Stellar Clusters

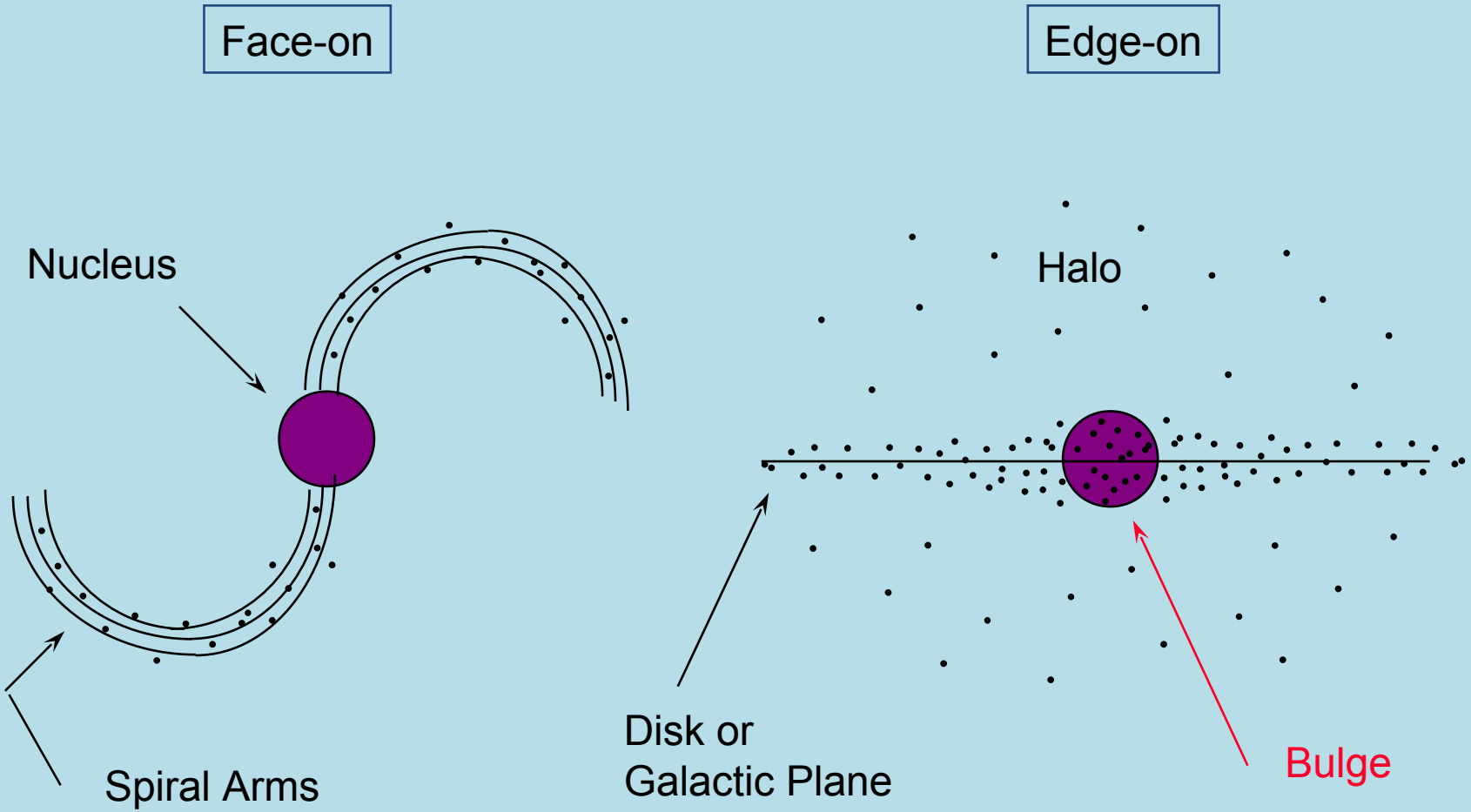
Lecture 11

Stellar Clusters

Star clusters and associations

- Groupings of stars
- Sometimes stay together for
  - a long time (> 10^{10} years) or
  - a short time (< 10^{8} years)
- Clusters are places where we can see the results of stellar evolution

A Spiral Galaxy



Population I stars

- Young stars - disk stars
- Make up the galactic disk
- Examples: Galactic star clusters
  O-B stellar associations
- High metal abundances
- Interstellar gas and dust may be present.

Population II Stars

- Old stars
- Make up the galactic halo and bulge
- Example: Globular Clusters
- Low metal abundances

Galactic Clusters

- Located in the disk of our galaxy
- Young stars (Population I)
- 50 to 10000 stars per cluster
- ~ 10 pc in diameter
- Star density ~ 0.1 to 10 stars/pc^3
- Irregularly shaped
- ~ 1000 in the Galaxy
- Examples: Pleiades, Hyades, Praesepe

Globular Clusters

- Located in the halo of our galaxy
- Old stars (Population II)
- ~ 10^4 to 10^6 stars per cluster
- ~ 20-100 pc in diameter
- Star density ~ 0.5 to 10^3 stars/pc^3
- Roughly spherically shaped
- ~ 150 in the Galaxy
- Examples: M3, M13 (Hercules), M15

O-B Stellar Associations

- Located in the spiral arms of our galaxy
- Young stars (Population I) w/ associated interstellar material.
- ~ 100 to 1000 stars per cluster
- ~ 100 - 200 pc in diameter, Irregularly shaped
- Star density ~ 0.01 stars/pc^3
- ~ 80 in the Galaxy
- Example: Orion O-B Association

Stability of Clusters

Globular Clusters	Very Stable
Galactic Clusters	Quasi Stable
O-B Associations	Unstable

- If the internal gravity of a cluster exceeds the tidal disruption by the central Milky Way, then the cluster is stable.

M45 (Pleiades)

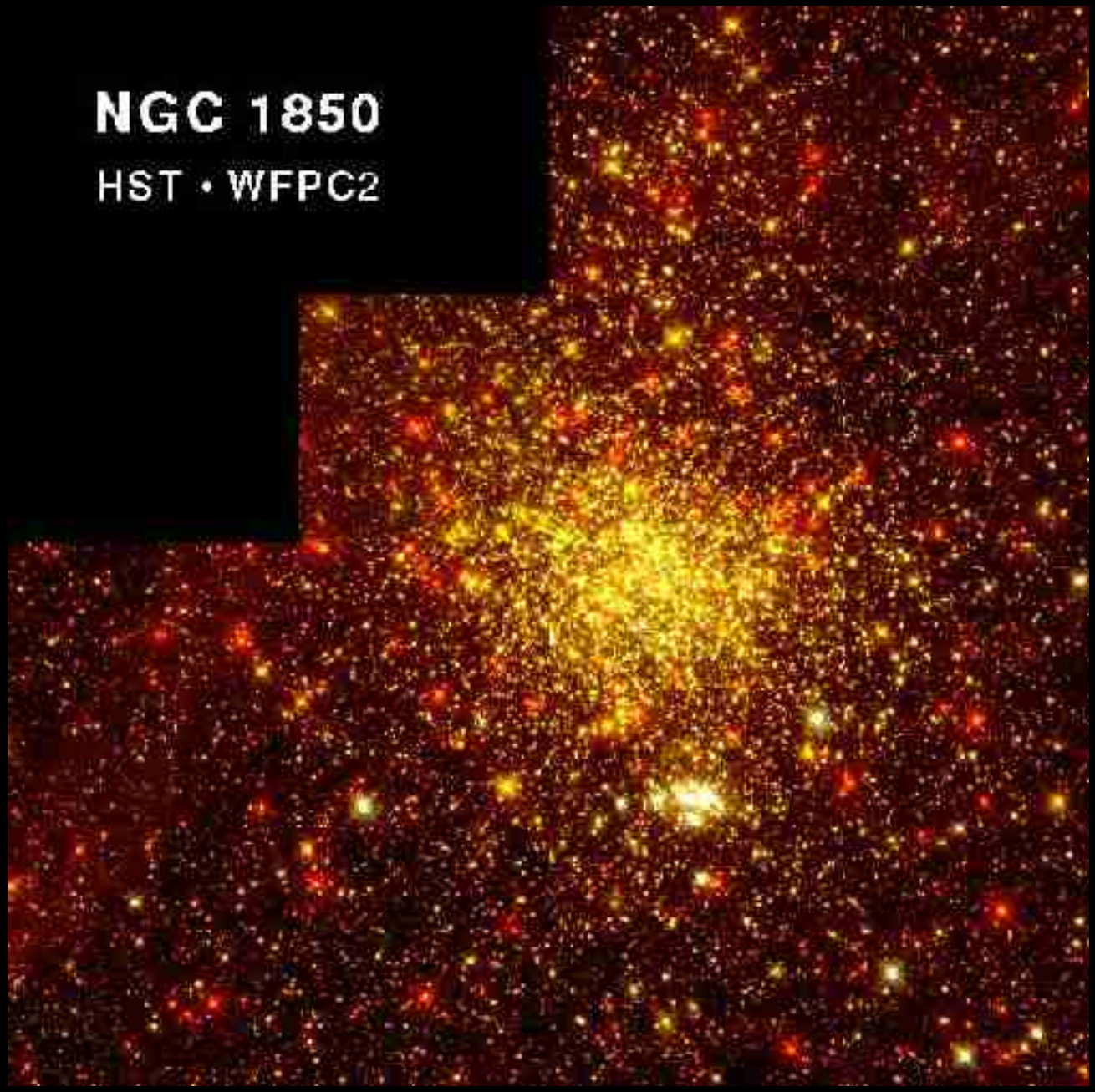
M44 (Praesepe or “Beehive”)

M11 (Wild Duck Cluster)

M7 (Ptolemy’s Cluster)


M6 (Butterfly Cluster)

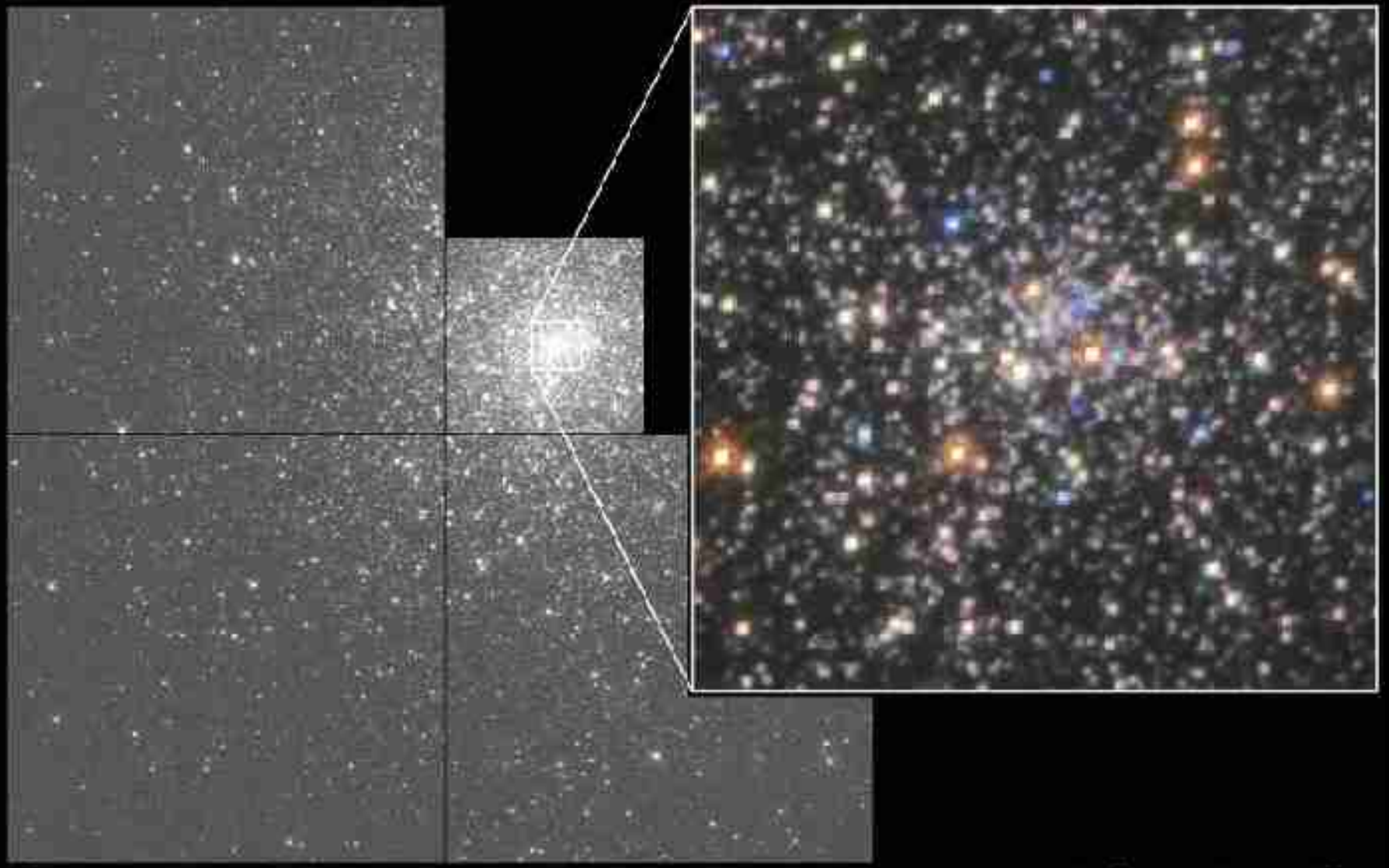
NGC 1850 in LMC (50 Myr + 4 Myr old)



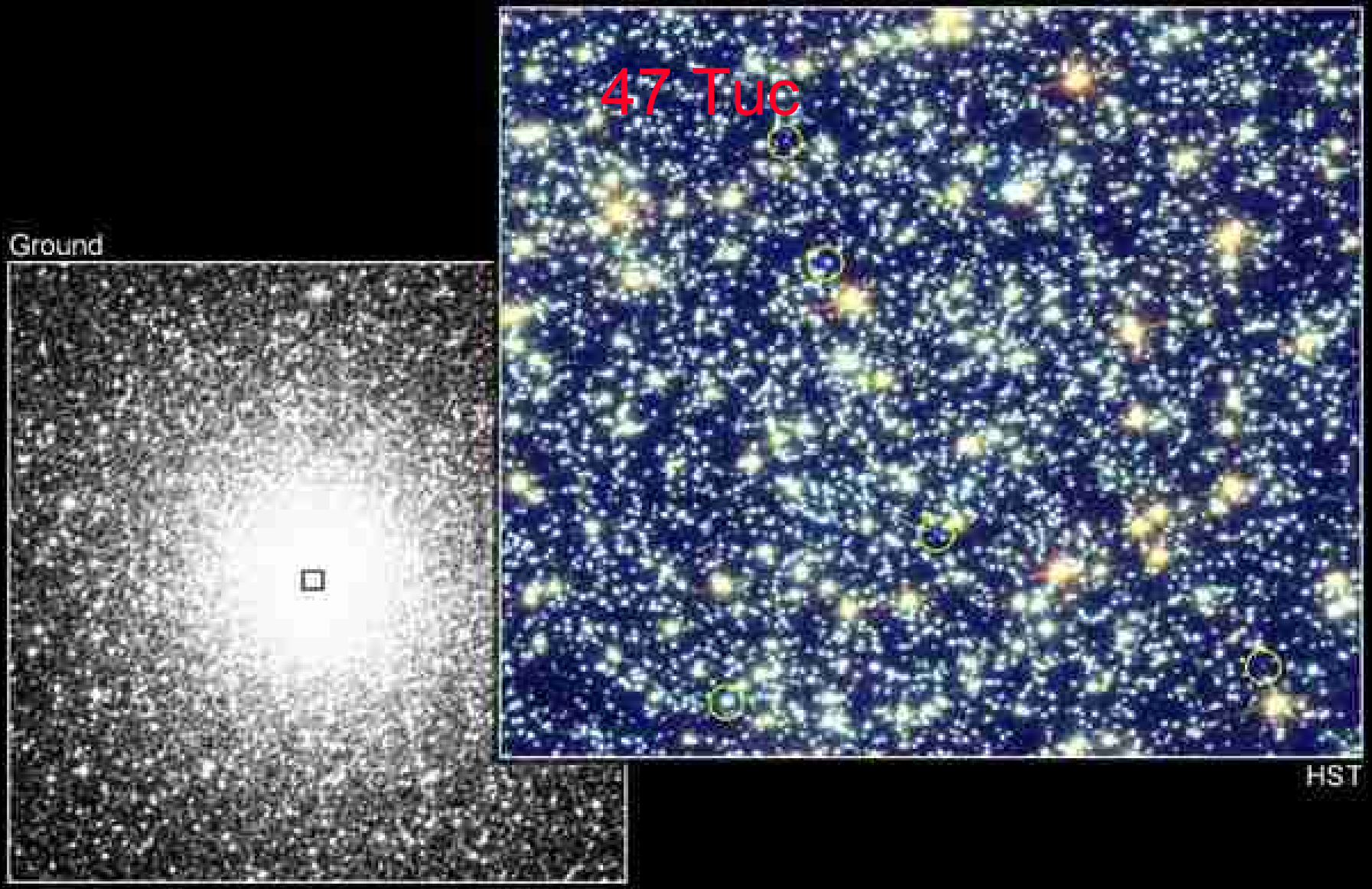
NGC 1850 in LMC (50 Myr + 4 Myr old)

M13 (Hercules)

M15 (in Pegasus)

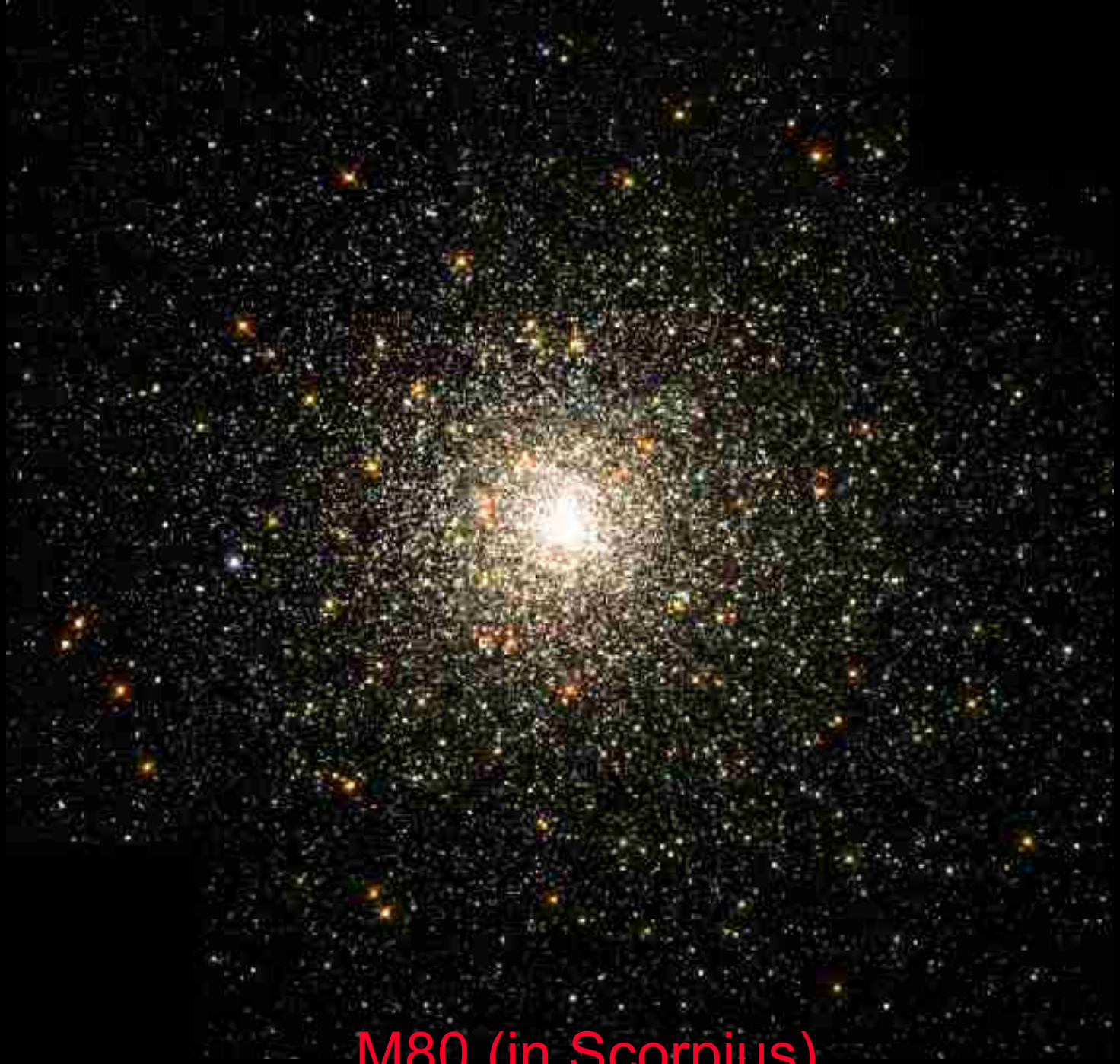


M15



Blue Stragglers in Globular Cluster 47 Tucanae

HST • WFPC2



M80 (in Scorpius)

M31 Globular Cluster

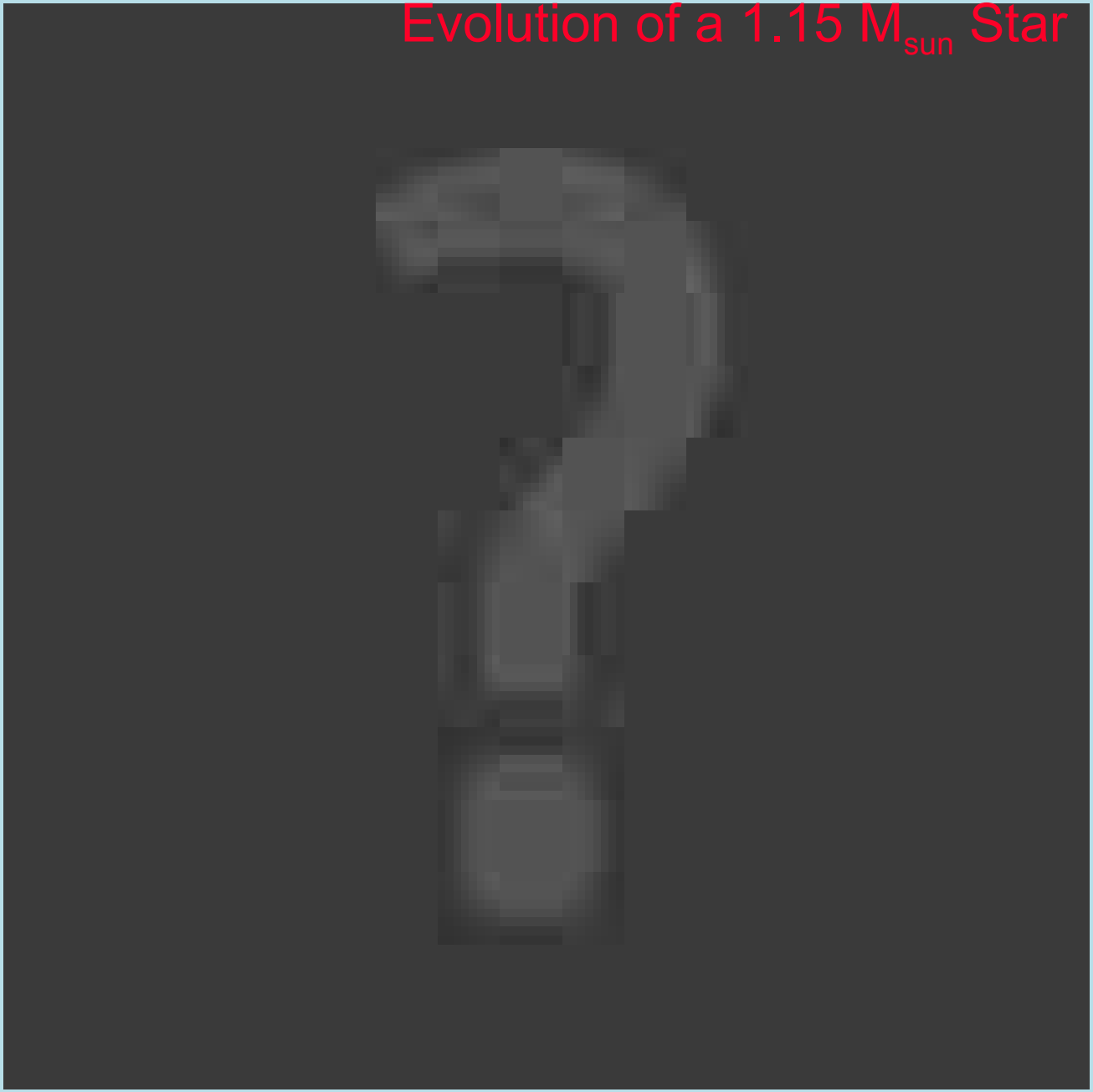
Evolution of Clusters of Stars

- Stars in a cluster are all thought to be born at the same time.
- This means the high mass stars evolve off the main-sequence first.
- The age of a cluster is determined by the highest mass stars present.

Comments on Stellar Evolution

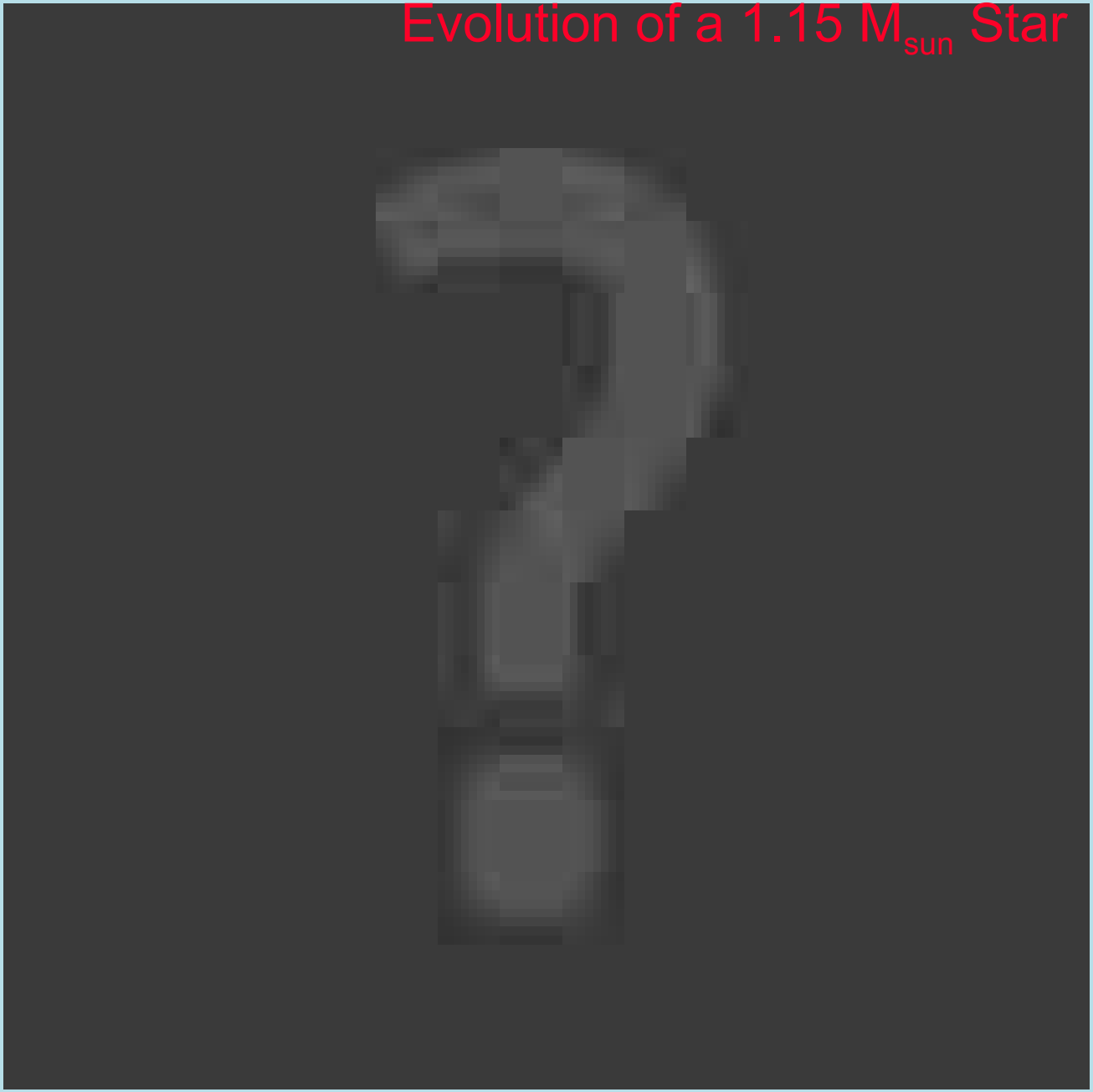
- Stars move off the main-sequence when H is exhausted in the core.
- Giant/Supergiant phases consist of shell burning (H, He, etc.) and core burning (of heavier elements)
  - Size, temperature and luminosity changes
- Star clusters are a good place to study stellar evolution since all stars are born at the same time.

Evolution of a 1.15 M_{sun} Star



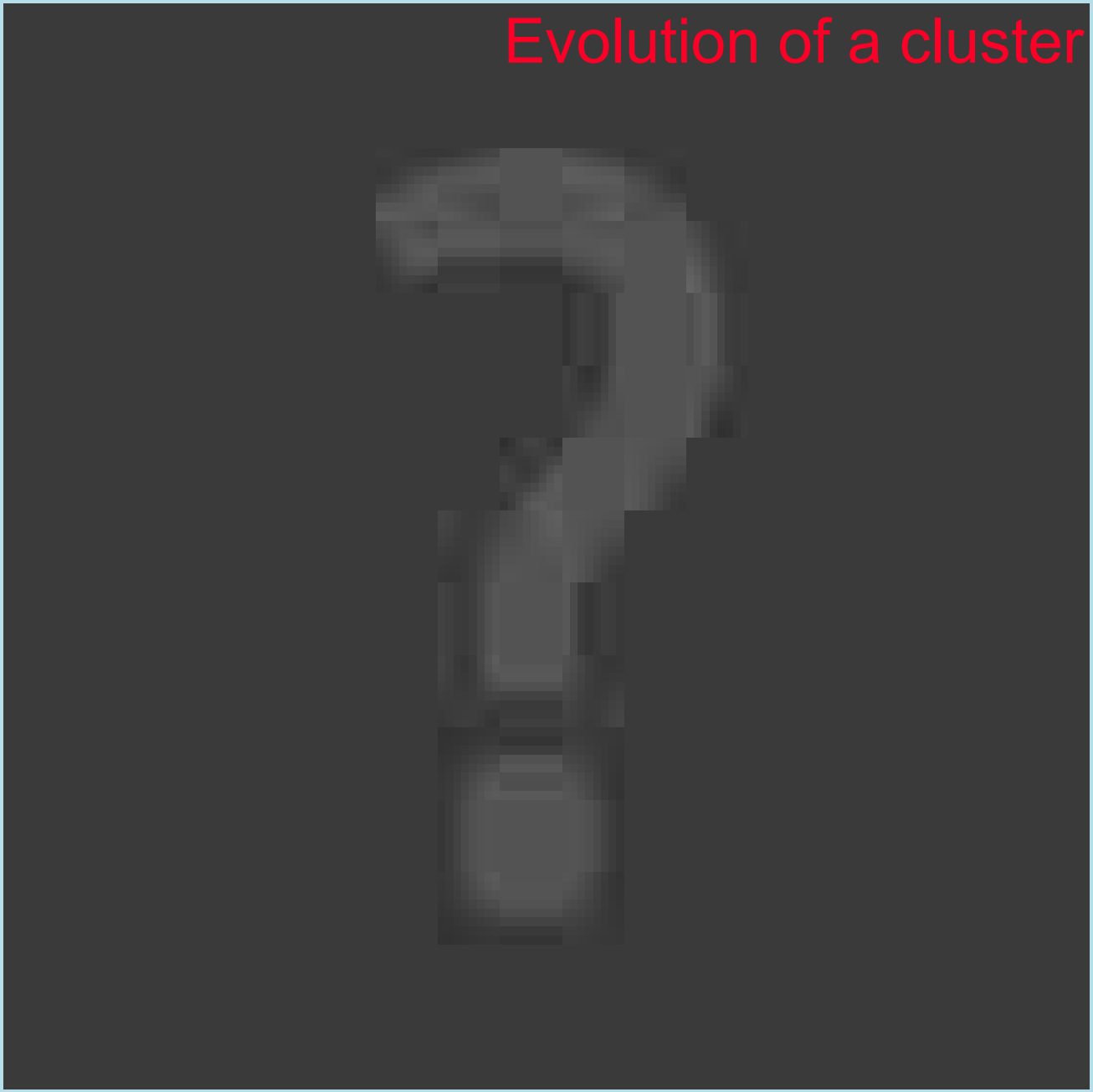
Uniform
Steps

Evolution of a 1.15 M_{sun} Star

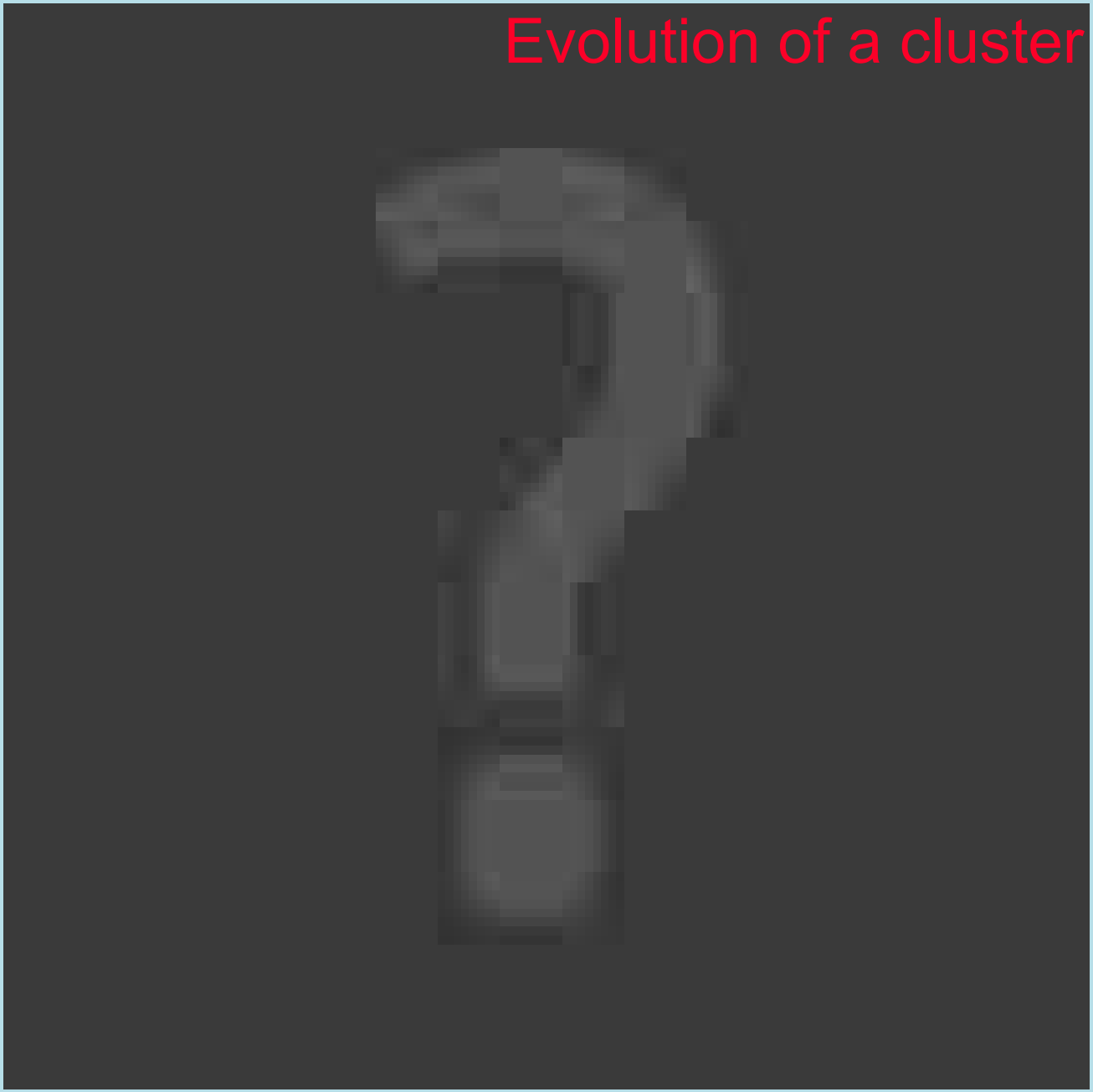


Correct
Relative
Timing

Evolution of a cluster

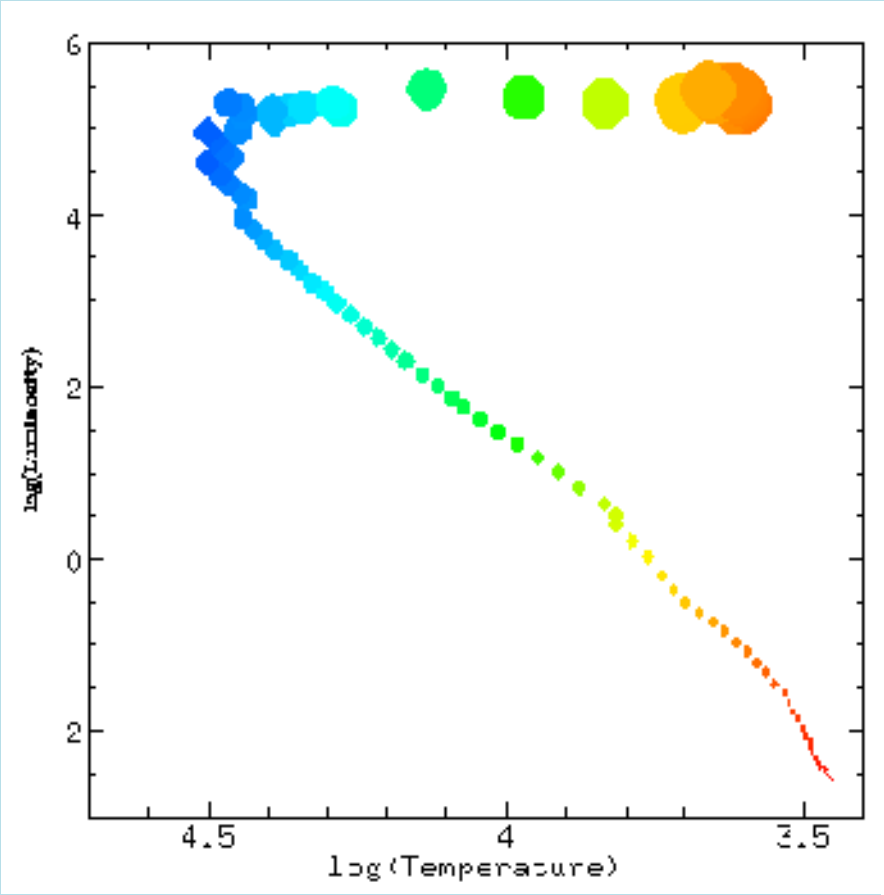


Evolution of a cluster

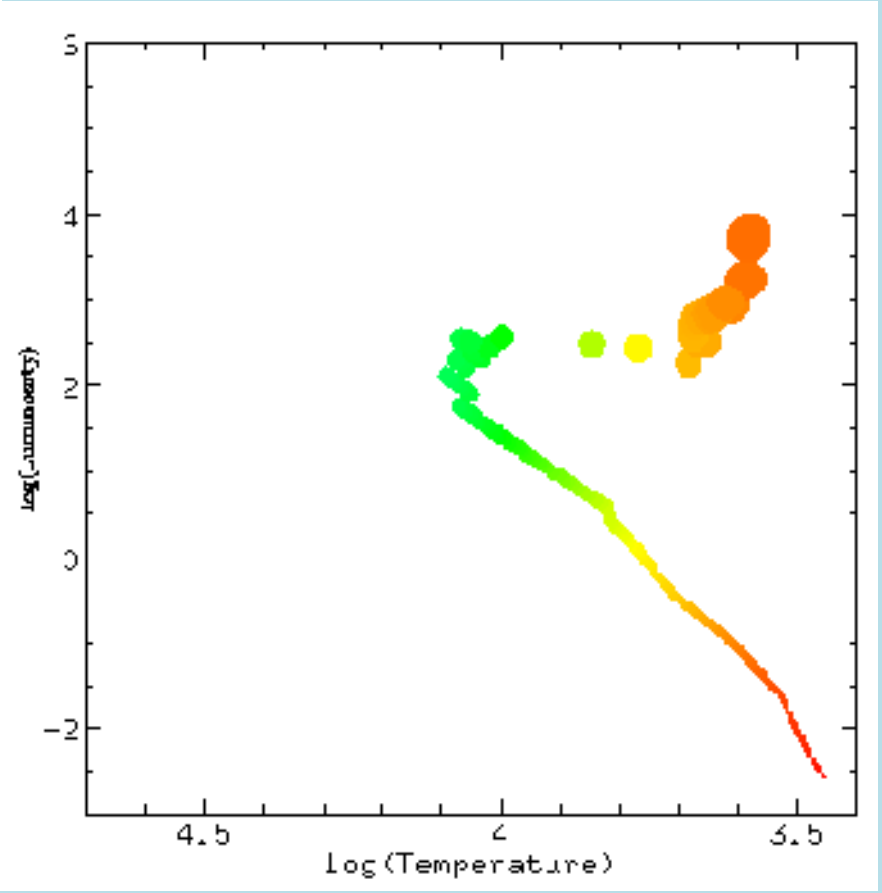


H-R diagram of aging cluster

T= 8×10^6 years

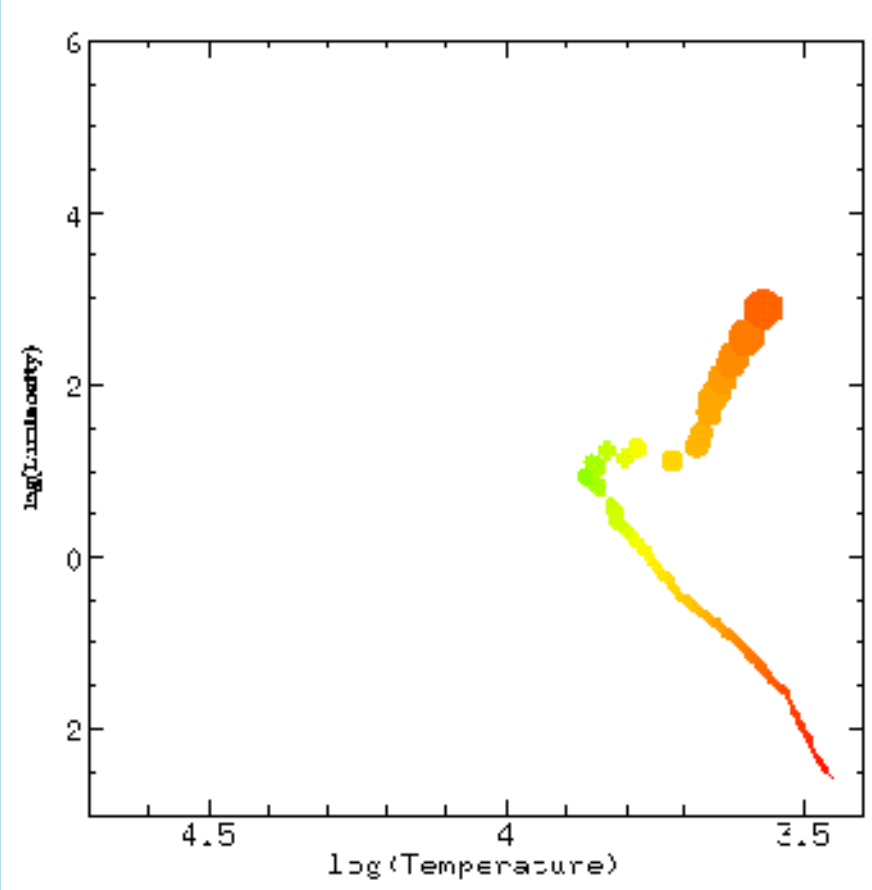


T= 256×10^6 years

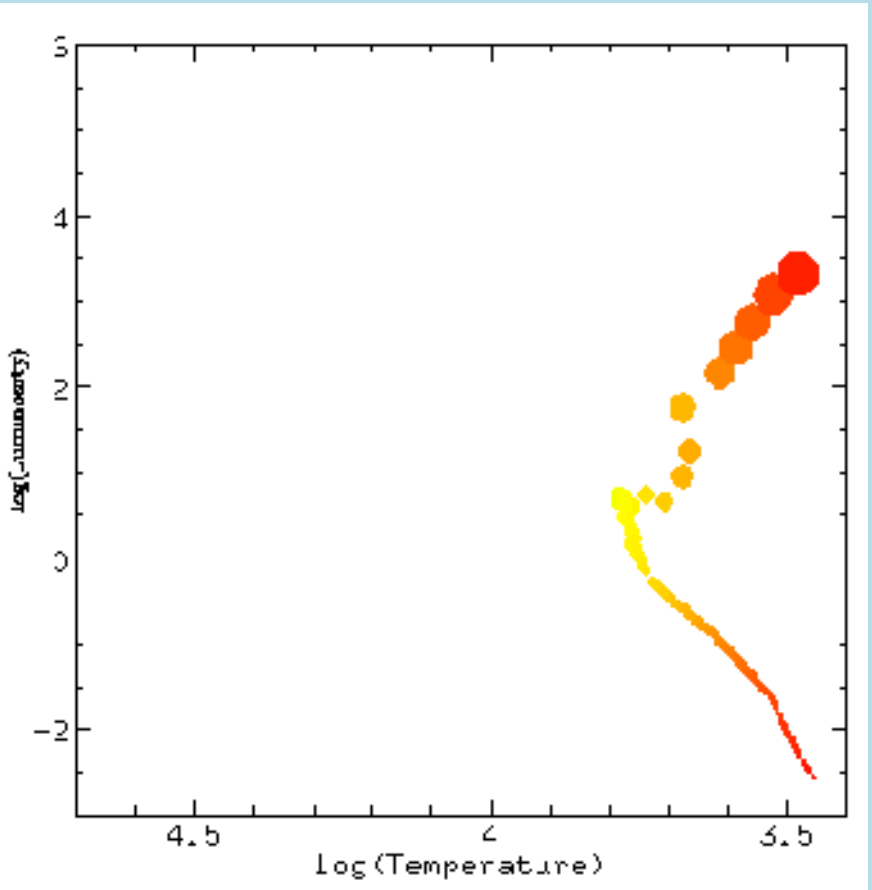


H-R diagram of aging cluster

T= 3.1x10^9 years

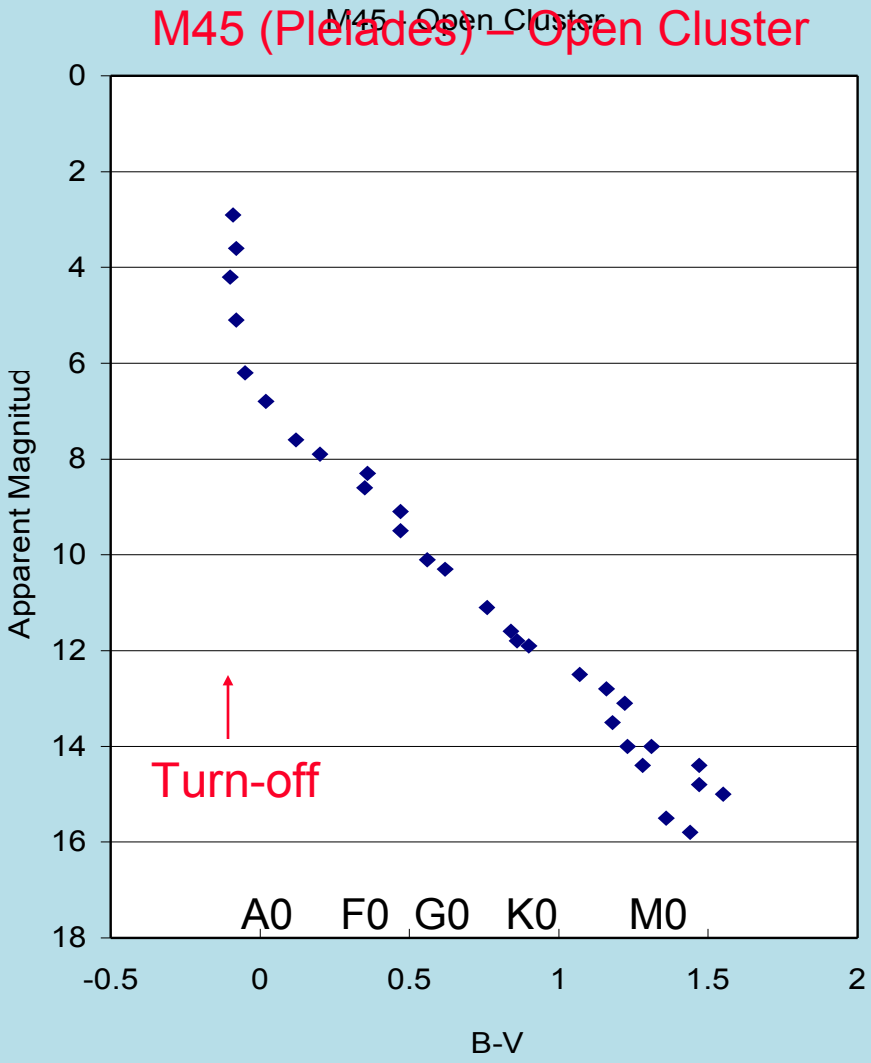


T= 8.2x10^9 years



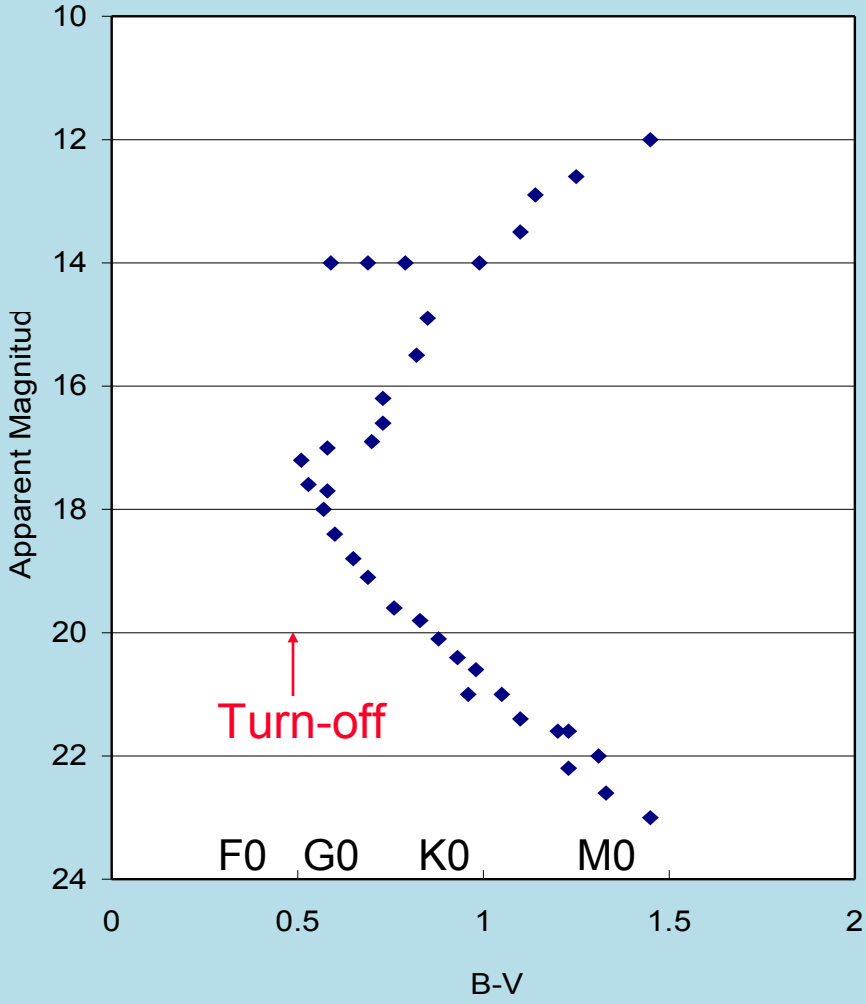
Cluster H-R Diagrams

M45 (Pleiades) – Open Cluster



< 100 Myr old

47 Tucanae – Globular Cluster



~ 10 Gyr old