Globular Clusters
Milky Way and beyond

Rashi JAIN
PhD, Observatoire Astronomique de Strasbourg
Under the supervision of
Ariane Lançon & Philippe Prugniel

Rencontres des Jeunes Physicien·ne·s 2021

Observatoire astronomique de Strasbourg | ObAS

Hubble's view of dazzling globular cluster NG

Contents

Stellar clusters

Globular clusters

- Very old
- Highly dense

NGC 2808

Open Clusters

- Relatively young
- Small number of member stars

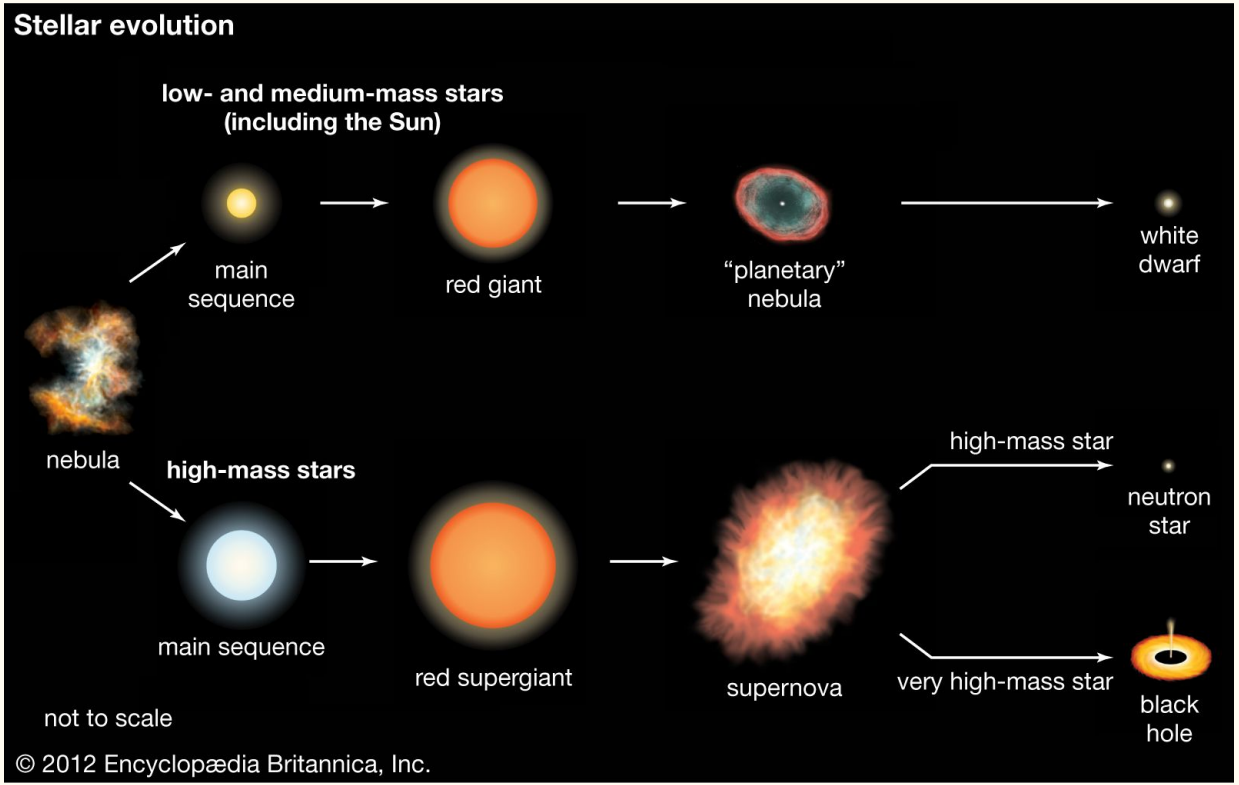
Pleiades
Open cluster

Globular clusters - What's the fuss?

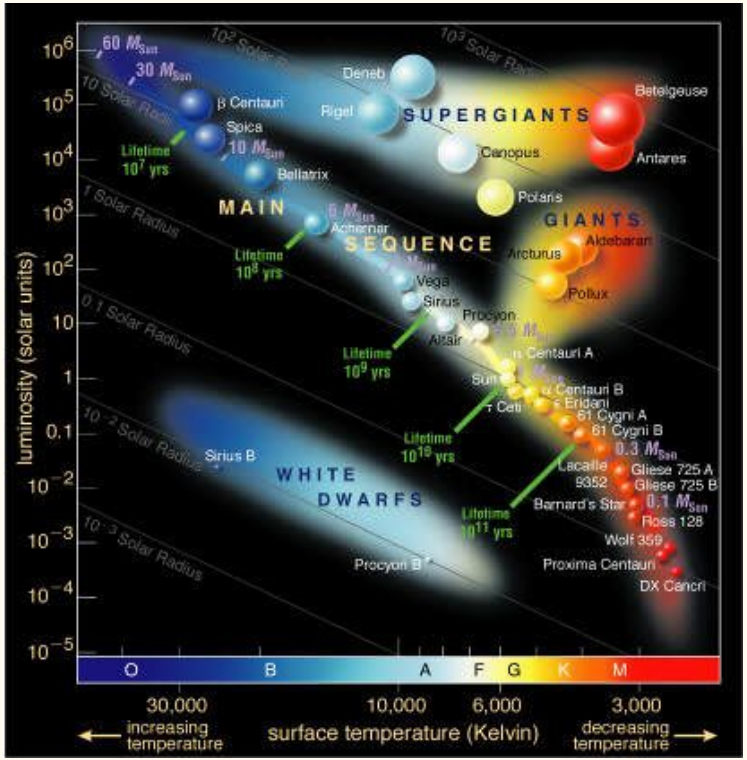
Life of a star

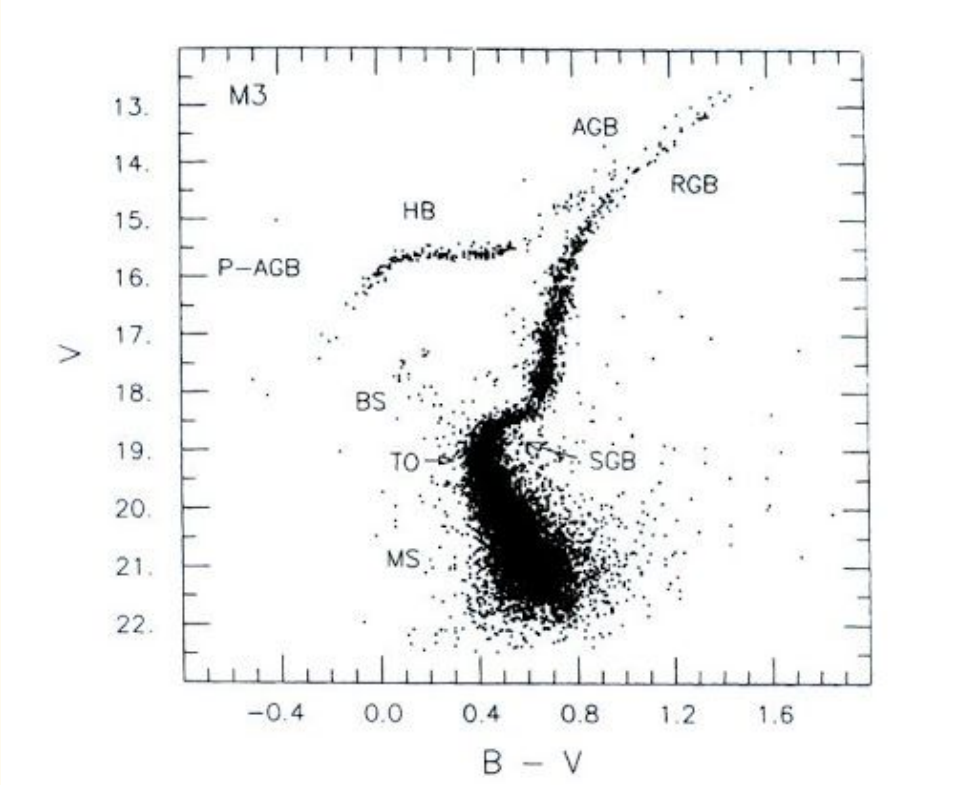
- Main Sequence
- Red Giant
- PN/Supernova
- Death of the star

Massive stars age faster.



The H-R Diagram and Color Magnitude Diagram





Globular clusters

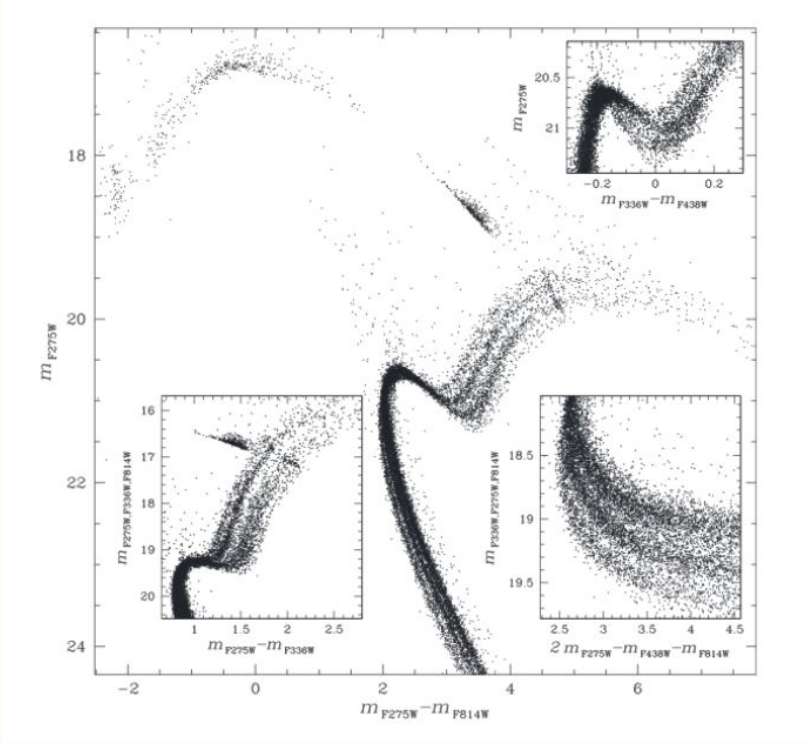
What do we know?

- Coeval and simple stellar populations.
- CMDs acts as ‘validity’ of stellar evolutionary models.
- Similar chemical composition shared by all stars.

But is it really the case?

Globular clusters are not as simple as first perceived.

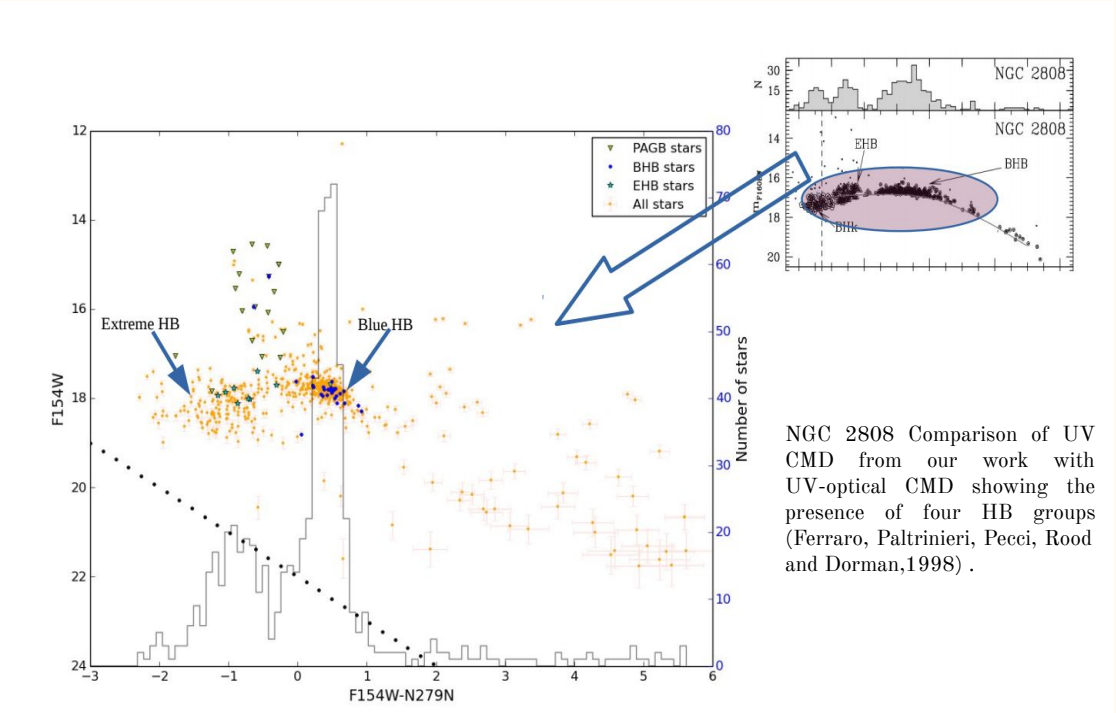
- Complex CMDs.
- Abundance anomalies.



Multiple MS in NGC 2808 (F275W-F814W)
(Milone et. al., 2015)

NGC 2808 : anomalous Horizontal Branch

- Horizontal Branch - core helium burning, shell H burning.
- HB of NGC 2808 is extremely elongated.
- Blue HB (hotter than ~ 8,000 K), Extreme HB (Teff $>$ 20,000K) and Blue hook stars (Teff $>$ 35,000 K) (Brown et al., 2016).

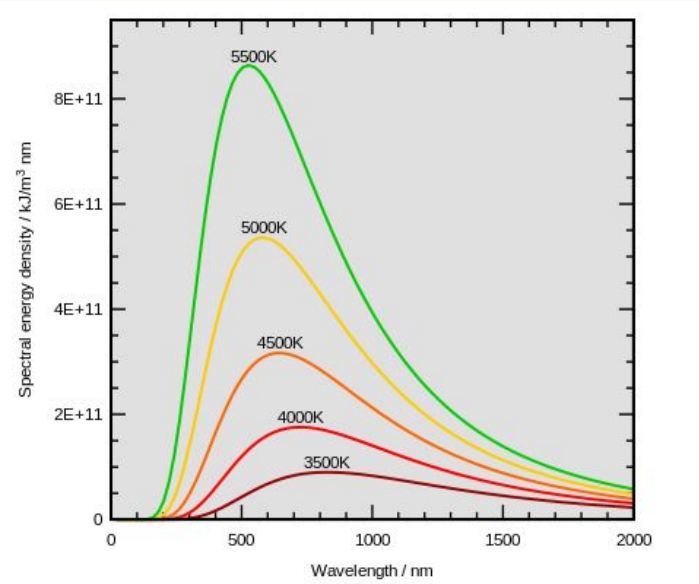


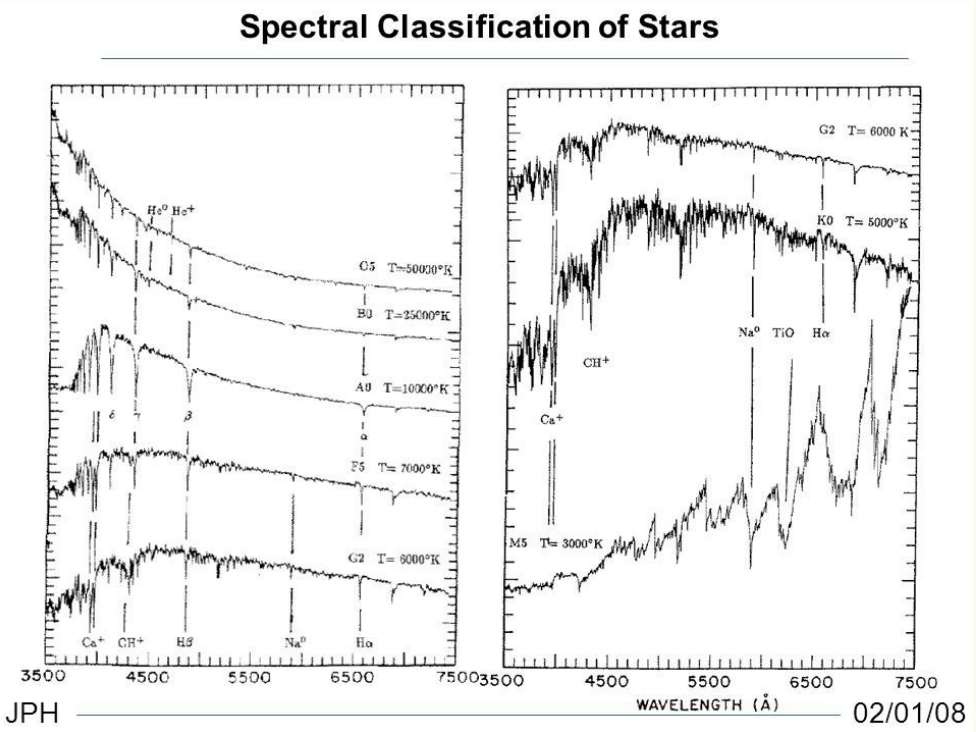
NGC 2808 Comparison of UV CMD from our work with UV-optical CMD showing the presence of four HB groups (Ferraro, Paltrinieri, Pecci, Rood and Dorman,1998) .

Jain et. al., 2019

Atomic diffusion in stars - Case of NGC 6397

- Stellar parameters : Effective temperature, surface gravity (indication of mass) and metallicity.

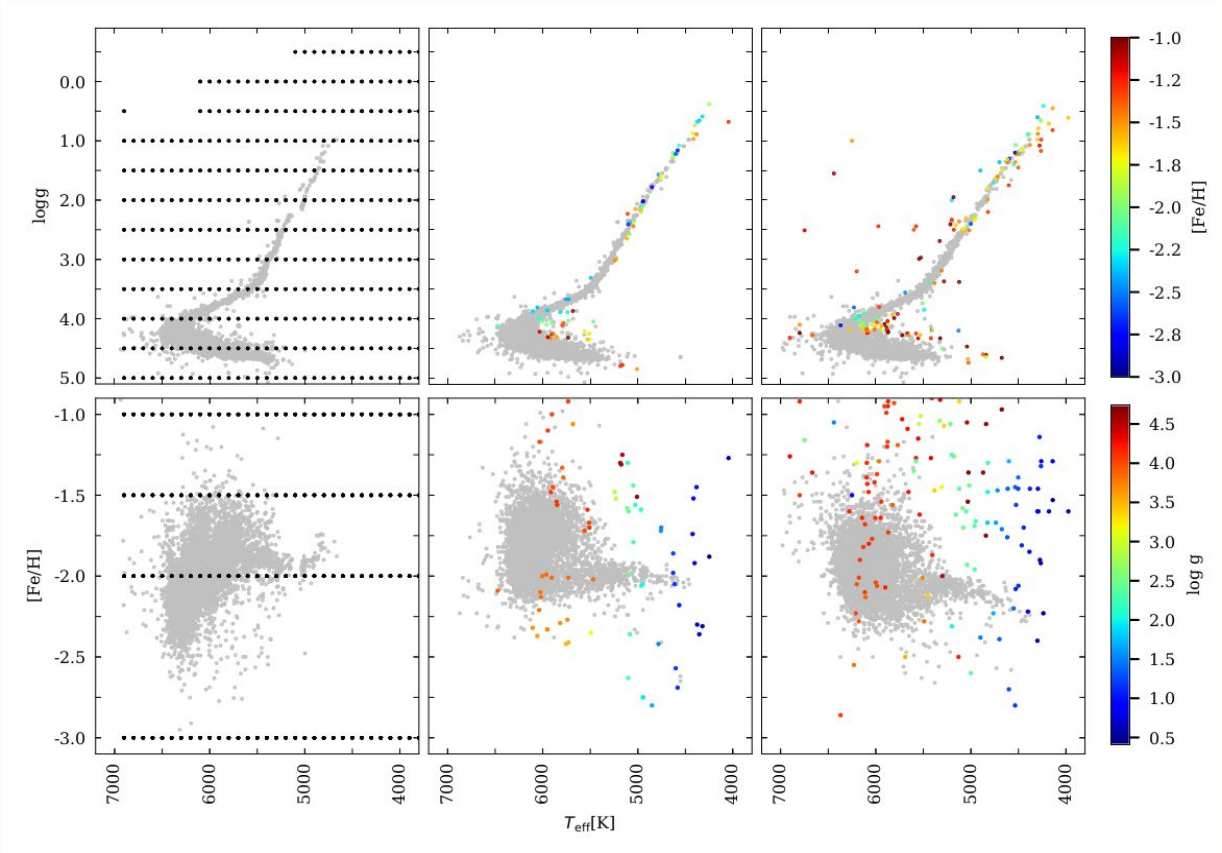




Stellar libraries

Theoretical Libraries - Computed from the stellar physics we know.

Empirical Libraries - From studying spectra of real stars.



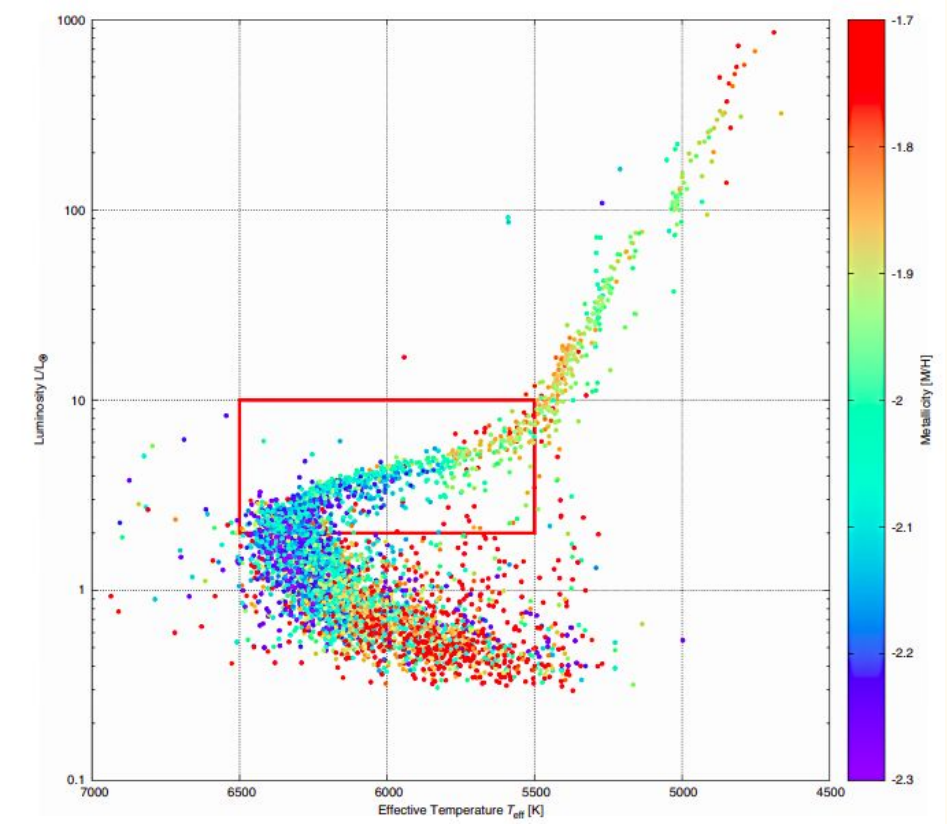
What are we seeking?

Atomic diffusion in stars :

- Diffusion in stars modifies surface abundance of stars.
- Shows in the CMD as metallicity gradient.

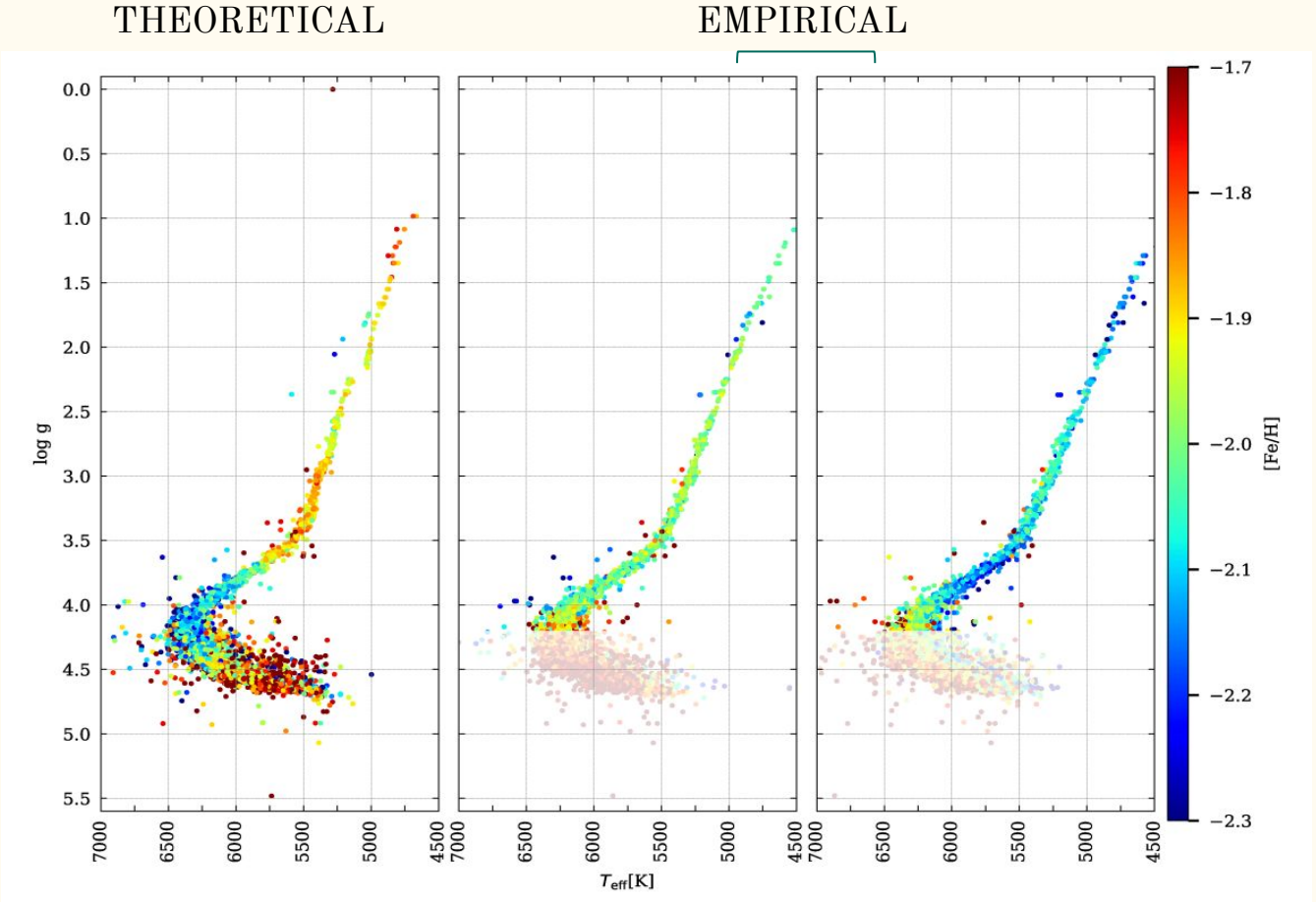
How can we detect this phenomenon?

Comparison between theoretical and empirical libraries.



Husser et. al., 2016

Results (or open questions?)

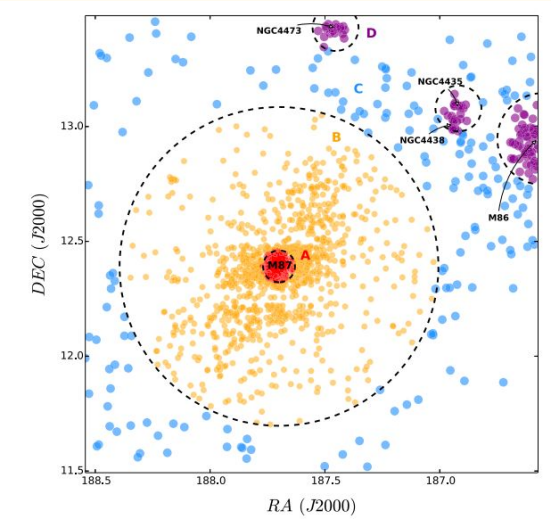


Jain et. al., 2020

Current project -

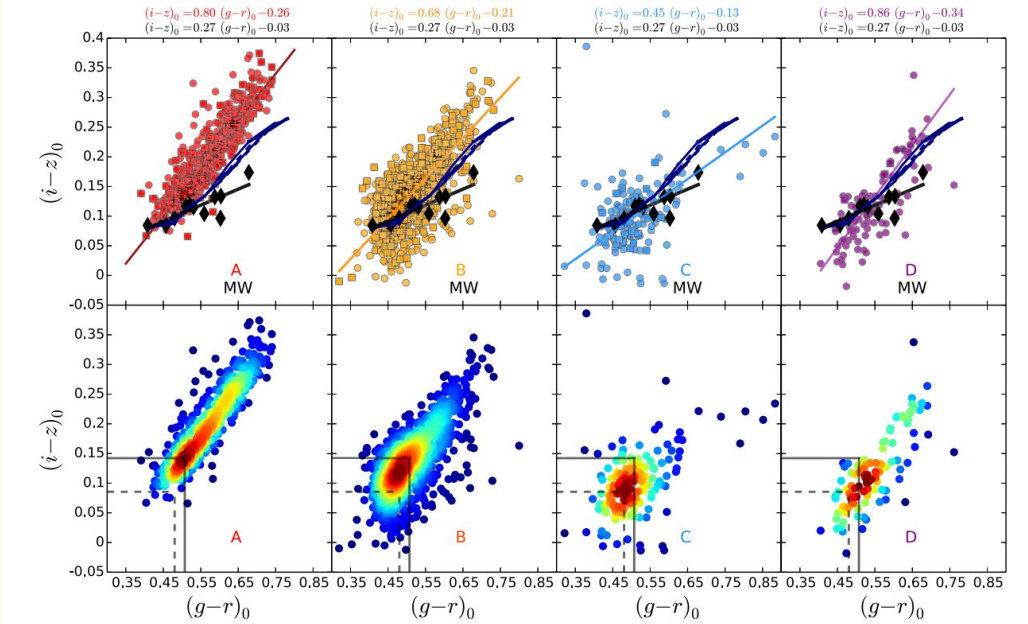
Looking for globular clusters in a swarm of galaxies in the Virgo galaxy cluster.

Against foreground stars and background galaxies.



WHY?

- Dependance of properties of GCs based on environment.
- Impact on stellar evolutionary models.
- Understand the evolution of host galaxies.



Powalka et. al., 2016

How?

Color - color diagrams

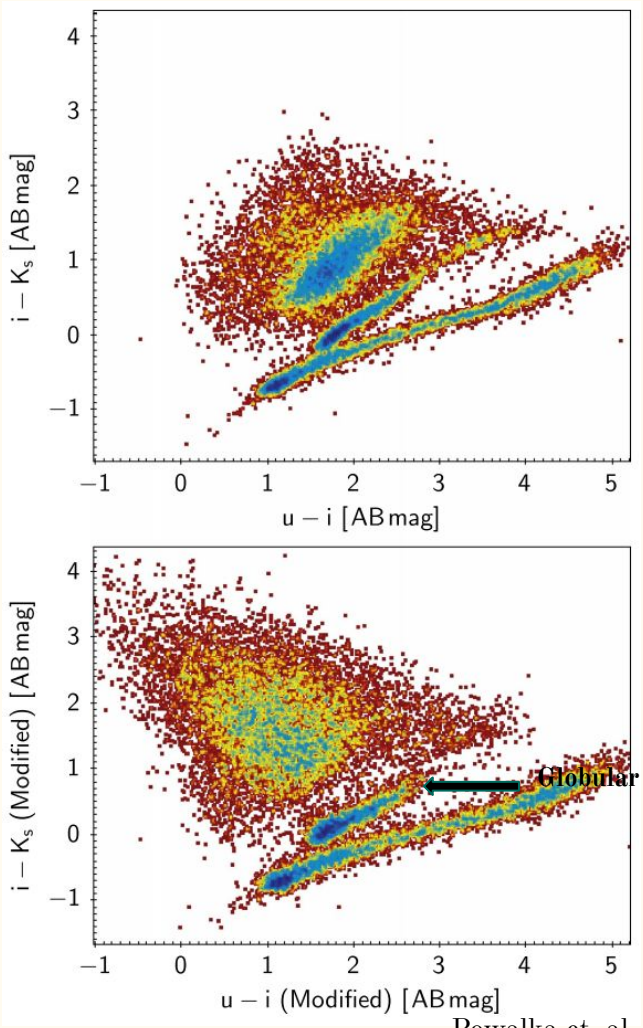
Special combination of filters -
UV/Optical/Near-IR

WHAT DO COLOR COLOR DIAGRAMS TELL US?

- **Spans a wide range in wavelength**
- **(u-i) sensitive to hot stellar population**
- **Separates GC from stars and galaxies**

In the color color diagram -

- Upper left : extended objects
- Middle sequence : GC candidates
- Lower sequence : Stellar sequence



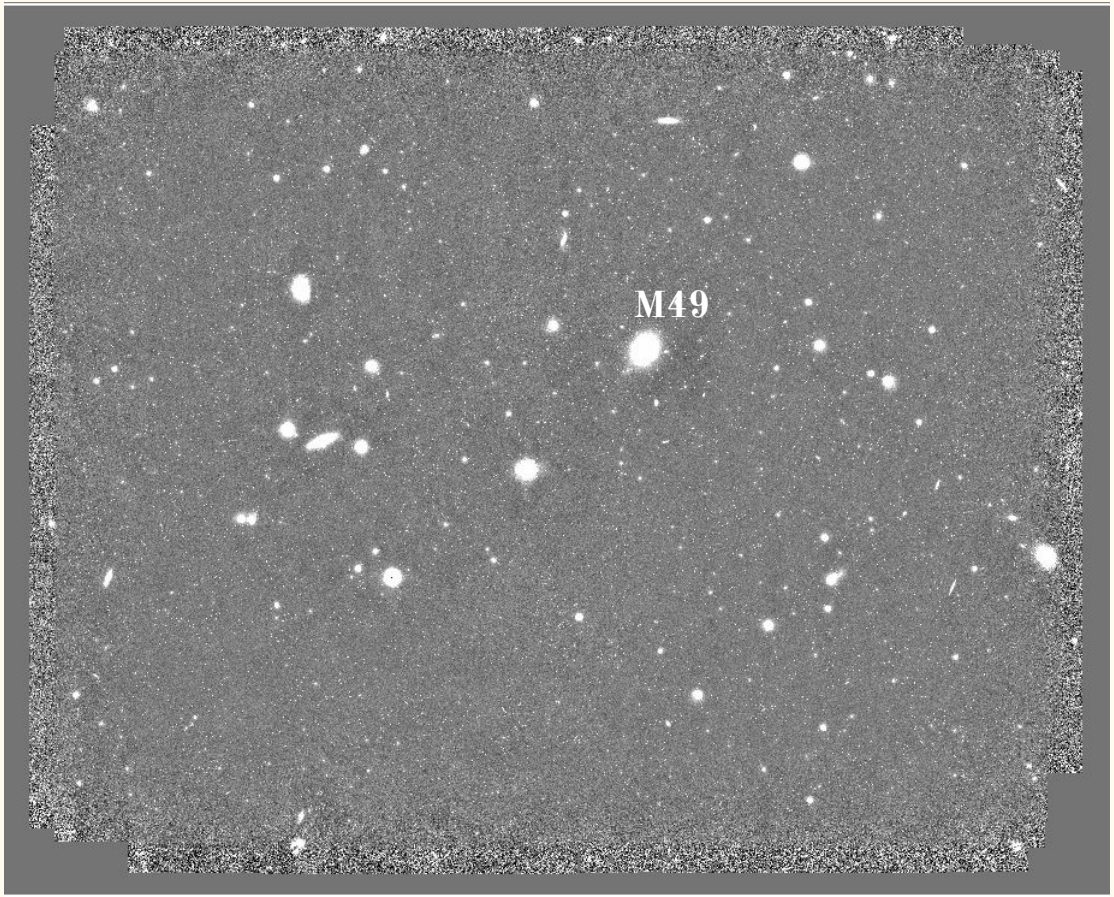
Powalka et. al., 2016

Technical challenges

NIR sky is variable on relatively small scales, spatially and temporally - getting rid of background

Small duration exposures to avoid saturation - storage and stacking of data

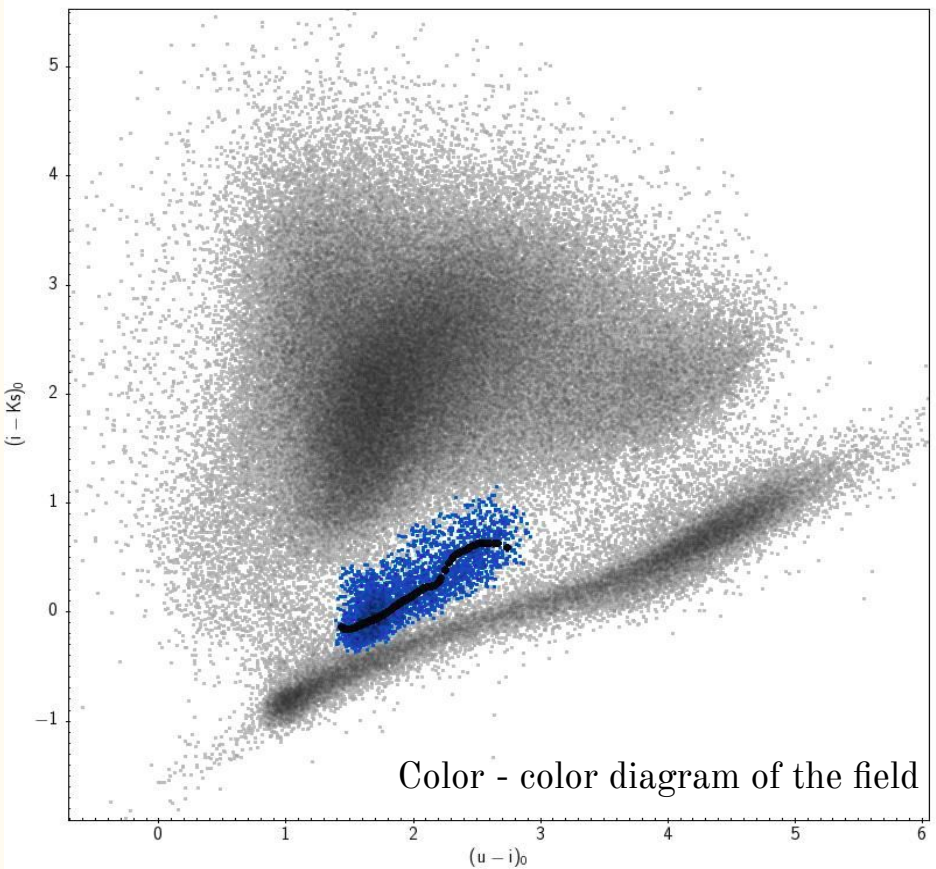
Errors $< 5\%$ for accurate classification.



3.69 degrees

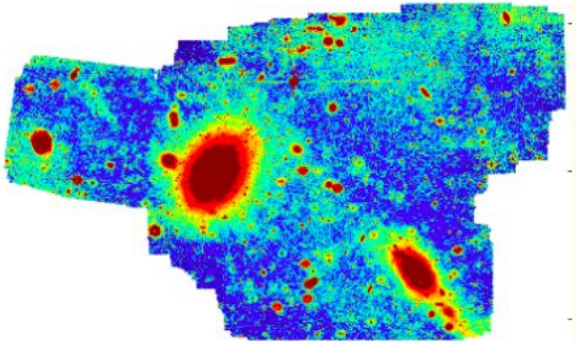
A part of Virgo cluster of galaxies
(65.23 million light years)

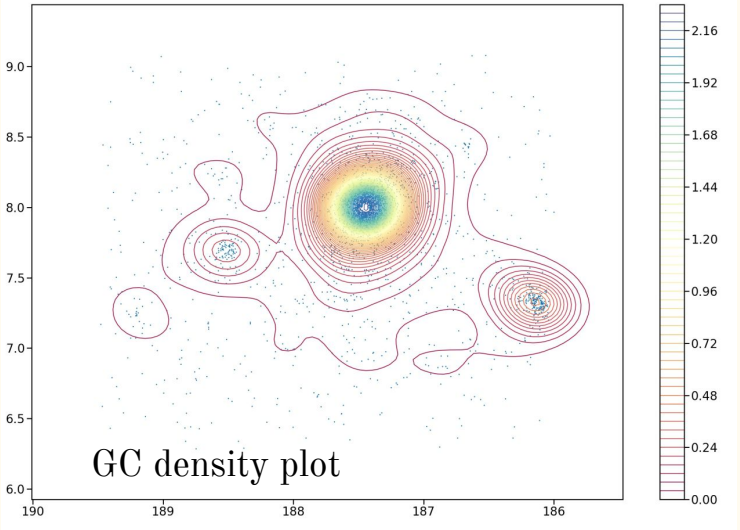
Globular clusters near M49



Color - color diagram of the field

Location of galaxies (Mihos+ 2017)

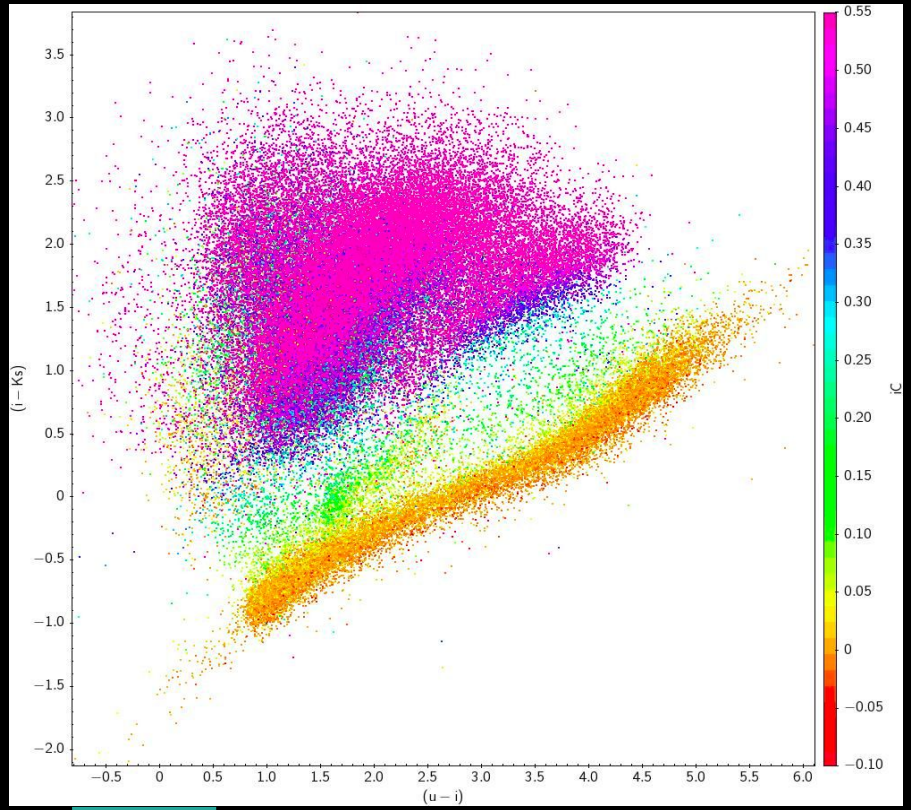




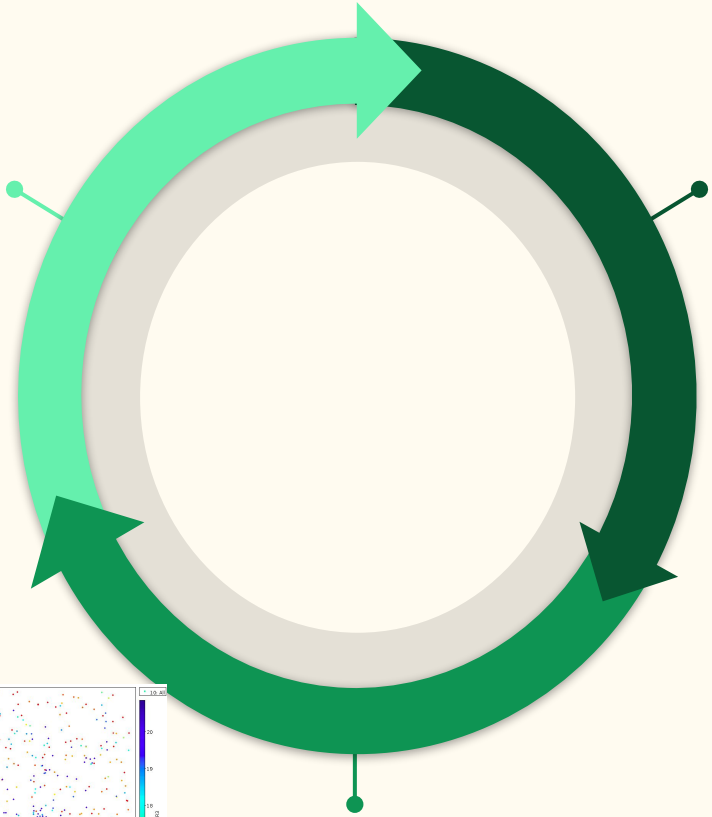
GC density plot

Ongoing work

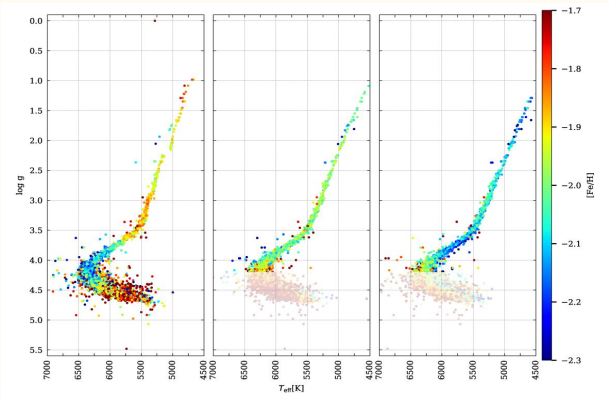
- Identifying cluster candidates in the field.
- Removing contamination from foreground stars and background galaxies.
- Characterizing colors of the GCs and study the implication of their environments and their effects.

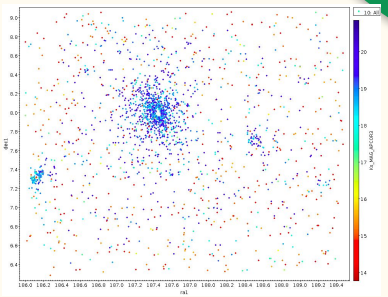


Multiple Stellar population in Globular clusters



Stellar libraries and models





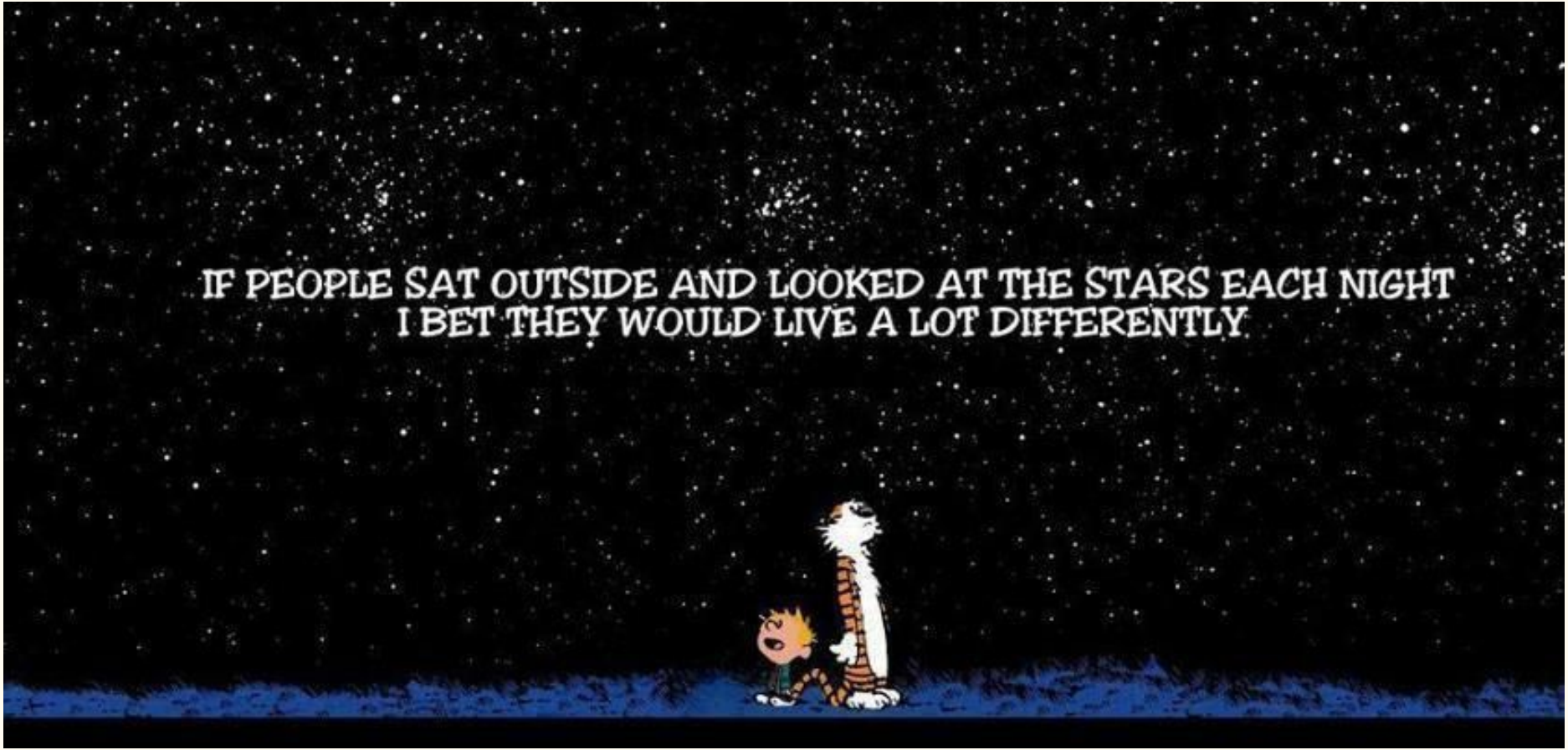
GC populations around galaxies

Summary

- Globular clusters seem simple and boring, but they really are not.
- Distinct populations with enigmatic origin.

- Stellar libraries - need to be more consistent with each other.
- Work is going on expanding the empirical libraries.

- Ongoing work on studying the properties of GCs outside of our own galaxy.
- Quantifying the properties affected by the environment.


IF PEOPLE SAT OUTSIDE AND LOOKED AT THE STARS EACH NIGHT
I BET THEY WOULD LIVE A LOT DIFFERENTLY

Thank You!