



Galaxies in the Universe

More on Galaxies and their
Distribution in Space



The Milky Way [AT Ch 23]

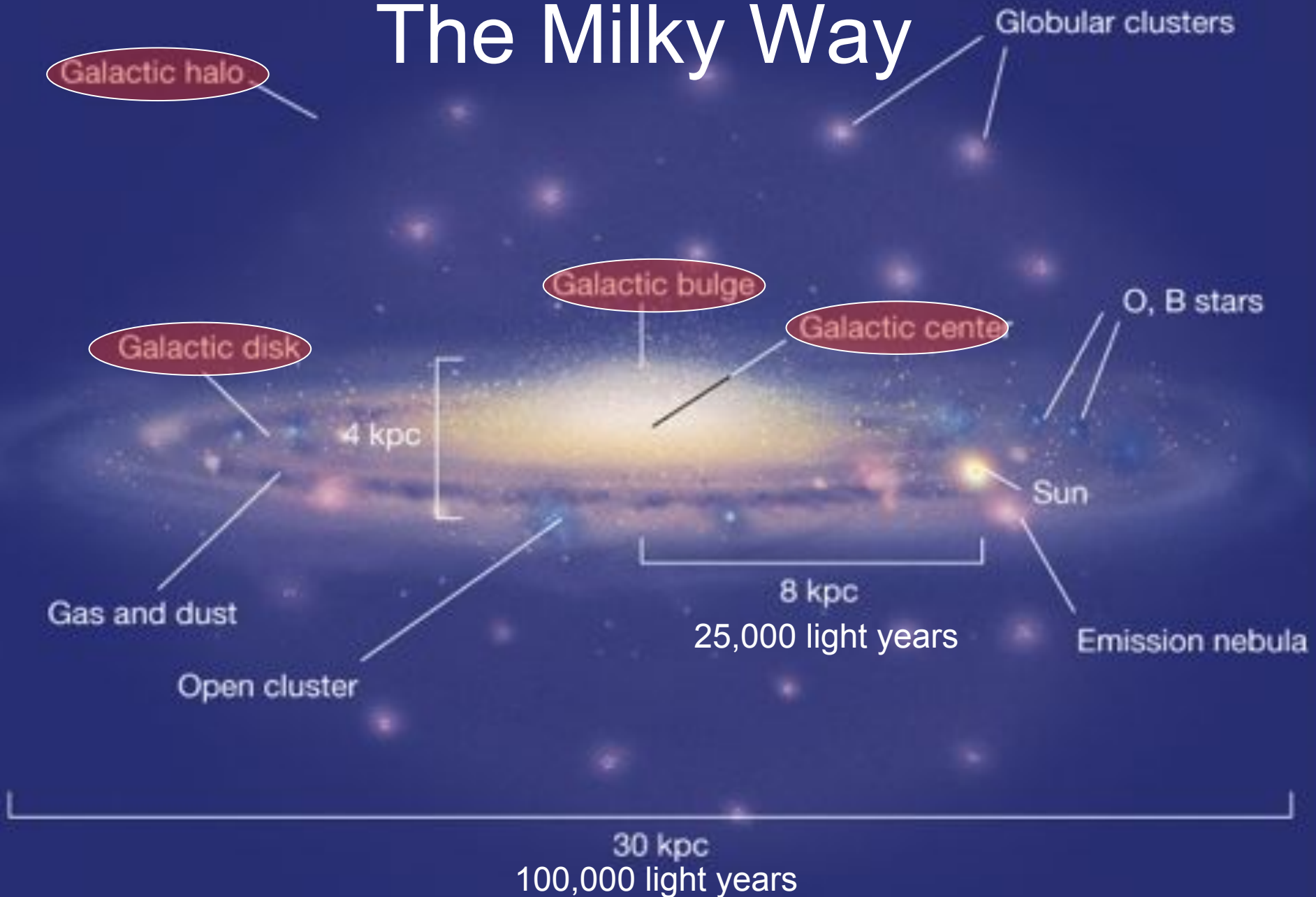
- the Milky Way is a galaxy
- the sun is one of 10-100 billion stars in the Milky Way
- 10^{12} solar masses, mostly “dark matter”
- bright part about 30,000 pc = 100,000 light years across
- the sun is located 8,000 pc = 24,000 light years from the centre

If we could observe the Milky Way from a great distance, it might look a bit like this (edge-on and face-on).





The Milky Way



Galaxies Similar to the Milky Way



Andromeda

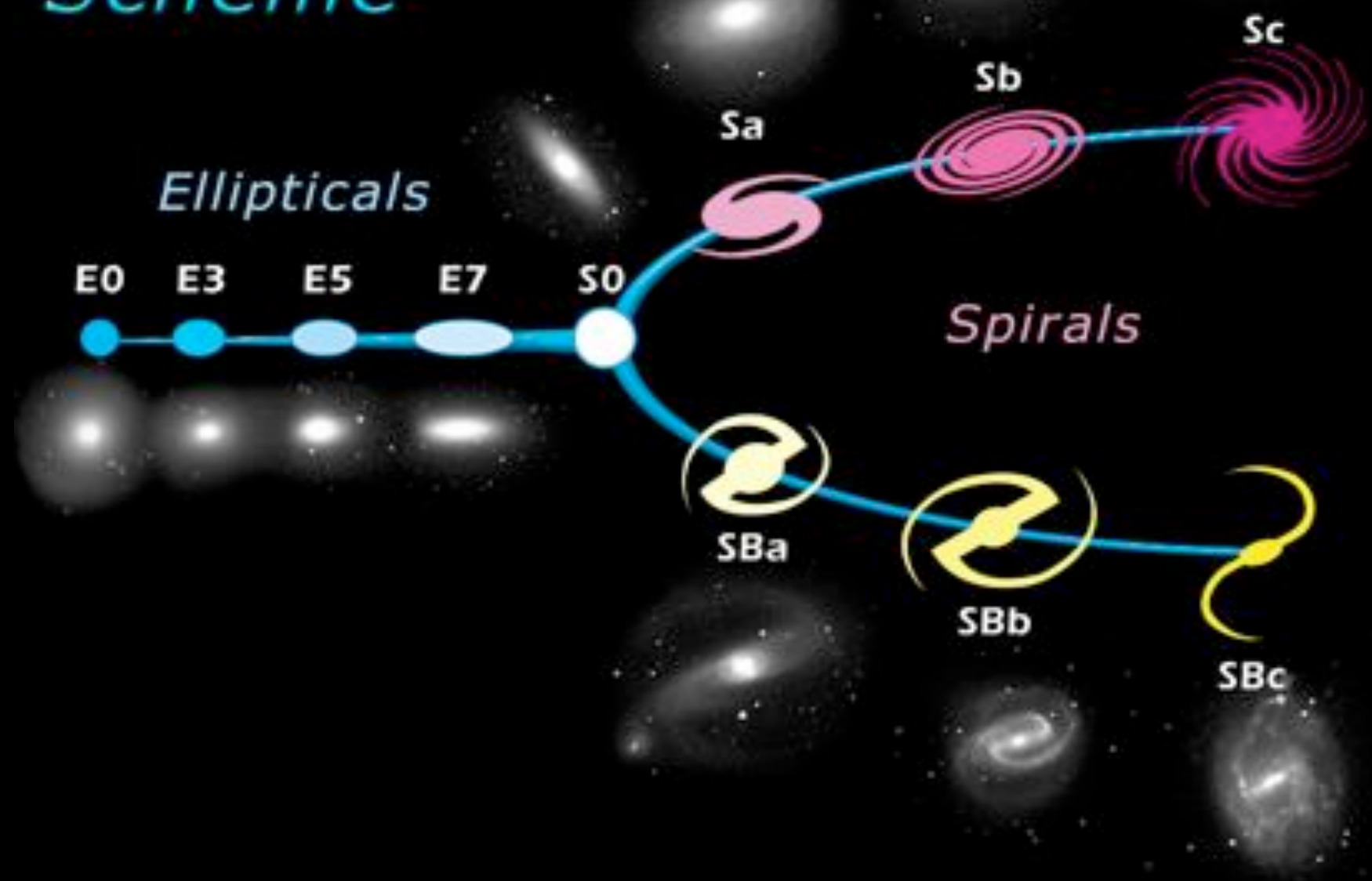
2. Galaxy Classification (24.1)

The Coma Cluster
d=100 Mpc (300Mly)
About $\frac{1}{2}$ deg across (~ 1 Mpc)



Coma cluster of galaxies:
almost every object visible
is a galaxy. There are
many kinds of galaxies!

Edwin Hubble's Classification Scheme



Edwin Hubble
1889-1953



Galaxy Classification (24.1)

Spiral galaxies are classified according to the size of their central bulge and the winding and prominence of their spiral arms. (Hubble)



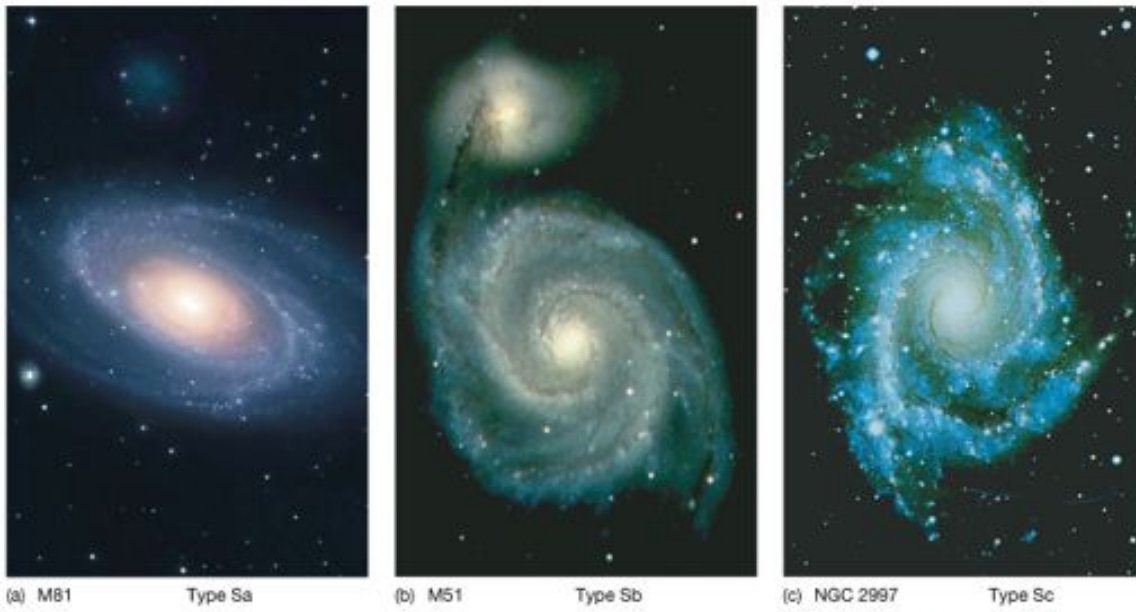
(a) M81 Type Sa



(b) M51 Type Sb



(c) NGC 2997 Type Sc



Spiral Galaxy Classification

Type Sa has the largest central bulge, Type Sb is smaller, and Type Sc is the smallest.

Type Sa tends to have the most tightly bound spiral arms with Types Sb and Sc progressively less tight, although the correlation is not perfect.

The components of spiral galaxies are the same as in our own galaxy: disk, core, halo, bulge, and spiral arms.



Galaxy Classification



Galaxy Classification


The Sombrero galaxy, with its large central bulge, is a type Sa. We cannot see the spiral arms, as they are edge-on.



Appearance depends on wavelength and viewing angle.

Andromeda
Visible light





Andromeda
UV light

Appearance depends on wavelength and viewing angle

Barred Spiral – NGC1300



Galaxy Classification – Barred Spirals



(a) NGC 1300 Type SBa



(b) NGC 1365 Type SBb



(c) NGC 6872 Type SBc



Elliptical Galaxy M87



Galaxy Classification - Ellipticals

Ellipticals are classified according to their shape from E0 (almost spherical) to E7 (the most elongated)



(a) M49 Type E2



(b) M84 Type E3



(c) M110 Type E5



Galaxy Classification - Ellipticals

Ellipticals are classified according to their shape from E0 (almost spherical) to E7 (the most elongated)



E0



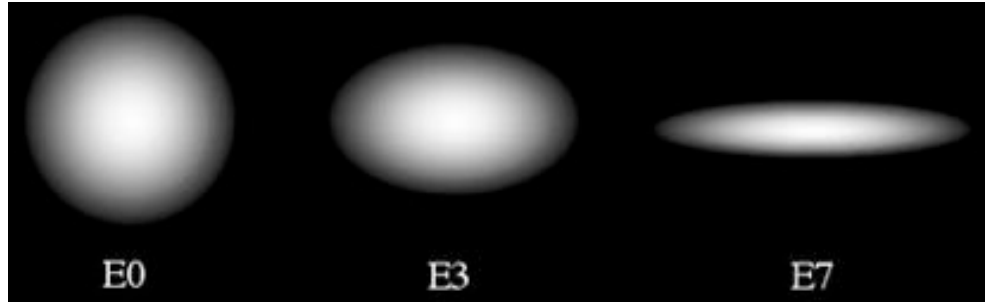
E3



E7

Galaxy Classification - Ellipticals

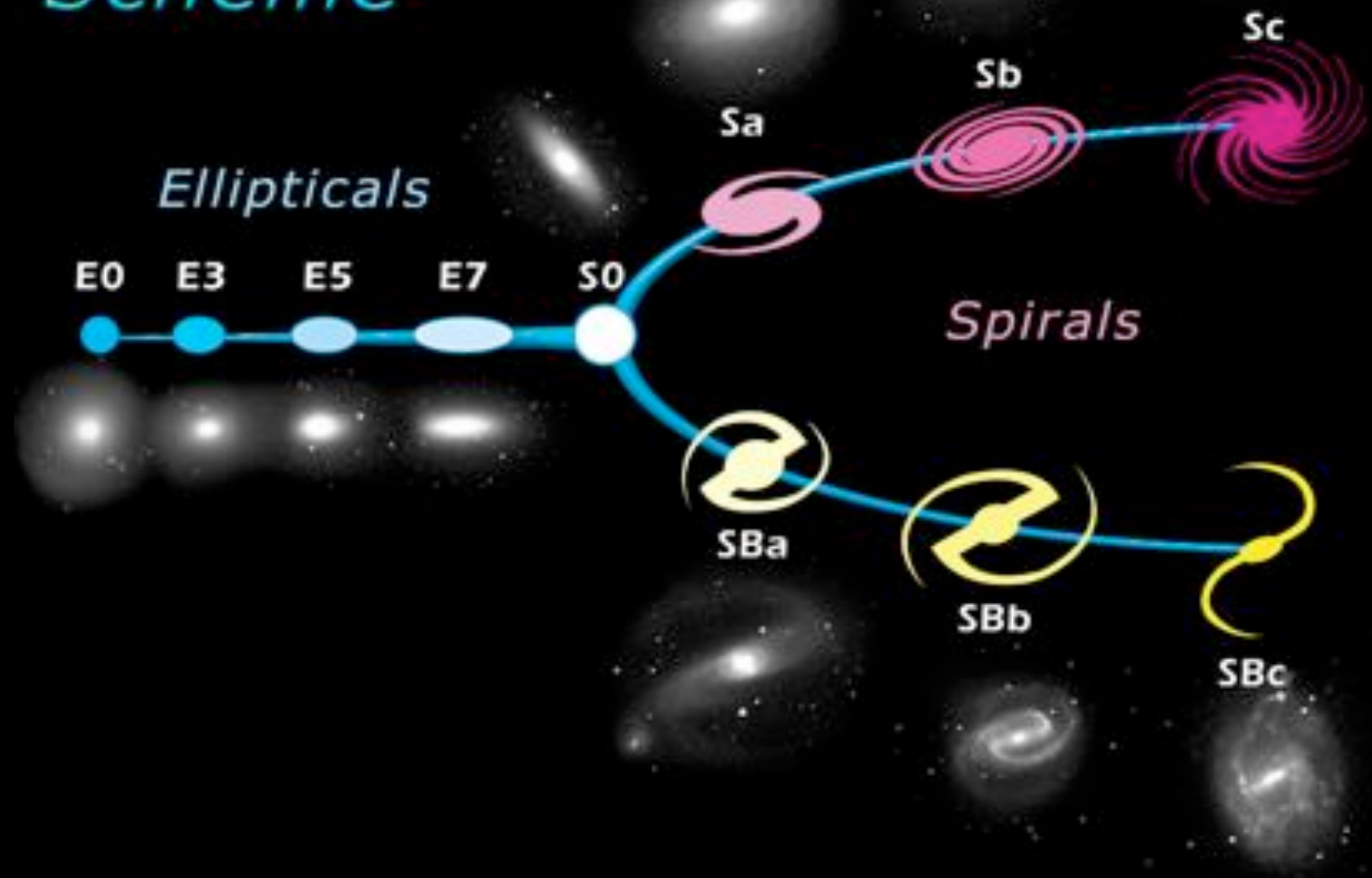
- No spiral arms, no disk
- Many sizes from giant E's to dwarf E's
 - Range of a factor of a million in mass
- Little to no dust or cool gas (some exceptions)
- Lots of hot gas for the big ones
- Old generally



NGC 1316 – a dusty elliptical



Edwin Hubble's Classification Scheme



NGC 4762— an S0 galaxy



M85 – a face-on S0 galaxy



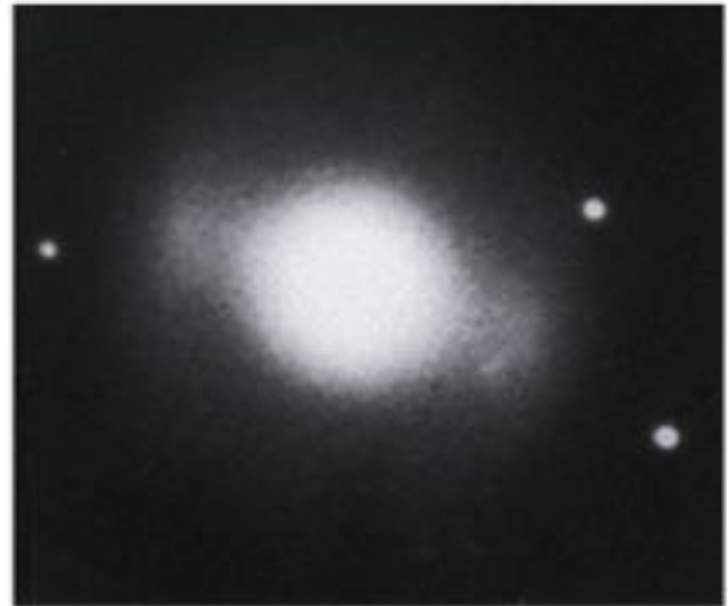
Galaxy Classification – S0

S0 (lenticular) and SB0 galaxies have a disk and bulge, but no spiral arms and almost no interstellar gas



(a) NGC 1201

Type S0



(b) NGC 2859

Type SB0





Irregular Galaxies

Irregular galaxies have a wide variety of shapes. The **Large and Small Magellanic Clouds** are close neighbors to our own Milky Way.

Large Magellanic Cloud



Small Magellanic Cloud



Galaxy Classification

Here are several other irregular galaxies: AM 0644-741 and its neighbors on the left, and NGC 1569 on the right.



(a) AM 0644-741

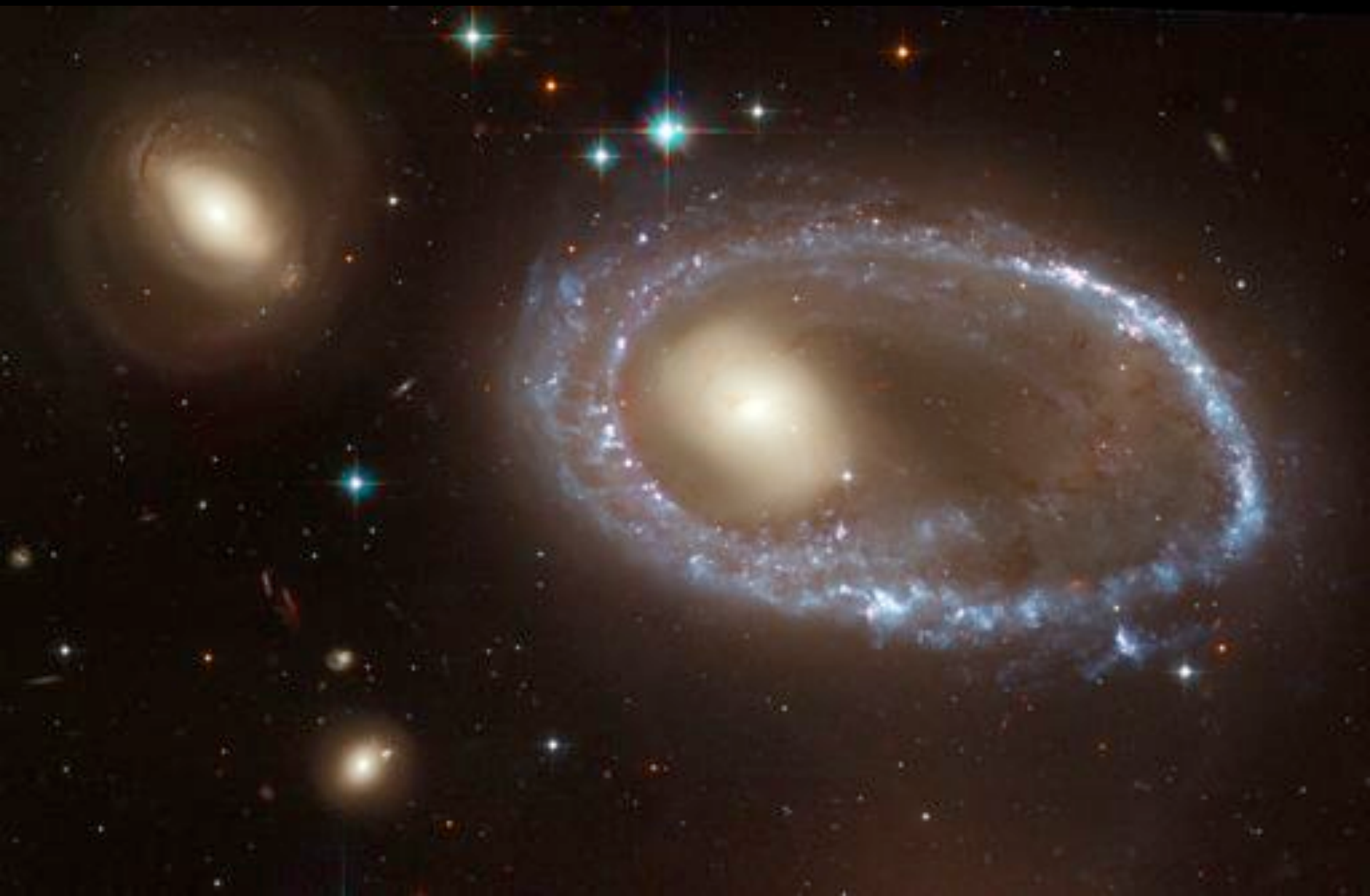


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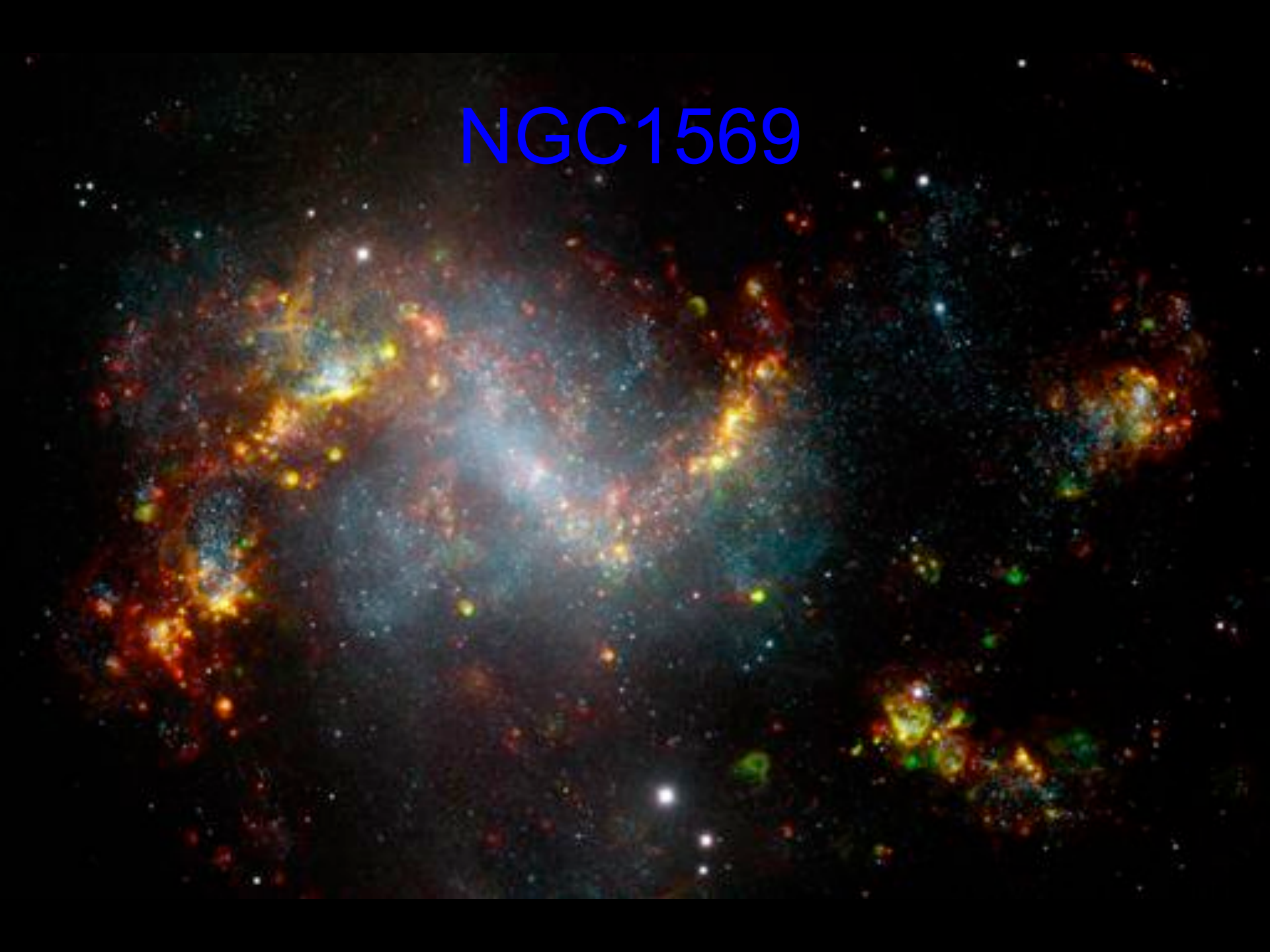
(b) NGC 1569





AM 0644-741

NGC1569





NGC 5128 (Cen A)





Hubble's Galaxy Classification

A summary of galaxy properties by type

| TABLE 24.1 Galaxy Properties by Type | | | |
|--|--|---|---|
| | Spiral/Barred Spiral (S/SB) | Elliptical* (E) | Irregular (Irr) |
| Shape and structural properties | Highly flattened disk of stars and gas, containing spiral arms and thickening central bulge. Sa and SBa galaxies have the largest bulges, the least obvious spiral structure, and roughly spherical stellar halos. SB galaxies have an elongated central "bar" of stars and gas. | No disk. Stars smoothly distributed through an ellipsoidal volume ranging from nearly spherical (E0) to very flattened (E7) in shape. No obvious substructure other than a dense central nucleus. | No obvious structure. Irr II galaxies often have "explosive" appearances. |
| Stellar content | Disks contain both young and old stars; halos consist of old stars only. | Contain old stars only. | Contain both young and old stars. |
| Gas and dust | Disks contain substantial amounts of gas and dust; halos contain little of either. | Contain hot X-ray emitting gas, little or no cool gas and dust. | Very abundant in gas and dust. |
| Star formation | Ongoing star formation in spiral arms. | No significant star formation during the last 10 billion years. | Vigorous ongoing star formation. |
| Stellar motion | Gas and stars in disk move in circular orbits around the galactic center; halo stars have random orbits in three dimensions. | Stars have random orbits in three dimensions | Stars and gas have highly irregular orbits. |
| * As noted in the text, some giant ellipticals appear to be the result of collisions between gas-rich galaxies and are exceptions to many of the statements listed here. | | | |

What kind of
galaxy is the
Andromeda
Galaxy?

- 
- A. Spiral – Sa or Sb
 - B. Spiral – Sc
 - C. Elliptical
 - D. S0
 - E. Irregular