“**Binary–single star interactions** can explain why some **dynamically-young globular clusters** have their first and second **stellar populations spatially mixed**.”

# Insights into spatial mixing of multiple populations in dynamically-young globular clusters

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## Introduction

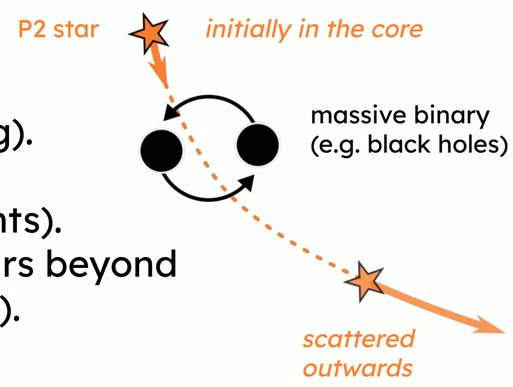
- Most galactic globular clusters (GCs) contain at least two populations of stars.
- It is conventionally assumed that the second population (P2) is more centrally concentrated at birth than the first population (P1).
- However, the radial distributions of P1 and P2 stars are vastly different in GCs of similar dynamically-young age, e.g. 1–2 relaxation times ($T_{rh}$).

(see also, e.g. Bastian & Lardo 2018; Lacchin et al. 2022; Leitinger et al. 2023; 2025)

**Why are P1 and P2 mixed (or even inverted) so quickly in certain GCs?**
**Are there some more complex dynamical processes specific to these GCs?**

## Methods

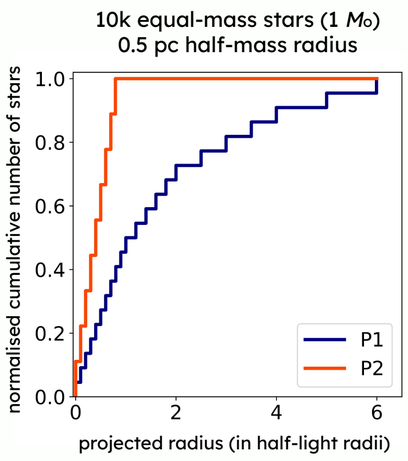
- We focus on the expansion of central P2 stars via binary–single interactions in the core (see the drawing).
- We use direct *N*-body models of GCs with primordial binaries (different masses, semi-major axes, and counts).
- Initially, we assume all central stars are P2 and all stars beyond the quarter-mass radius are P1 (see the figures below).



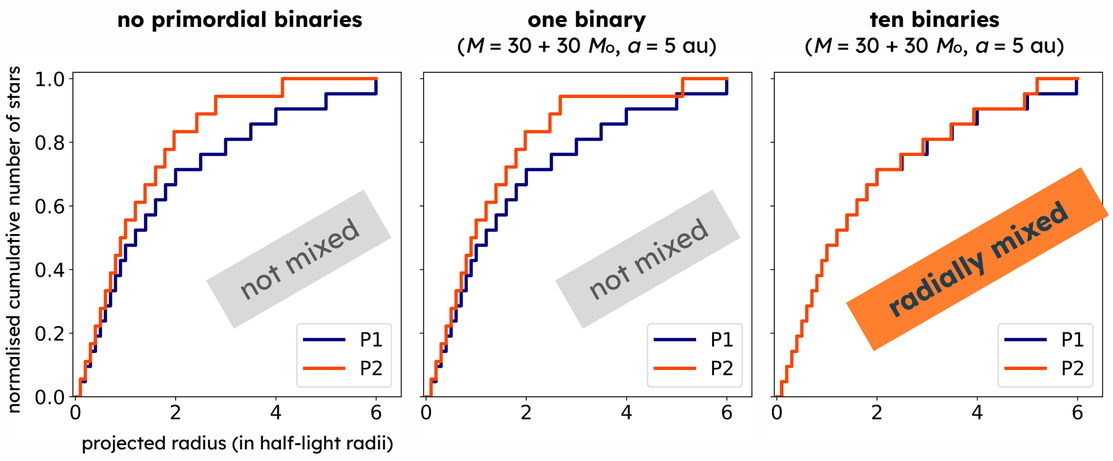

## Results

- We do not find radial inversion of P1 and P2 in any of our models.
- However, in dense GCs, **massive binary stars** can push central stars outwards and **fully mix P1 and P2 stars in less than two relaxation times**.

– Initial conditions



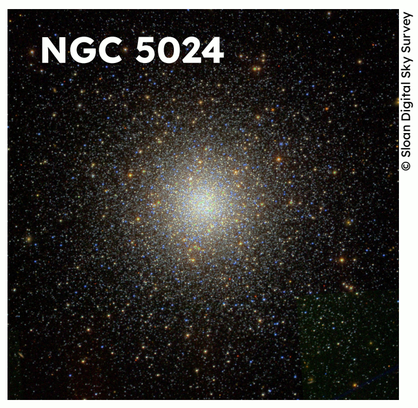

– Star cluster models with dynamical age 1.3 $T_{rh}$

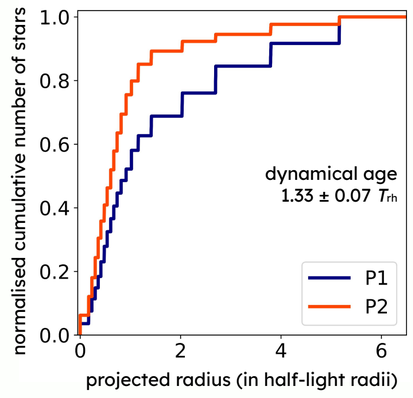



- Our simple model can **replicate the properties of some observed mixed GCs**, such as NGC 5053, 4590, 5904 and others (compare the figures above and on the right-hand side).
- Our models also agree with theoretical estimates which we further discuss in the upcoming paper.

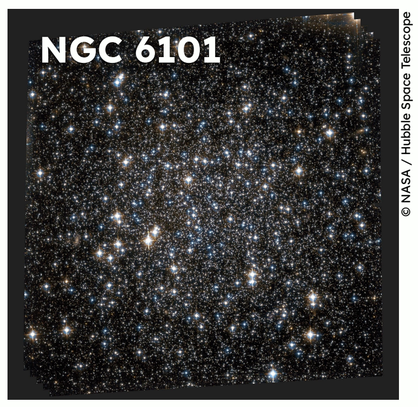
## Examples: dynamically-young GCs

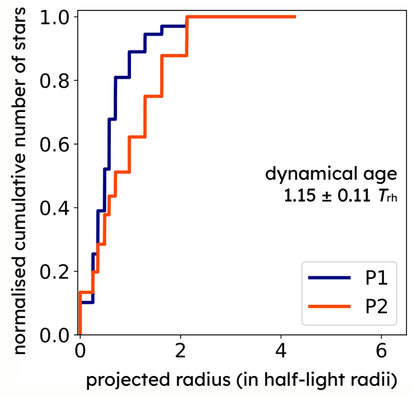
– P2 is centrally concentrated



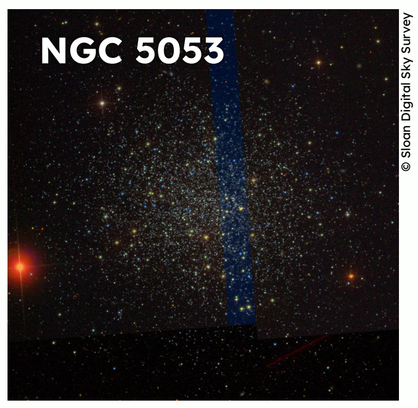



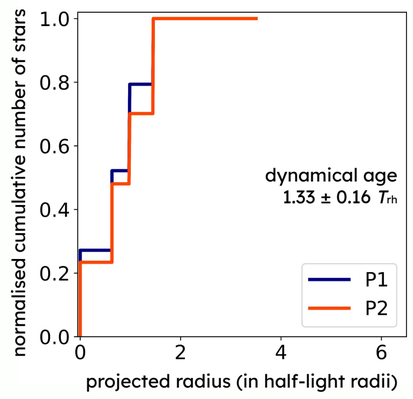

– P1 is centrally concentrated

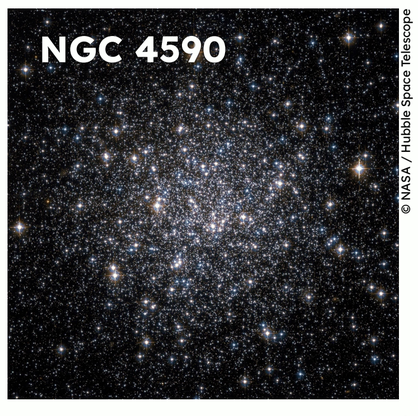


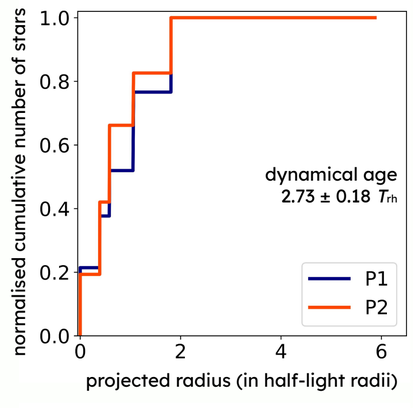




– P1 and P2 are radially mixed

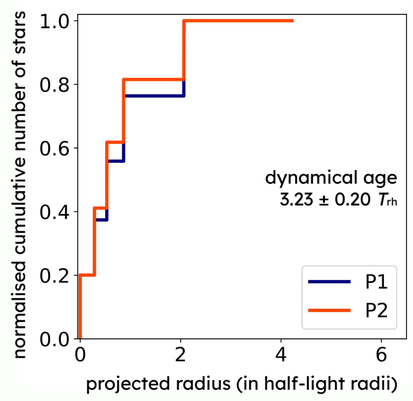







(GC data and numerical values in this section were taken from Leitinger et al. 2023)

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