Key Questions and Conference Highlights:Theory

A theoretic, mildly geriatric, egocentric view

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Conference Themes

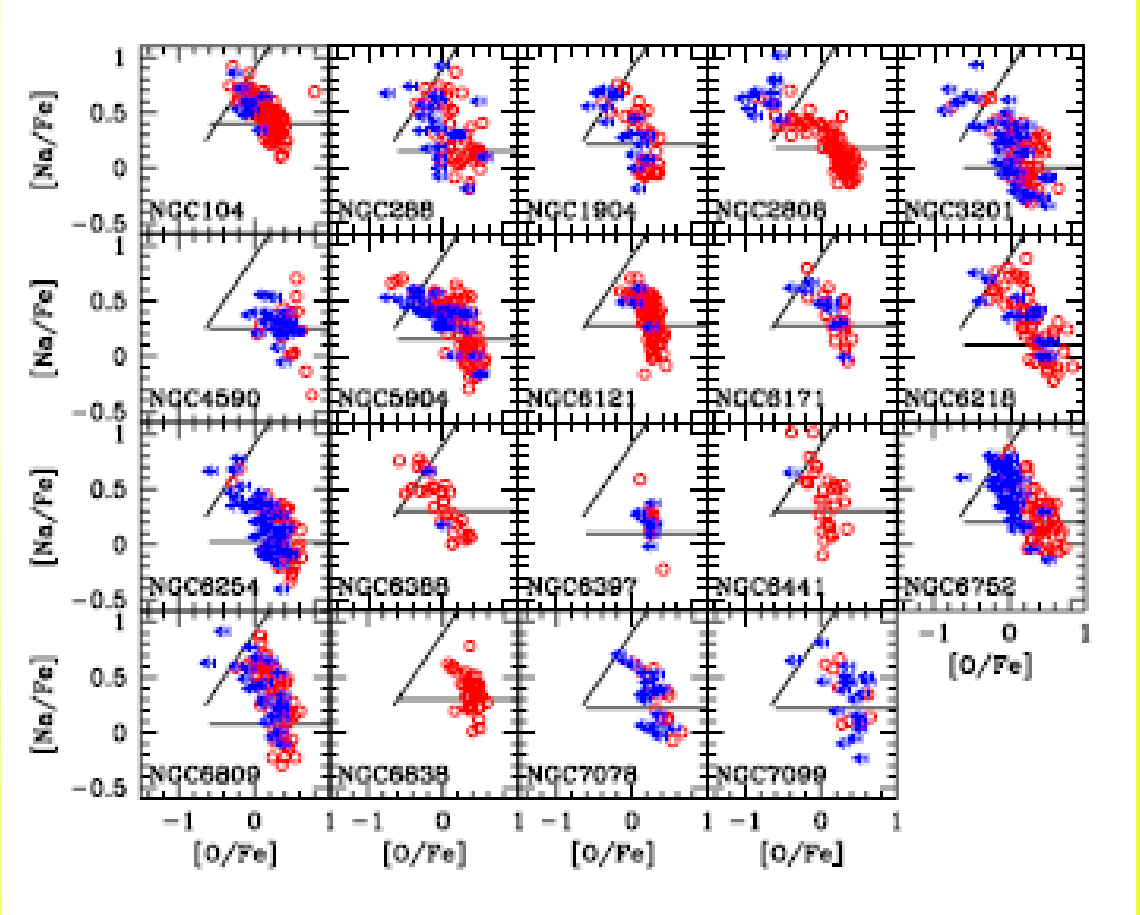
1. Dynamical modelling of Galactic globular clusters

2. Compact objects in Galactic and extragalactic globular clusters

3. Formation and evolution of globular clusters and globular cluster systems

Conference Highlights I

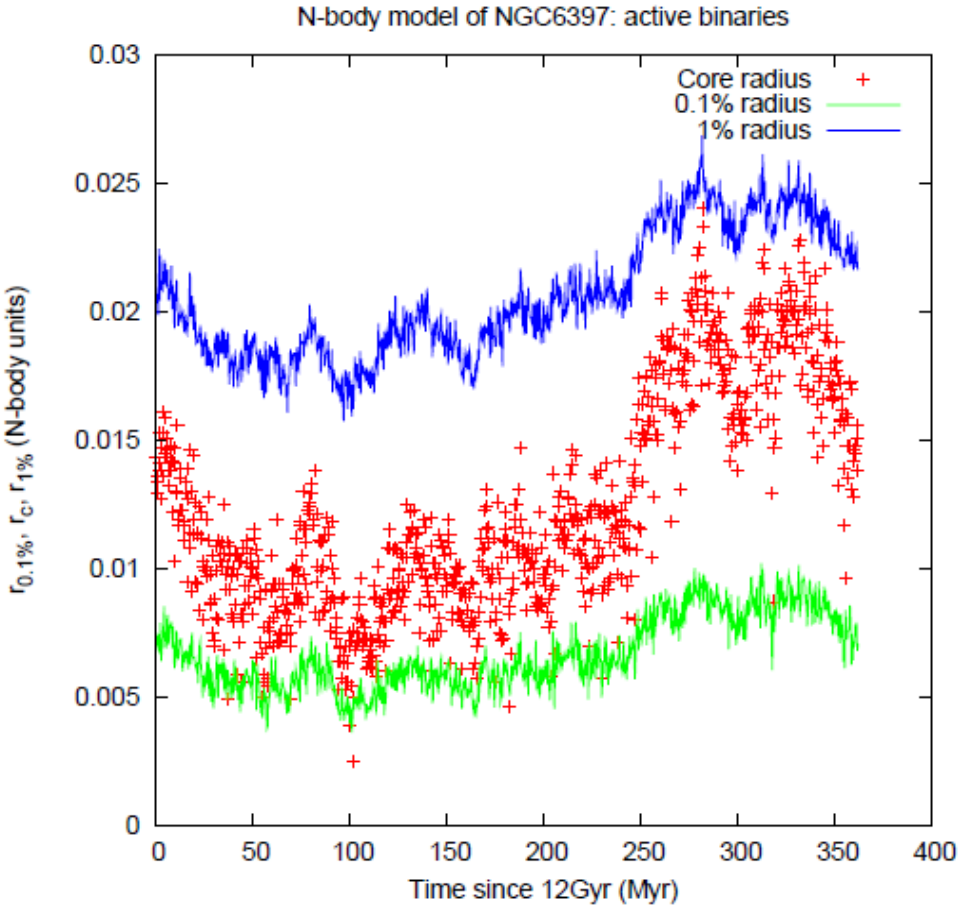
The *ubiquity* of multiple stellar populations

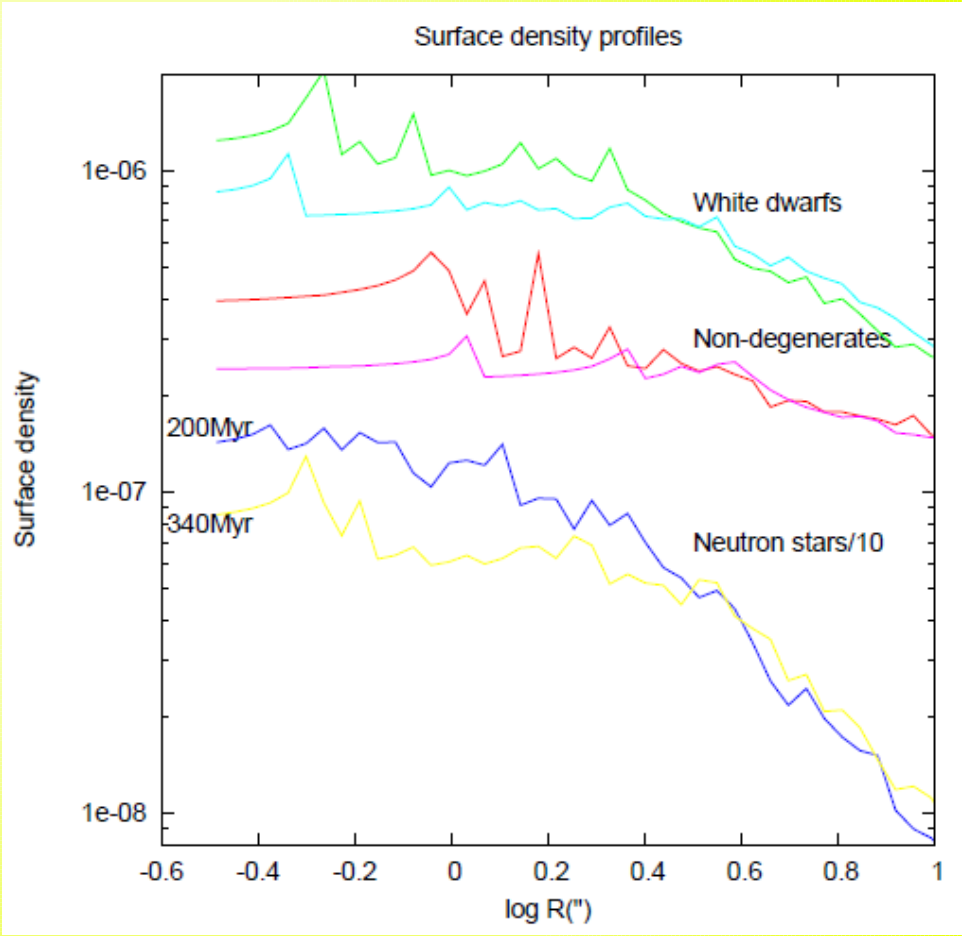


Carretta et al 2008

Conference Highlights II

The daily progress of my N-body model of NGC 6397





Key Question 1. When will we see the first star-by-star *N*-body model of a globular cluster?

- Honest N-body simulation
- Reasonable mass at 12 Gyr (~$5 \times 10^4 M_\odot$)
- Reasonable tide (circular galactic orbit will do)
- Reasonable IMF (e.g. Kroupa)
- Reasonable binary fraction (a few percent)
- Any initial model you like (Plummer will do)
- A submitted paper (astro-ph will do)

An inducement: a bottle of single malt Scotch whisky worth €50

Key Questions II. How do we model globular clusters?

1. Method of choice: Monte Carlo code (Fregeau or Giersz)
   1 model takes a day or two
   Some improvements still needed, e.g. Hierarchical triples
2. Simple analytic models
3. Toy models

Shogo Inagaki

Key Questions III: What should *N*-body modellers do in the meantime?

- Scaled down clusters: but take care if two processes scale differently (e.g. Tidal mass loss, MF evolution, core evolution, binaries)
  Don't claim too much

- Open clusters. Follow up spectacular work on M67 (Hurley et al)
  Example:

  The Puzzling White Dwarf Cooling Sequence in NGC6791:
  A Simple Solution
  L. R. Bedin et al
  Abstract: In this paper we demonstrate that the puzzling bright peak in the luminosity function of the white dwarf (WD) cooling sequence of NGC6791 can be naturally accounted for if ~34% of the observed WDs are WD+WD binary system
  arXiv:0804.1792v1

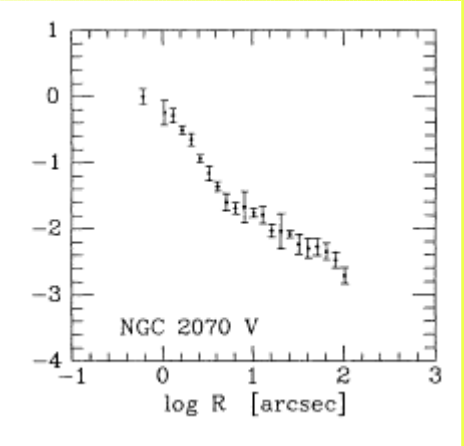
- Idealised models e.g. Isolated models, equal-mass models. Good for developing understanding and intuition, but not for numbers and comparison with observations! E.g. Mass segregation of binaries. Similar caveats about analytical and toy models.

Key Questions IV: What is the new paradigm for initial conditions?

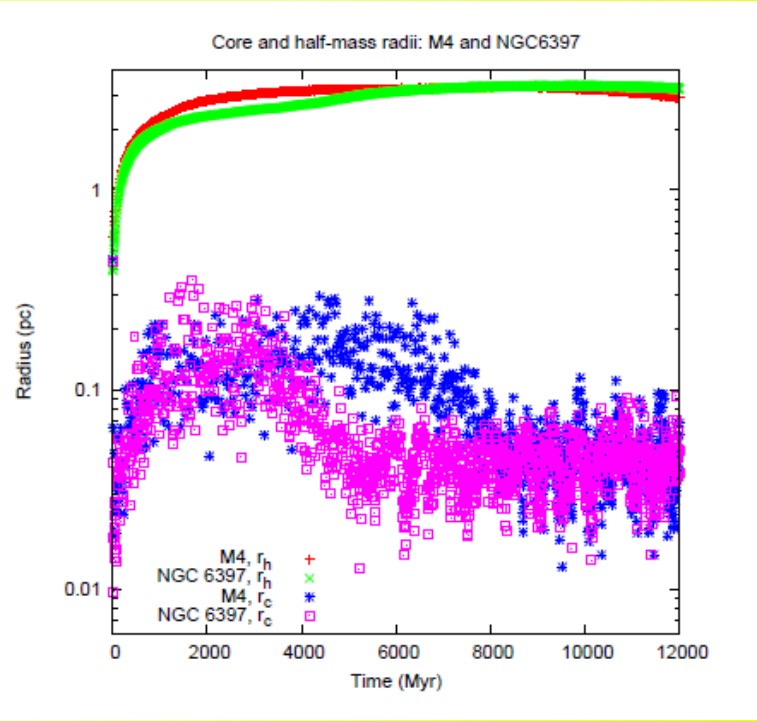
What is an interesting, reasonable and feasible way to incorporate

1. Gas ejection
2. Primordial mass segregation
2. A second generation (a MODEST theme)

A nearby structural analogue: R136 + NGC2070
Meylan 1993



Key Questions V: How well do we understand the theory?



"Is it true that the half-mass radius is nearly constant?"

We theorists should mention the essential simplifying assumptions

Example: does the fraction of binaries increase, decrease, stay constant?
Answer: it depends on the initial period distribution, e.g. uniform in log P or log a (Hurley M67), or lognormal in P.

Conferences are a good opportunity for educating each other

Key Question V^{bis}: What is the cooling mechanism in globular cluster cores?

Many heating mechanisms:

- Stellar evolution mass loss
- Tidal shocking
- Black hole sinking
- Black hole binaries
- Stellar mass binaries
- White dwarf kicks
- Intermediate mass black holes

But there are clusters with *tiny* cores

Key Questions VI: What is the core?

1. *Multiple definitions*
   - Casertano & Hut
   - NBODYx
   - $4\pi G\rho_c r_c^2 = 9\sigma_c^2$ (and just what is σ_c anyway?)
   - The observer's core radius (radius where surface brightness = 50% central)

2. *How useful is r_c?*
   - Does the core radius characterise *anything* about the spatial distribution of heavy remnants?
   - If something is formed in the core does it stay there?
   - If something is in the core was it formed there?
   - If something is observed in the core is it in the core? (or projected there?)
   - Is the present core radius representative of its historical radius?

Key questions VII: what observations do we need?

The properties of the binary population

1. The binary fraction (*and why does it anticorrelate with core mass?)*
2. The distribution of periods
3. The distribution of mass ratio
4. The distribution of eccentricity

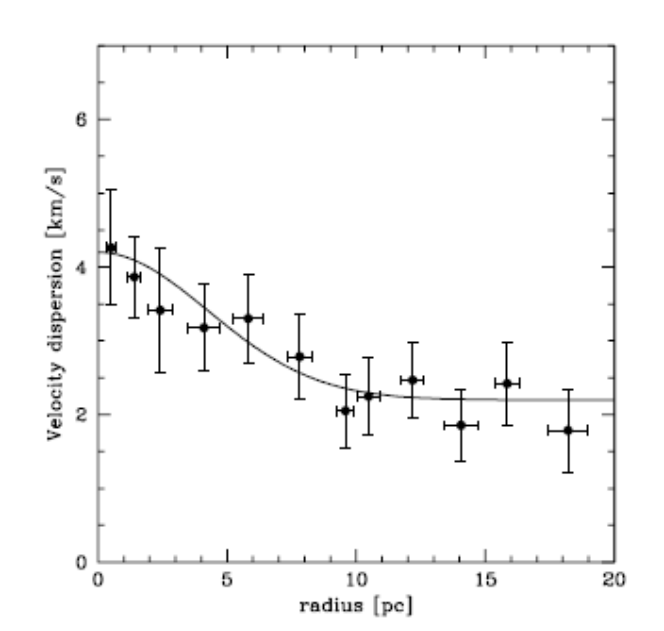
Can we do better than surface brightness profiles?

1. Magnitude-limited star counts
2. Absolute luminosity functions

Key Question VIII: “What shall I work on next?

Example 1: “What can I do with 33 pulsars in Ter 5?”

Example 2: Where are the “potential escapers” in some well-observed cluster?



NGC7099, Scarpa et al 2006/8

Key questions IX: Can we trust the literature?

Even for well observed Galactic Globular clusters, published values of
L, M, r_c, r_h, r_t , f_b
may be out by a factor of 2.

Example: Half-light radius of M4
From Trager et al 1995 (polynomial fit): R_h = 104” (my computation)
Richer et al 2004 269”

Some quotations

"One should have the profoundest suspicion of any observational fact that does not have a sound theoretical interpretation"

Eddington, quoted by Spitzer

One experimental fact, soundly established, is worth all the theories that can be invented.

Bunsen

Would you like to restart your computer now?

W. Gates

"..the largest interesting objects in the universe."

David Gross


For what could be more beautiful than the heavens, which contain all beautiful things?
Copernicus
N6397 (ESO)