 2014).

These stellar systems, often referred to as extended clusters, are preferentially found in the outer halos of galaxies and are characterized by a more diffuse structure than typical GCs of similar luminosity. With a half light radius of about ≈ 30 pc, extended clusters are one order of magnitude larger than the average known GCs. Their intermediate size, between the regime of dSphs galaxies and GCs, make them interesting and puzzling objects, crucial for the understanding of the differences and similarities of the formation scenarios of small stellar systems.

The debate on the nature of these extended objects has been recently enhanced by the discovery of the peculiar MW satellite Laev1/Crater (Laevens et al. 2014; Belokurov et al. 2014). With an estimated half light radius between 20-30 pc and a distance to the sun between 145-170 kpc, its classification is still debated. Laevens et al. (2014) define it as the most distant globular cluster in the Milky Way yet known, while Belokurov et al. (2014) favor the hypothesis of a dwarf galaxy with unusual properties, due to the presence of a few blue loop stars.

Moreover, Frank et al. (2014) found the surprising evidence of mass segregation in the extended cluster Pal 14. The current relaxation time of this cluster exceeds the Hubble time and therefore is too long to explain the settling of segregation though standard dynamical evolution. Since mass segregation takes place in a few relaxation times, some more complex evolutionary process must have taken place. The study of the internal properties of such stellar systems is therefore crucial to unveil their formation. In turn, this will shed light to the formation processes that build up the MW satellites and the GCs systems in galaxies.

The presumed origin of extended clusters include two main mechanisms: 1) they were genuinely formed extended; 2) they were born as normal (compact) clusters and later experienced an expansion due their peculiar evolutionary history. Evolutionary processes that are often assumed to cause

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an expansion are strong tidal shocks or accretion process in the MW halo (Spitzer 1958; Ostriker et al. 1972; Marín-Franch et al. 2009; Mackey et al. 2010). The latter mechanism assumes that these clusters were formed in dwarf-like satellite galaxies that later were accreted and stripped into the halo of the host galaxy. We note that the accretion of dwarf galaxies is a common process often used to explain the formation of GC systems. In fact, growing evidence (both chemical and dynamical, Leaman et al. 2013) show that a significant fraction of MW GCs are accreted stellar systems while the remaining formed in-situ during the early phase of galaxy formation (Forbes & Bridges 2010; Tonini 2013).

In this work we focus on the possibility that extended clusters formed in the context of an accretion event, testing if their observed extended sizes can be explained by the structural adjustment of the clusters to the time-dependent tidal field. We test this hypothesis using N-body simulations considering the extreme case of a cluster formed in the central regions of dwarf-like galaxies, where it experiences a compressive tidal environment during its early evolution, and then it is accreted into a MW-like galaxy.

The paper is organized as follows: first we introduce the compressive tidal environment typical of the core regions of galactic potentials, then we show in Section 3, using a simple analytical calculation that an accretion mechanism naturally causes an expansion of stellar systems. In Section 4 we present our N-body simulations testing different initial condition and configurations. We discuss our results in Section 5 and finally we report our conclusions and future developments.

2 COMPRESSIVE TIDES IN GALAXY CORES

In this work we will consider two main test cases for a globular cluster in the core of a galactic potential. First we will consider a cluster placed stationary in the center of the potential, then we will explore the case of a cluster in orbit around the central region of the galactic potential.

Given an arbitrary external potential ϕ into which the cluster is embedded, it is possible to calculate the associated tidal tensor $\mathbf{T}$ (Renaud et al. 2008) as

$$T^{ij} = -\partial^i \partial^j \phi, \quad (1)$$

If the eigenvalues λ_i associated to this tensor are all negative the tides are fully compressive, and extensive if at least one eigenvalue is positive. In the case of a Plummer potential with characteristic radius r_0 and total mass M_G

$$\phi = -\frac{G\, M_G}{(r_0^2 + r^2)^{1/2}} \quad (2)$$

the components of the tensor are (Renaud et al. 2009)

$$T^{ij} = -G\, M_G \frac{\delta^{ij}(r_0^2 + r^2) - 3x_i x_j}{(r_0^2 + r^2)^{5/2}} \quad (3)$$

and the regime of compressive tides is limited to the core region of the configuration, delimited by $r < r_0/\sqrt{2}$.

If the cluster is in a circular orbit in the core of the galactic potential, an effective tidal tensor can be associated to the problem. The effective tidal potential ϕ_e can be defined incorporating the non-inertial terms from fictitious forces (Renaud et al. 2011), and consequently the corresponding tidal tensor $\mathbf{T}_e$ is

$$\mathbf{T}_e = \begin{pmatrix} \lambda_{e,1} & 0 & 0 \\ 0 & \lambda_{e,2} & 0 \\ 0 & 0 & \lambda_{e,3} \end{pmatrix} \quad (4)$$

where the $\lambda_{e,i}$ are the effectives eigenvalues, and $\lambda_{e,1} \geqslant \lambda_{e,2} \geqslant \lambda_{e,3}$.

We recall that in the case of Plummer potential centered at $(-R_G,0,0)$,

$$\{\lambda_{e,1},\, \lambda_{e,2},\, \lambda_{e,3}\} = \frac{G\, M_G}{r_0^3(1+\xi^2)^{3/2}} \left\{ \frac{3\xi^2}{(1+\xi^2)}, 0, -1 \right\}, \quad (5)$$

with $\xi = R_G/r_0$. When $\xi < 2^{-1/2}$, the effective tidal potential (i.e. including gravitational tides as in Eq 3, and centrifugal effect) experienced at R_G is fully compressive.

3 ANALYTICAL DESCRIPTION: IMPULSIVE APPROXIMATION

Before studying the effect of compressive tides on the evolution of a cluster with N-body simulations, we undertake a preliminary study of the problem using analytical calculations. We describe a globular cluster initially embedded in a isotropic compressive tidal field that is then instantaneously removed (impulsive approximation). In this section, we follow the procedure outlined in (Hills 1980).

Let's consider an isotropic tidal field such that the eigenvalues of the tidal tensor are all equal $\lambda_i = \lambda$. Since we want to consider the case of fully compressive tides the eigenvalues of the tidal tensor are all negative, $\lambda < 0$. The initial energy of the cluster embedded in such field is (Renaud 2010, their eq. E.12)

$$E_0 = \frac{1}{2} M_c \sigma^2 - \frac{G M_c^2}{2 r_v} - \frac{1}{2}\lambda\alpha M_c\, r_t^2 \quad (6)$$

where the last term describes the energy due to the compressive tides, M_c the total mass of the cluster, σ the velocity dispersion of the cluster, r_v the virial radius, r_t the radius where the density of the cluster drops to zero, and α describes the mass profile of the cluster and is defined as $\alpha = 1/(M_c\, r_t^2) \int_0^{M_c} r^2\, dm$. In addition, we assume that the system is initially virialised, so that the following virial relation holds (Renaud 2010, their eq. E.13)

$$M_c \sigma^2 - \frac{G M_c^2}{2 r_v} + \lambda\alpha M_c\, r_t^2 = 0. \quad (7)$$

In the impulsive approximation, we assume that at a certain time the tidal field is instantaneously removed, keeping both velocity dispersion and the radii of the cluster unchanged. This approximation is justified by the fact the the time scale in which the stripping of a dwarf-galaxy occurs is small compared to its dynamical time. The new energy of the system is therefore

$$E_1 = \frac{1}{2} M_c \sigma^2 - \frac{G M_c^2}{2 r_v}. \quad (8)$$

Using the virial equation 7 we can rewrite is as

$$E_1 = -\lambda\alpha M_c r_t^2 - \frac{1}{2} M_c \sigma^2. \quad (9)$$

We note that the system in the final state is bound when

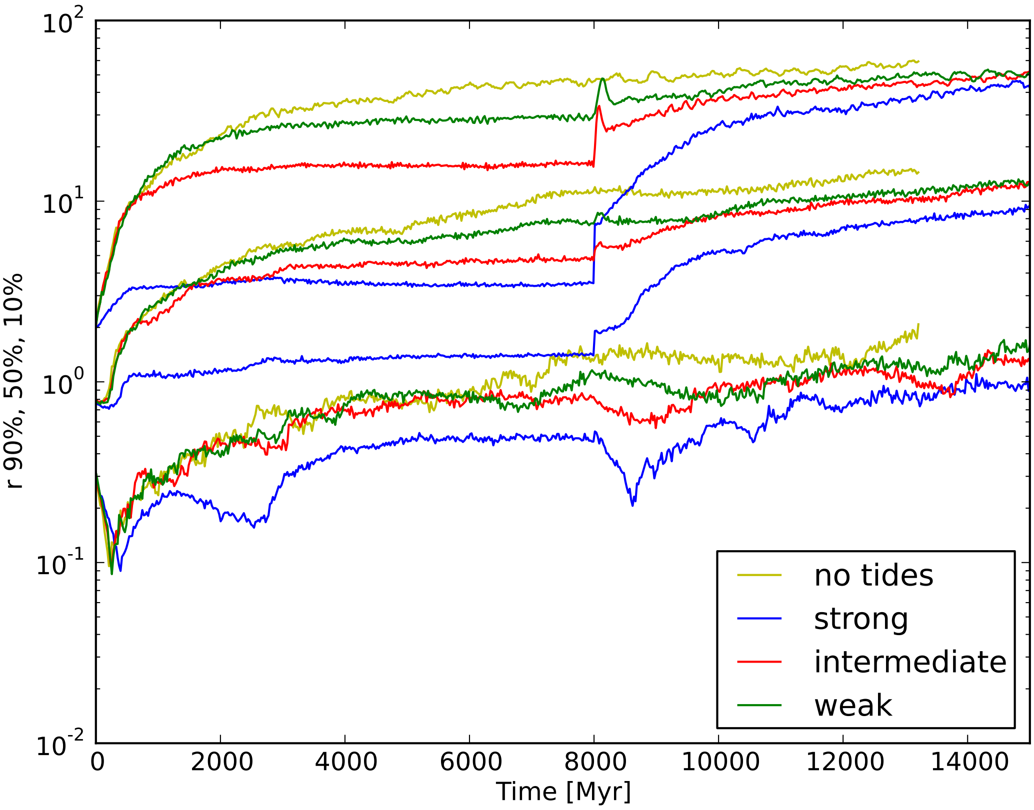


Figure 1. Time evolution of the spatial extent of a cluster in 3 different compressive tidal fields, corresponding to the center of a Plummer potential describing the dwarf galaxy with $M = 10^8 M_\odot$ and scale radius $r_0 = 1000$ pc, 500 pc, 100 pc, labeled as weak (green lines), intermediate (red lines) and strong (blue lines) tidal field, respectively. The evolution of the Lagrangian radii enclosing 10%, 50% and 90% of the total particles is shown. The compressive tides are switched off at 8 Gyr, leading to the expansion of the cluster. For comparison we show the evolution of a cluster in isolation with the same initial condition (no tides, yellow lines).

the final energy $E_1 < 0$. This sets a maximum value for the strength of the compressive tides, that corresponds to values of λ

$$\lambda > -\frac{1}{2}\frac{\sigma^2}{\alpha r_t^2}. \quad (10)$$

Therefore if the system is initially embedded in a very strong compressive tidal field (large absolute values of λ) it acquires too much energy that need to be dissipated during the impulsive change. The cluster is then super-virialised and become unbound when the tides are switched off.

After instantaneously turning off the tidal field, we expect the cluster to settle in a dynamical time scale toward a new equilibrium state, characterized by a new radius r'_v and a new velocity dispersion σ', neglecting any mass loss (i.e. constant M_c over a dynamical time). This is described by the virial equation

$$M_c \sigma'^2 - \frac{G M_c^2}{2 r'_v} = 0, \quad (11)$$

and a total energy

$$E = \frac{W}{2} = -\frac{G M_c^2}{4 r'_v}. \quad (12)$$

Using equation 7, 8 and 12 we obtain a relation between the virial radius at the final state r'_v and the initial radius r_v

$$r'_v = r_v \left(\frac{1}{1 + \frac{2\lambda\alpha r_t^2 r_v}{G M_c}} \right). \quad (13)$$

In the case of compressive tides (i.e. $\lambda < 0$), the final virial radius r'_v is always larger than the initial r_v. The cluster therefore expands.

4 N-BODY SIMULATIONS

We now proceed to study the problem using N-body simulations. Our simulations are carried out with nbody6tt (Renaud et al. 2011) based on Nbody6 (Aarseth 2003) and allows to incorporate an arbitrary time dependent tidal field.

Our fiducial set up for the initial conditions for the globular cluster consist in 4096 particles drawn by a Plummer sphere. No stellar mass function or stellar evolution is considered in our simulations. The compressive tides are given by the central region of a Plummer potential, mimicking the potential well in the center of a dwarf galaxy (see Sect. 2). The tidal potential will be switched off to simulate the stripping of the dwarf galaxy occurring as a consequence of the

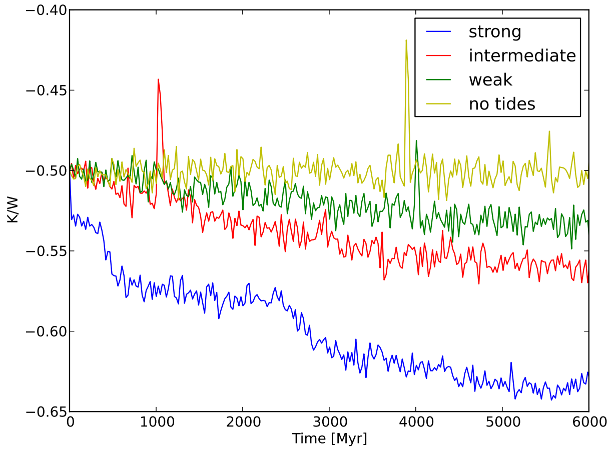


Figure 2. Time evolution of the ratio between kinetic and potential energy K/W of the same runs presented in Fig. 1. The clusters are initialized by neglecting the tidal field, and subsequently adjust very quickly to it. Compressive tidal fields keep the cluster in a supervirialized regime.

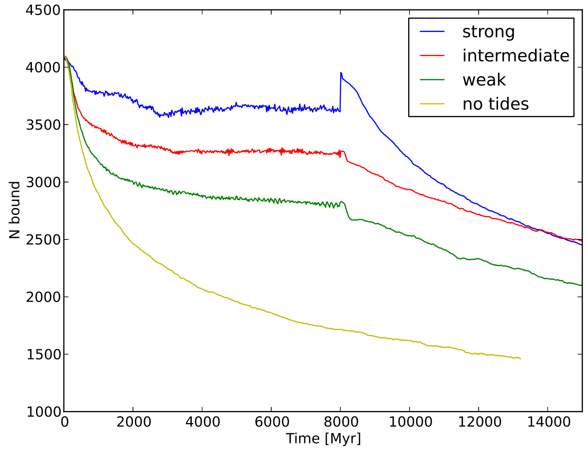


Figure 3. Time evolution of the number of bound stars to the cluster (N bound), for the same runs presented in Fig. 1. Stronger compressive tides slow down the stellar loss. The tidal field is switched off instantaneously at 8 Gyr.

accretion process onto the Milky Way, bringing the cluster into an isolation regime[1]. Note that we neglect the motion of the dwarf-galaxy around the Milky Way.

In the following sections we present the results of the long time dynamical evolution of the cluster considering different tidal field strengths, different initial densities for the cluster, different transitions between the compressive tides and isolation (impulsive or slow variation), and different orbits inside the dwarf galaxy potential. For consistency throughout the paper, we use the criteria of $E < 0$ to define those particles still part of the cluster (Renaud et al. 2011), where the energy is given by the sum of the potential and kinetic energy, E=W+K.

4.1 Evolution in the center of a compressive tidal potential: no orbit

The first case we test consists in a 4096 particles Plummer sphere with virial radius[2] $r_v = 1$ pc placed in the center (with no orbital motion) of a compressive tidal potential that is then instantaneously switched off (at the arbitrary time of 8 Gyr).

We aim to study the dependence of the cluster's evolution on the strength of the tidal field. For this reason we specify 3 constant compressive tidal fields, corresponding to the tides in the center of a Plummer potential with total mass $M = 10^8 M_\odot$ and scale radius $r_0 = 1000$ pc, 500 pc, 100 pc (typical values for dwarf galaxies mass and characteristic radii, McConnachie 2012). We label these 3 compressive tidal potentials as weak, intermediate and strong, respectively. The values chosen correspond to increasing central densities of the dwarf galaxy potential, ≈ 0.02, 0.2, 20 $M_\odot/pc^3$ respectively. The tidal field is isotropic.

We show in Fig. 1 the time evolution of the 10%, 50% and 90% Lagrangian radii (i.e., the radii containing 10%, 50% and 90% of the total mass, respectively) for the strong, intermediate and weak compressive tidal fields. We overplot the evolution of the radii corresponding to an isolated case (no tides). The figure shows that, while the compressive tides are on, the spatial extent of the cluster depends on the strength of the tidal field: the strongest the field is, the more compact the cluster is. What is effectively happening is that the cluster is kept in a supervirialized status with a higher K/W ratio, that is the ratio between the kinematic energy K and potential energy W. This is displayed in Fig. 2, where all the runs are characterized by a starting value of $K/W = -0.5$ (virialized cluster) and progressively decrease toward more negative values for stronger compressive tides.

In the regime in which compressive tides are on, the stronger the tides are the more compact and supervirialized the cluster is. In addition, the mass loss is slowed down (see Fig. 3). When the compressive tidal field is switched off (8 Gyr), the cluster experiences an expansion, that is higher for stronger tides. We note that the expansion is significant for the 50% and 90% Lagrangian radii, while is negligible for the inner 10% Lagrangian radius, confirming that tides only affect the outer regions of the clusters.

So far we considered the case in which the transition between the compressive tidal field regime and no tidal field is impulsive. We explore the possibility of a slower transition, occurring in a time interval of 600 Myr. We study this case with the intermediate strength of the compressive tidal field. The result is shown in Fig. 4. The panel on the left shows the evolution of the 90% Lagrangian radius in the

[1] The assumption of isolation for the cluster in the final state (after the compressive tides are switch off) is consistent with the hypothesis of placing the system in the outer halo of galaxy, where the expected tidal effects are low. This is consistent with the observational evidence that extended clusters are preferentially found in the outer halo of galaxies (Mackey & van den Bergh 2005; Huxor et al. 2005, 2008, 2014)

[2] We recall that for a Plummer sphere with half mass radius r_m and scale radius r_0, the following relations hold: $r_v \approx 1.7\, r_0$ and $r_m \approx 1.3\, r_0$. The virial radius is defined as the radius that satisfies $W = G\, M_c/(2\, r_v)$, with W the total potential energy and M_c total mass of the cluster.

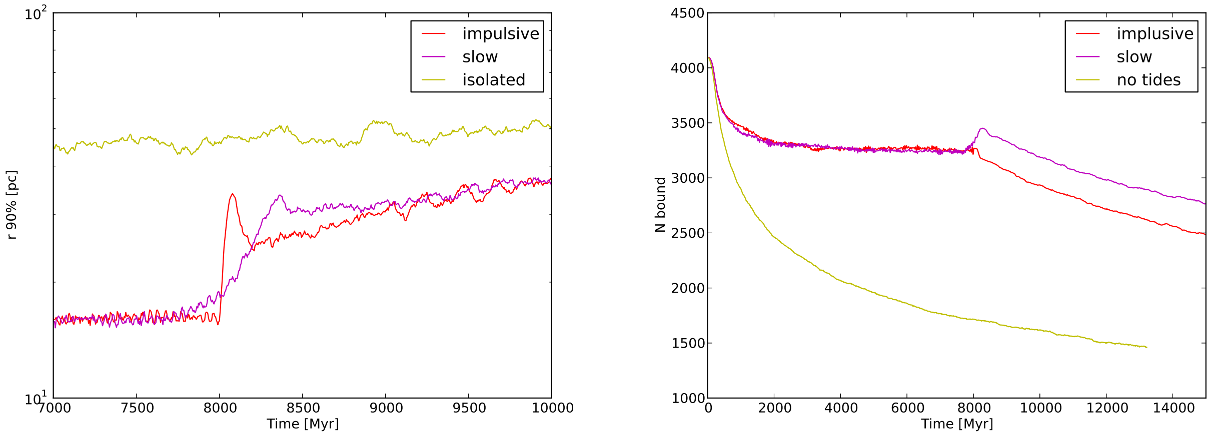


Figure 4. *Left panel*: Time evolution of the 90% Lagrangian radius for two simulations with different transition between compressive tidal field and no tidal field. An intermediate strength for the tidal field is used (see Fig. 1). The red curve represents the impulsive transition, while the magenta a slow transition lasting 600 Myr. The evolution of the corresponding isolated case is shown in yellow for comparison. The 90% Lagrangian radii converge at the same value independently of the speed of the transition. *Right panel:* Time evolution of the number of bound stars for the same runs in the left-side panel. When a slow transition is applied the cluster is able to recapture some of the previously ejected stars.

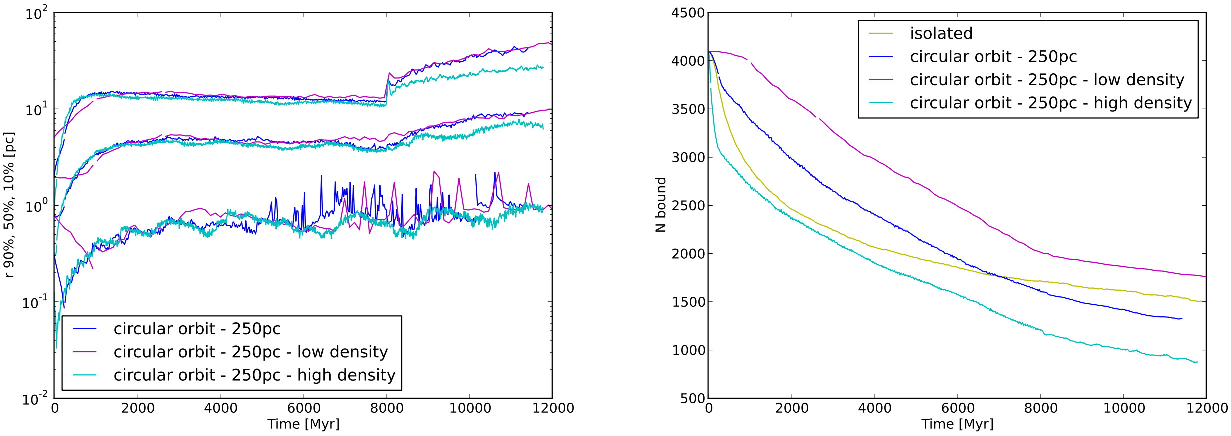


Figure 5. *Left panel:* Time evolution of the 10%, 50% and 90% Lagrangian radii for a cluster in the fully compressive regime orbiting at 250 pc from the center of a Plummer potential (total mass $M = 10^8 M_\odot$, scale radius $r_0 = 500$ pc) The 3 color lines indicate the 3 different initial conditions for the cluster with virial radii of $r_v = 0.4$, 1, 2.5 pc (magenta, blue, cyan lines respectively), corresponding to decreasing initial densities, increasing filling factors, and increasing relaxation times. The compressive tidal field given by the Plummer potential is turned off at 8 Gyr, where the expansion of the clusters occurs. *Right panel:* Time evolution of the number of bound stars for the same runs in the left-side panel. The yellow line corresponding to the isolated case with initial $r_v = 1$ pc is over plotted for comparison. The rate of stellar loss is modified by the interplay between the presence of the circular orbit and the compressive tides, with the initially densest system (the most initially under-filling system) experiencing a more rapid stellar loss.

transition region only. Despite the difference shapes of the transition, the values reached for the radial extent by the two simulations converge in short dynamical time. So no significant differences in the final outcome are present. The panel on the right shows that a difference in the number of bound particles is present, with the slower transition run recapturing efficiently some of the unbound stars during the switching off the tidal field.

4.2 Circular orbit

We now consider the more realistic case in which the cluster moves in circular orbits around the center of the dwarf galaxy, instead of simply be placed with no motion in its center. Considering the case labeled previously as intermediate tidal strength (total mass of $M = 10^8 M_\odot$ and scale radio of $r_0 = 500$ pc) we assure that the cluster is always in the regime of compressive tides placing it into circular orbit at 250 pc distance from the center (see Sect. 2).

Given that the cluster is now moving in a orbit, a tidal boundary can be defined, reflecting the formation of the Jacobi equipotential surface delimiting the region inside which the cluster is gravitationally dominant (Fukushige & Heggie 2000). We define the Jacobi radius r_J as the distance from the Lagrange point L_1 and the center of the cluster (Renaud et al. 2011)

$$r_J = \left(\frac{G\, M_c}{\lambda_{e,1}} \right)^{1/3}, \qquad (14)$$

with M_c the mass of the cluster and $\lambda_{e,1}$ given by equation 5. We use the sphere of radius r_J as an approximation of the Jacobi surface, usually referred to as Roche sphere. This can be used to define the degree of filling of the Roche sphere of our initial conditions using the ratio r_t/r_J, where r_t is the physical boundary of the cluster, that in the case of a Plummer sphere can be approximated by $r_t \approx 12\, r_0$ (radius that encloses the 99% of the total mass).

We want to study the effect of different initial conditions. Therefore we study three cases characterized by the same initial mass (4096 particles) and different virial radii, $r_v = 0.4$, 1, 2.5 pc. This gives us three initial conditions with:

- decreasing densities,
- increasing filling factors ($r_t/r_J \approx 0.1$, 0.3, 0.8, respectively),
- increasing relaxation times

Note that all three initial conditions under-fill their corresponding Roche sphere.

The results of our three runs are shown in Fig. 5 and are indicated by magenta, blue and cyan lines, for increasing initial densities, respectively. The initial evolution of the 3 clusters is dominated by their internal dynamics (causing an initial expansion and core collapse, $t < 1000$ Myr). The densest cluster is the one that experiences the largest initial expansion (due to its shortest relaxation time and higher density). The stellar loss rate (right panel Fig. 5) differs for the 3 runs, with the initially denser clusters experiencing an enhanced stellar loss. There is no obvious dependence between the degree of initial filling of the Roche sphere and stellar loss or evolution of the Lagrangian radii. When the tidal field is turned off at 8 Gyr the clusters experience an expansion, as already noted in the previous section.

5 DISCUSSION

We showed in the previous section that the evolution of a cluster in a compressive tidal field causes the cluster to acquire a more compact configuration, keeping the cluster energetically super-virialized. When the tidal filed is switched off and the cluster is left in isolation (or in a weak tidal field, as those experienced in the outer halo of MW-like galaxies), it experiences an expansion that involves the intermediate and outer regions. How does this expansion modify the spatial structure of the cluster? Is the expansion strong enough to the level of giving rise to stellar systems morphologically similar to the observed extended clusters (i.e., half light radii an order of magnitude larger than typical clusters)?

In order to answer these questions, we compare clusters that have evolved in compressive tides with the corresponding clusters evolved in isolation (i.e., we evolve clusters with the same initial conditions in a zero tidal field). Fig. 6 shows a comparison between the isolated case, the corresponding case of a stationary cluster in the center of a Plummer potential (intermediate strength, see Sect. 4.1) and one in circular orbit at 250 pc from the center. It is clear that the expansion due to the switching off of the compressive tides never produces objects that are more spatially extended than the isolated case at the same stage of is evolution.

This is confirmed by the analysis of the surface density profiles as a function of the projected radius R of different snapshots reported in Fig. 7. The left panel displays the time evolution of the surface density profiles of the cluster in a circular orbit of 250 pc, evolving in the compressive tides (a similar result applies in the case of no orbit). The formation of tidal tails features is observable in the outer parts of the profiles, due to the escape of stars through the Lagrangian points, and after the tides have been switched off the profiles are more extended. However, the right panel shows that the surface density profile for the isolated case at 10 Gyr (black line) is still more extended than the density profile of the cluster that experienced compressive tides (cyan line). Note that the number of particles of the two clusters at 10 Gyr is comparable ($N_{isolated} = 1619$ and $N_{tides} = 1413$ and the measured half mass radii are $r_m = 11.49$ pc and $r_m = 8.16$ pc, for isolated and compressive tides case, respectively. So no significant structural difference is present.

Finally, we note here that our result can be considered as conservative. In fact, in the most realistic case, the accretion process of the dwarf galaxy (corresponding to the switching off of the compressive tides) brings the cluster in the (extensive) tidal potential of the host galaxy. This would set a natural boundary for the spatial extent of the cluster (Lagrange surface), that would limit its subsequent expansion.

6 CONCLUSIONS AND PERSPECTIVES

We tested the possibility that extended clusters originally formed as compact (normal) clusters in the denser central regions of dwarf galaxies and later expanded due to a time-variation of the tidal field. In these core regions, the clusters experience a regime of compressive tides that keeps them in a supervirialized state. When the dwarf galaxy is accreted into the MW, the cluster is released in the outer halo it expands due to the sudden change of environment.

We demonstrate that the expansion imprinted to the clusters does not give origin to object that are more spatially extended than systems that were born compact and simply evolved in isolation. We tested our conclusion exploring different initial densities for the clusters, different orbits inside the core of the dwarf galaxy, different strengths of the compressive tides and different time-transitions between the regime of compressive tides and isolation.

We conclude that an accreted origin of outer halo extended globular clusters is unlikely to explain their large spatial extent. For this reason, we favor the hypothesis that these stellar systems were genuinely formed extended.

An alternative explanation of their extended structure could be given by the possibility that these systems are actually tidally disrupted and therefore any estimates of their

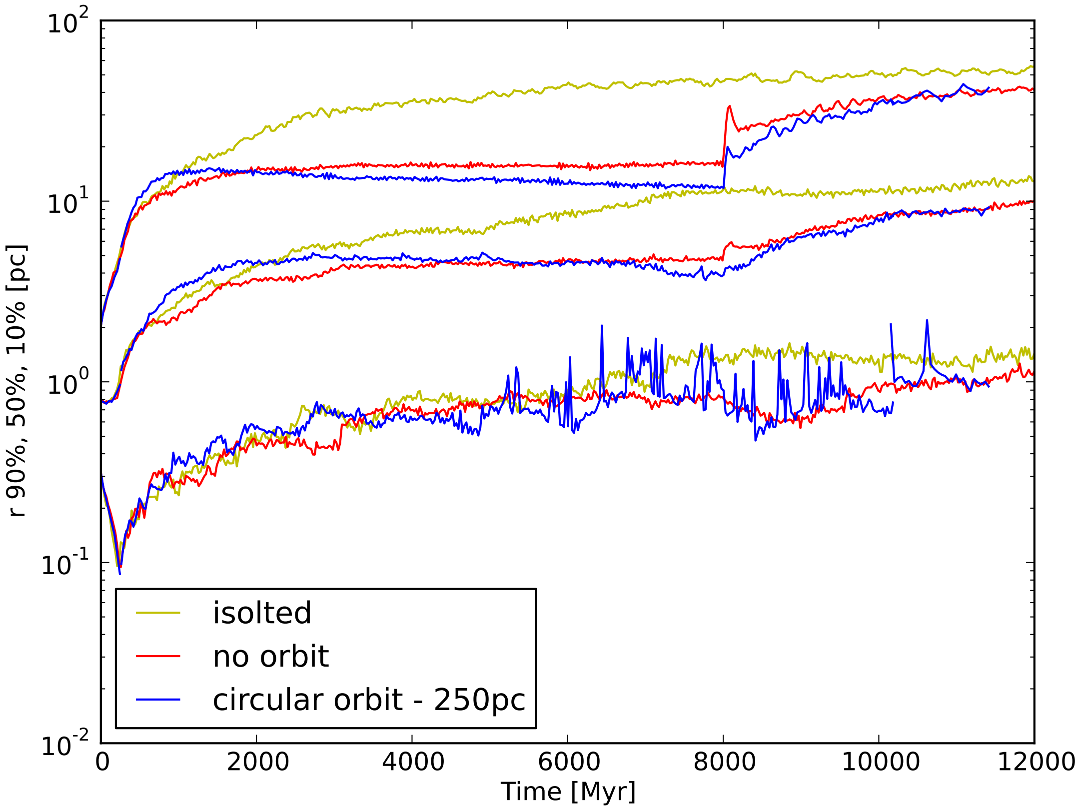
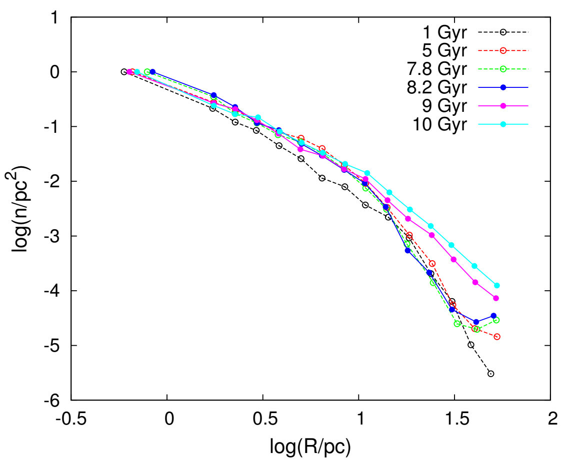


Figure 6. Time evolution of the 10%, 50% and 90% Lagrangian radii of 3 simulations with the same initial conditions (4096 particle and $r_v = 1$ pc): no tidal field, stationary cluster in the center of a Plummer potential (intermediate strength, see Sect. 4.1) and cluster in circular orbit at 250 pc from the center, indicated respectively with yellow, red and blue lines. Despite the clusters increase in size when the compressive tidal field is turned off, the expansion is not enough to generate objects that are more extended than the one in the corresponding isolated case.



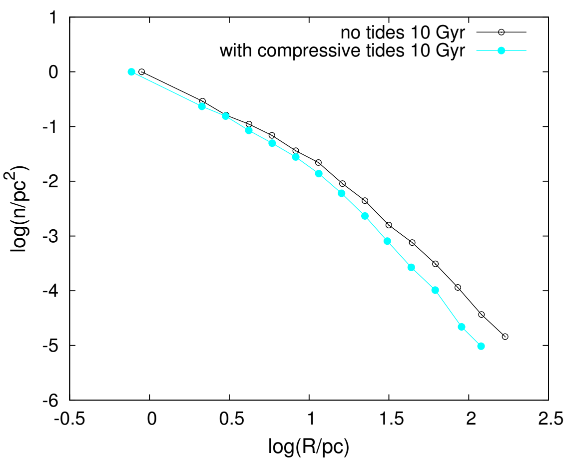


Figure 7. *Left panel:* evolution of the surface density profile for a cluster as a function of the projected radius R, in a circular orbit at 250 pc from the center of a Plummer potential (corresponding to set up indicted by blue lines in Fig. 6). The dashed lines indicate the snapshots where the cluster is embedded in the compressive tides, while solid lines indicate snapshots after the tidal field has been switched off. *Right panel*: Comparison of the surface density profile at 10 Gyr of the cluster evolved in isolation (black line) and the cluster evolved in compressive tides (cyan line, see left panel). The expansion imprinted to the cluster, after the tidal field has been switched off, is not enough to form objects that are more extended than the one in the isolated case.

half radius is artificially overestimated and not representative of a bound virialized system (Küpper et al. 2010).

We plan to extend our simulations to more realistic cases in which a stellar mass spectrum, stellar evolution and more realistic galactic potentials are taken into consideration. With these additional ingredients we will have the possibility to thoroughly investigate what unique structural and kinematic signatures are imprinted by the peculiar regime of compressive tides and by the following stripping process. This represent a fundamental tool to further understand the origin of globular cluster systems using clusters as footprint of the complex accretion history of the Milky Way.

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