



DARA Basic Training

NAMIBIA-BOTSWANA 2019

UNIT 1: INTRODUCTION TO ASTROPHYSICS

Windhoek, 7 –18 January 2019

Star Clusters

- Colour-magnitude diagrams
- Open Clusters
- Globular Clusters
- Chemical evolution
- Stellar populations

Star Clusters

- Star clusters are a collection of stars that are concentrated in space
- They all formed together out of the same cloud and at the same time
- There are two common types of star cluster
 - Open clusters
 - Globular clusters

Colour-Magnitude Diagrams

- for star clusters m_V (or V) is equivalent (apart from an offset) to M_V since all stars are at the same distance
- can also use colour, e.g. $B-V$ as a measure of temperature
- hence colour-magnitude diagrams (CMDs) for star clusters are similar to H-R diagrams

Open Clusters

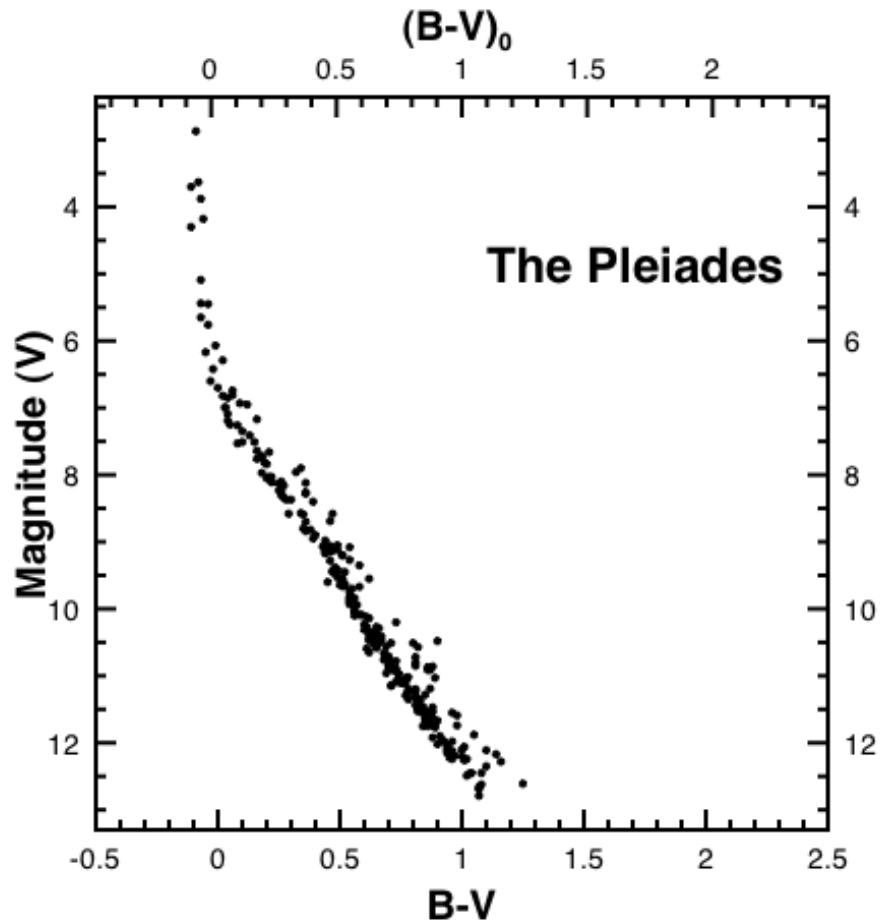
- Typically have of order 1000 members
- Not gravitationally bound – will disperse over time
- Located in spiral arms
- Consist of young, hot, blue main sequence stars



Open cluster NGC 457. Credit: ROBERT GENDLER/SCIENCE PHOTO LIBRARY



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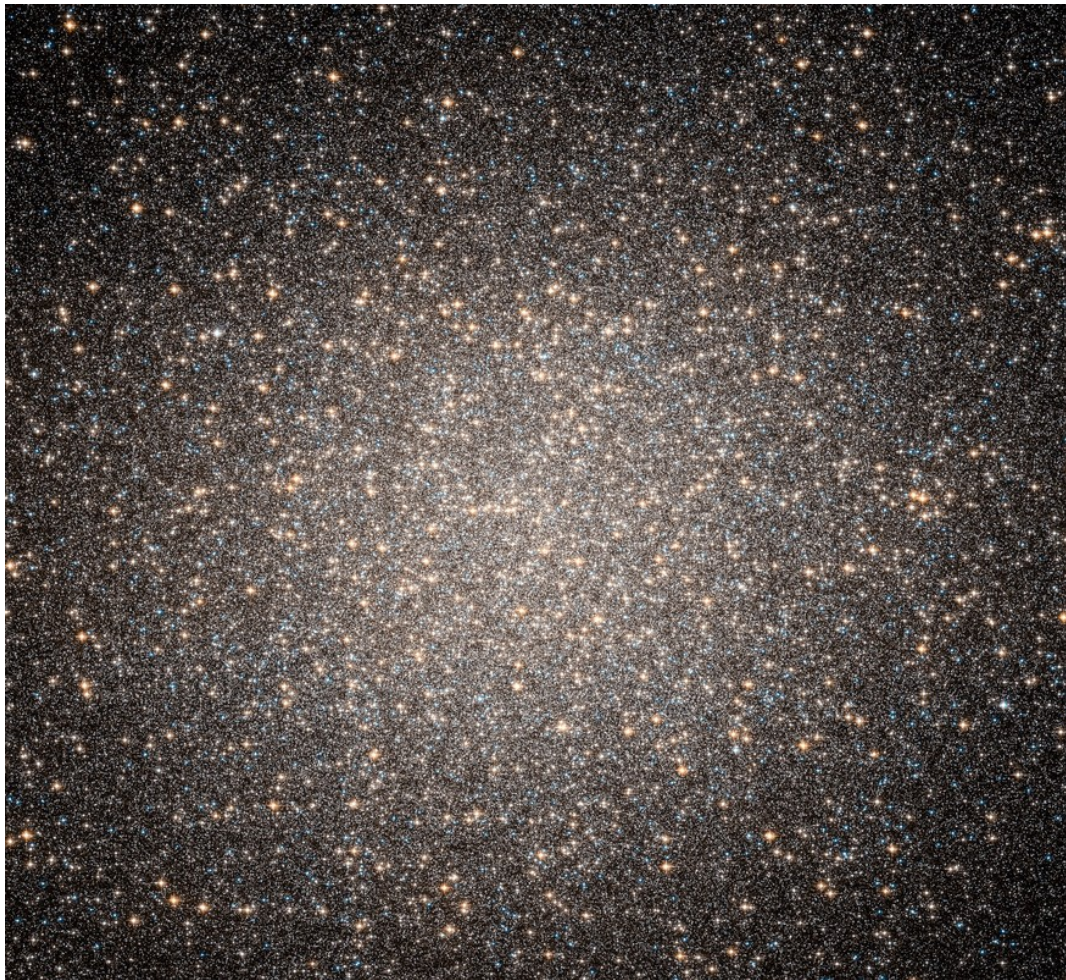
Colour-magnitude diagram of the Pleiades open cluster

Globular Clusters

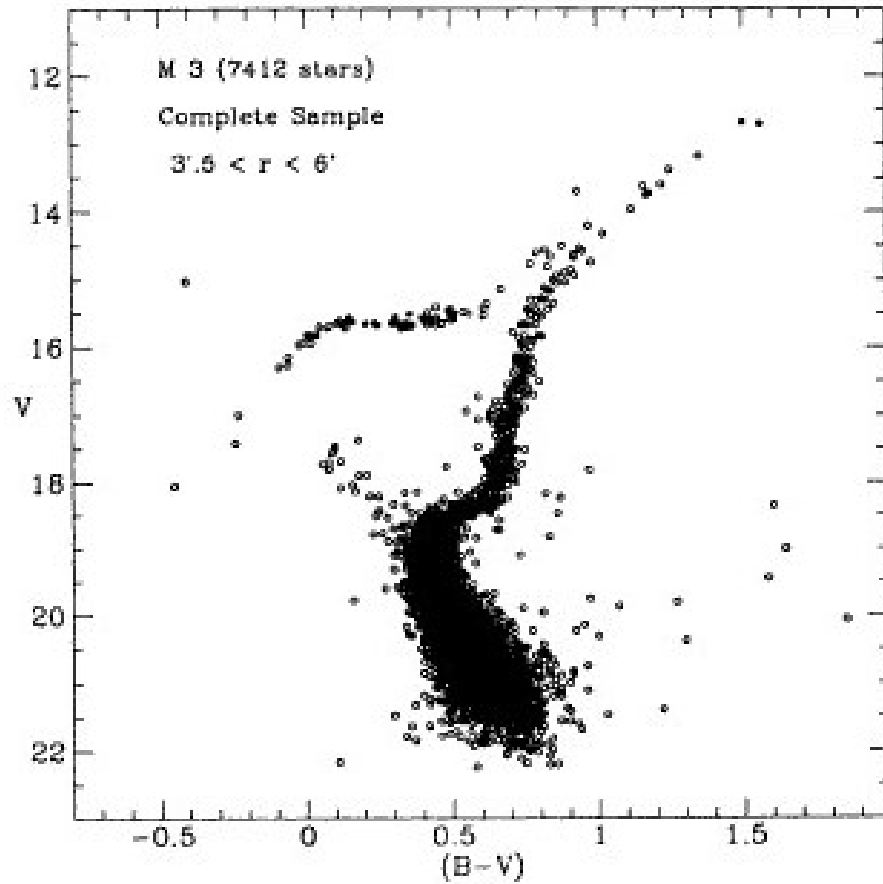
- Typically have of order 10^5 members
- Gravitationally bound
- Found in the Galactic halo
- Consist of old, cool, red, stars



Globular cluster M80. HST



Globular cluster Omega Centauri. HST



Colour-magnitude diagram for the globular cluster M 3.

Buonanno, R.; Corsi, C. E.; Buzzoni, A.; Cacciari, C.; Ferraro, F. R.; Fusi Pecci, F. *Astron. Astrophys.* 290, 69-103 (1994)

Chemical Evolution

- The first stars to form were made from material left over from the Big Bang
- This was almost pure hydrogen and helium
- Nucleosynthesis within stars due to fusion of light nuclei produces heavy elements
- These are returned to the interstellar medium via supernovae explosions and planetary nebulae

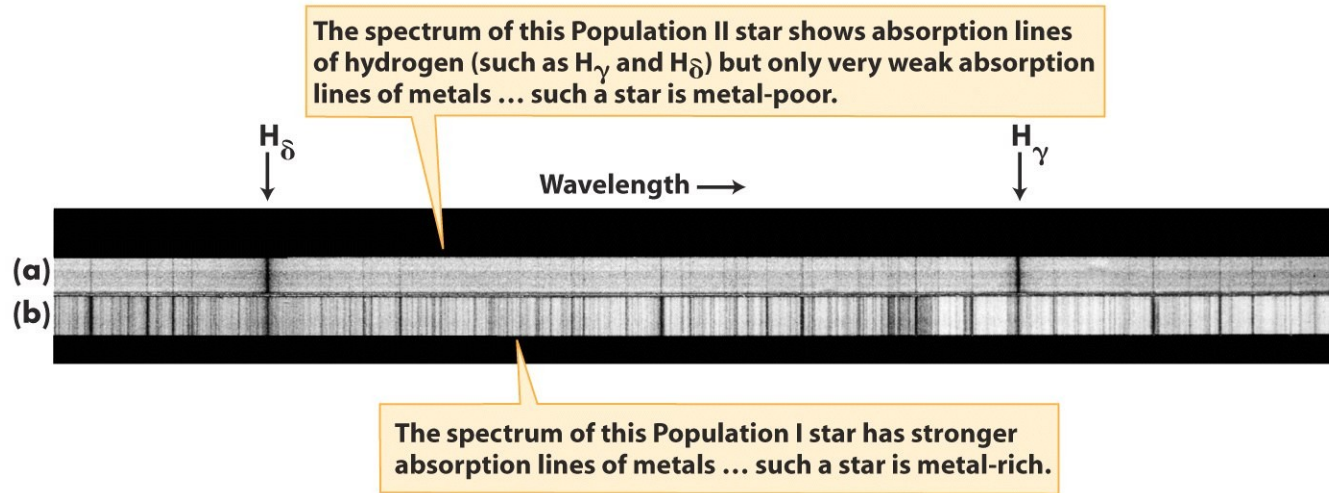


Supernova remnant



Planetary nebula
NASA HST

- This enriched material is then the raw material for the next generation of stars
- Hence, successive generations become progressively more enriched in heavy elements or 'metals'
- Can be tracked by measuring the composition via the spectra of stars



Stellar populations

- Stellar populations are divided into two groups
- Population I stars
 - young
 - 10^7 to 10^9 years
 - metal-rich
 - >1% metals by mass
 - ongoing or recent star formation
 - e.g. open clusters

- Population II stars
 - old
 - 10^{10} years
 - metal-poor
 - $\sim 0.1\%$ metals by mass
 - no star formation for a long time
 - e.g. globular clusters

Summary

- Colour-magnitude diagrams for star clusters enable us to determine their age
- They are a key tool in the study of stellar and galaxy evolution
- Stellar populations are divided into old, metal-poor stars and young, metal-rich stars