AS1001:Extra-Galactic Astronomy

Lecture 2: Galaxy Morphology

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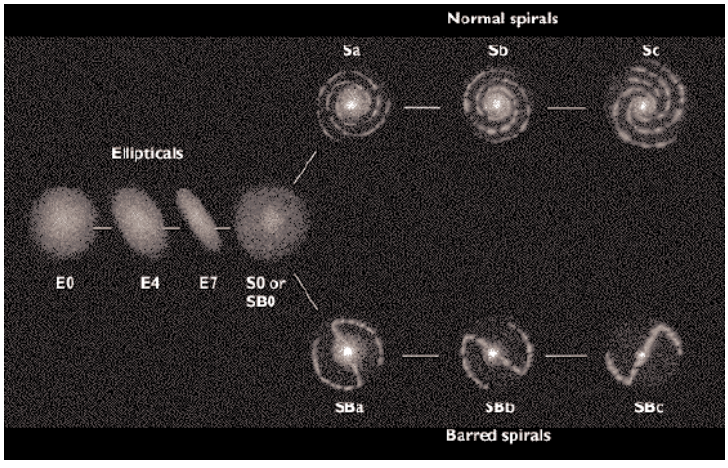
Galaxy Morphology

- Hubble Tuning Fork Devised 1929
- Originally covered Ellipticals to Spirals



The Hubble Tuning Fork

- Objects classified from Early-to-Late
- Ellipticals = Early, Spirals= Late
- Spirals are subdivided according to whether they exhibit a bar or not
- Lateness is given by the bulge-to-disk ratio and
- the tightness of the spiral arms
- Classification is subjective and open to debate
- Is there a better way ?

Three Generic Galaxy Types

- Ellipticals, E0-E7
  - E0-E7 where n=10(a-b)/a (a=major and b=minor axis)
  - S0 or Lenticular. A transition class where a very faint disk is just seen
- Spirals, Sa,Sb,Sc,Sd
  - Sa = Dominant Bulge, tightly wound arms
  - Sb=Obvious Bulge, spiral arms
  - Sc=Faint bulge, spiral arms
  - Sd=No bulge, diffuse spiral arms
- Irregulars, Sdm, Im, Irr
  - m=Magellanic, no bulge, asymmetrical

Elliptical

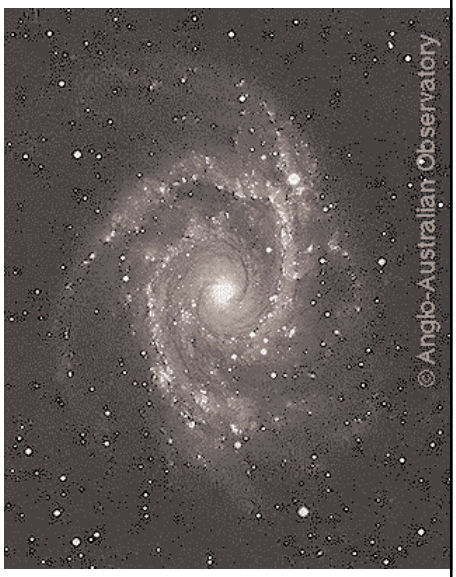
- Red , I.e., (B-V) >1
- Smooth profile
- High Surface Brightness
- Egg shaped
- Little or no dust lane
- Absorption Lines only
- Many Globular Clusters
- No rotation
- Found in Clusters
- Typically: $-22 < M_V < -18$

Elliptical

- Red , I.e., (B-V) >1 = Old stellar population
- Smooth profile = Relaxed old system
- High Surface Brightness = Densely packed
- Egg shaped = Massive
- Little or no dust lane = Reservior Exhausted
- Absorption Lines only = No Star-formation
- Many Globular Clusters = Formed via mergers
- No rotation = Formed via mergers
- Found in Clusters = Formed via mergers
- Typically: $-22 < M_V < -18$ = Massive

Spirals

- Red bulge (B-V) >1
- Bluish Arms/Disk, (B-V) ~1
- Moderate Surface Brightness
- Dusty
- Emission+Absorption lines
- Rotating disk
- Numerous Globular Clusters
- Seen in high and low density environments
- Typically: $-21 < M_V < -17$

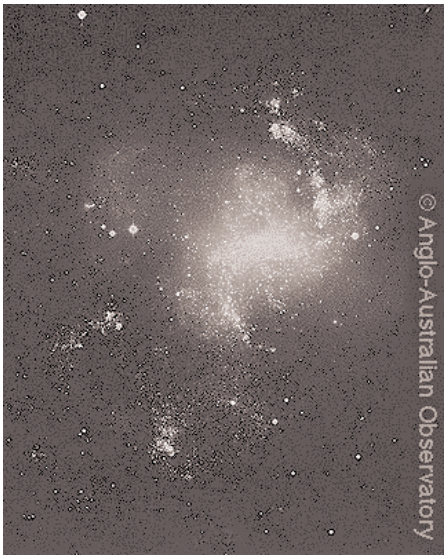


Spirals

- Red bulge (B-V) >1 = Central bulge is old
- Bluish Arms/Disk, (B-V) ~1 = Disk is intermediate
- Moderate Surface Brightness = Relaxing
- Dusty = SF will continue
- Emission+Absorption lines = SF ongoing
- Rotating disk = Formed via collapse
- Numerous Globular Clusters = plus some merging
- Seen in high and low density environments = Collapse+merging
- Typically: $-21 < M_V < -17$

Irregulars

- Blue (B-V) <0.8
- Strong Emission lines
- Very dusty
- Low surface brightness
- Highly Assymetrical
- Rotating
- Few Globular clusters
- Mainly in the field
- Typically: $-18 < M_V < -10$



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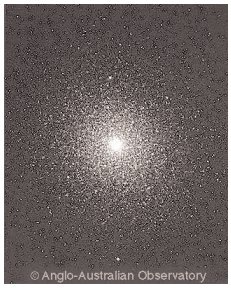
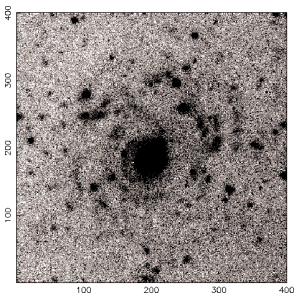
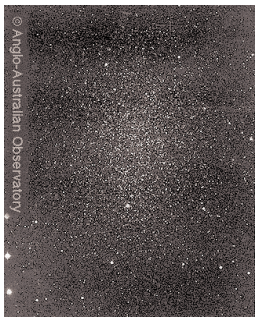
- Young stellar population
- Lots of Star-formation
- SF will continue
- Forming
- Forming/low mass
- Formed via collapse
- Formed via collapse
- Formed via collapse

Other Galaxy Types

- Globular Clusters
- Dwarfs
  - Dwarf Ellipticals
  - Dwarf Irregulars
  - Dwarf Spheriodals
- Crouching Giants
  - LSBGs
  - Malin1s

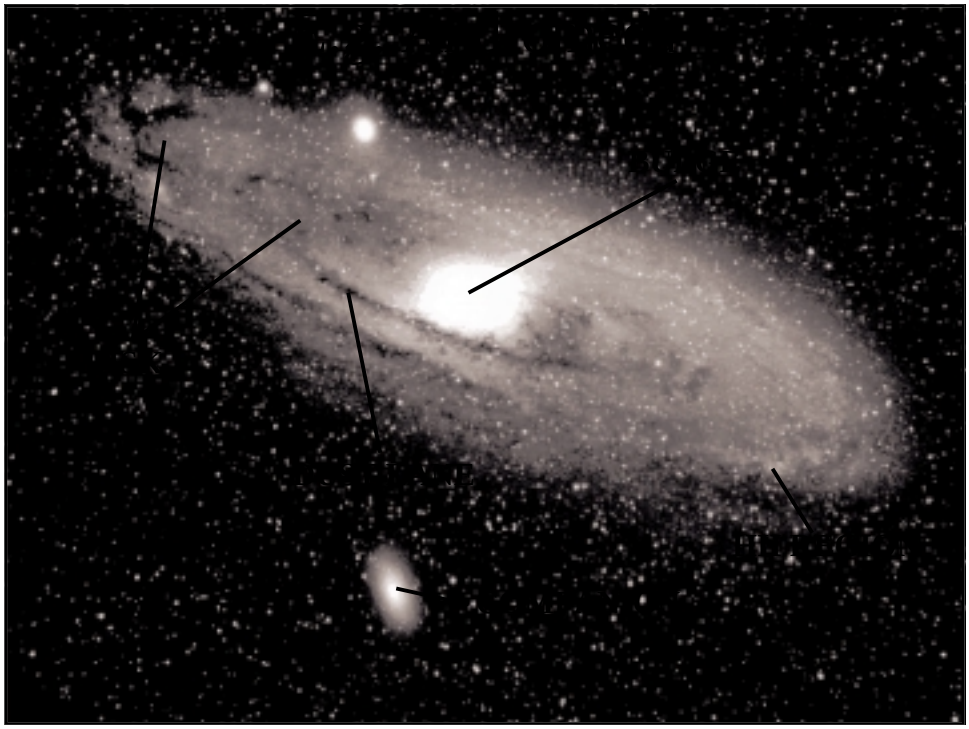






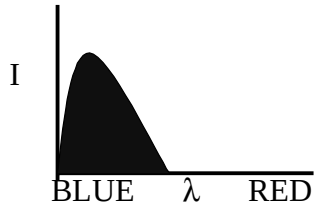
Galaxy Components

- Main Ingredients (%M):
  - Dark Matter (90%)
    - Baryonic,e.g. Dust, neutrinos
    - Exotic, e.g. WIMPS
  - Gas Disk (9%)
  - Stars (0.9%)
  - Planets, Asteroids, Comets
- Principle Features:
  - Bulge
  - Halo
  - Disk (Thin, Thick, Gas)
  - Spiral Arms
- Other (Interior)
  - Open Clusters
  - Giant Molecular Clouds
  - HI regions
  - Dust lane
- Other (Exterior)
  - Globular Clusters
  - Tidal tails
  - Polar ring
  - Companion

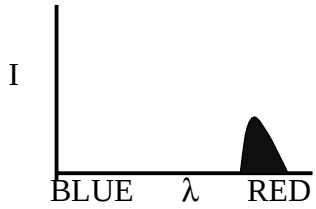


Why are Ellipticals red ?

- A galaxy's light is dominated by the stars
- A Spectrum of a galaxy = Sum of stellar spectra
- Stellar spectra = Black body , I.e., $L \propto T^4$



Hot & Short Lived Star



Cold & Long Lived Star

An Elliptical Galaxy Spectra

- A galaxy spectra is the sum of many stars, if there are few blue stars the overal shape will look red: