Binaries in Galactic globular clusters

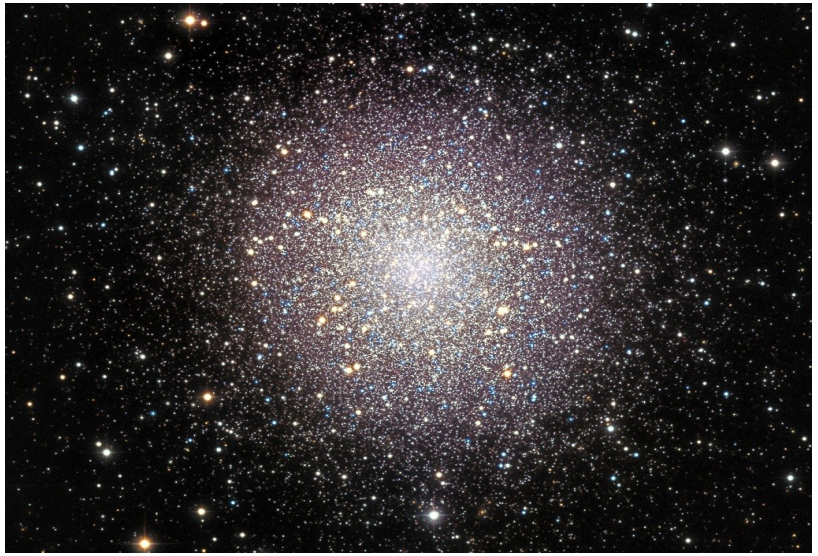
Roles, abundances & models

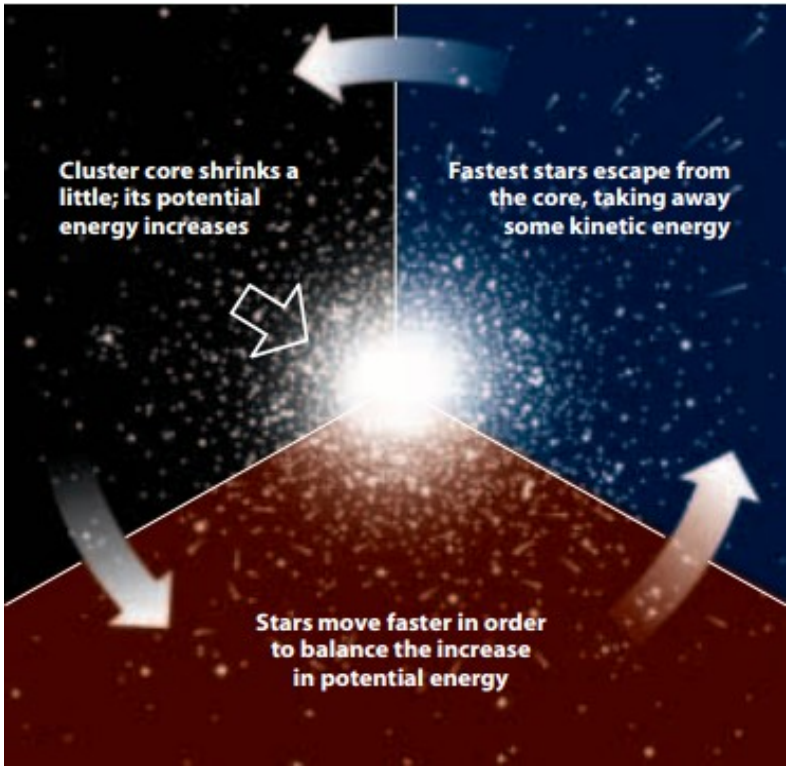
Outline

- Stability of GCs
- Blue stragglers
- LMXBs
- Abundance of binaries vs cluster age
- Binary creation & disruption processes
- Models

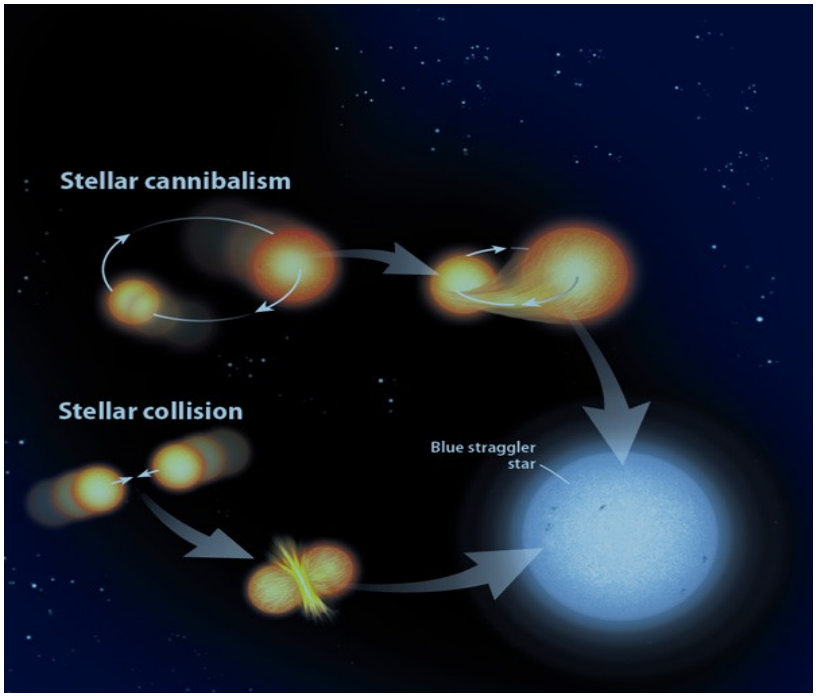
Stability of GCs

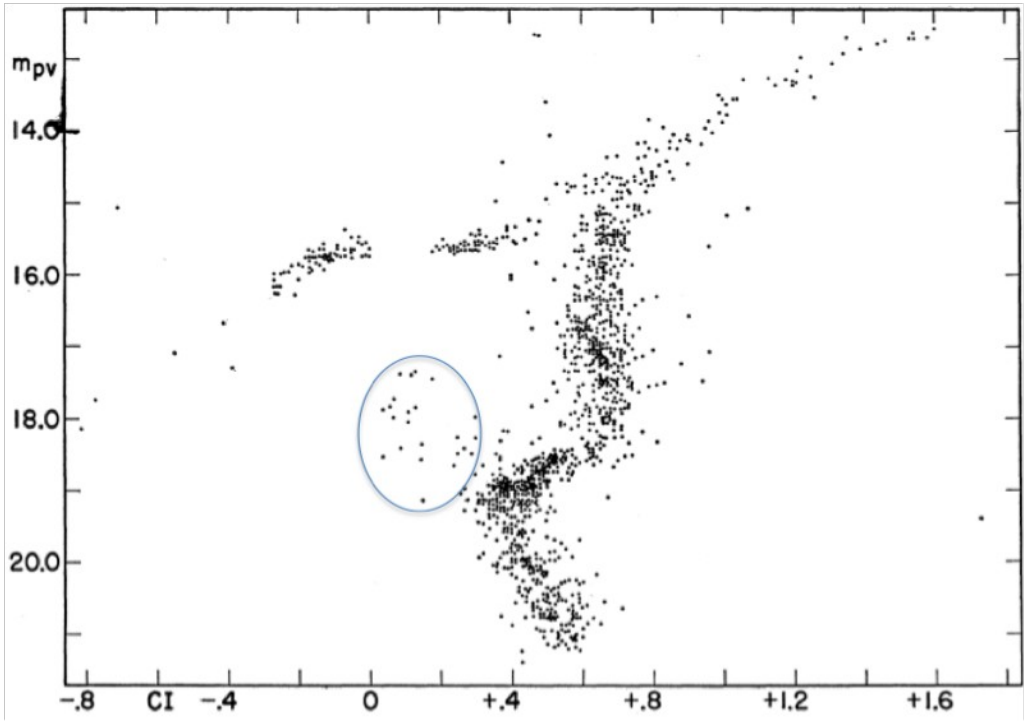
- First successful models of GCs in the sixties (e. g. King, Michie, Henon)
- Some models (Henon, and later in 1980s e.g. Lynden-Bell, Cohn, Goodman) – gravothermal catastrophe (core collapse)
- Binary stars as the energy source which stabilize GC cores against collapse
- Gravothermal oscillation cycle



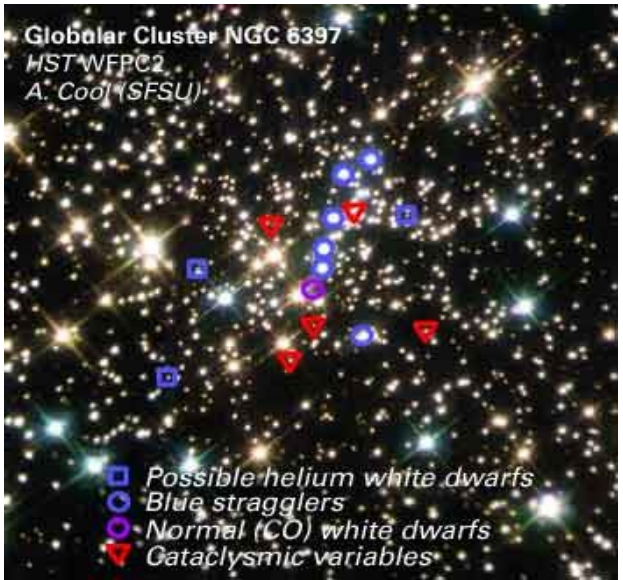


Blue stragglers



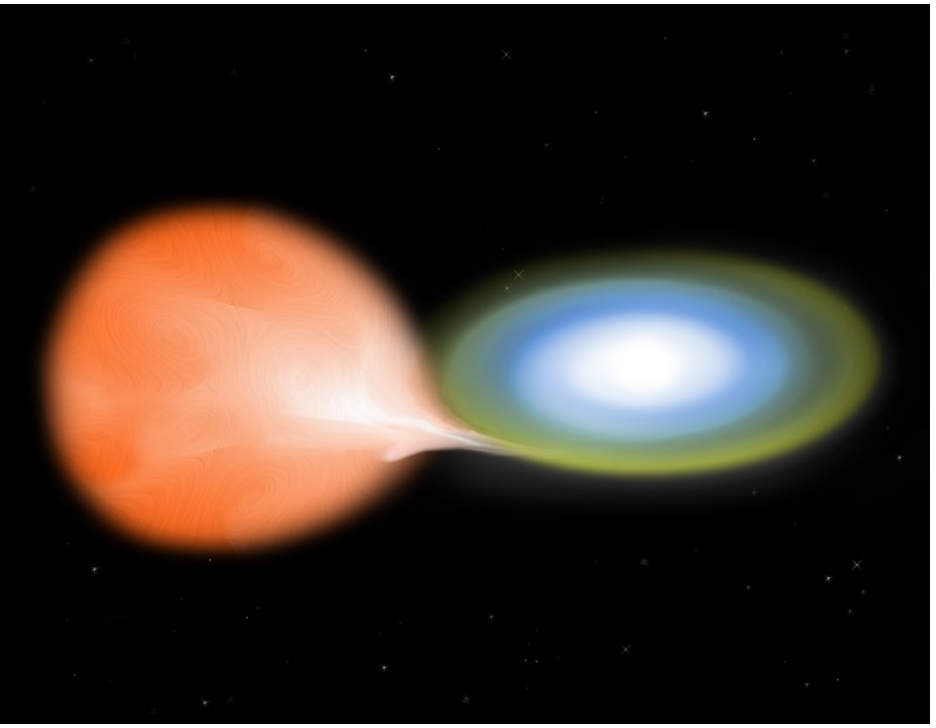


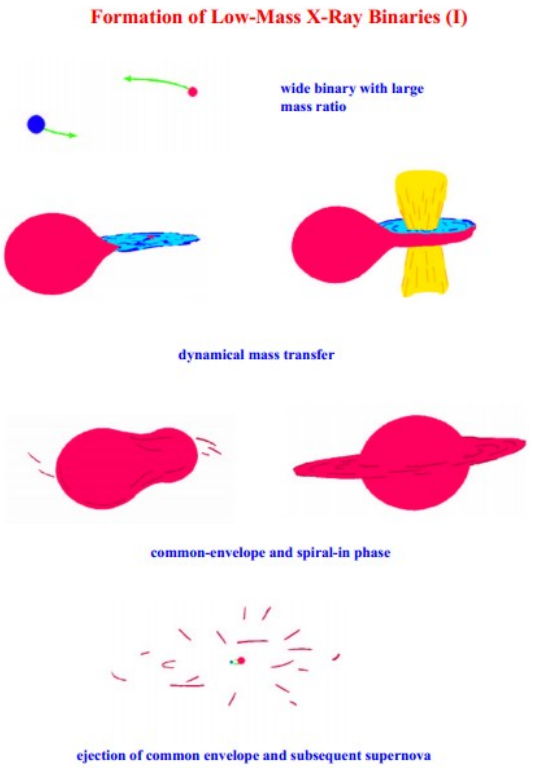
CMD for M3 (Sandage 1953)

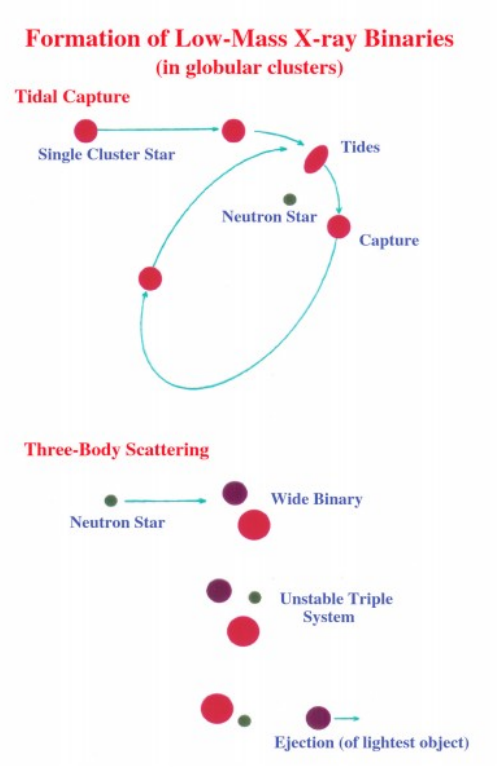


- First discovered in GC M3
- Produced by stellar collisions – lone stars or binaries in the process or after merging
- Mass transfer in tight binaries

LMXBs







- Hard to form due to the difference in masses of the components – potential disruption due to SN explosion
- Overabundant in GCs (~20 times) + runaway velocity problem -> different formation channels?
- Tidal capture & Three-Body scattering

Abundance of binaries in GCs

- $\xi_{neigh} \sim 50\%$
- $\xi_{GC\text{-}spec,\ phot} \sim 20\% \pm$ huge uncertainities (e.g. Yan & Mateo (1994), Yan & Reid (1996), Albrow (2001), ...)
- Use of simulated CMDs - not universal, many free parameters -> need to properly choose the right sample – low extinction, low central density, high galactic lattitude – but quite precise (Sollima et al. (2007))
- Is there a correlation of the binary population with the age of GCs?

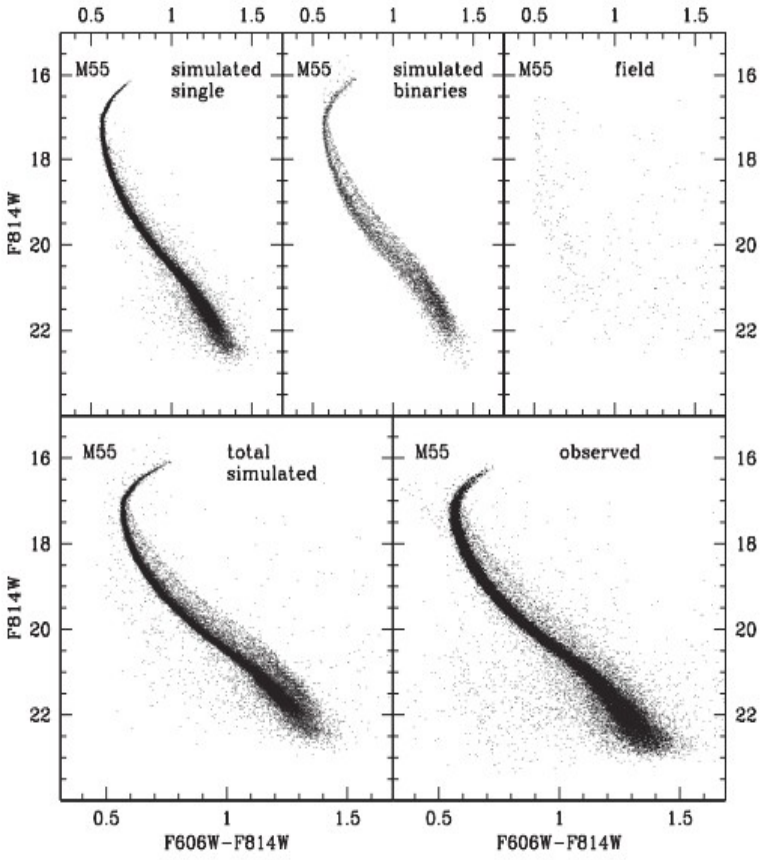
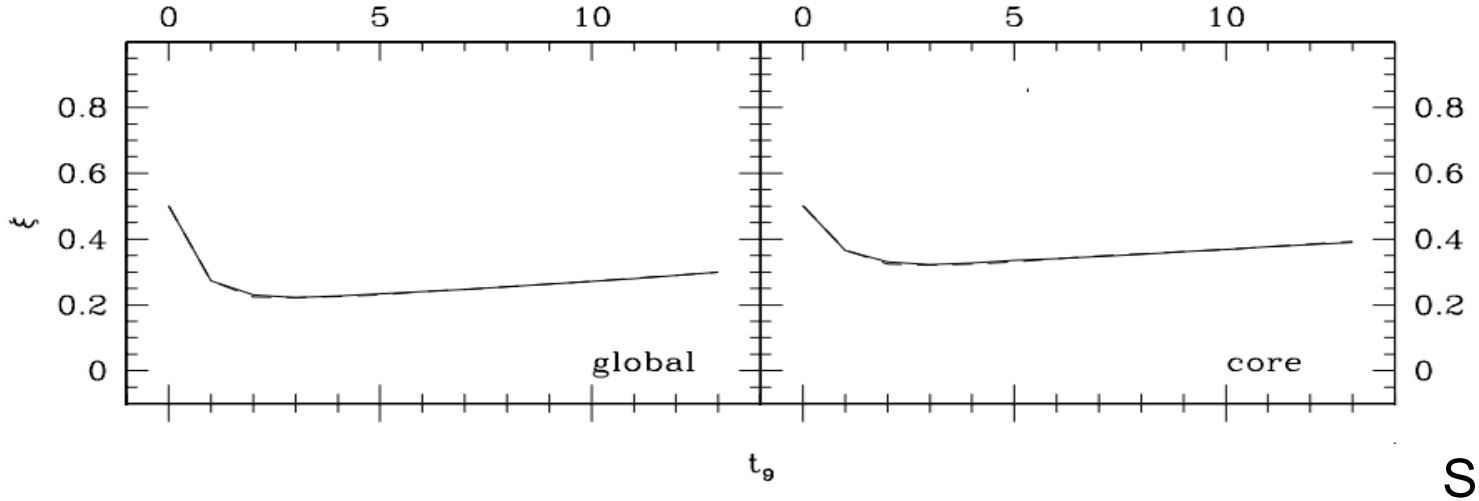


Figure 7. Simulated (lower left-hand panel) and observed (lower right-hand panel) CMD of M55. In the upper panels the individual CMDs of the simulated single stars (upper left-hand panel), binaries (upper central panel) and field stars (upper right-hand panel) are shown.

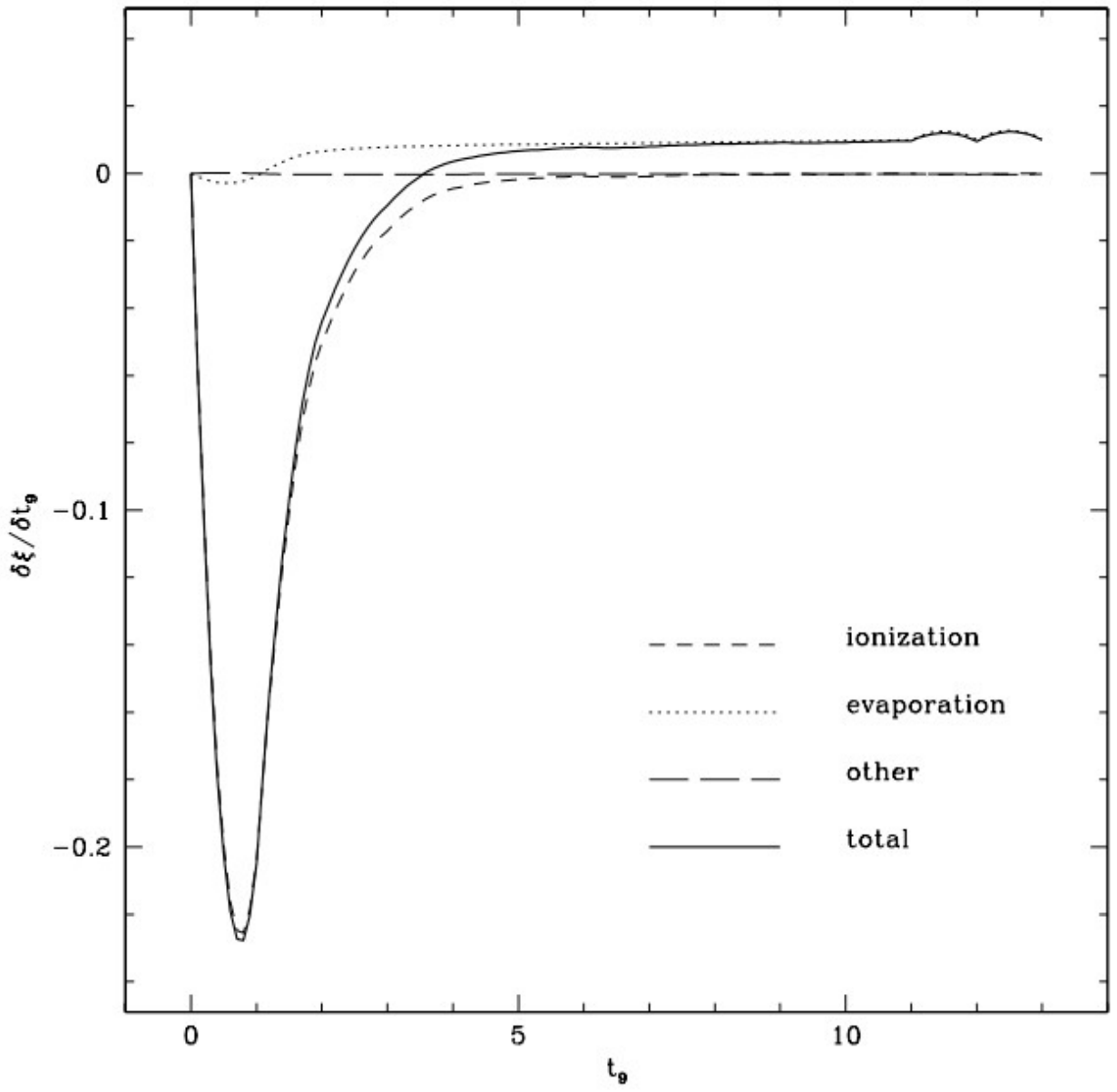
Sollima et al. (2007)

Models

- N-body simulations – ~100 000 stars, high demands for computational power (Hurley et al. (2007))
- Monte-Carlo simulations– faster, but sparse & giving conflicting results (Ivanova et al. (2005)
- Statistical approach – simpler but consistent with N-body simulations, number of simplifications, less demanding to compute -> more simulations can be made (Sollima (2008))
- Statistical treatment of interactions – tidal capture, ionization, exchange, stellar evolution, evaporation, mass segregation, cluster dynamical evolution
- Different initial conditions – central density, velocity dispersion, initial binary fraction, evaporation efficiency



Sollima (2008)



- Sudden drop followed by a sharp increase
- More binaries in the GC core
- Binary ionization dominant in the first 2 Gyr
- Steady increase of the binary fraction by evaporation of the single stars in the later stages
- Other processes negligible

Sollima (2008)

Summary

- Binaries are crucial for stability of the globular clusters
- Globular clusters provide a suitable enviroment for formation for a variety of exotic astrophysical objects (blue stragglers, LMXBs, cataclysmic variables, etc.)
- Binary fraction in the globular clusters evolve in time – disruption during the early stages and then a steady increase