Ambient accretion: a possible origin of multiple-stellar populations?

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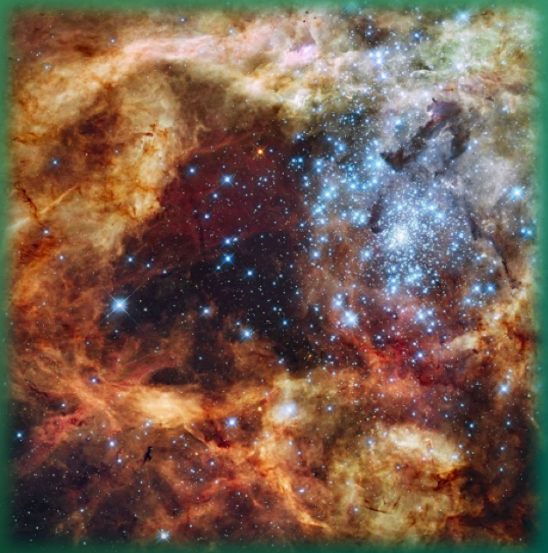
Introduction

Because of the gas expulsion and type II supernovae, star clusters are believed to quickly exhaust their primordial gases, make them to be simple-stellar populations.



R136 (1－2 Myr)

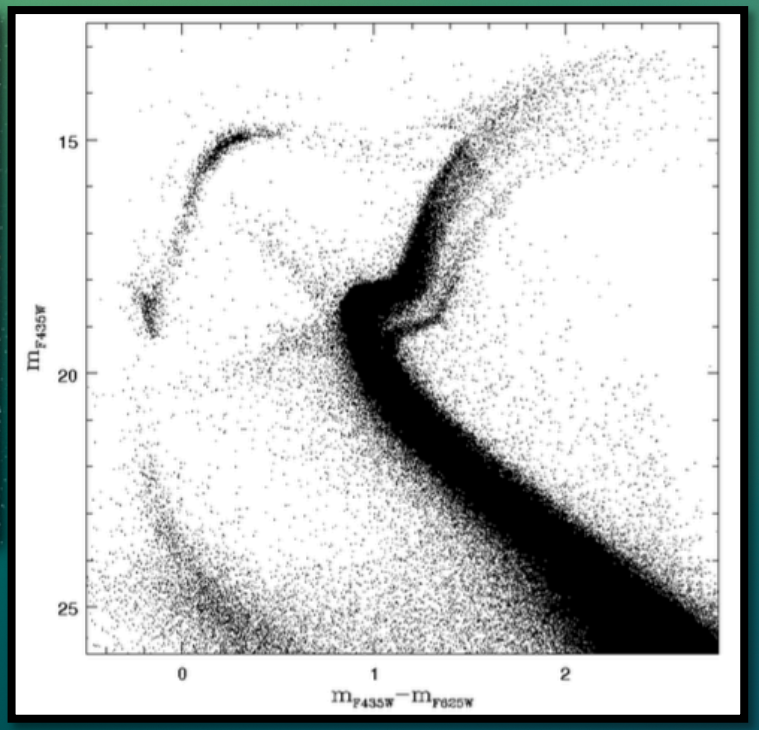
NGC602 (5 Myr)

NGC1805 (~30 Myr)

Introduction

However, most Galactic globular clusters are found to possess multiple-stellar populations.

ω Centauri (Villanova et al.2013)



Introduction

The scenarios suggests that the globulars may have different origin to young star clusters.

They origin from dwarf galaxies (Bekki & Freeman. 2003; Mayya et al. 2013).
They are the results of sub-clusters' merger (Brunes et al, 2009; Bruns & Kroupa, 2011).

The scenarios suggests that the globulars may have the same origin to young star clusters.

The multiple-stellar populations comes from the ejector of first generation AGB stars (Ventura & D'Antona. 2009), stellar winds of massive fast rotators (Decressin et al. 2007), massive or intermediate-massive binaries (de Mink et al. 2009, Jiang et al. 2014)。

Introduction

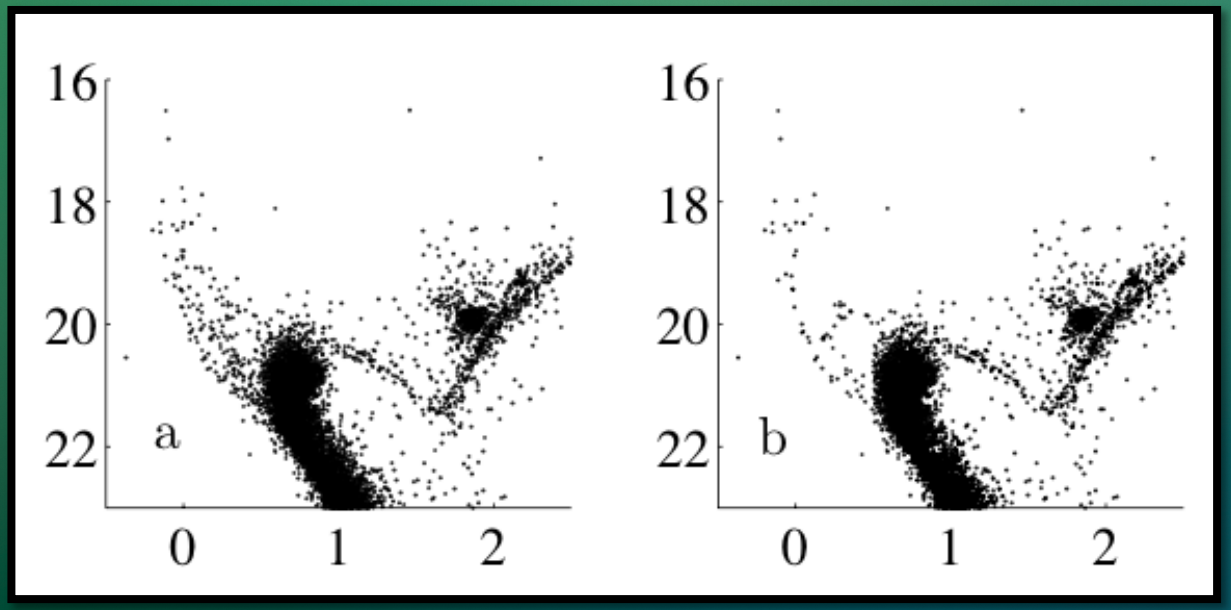
The problem of those scenarios

Most globular clusters located in the Galactic halo, the probability of merger is very small, can not explain the ubiquitous multiple-stellar populations in globulars. It is still not clear what mechanism could disrupt the dark matter halo of dwarf galaxies if they are ancestors of globulars.

If globulars can self-enhance their stellar populations, then it should contains 10-100 more massive initial materials. If the multiple stellar populations are contributed by intermediate massive binaries (Jiang et al. 2014), then people should found multiple stellar populations in open clusters.

Results

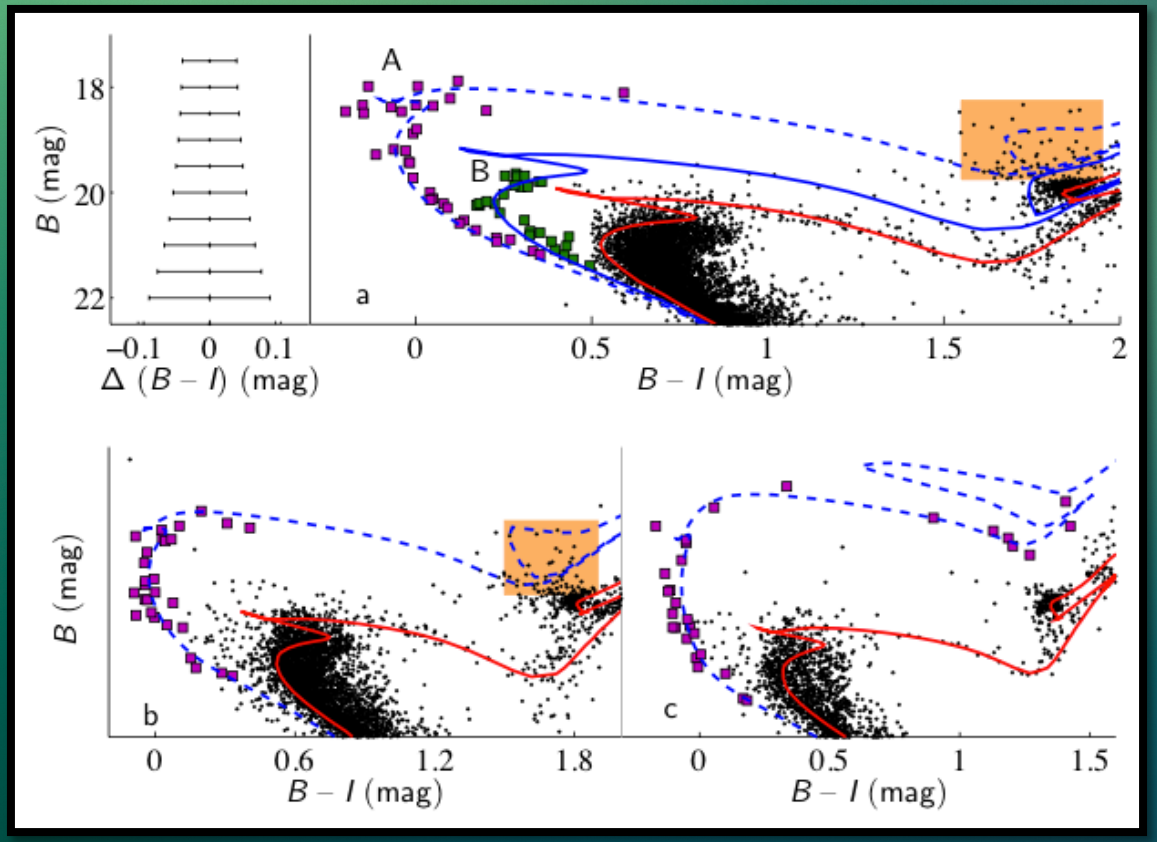
In Dec. 2014, we occasionally found two apparent young sequences that embedded in an 1.5 Gyr massive clusters. (Observed by HST/WFC3 & ACS/WFC)



Results

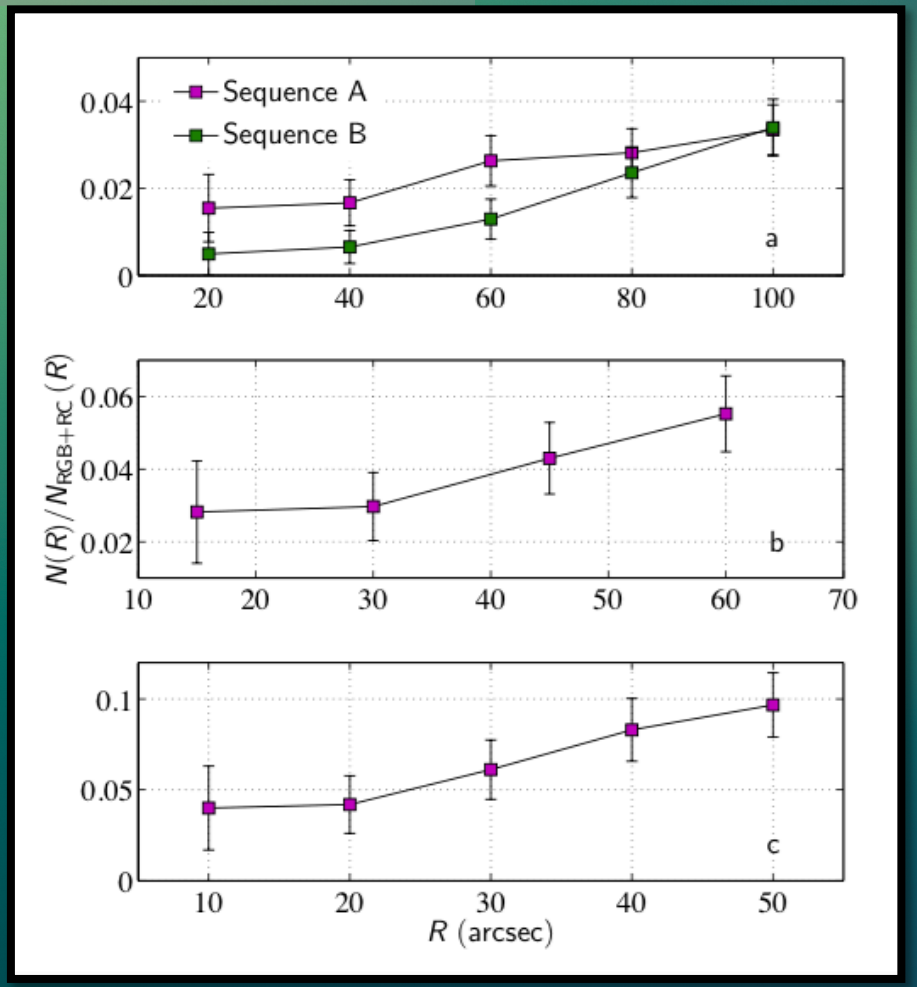
We quickly confirm that another two clusters also possess similar feature.

These features can be explained by more recent star -burst events (hence SSP) and helium enhancement (hence secondary stellar populations)

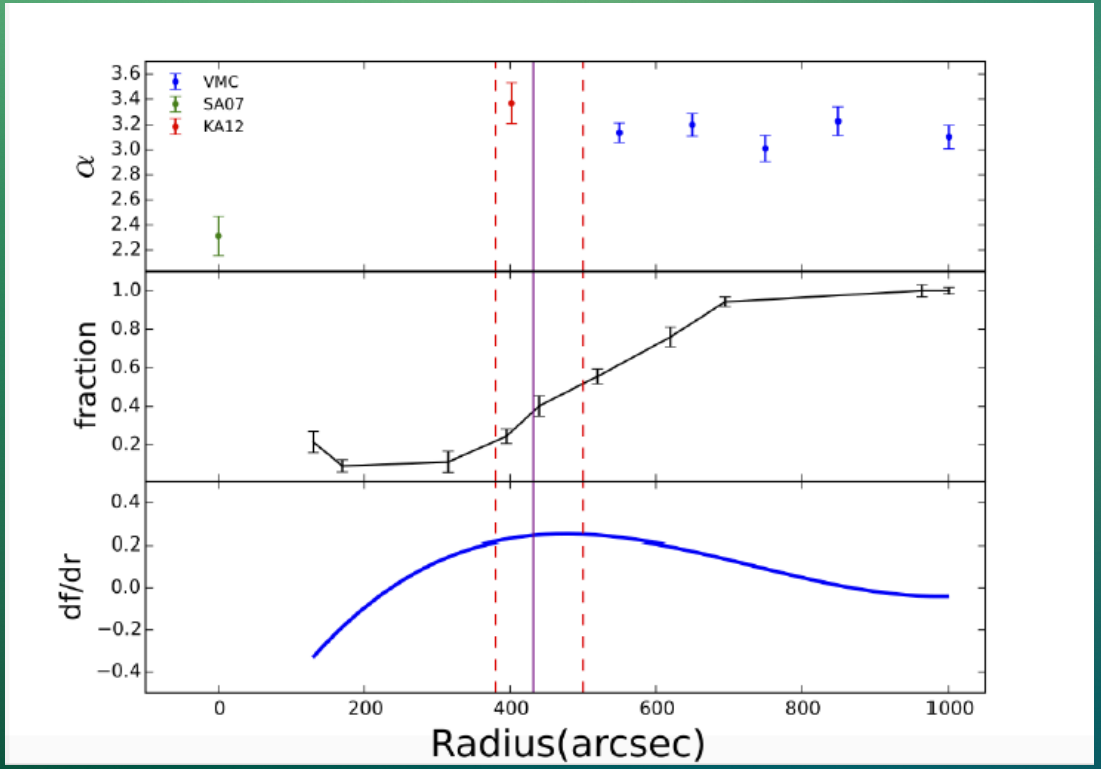


Results

But their dynamics show that those sequences may have external origin rather than self enhancement processes (also can not be explained by blue straggler stars).



Results

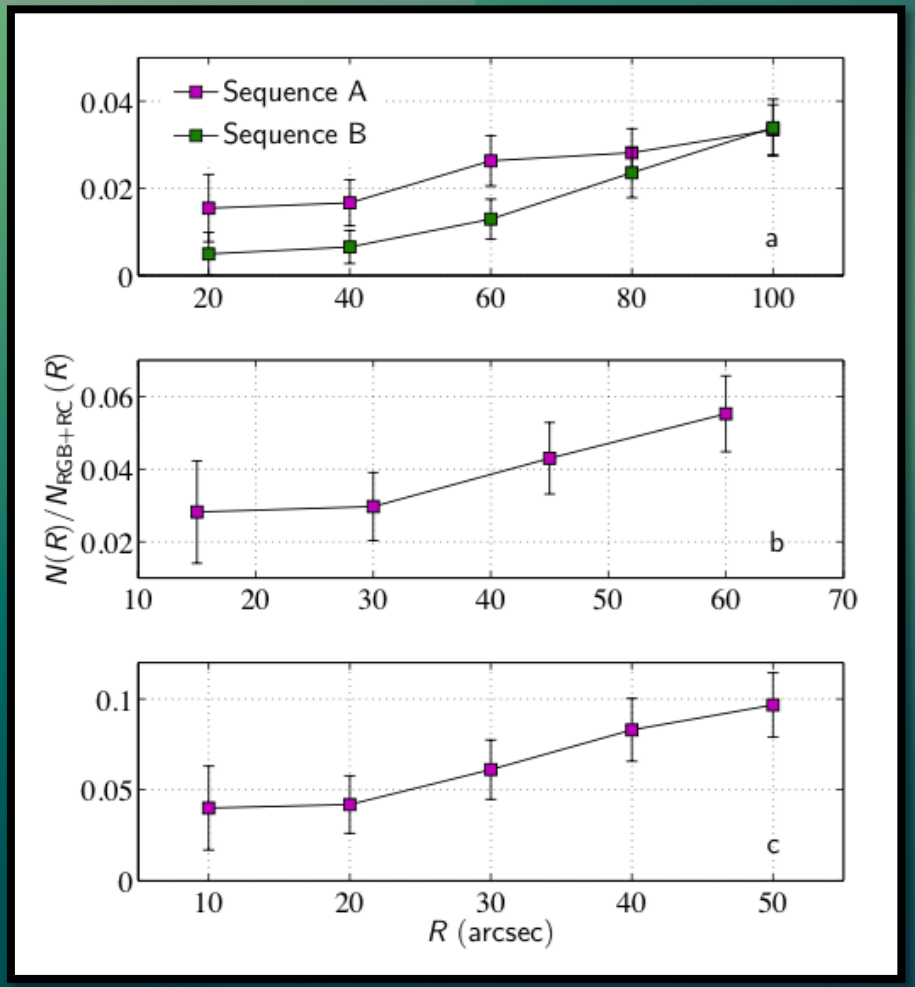


Different stellar populations indicate different dynamics, which can be reflected by their mass functions. (Zhang et al., 2015, ApJ, accepted)

Results

But their dynamics show that those sequences may have external origin rather than self enhancement processes (also can not be explained by blue straggler stars).

However, since these three clusters are dynamically young (less or only one half -relaxation times), it would possibly evolve to a dynamical status that similar to globulars.



Results

We speculate such young sequences may origin from the accreted gases, as those massive clusters are close to galactic disk, if they have frequently collide with molecular clouds.

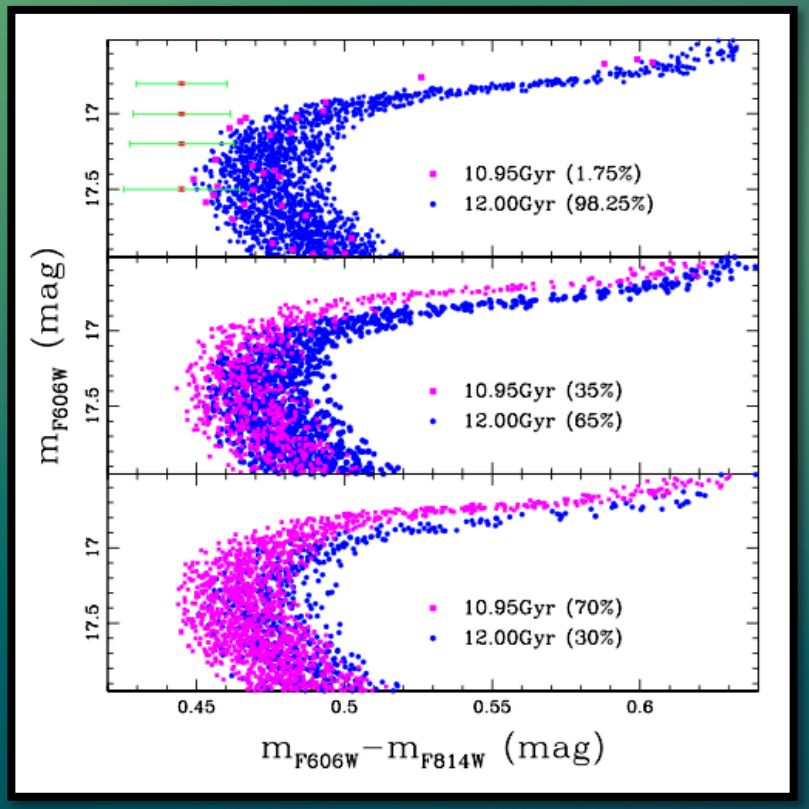
Our calculations based on Conroy & Spergel. (2011) tell us, when the relative velocity between molecular cloud and star cluster is around 4 km/s and assume a density of 0.05/cm^3, with star formation efficiency of 10%. Then the massive clusters could accrete enough gases to make stars within observed time range (the age gap between the observed young sequences and bulk stars).

Discussion

The advantage of this scenario:

The ambient accretion rate is proportional to M_t^2, where M_t is the total mass of star cluster. That means for a extremely massive globular cluster, it can accrete much more materials to make a secondary stellar population that comparable to bulk stars in mass.

The observed age gap would produce a ~0.05 mag offset in sub-giant branch when they evolve to 12 Gyr, which is consistent with the observations (e.g.,47 Tuc, Anderson et al. 2009).



Discussion

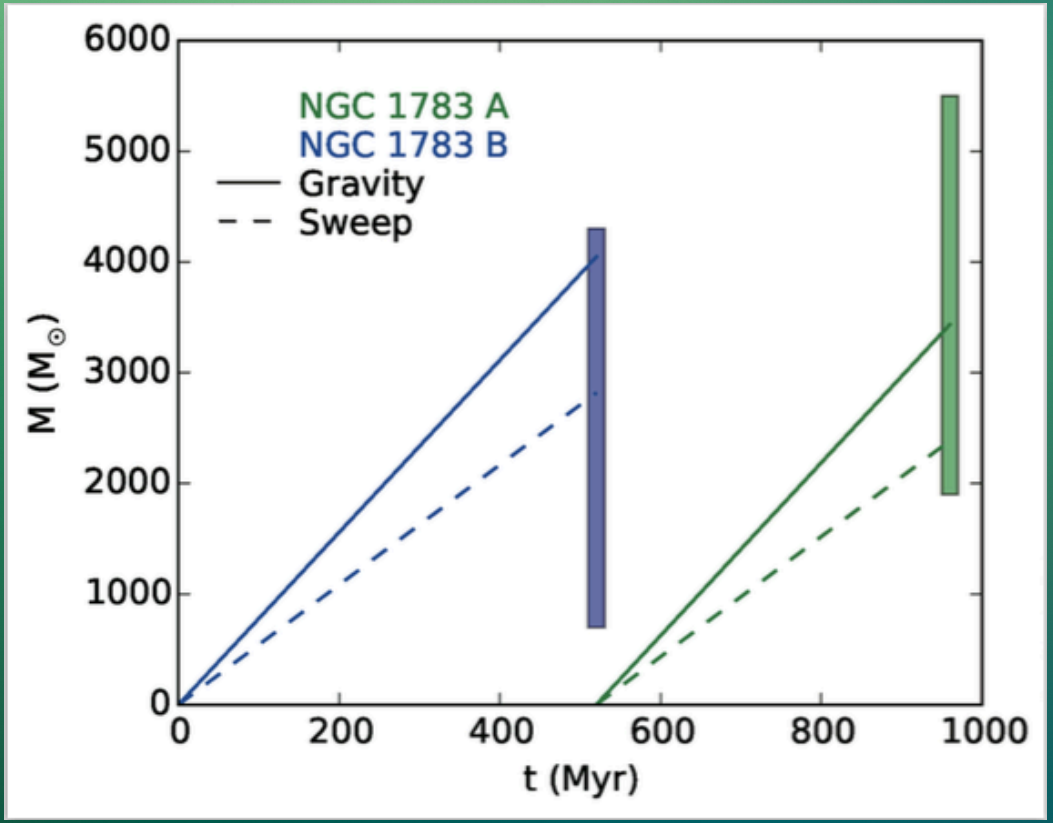
The disadvantage of this scenario:

The observed secondary stellar populations in at least two globulars are more concentrated than bulk stars. However, our observations show that they are actually more extended.

Possible explanations:

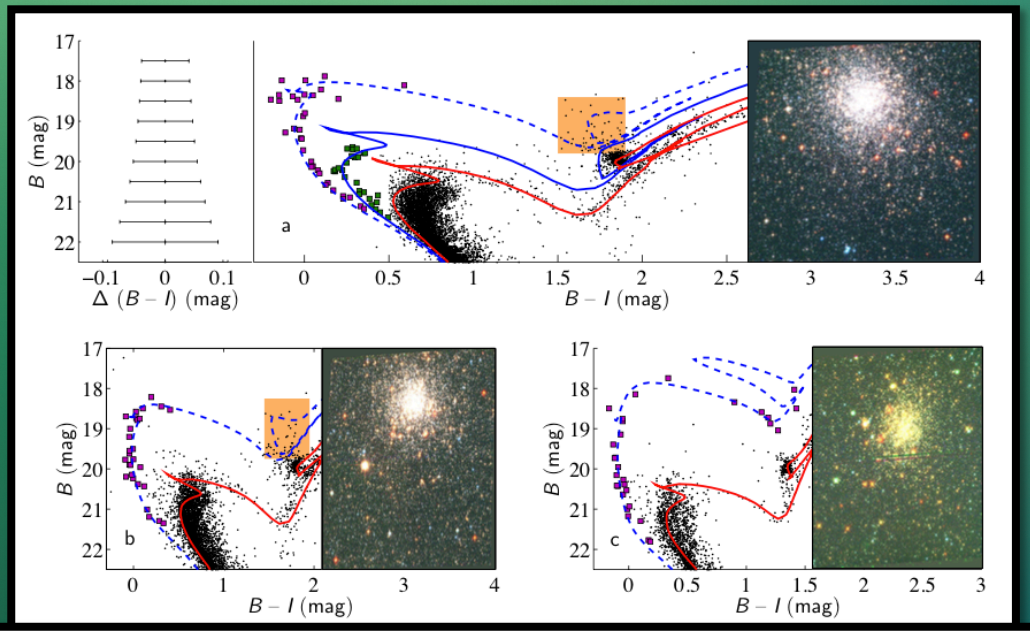
Those observed stellar populations are still dynamical young, they could evolve to a more compact state by dynamical frictions.

Those stellar populations are already close to cluster half-mass radius, which may indicates they already began sinking towards cluster center.



Gas mass accreted from the interstellar medium as a function of time.

Thanks!



Letter

Formation of new stellar populations from gas accreted by massive young star clusters

Chengyuan Li[1,2,3], Richard de Grijs[1,4], Licai Deng[3], Aaron M. Geller[5,6], Yu Xin[3], Yi Hu[3] & Claude-André Faucher-Giguère[5]

Nature accepted