Building part of the Galactic halo from globular clusters

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Collaborators

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Chemical properties of GCs

Heavy elements

Low scatter and same trends as field stars

$\Longrightarrow$ Heavy metals come from pre-enrichment of the galactic halo (i.e., are not produced in situ) Harris & Pudritz (1994)

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Light elements: Li to Al

- C-N, O-Na, Mg-Al and Li-Na anticorrelations
- C+N+O nearly constant
- in TO and giants stars

(see eg. Carretta et al. 2010)

He content

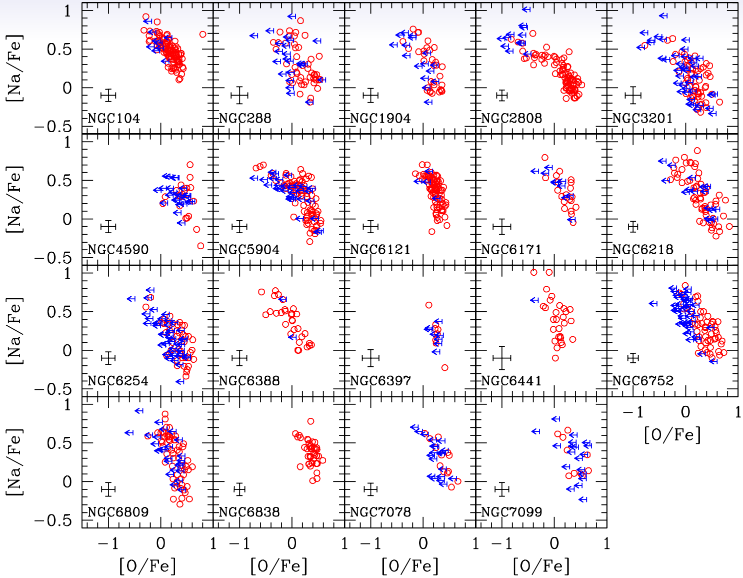
- Multiple main sequences (NGC 2808, ω Cen...)
- Blue HB

$\Longrightarrow$ need He-increase

(see eg. Piotto et al. 2009)

$\Longrightarrow$ Complex history for GCs evolution

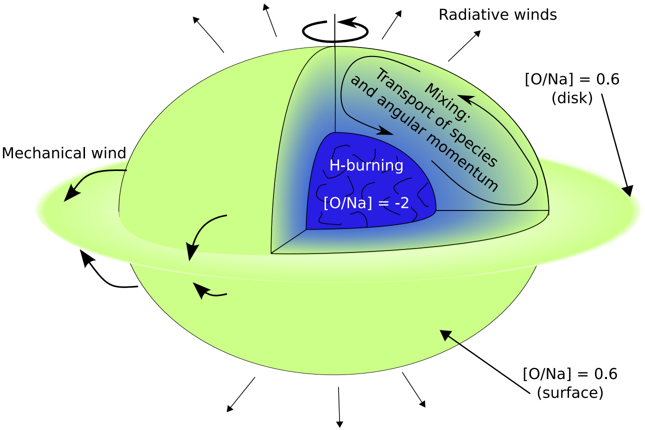
O-Na anticorrelation



Carretta et al. 2009

Overview: fast rotating massive stars

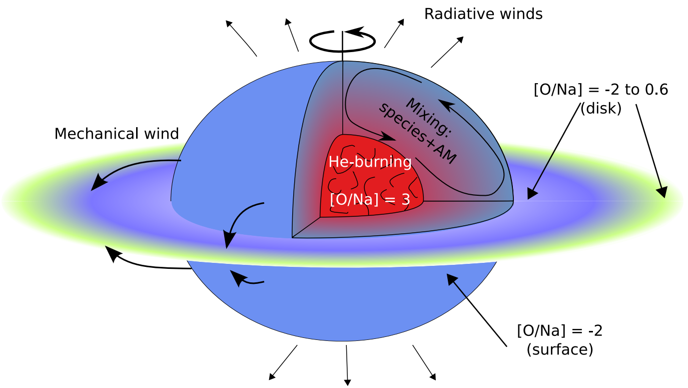
Early main-sequence



Decressin, Meynet, Charbonnel, Prantzos & Ekstrom 2007

Overview: fast rotating massive stars

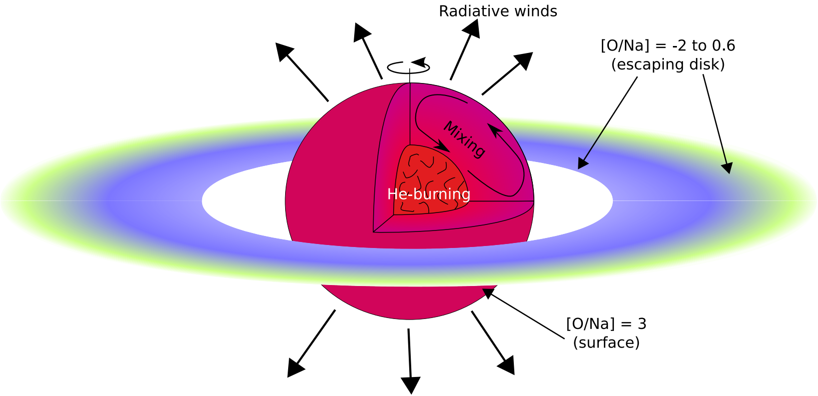
Main-sequence to early He-burning



Decressin, Meynet, Charbonnel, Prantzos & Ekstrom 2007

Overview: fast rotating massive stars

End He-burning



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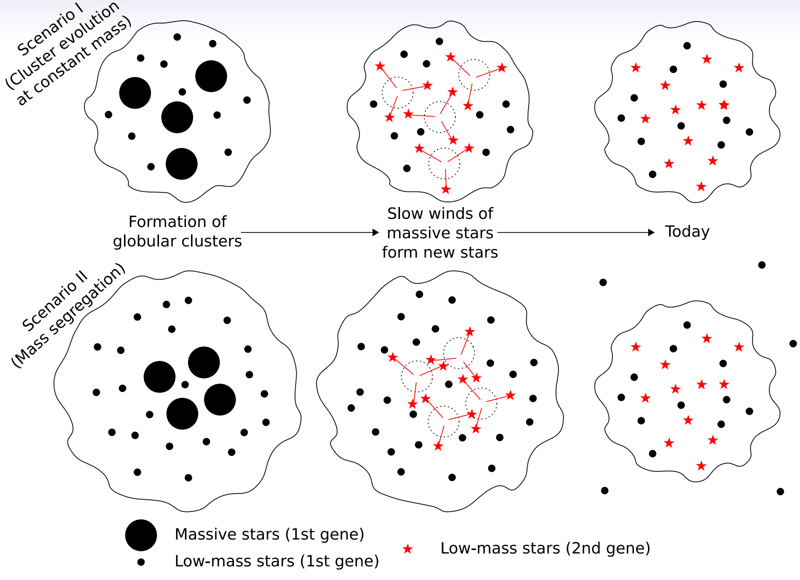
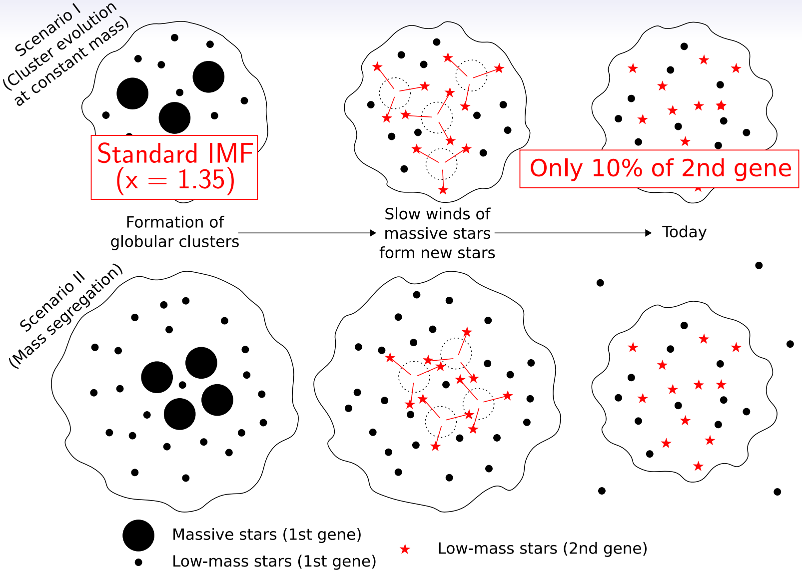
Evolution of globular clusters



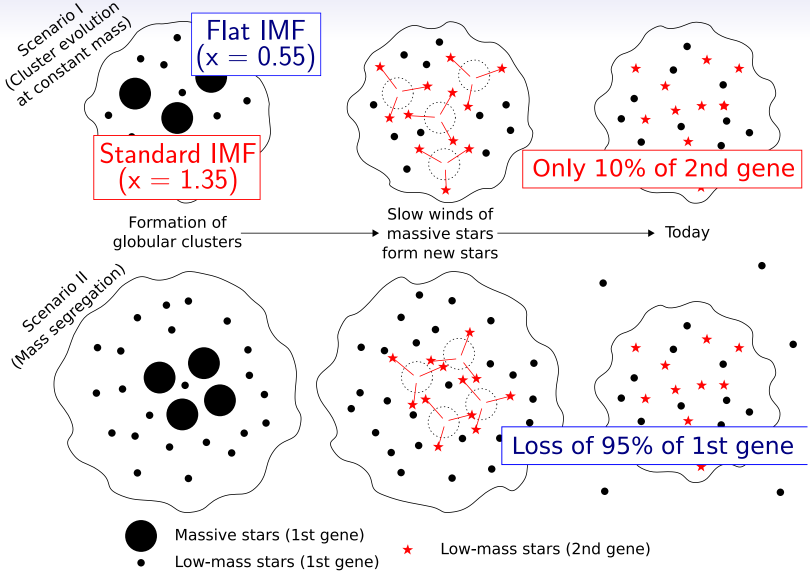
Decressin, Charbonnel & Meynet (2007)

Evolution of globular clusters



Decressin, Charbonnel & Meynet (2007)

Evolution of globular clusters



Decressin, Charbonnel & Meynet (2007)

Effect of gas expulsion

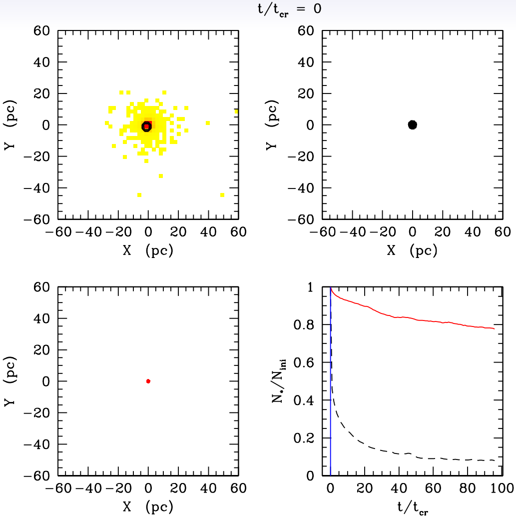
N-body models

Baumgardt & Kroupa (2007)

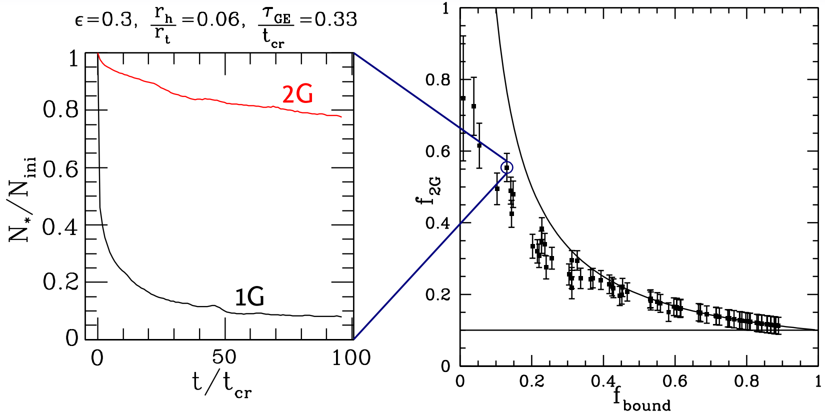
- 20 000 stars
- gas =
additional potential
+ time dependent

Physical inputs

- SFE (ϵ)
amount of gas
- r_h/r_t
concentrated cluster
- τ_{gas}/t_{cr}
timescale of GE



Gas expulsion



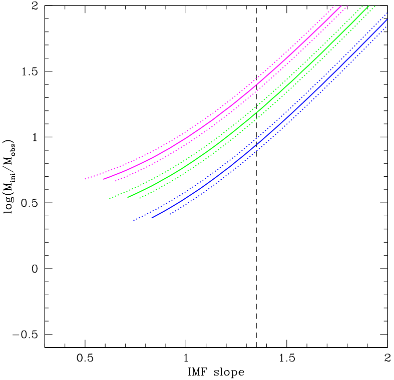
Decressin, Baumgardt, Kroupa & Charbonnel (2010)

⟹ Efficient way to expel 1st gene. stars

Total mass of GC system

About 2.5% of halo stars are 2G stars (Martell et al. 2010,2011)

Initial/Actual mass



For a given GC

$M_{\mathrm{ini}} = 10 - 30 \times M_{today}$

Schaerer & Charbonnel (2011)

Loss of 2G. stars: 0, 43, 65%

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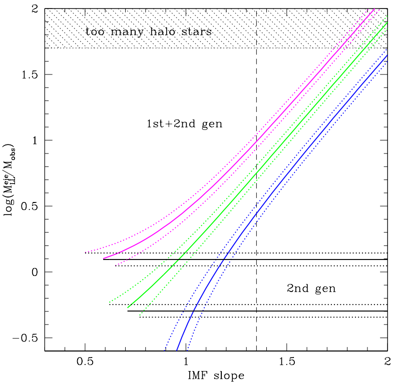
Ejected/Actual mass



Schaerer & Charbonnel (2011)

Loss of 2G. stars: 0, 43, 65%

For a given GC

$M_{\rm ini} = 10 - 30 \times M_{today}$

For whole population of GC

IMFGC $\propto$ lognormal

$\Longrightarrow$ 40-50% of Halo = GC stars

IMFGC $\propto$ slope

$\Longrightarrow$ GC stars » Halo

Conclusions

Chemical properties of GCs

- Complex history
- First generation similar to fields stars
- Second generation recycles slow wind of massive stars

Dynamical consequences

- Strong ejection of stars due to gas expulsion
- Initial mass of GC much higher

$\Longrightarrow$ Stars loss from GC: important part of the halo