Accretion of sub-stellar companions as the origin of chemical abundance inhomogeneities in globular clusters

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Multiple Populations in Globular Clusters

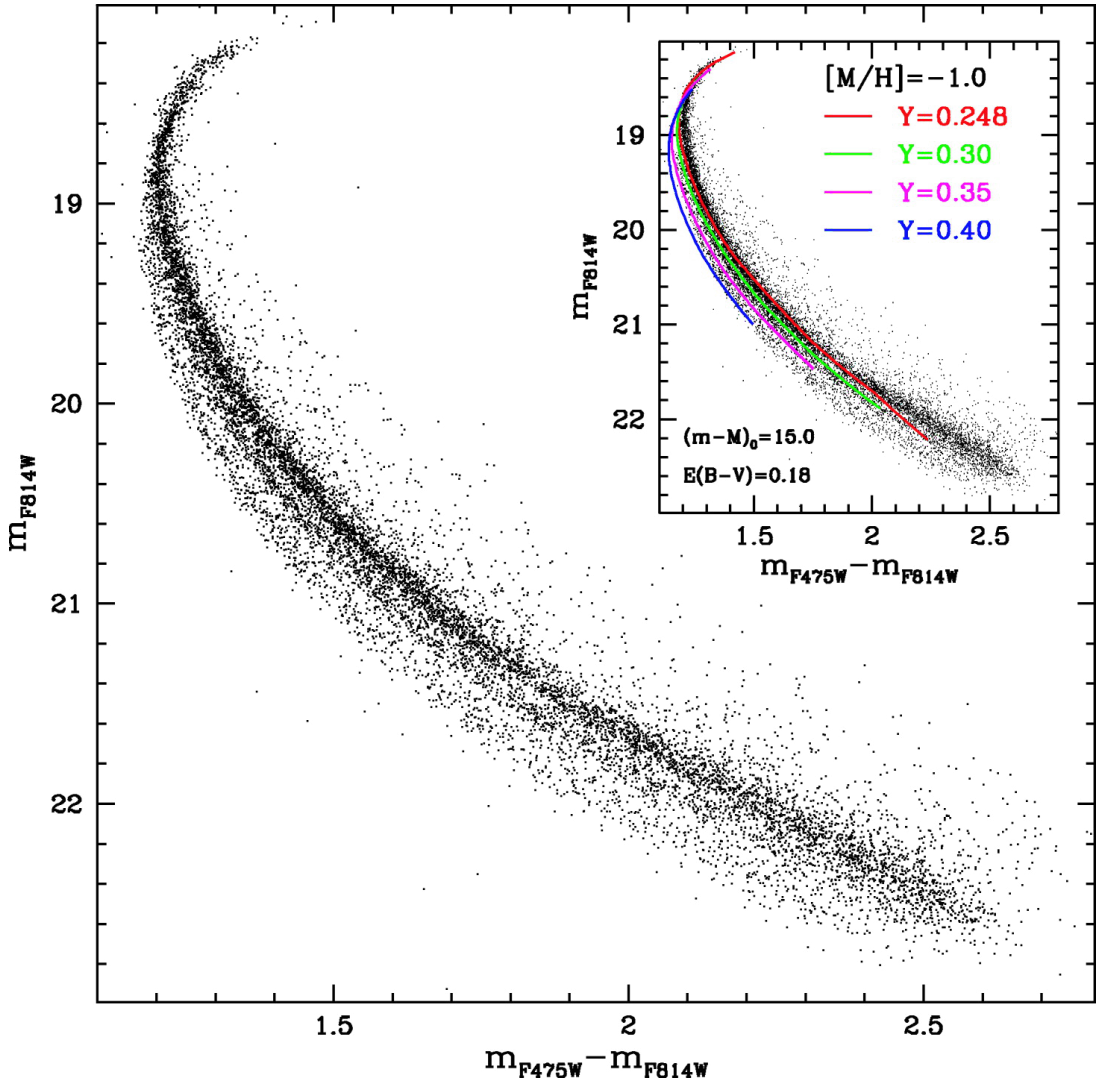

Figure: Figure from Piotto et al. (2007) showing multiple identified populations in the cluster NGC 2808

Multiple Populations in Globular Clusters II.

- Light-element abundance variations

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- Light-element abundance variations
- Uniform Fe Abundance

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- Light-element abundance variations
- Uniform Fe Abundance
- Uniform Main Sequence (MS), Turn off (MSTO), and Red Giant (RGB) abundances.

Multiple Populations in Globular Clusters III.

- Standard formation channels fail

Formation Channels

- Pollution from AGB
- Pollution from Massive Rotating Binaries (MRBs)
- Early Disk Accretion

Formation Channels II.

- Mass Budget Problem [Catastrophe?]
- Timescale / Age Problem [Catastrophe?]

Formation Channels III.

Mass-Budget Problem

- $\sim$ 90% of cluster mass is polluted populations.

Formation Channels III.

Mass-Budget Problem

- How does 10% of mass pollute 90%

Formation Channels III.

Age Issues

- MS, MSTO, RGB all show uniform pollution.

Formation Channels III.

Age Issues

- MS, MSTO, RGB all show uniform pollution.
- Implies deep mixing. (Non trivial for non fully convective stars)
- Populations form on the order of 10s of Myrs however, only GCs older then 2Gyr show MPs

A new challenger enters the ring!

- Early Disk Accretion + Merger

A new challenger enters the ring!

1. First generation stars form in pristine media.
2. AGB & MRBs pollute media
3. Stars moving through polluted media accrete polluted media into a disk
4. Sub stellar companion forms from polluted disk
5. Perturbations due to the dense cluster increase the eccetricity of the companion until it merges with the primary
6. The merger results in deep mixing
7. The primary returns to the MS within thermal timescales, now fully polluted.

A new challenger enters the ring!”

- Addresses age issues
- Address mass issues

Mixing Theory

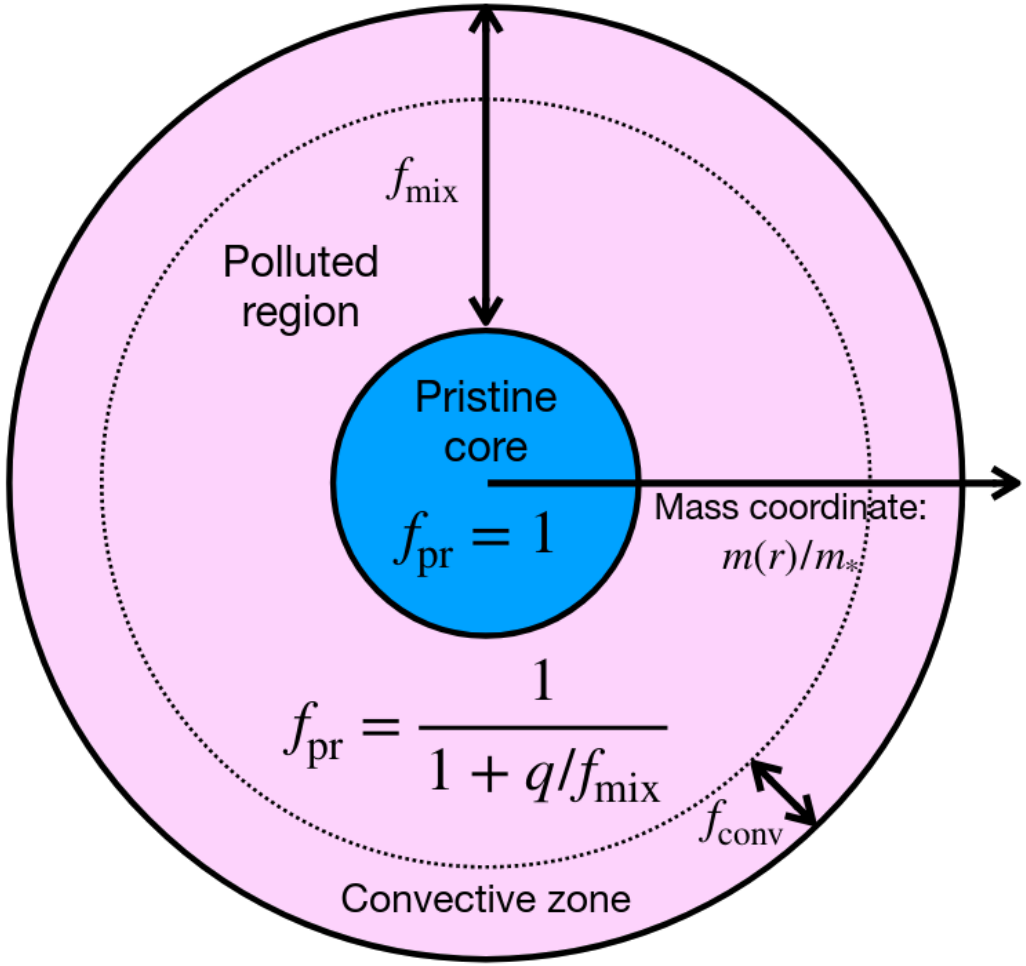

Figure: Theoretical Mixing regions for a merger event with $q \sim 0.1$

Mixing Theory II.

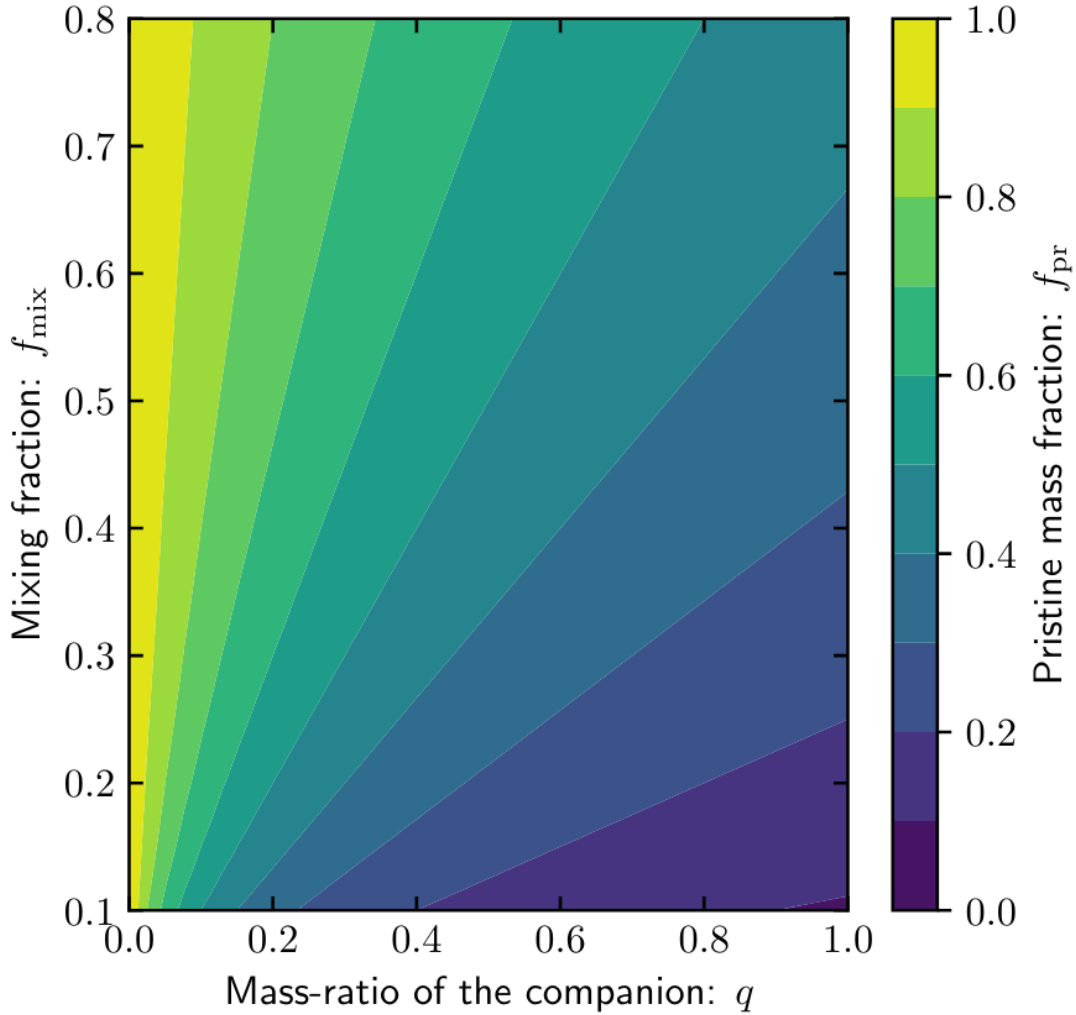

Figure: Theoretical Mixing fractions as a function of mass fraction.

Population Synthethis

- Star formation as a function of free fall time
- Pollution
- Instantanious Mixing

Population Synthethis II.

- Model fits are preformed manually / qualitativly

Population Synthethis III. (47 Tuc)

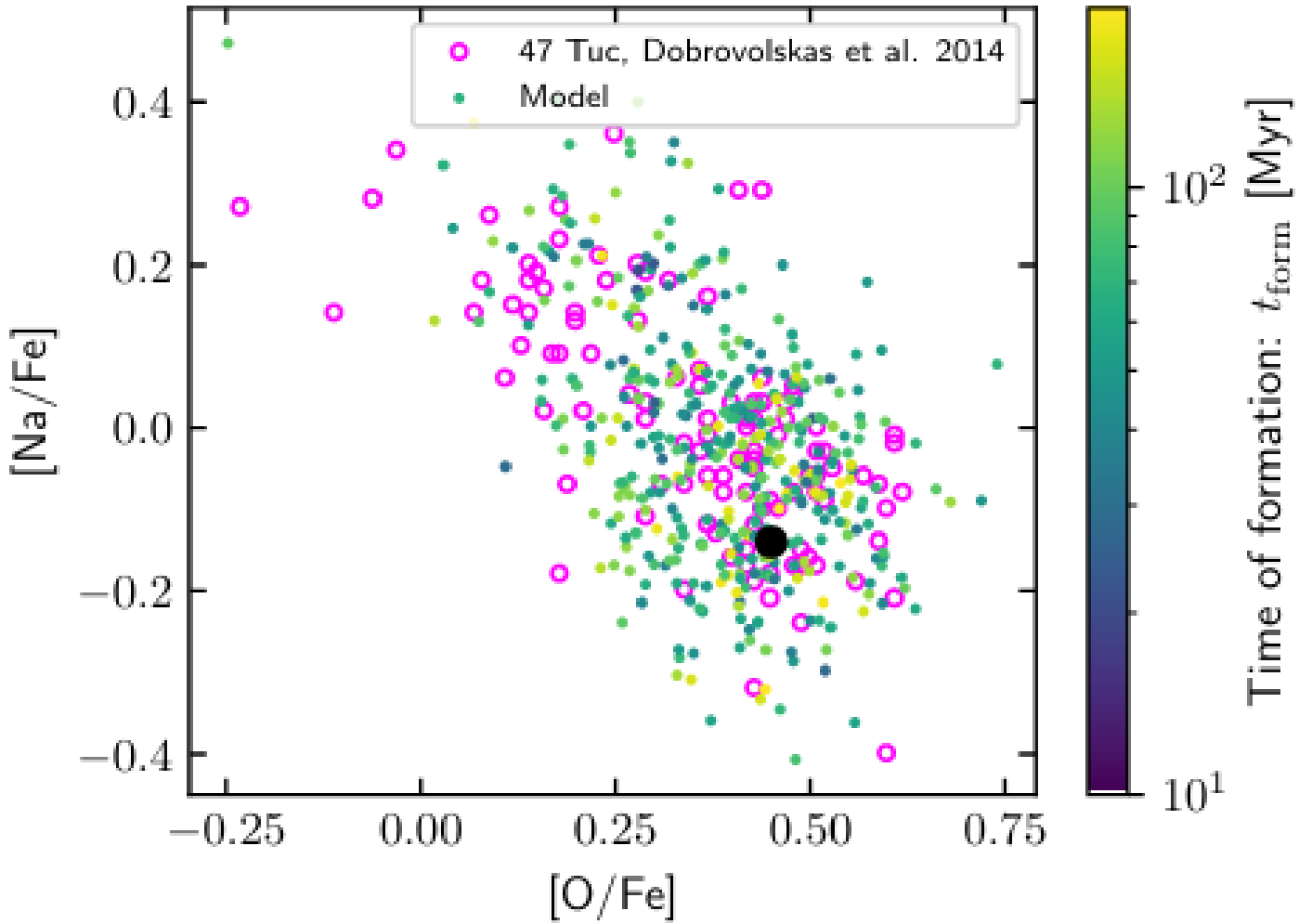

Figure: Comparison of [Na/Fe] between authors model and Dobrovolskas et al. 2014

Population Synthethis IV. (M54)

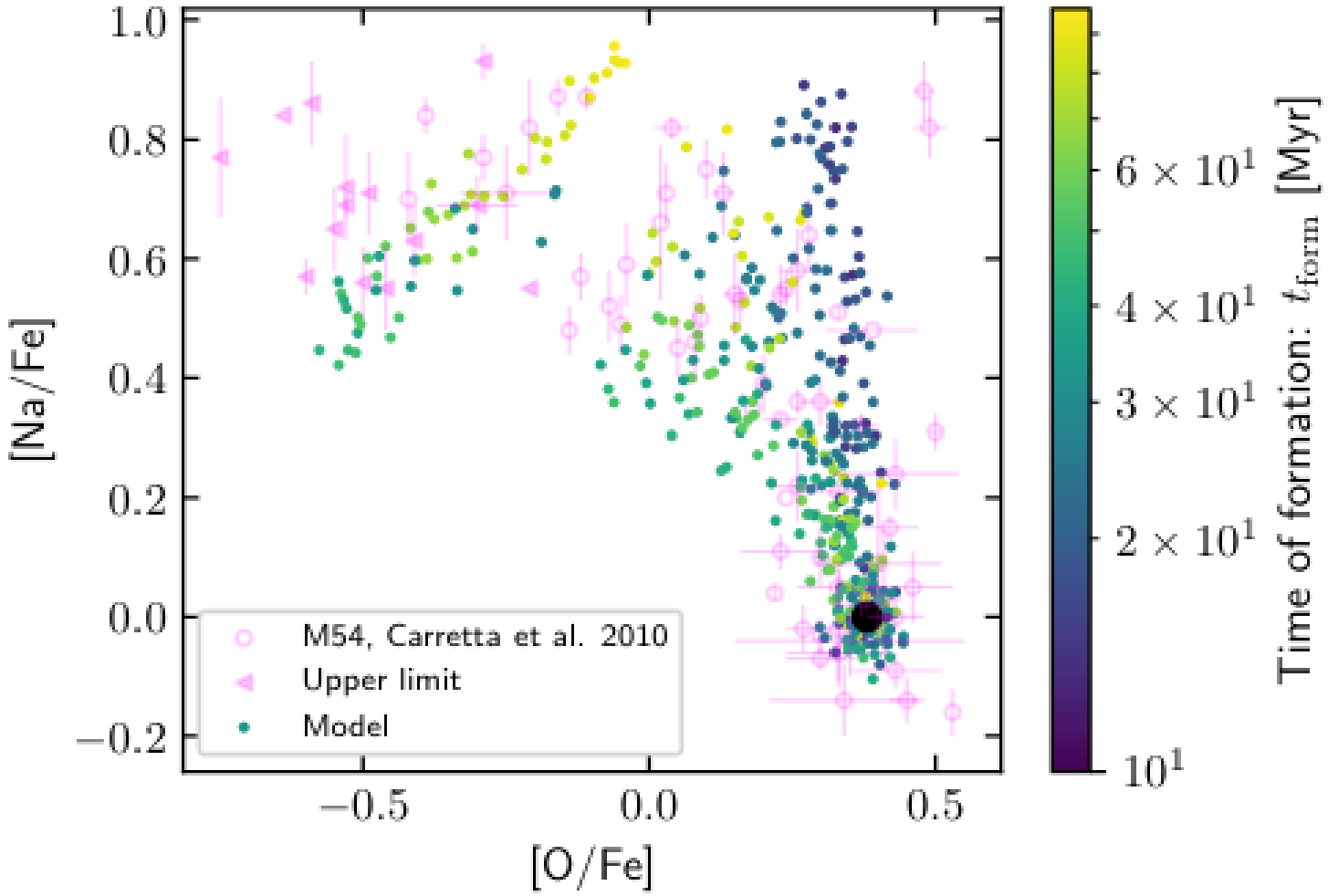

Figure: Comparison of [Na/Fe] between authors model and Caretta et al. 2010

Population Synthethis V. (NGC 2808)

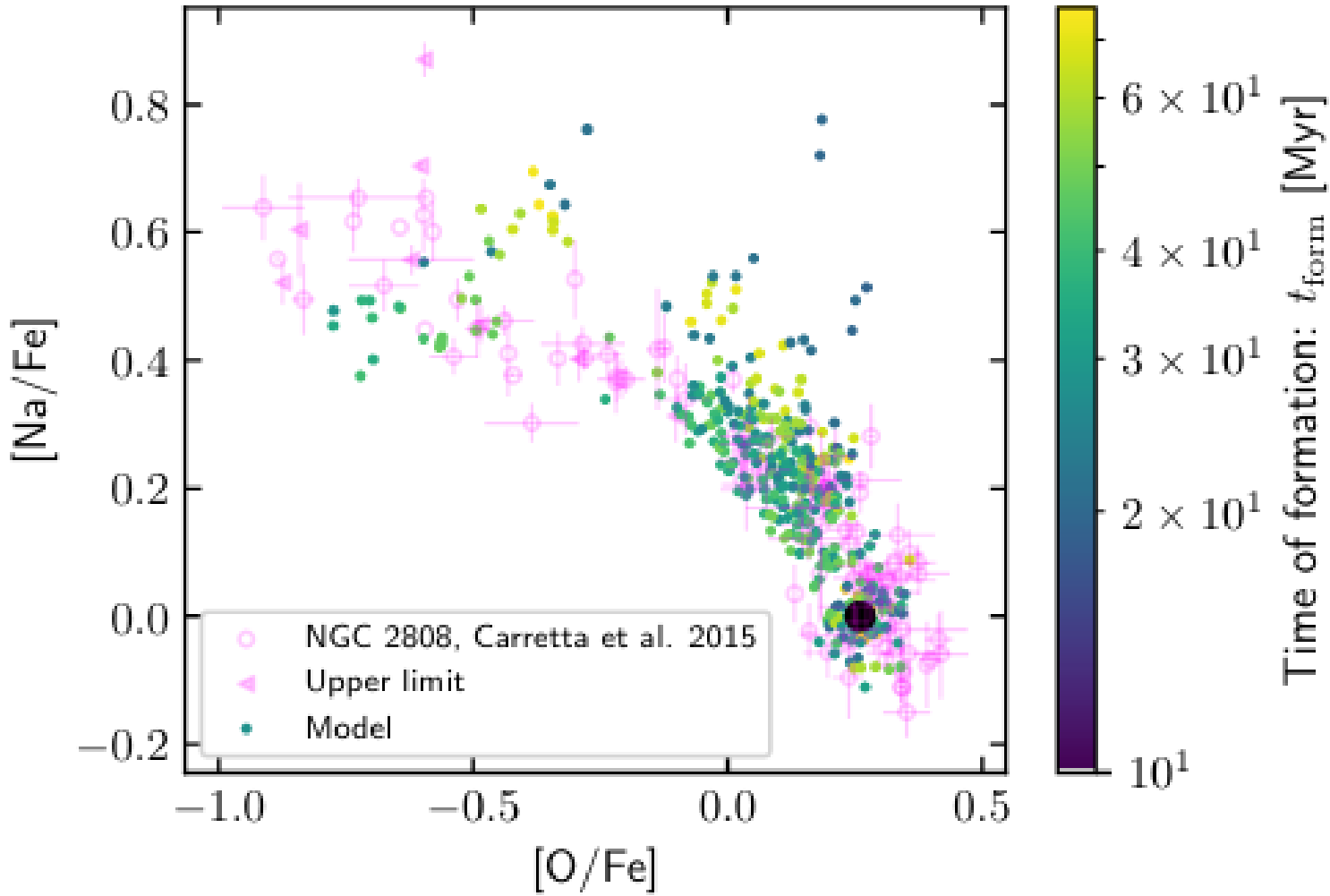

Figure: Comparison of [Na/Fe] between authors model and Caretta et al. 2015

Population Synthethis VI. (NGC 2808)

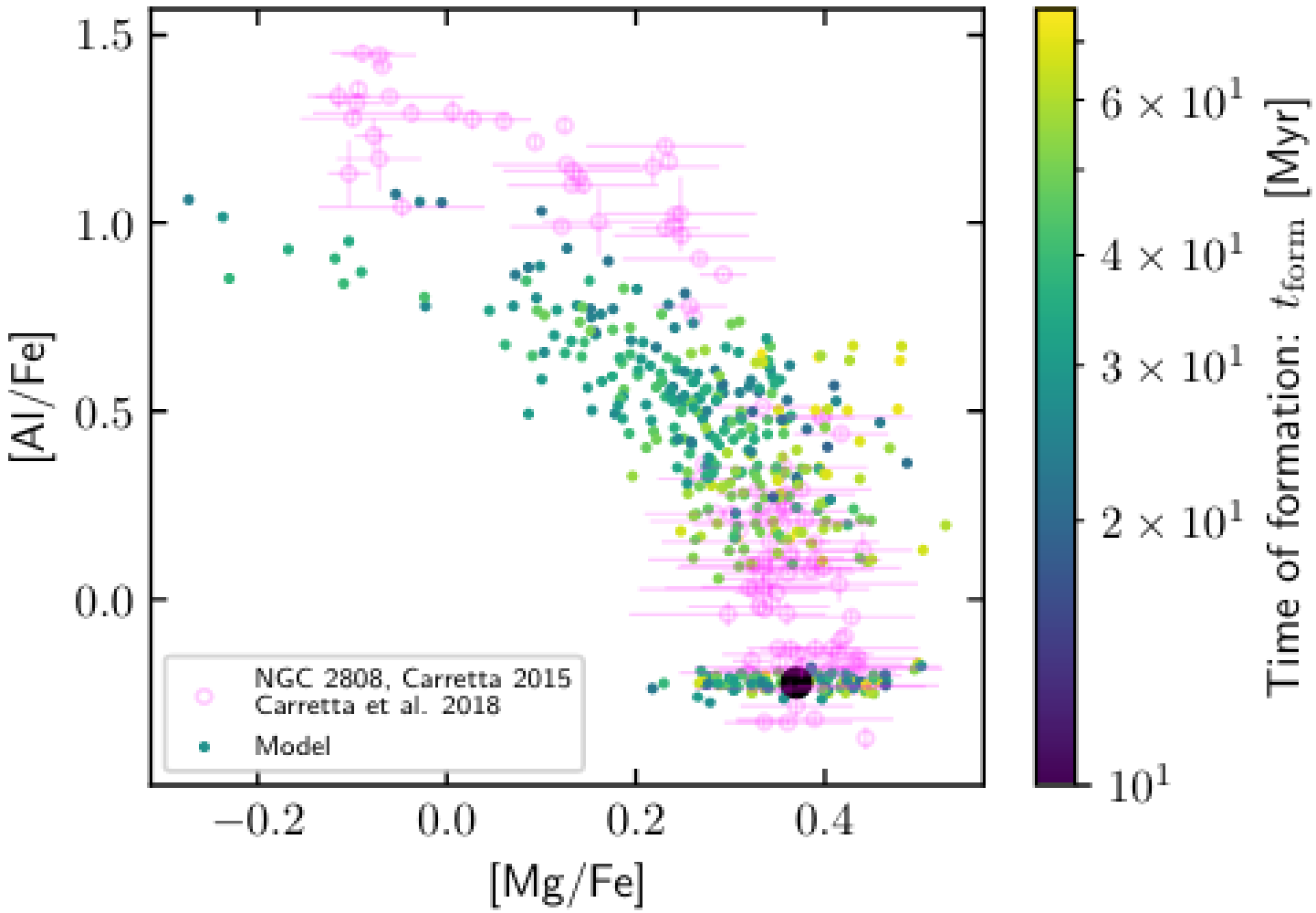

Figure: Comparison of [Al/Fe] between authors model and Caretta et al. 2015

Population Synthethis VII. (NGC 2808)

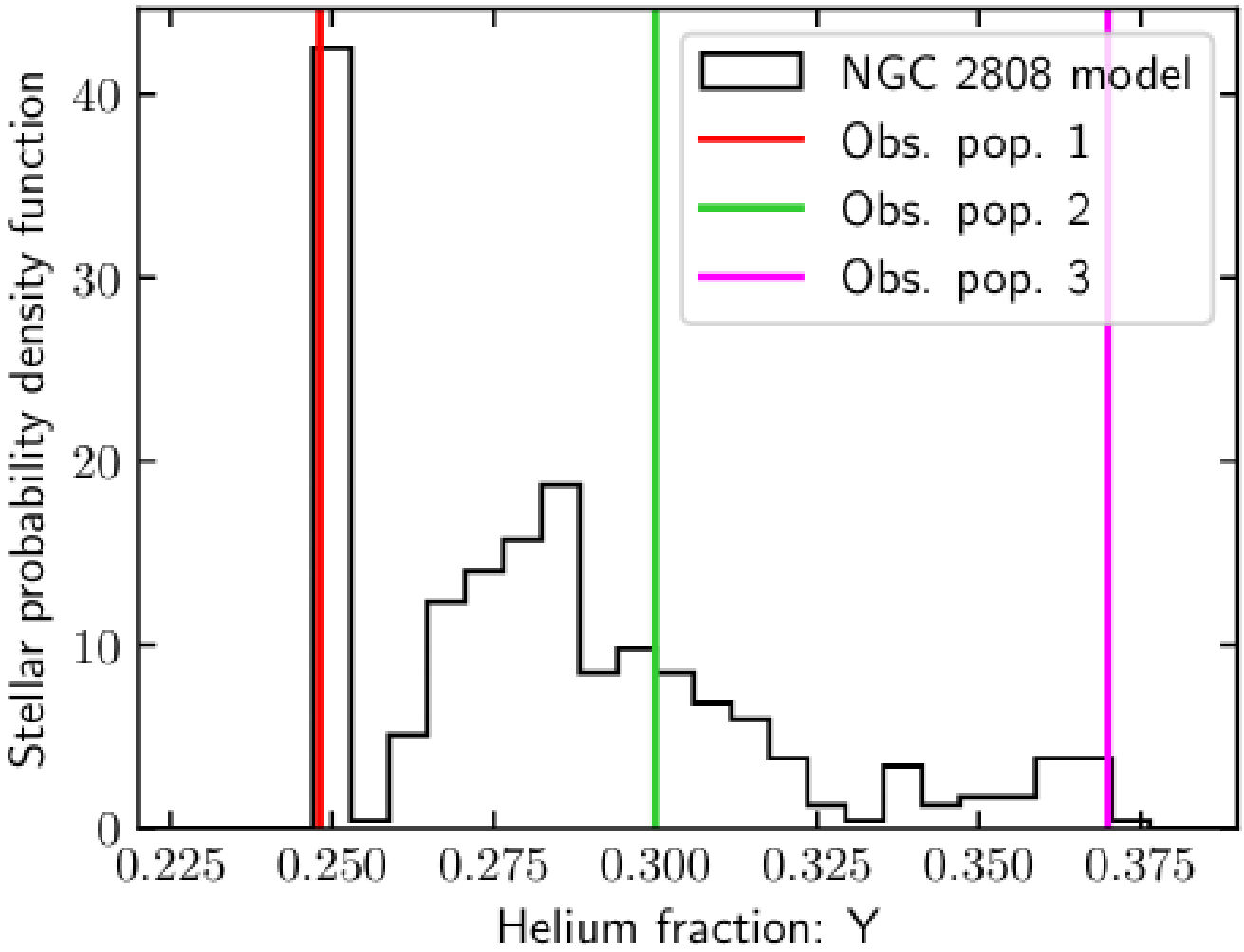

Figure: Comparison of Helium Mass Fraction between authors model and Piotto et al. 2007

Confirmation

- Search for companions with $q \sim 0.1$ in massive clusters aged 1-4 Gyr
- Chemistry of RGB companions (easier to identifiy)
- Companion merger simulations

Thank you!

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