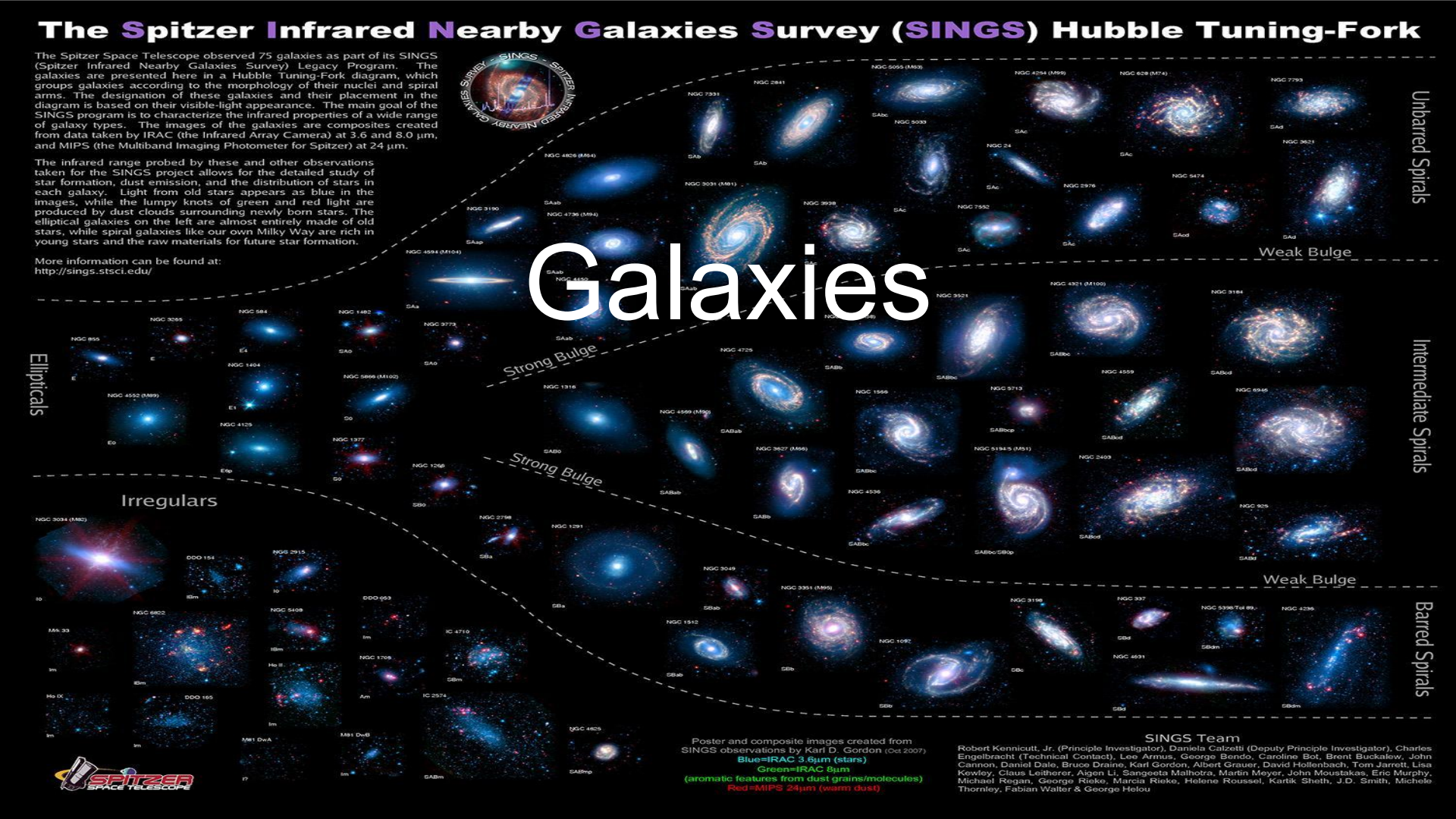
The Spitzer Infrared Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork



Spiral galaxies

- Blue to white in color—young stars
- Spiral arms with halo and bulge
- Medium to large in size

Spiral galaxies

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Spiral galaxies

Spiral galaxies

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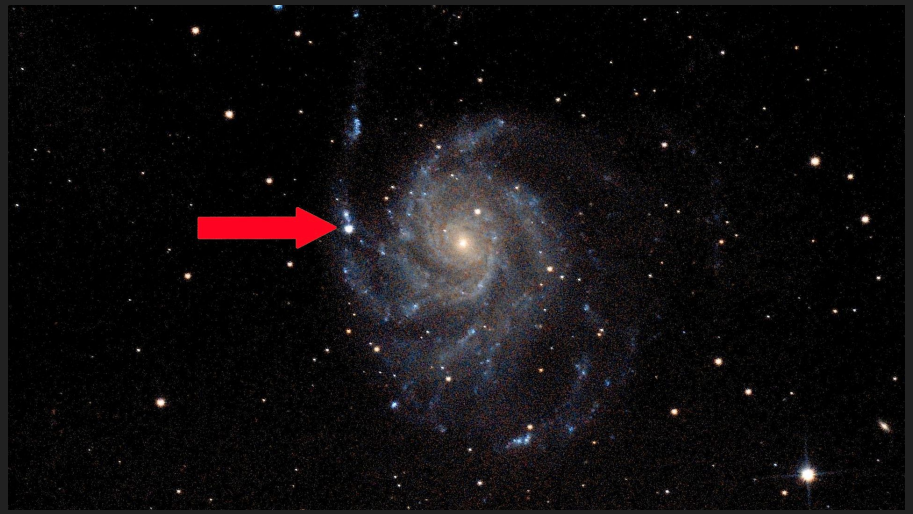
Spiral galaxies

- Young stars means massive stars
- We can see supernovae in distant spiral galaxies
- Type Ia Supernovae are used as standard candles to find distances (more on this later)



Why do we see spiral arms?

- They are easily seen because the spiral arms contain numer bright O and B stars
- Luminous stars in the spiral arms illuminate the dust in the arms
- Stars however are evenly distributed throughout the disk
    - They are old and dim

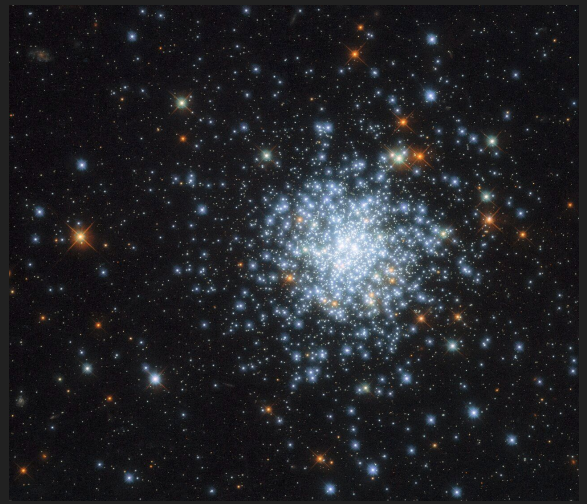
Poll Everywhere

1. A giant gas cloud enters the spiral arm of a galaxy, which makes it collapse and triggers star formation. The cloud forms a large cluster of many stars, which all reach the main sequence at about the same time. About 50 million years later, the cluster of stars leave the spiral arms, which main sequence stellar types still exist in the star cluster?

a. O, F, G, and M stars (no B, A or K stars)
b. O and B stars (no A, F, G, K, or M stars)
c. B, A, and K stars (no O, F, G, or M stars)
d. A, F, G, K and M stars (no O or B stars)

When poll is active respond at **PollEv.com/nikhilpatten355**

Send **nikhilpatten355** to **22333**

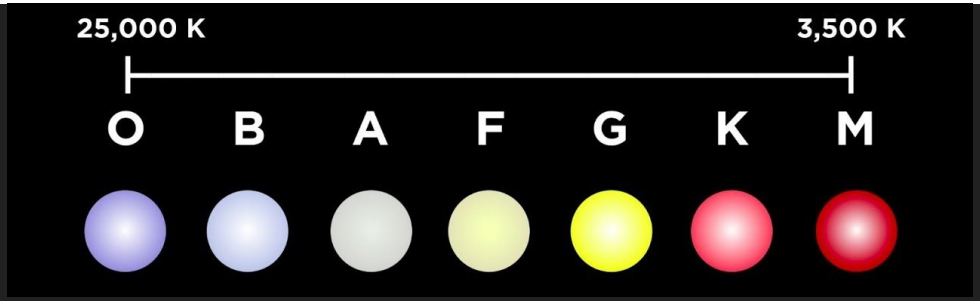


Poll Everywhere

results

Poll Everywhere

Mass (solar masses)	Time (years)	Spectral type
60	3 million	O3
30	11 million	O7
10	32 million	B4
3	370 million	A5
1.5	3 billion	F5
1	10 billion	G2 (Sun)
0.1	1000s billions	M7



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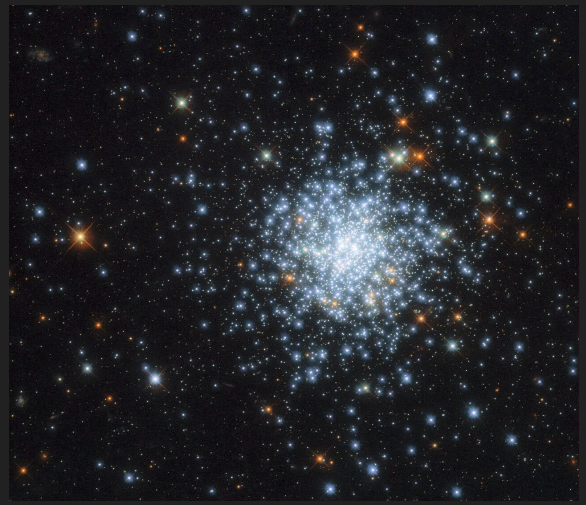

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Viewing Angle Effects

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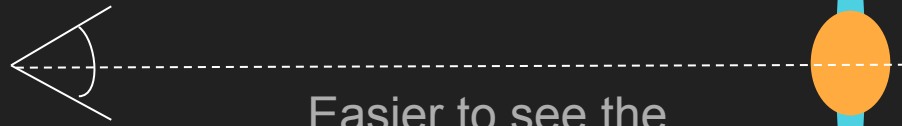
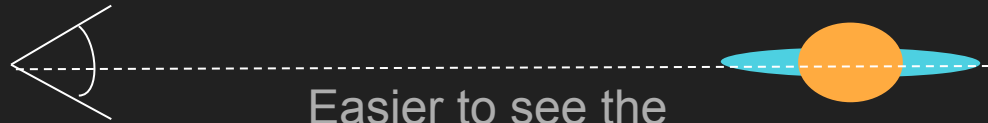
Face-on

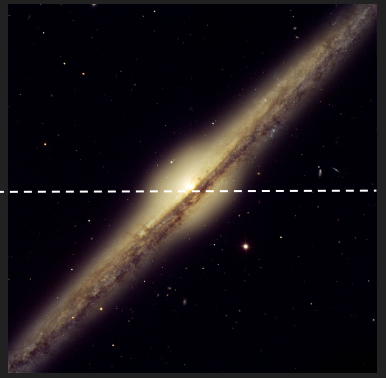


Easier to see the spiral arms

Edge-on



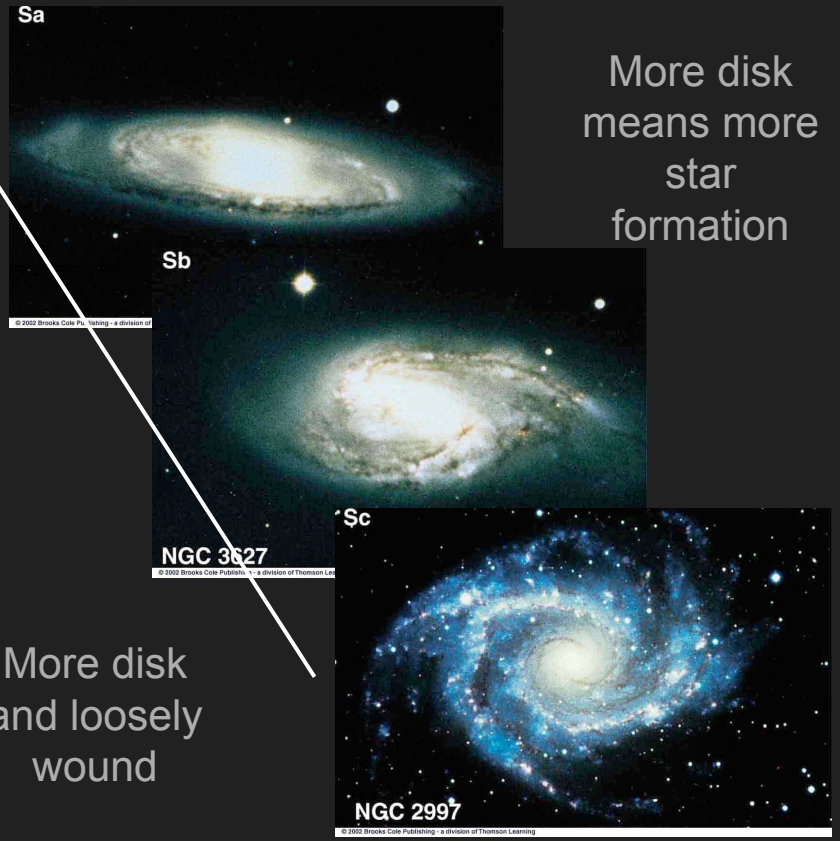
Easier to see the dust in the disk and the bulge



Spiral subclassifications

- Spiral galaxies are classified by the among of bulge and how tightly wound the arms are
- These designations are Sa, Sb, and Sc, in order of decreasing bulge

More bulge and tightly wound



More disk means more star formation

More disk and loosely wound

Barred Spirals

- About 20% of spirals are barred spirals
- The spiral arms branch off from a straight bar of stars that passes through the central bulge
- They are designated with SB rather than S
- Subclasses of barred spirals the same as regular spirals: SBa, SBb and SBc

The Winding Problem

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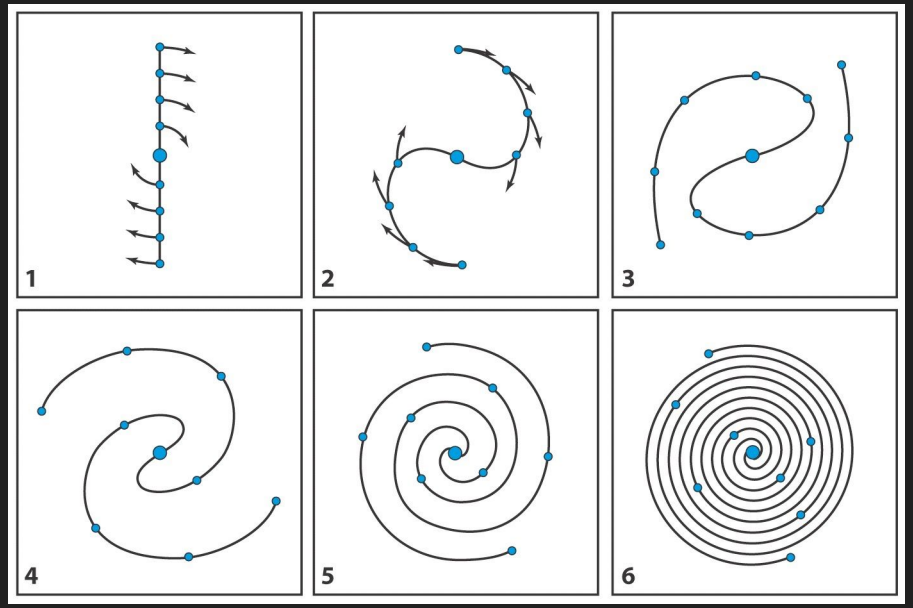
- If the spiral arms are stationary, they should wind up and disappear as stars orbit
- We observe many spiral galaxies
- Spiral arms are not a permanent collections of stars
- Stars, gas and dust pass through the spiral arms. Spiral arms are standing density waves



Density waves

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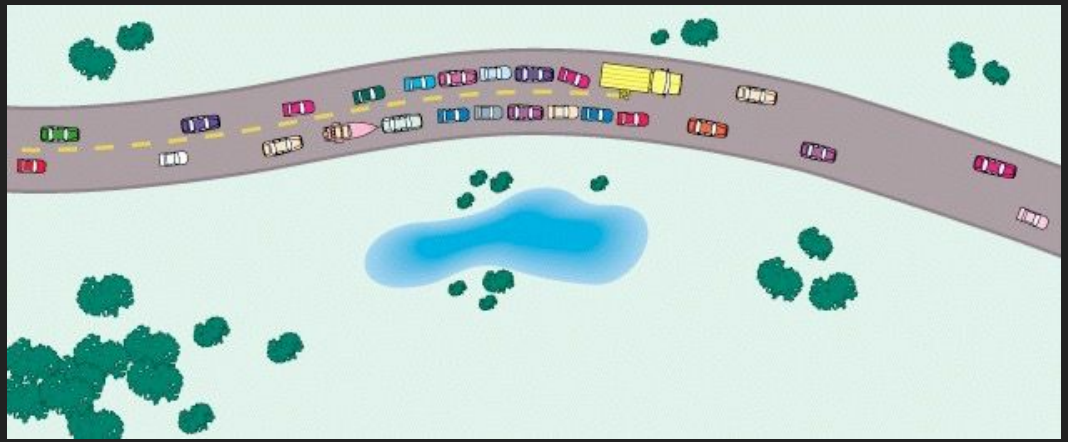
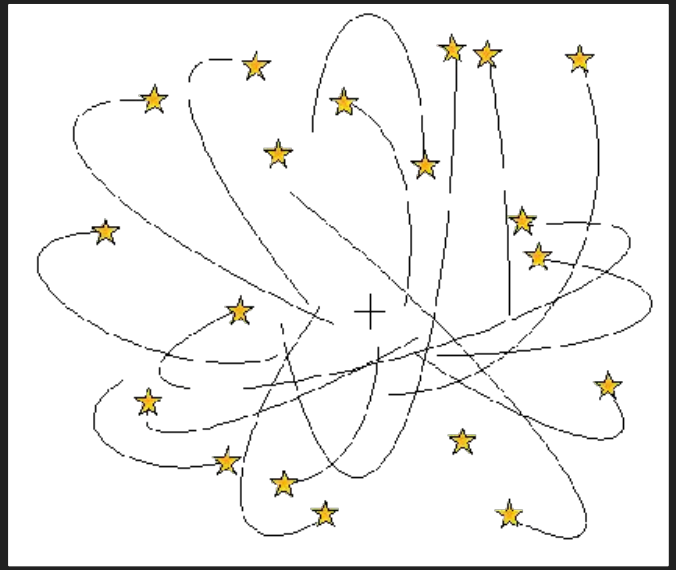
- Spiral arms are caused by waves in the gas and dust
- Makes the gas clump
- Like an interstellar traffic jam
- Increased density of gas and dust sparks formation of new O- and B-type stars that illuminate the spiral arms

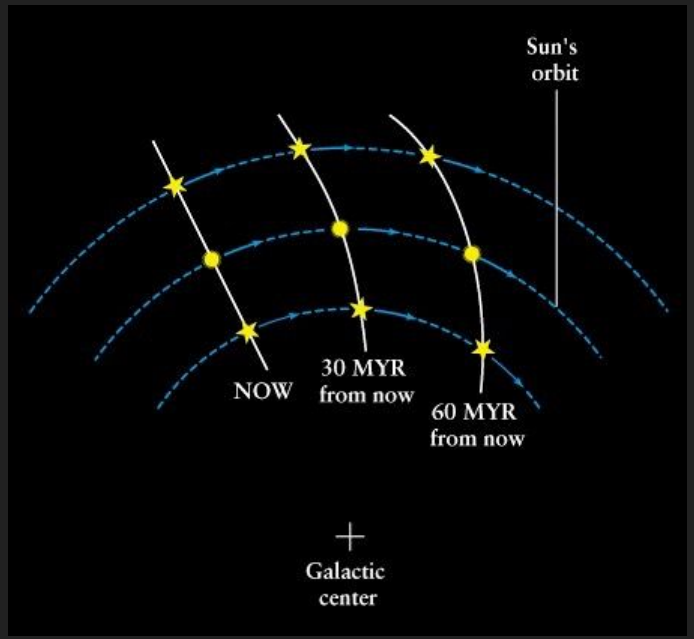


Stellar orbits



Elliptical or spiral bulge stellar orbits

Spiral disk stellar orbits



Irregular Galaxies

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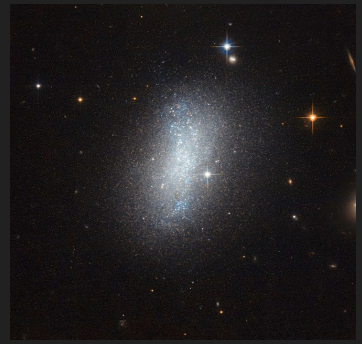
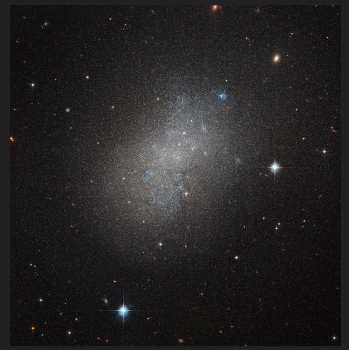
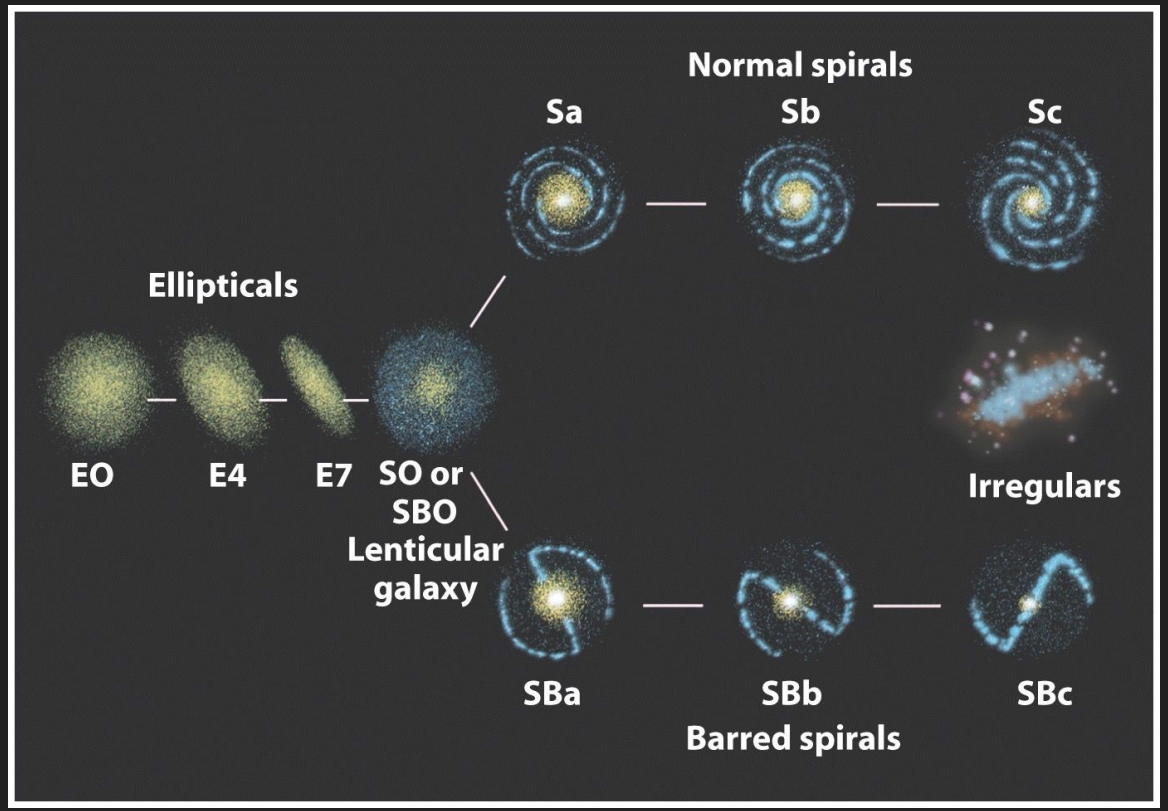
- Chaotic systems of stars
- Two most prominent examples: The Magellanic Clouds
  - Two of the Milky Way's satellite galaxies
- Generally smaller than most galaxies
  - Thousands to tens of times smaller than the Milky Way
- No disk, no elliptical structure
- Dominated by young, blue stars
- Often interact with nearby massive galaxies



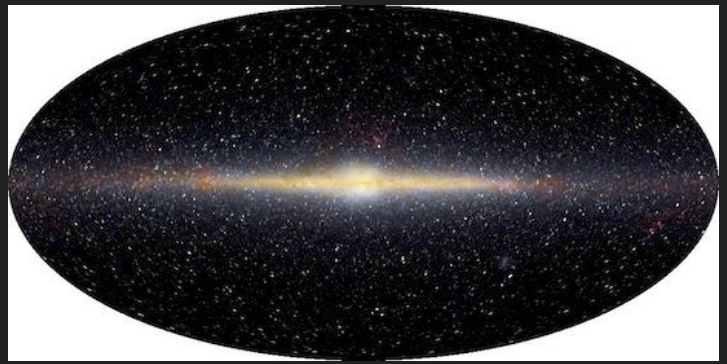


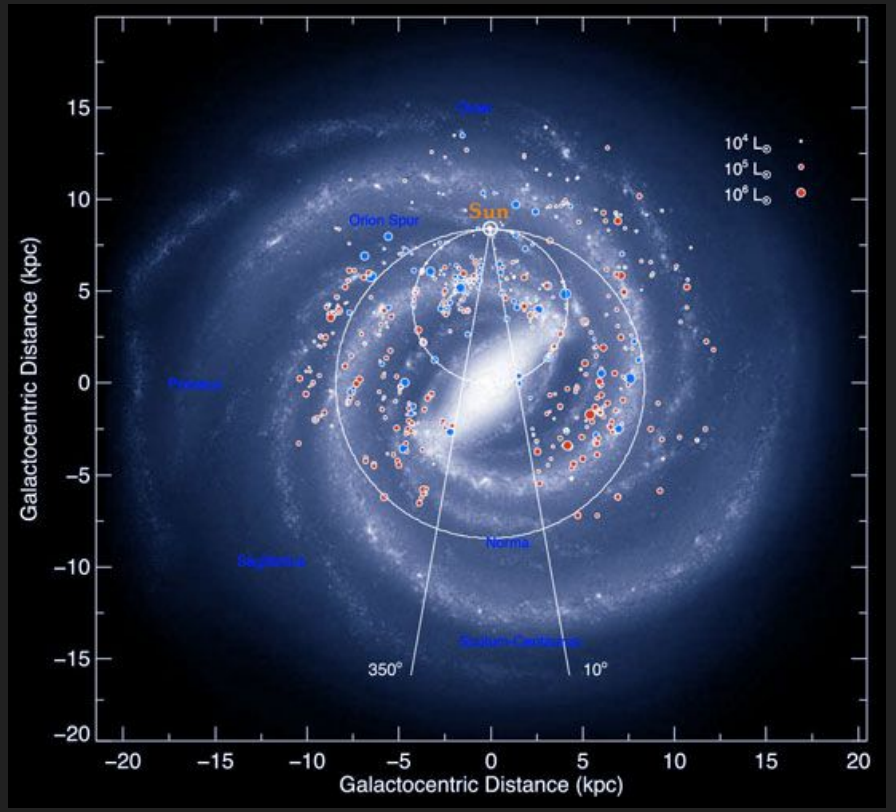
Hubble's Tuning Fork



The Milky Way

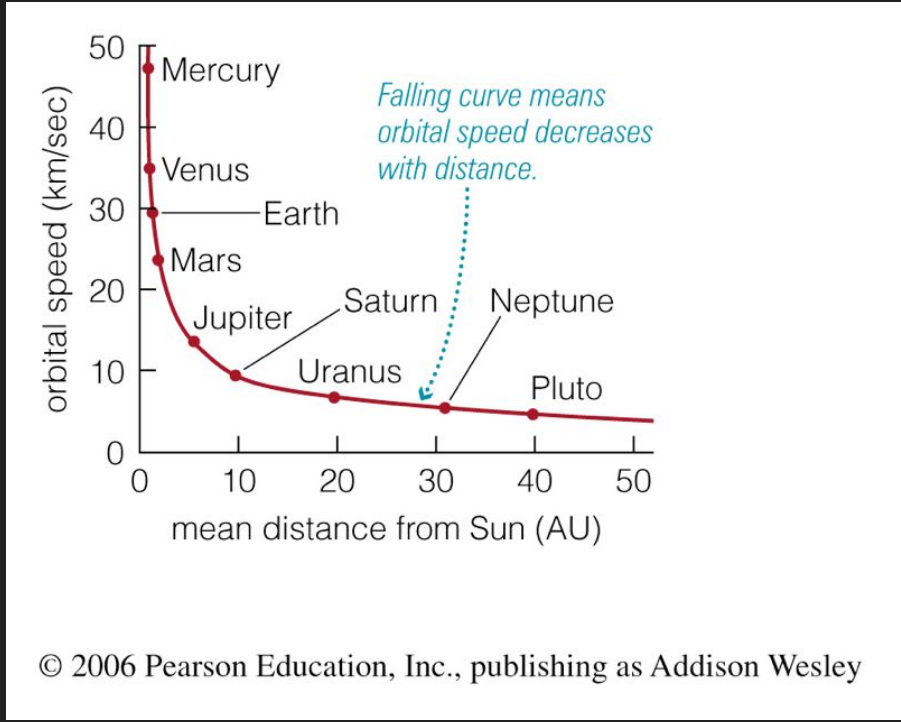
- The Milky Way is a spiral galaxy
- Probably SBb





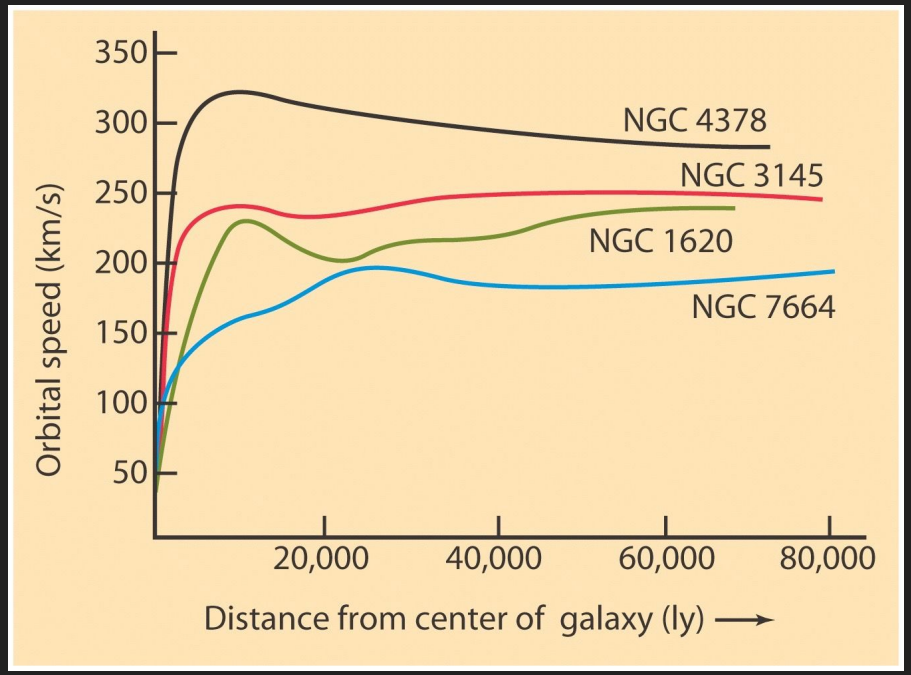
Rotation Curves

- The speed of orbiting bodies versus distance tells us about how mass is concentrated in a system
- Call this a rotation curve
- Rotation curve for the Solar System drops off exponentially, the mass is concentrated at the center



Rotation Curves

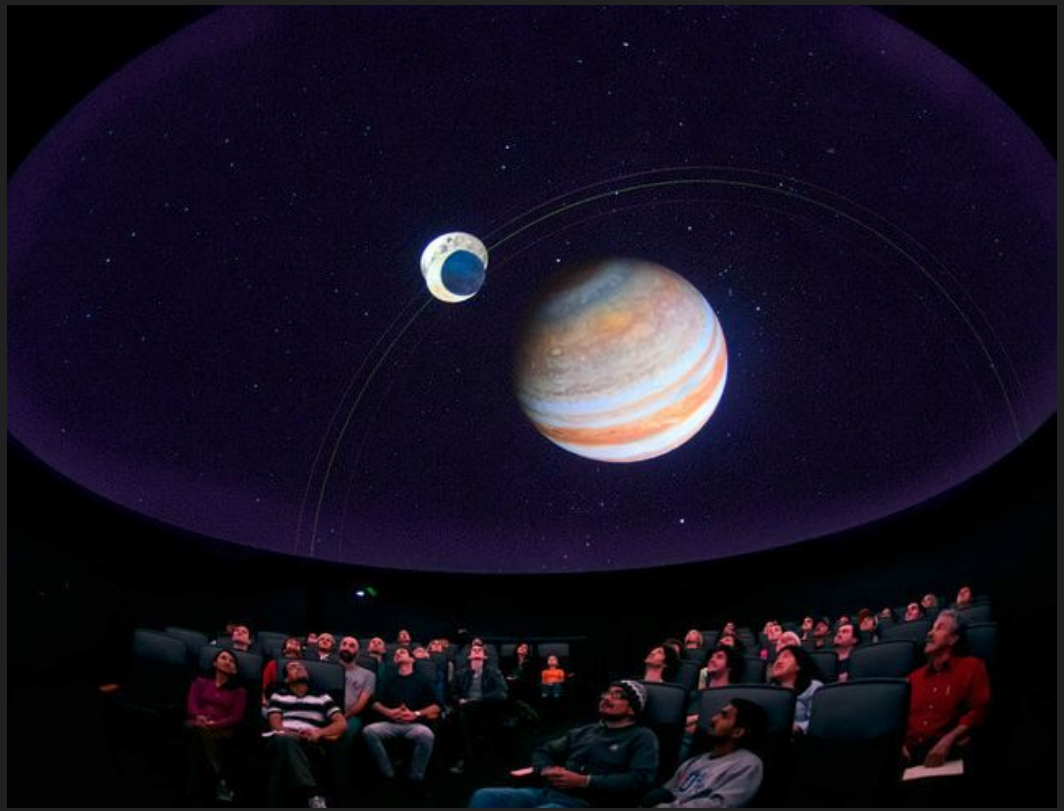
- When we measure the speeds of stars in our's and other galaxies, and use Kepler's Laws, we find something different
- Galaxies have **flat** rotation curves
- As we move out from the center, the mass increases exponentially
- Stars decrease as we move out
- Call this unobserved matter "dark matter"



Announcements

- Meet in planetarium next class
- Homework 8 due Friday

Meet in Planetarium Next Class



Next time

- Galaxies II