

### Last time: Our Milky Way Galaxy

- the structure of the Milky Way - nucleus, halo, and spiral arms
- we know the mass of the Milky Way by mapping the orbits of stars, clusters, and clouds around the galactic center
- ours is a 'spiral' galaxy with spiral arms that are shaped by complex dynamics



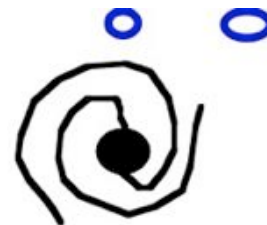
### Today: Galaxy Morphologies and Distances

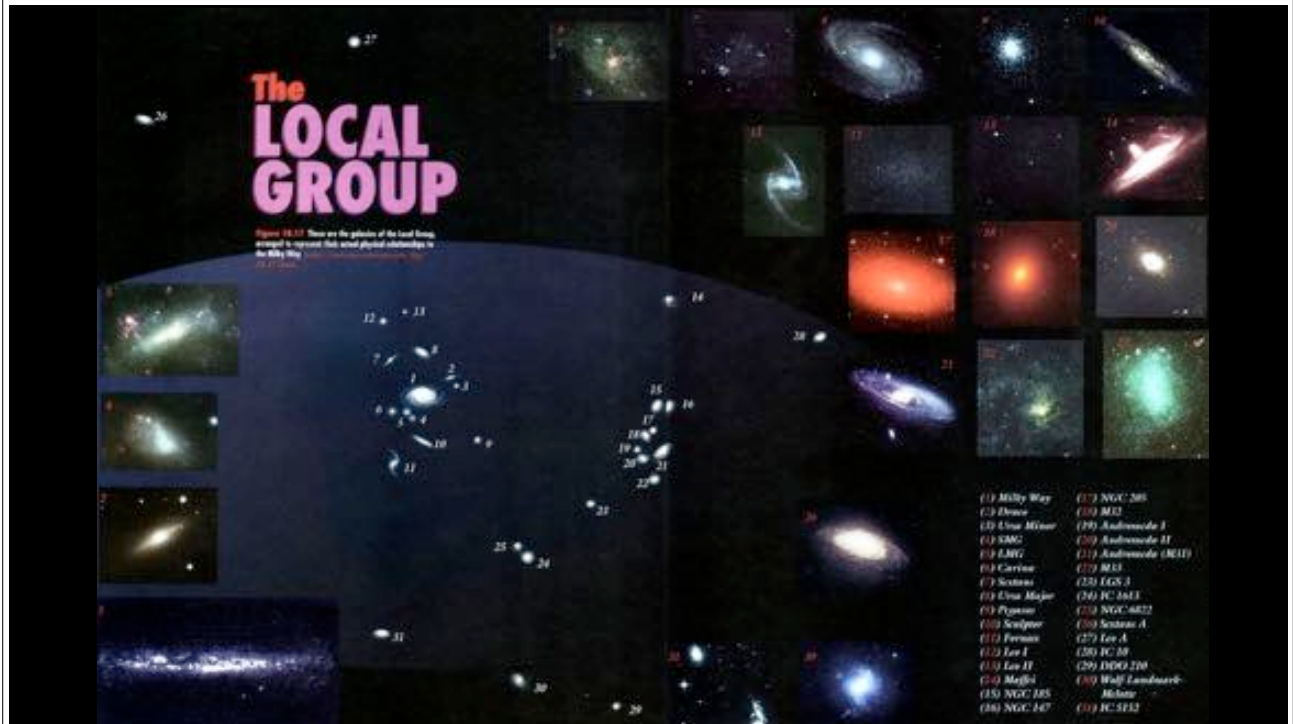
- dozens of galaxies lie near the Milky Way in our "local group"
- Spirals come in many forms, but most galaxies are not spirals, but ellipticals or irregular
- Galaxy mergers and collisions are responsible for making ellipticals and irregulars from spirals

## The Milky Way's Neighborhood: **the Local Group**

~ 25 Galaxies within 1,000,000 pc of the MW

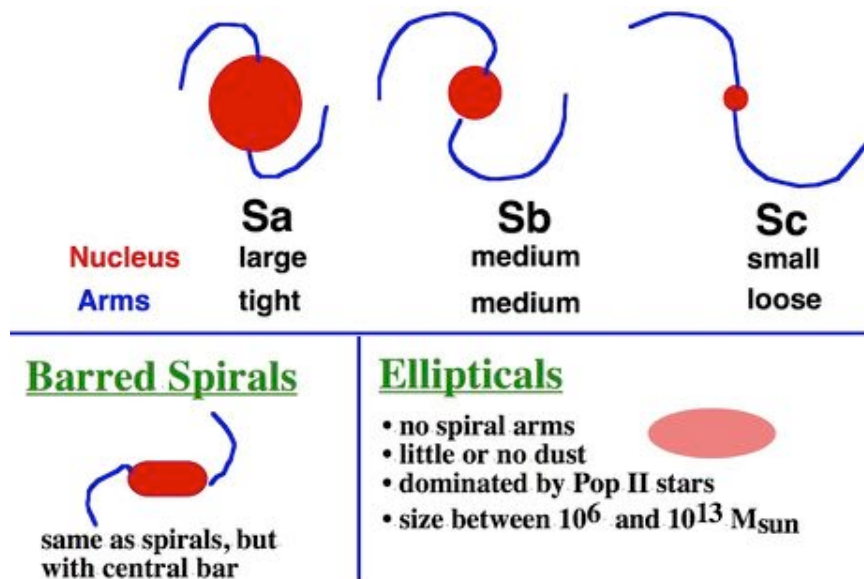
- **The Magellanic Clouds**
  - Small Magellanic Cloud, Large Magellanic Cloud
  - diameters ~ 10, 20 kpc
  - masses ~  $2 \times 10^9 M_{\text{sun}}$
  - Value of the Magellanic Clouds
    - close enough to see clearly
    - far enough so all components are ~ same distance from us
- **Dwarf Ellipticals**
  - sparse, faint, and hard to see
  - masses ~  $10^{5-7} M_{\text{sun}}$
- **Andromeda:** big brother to MW,
  - 670 kpc away, 35 kpc across
  - an "outside" view of MW: stars, clusters, companions



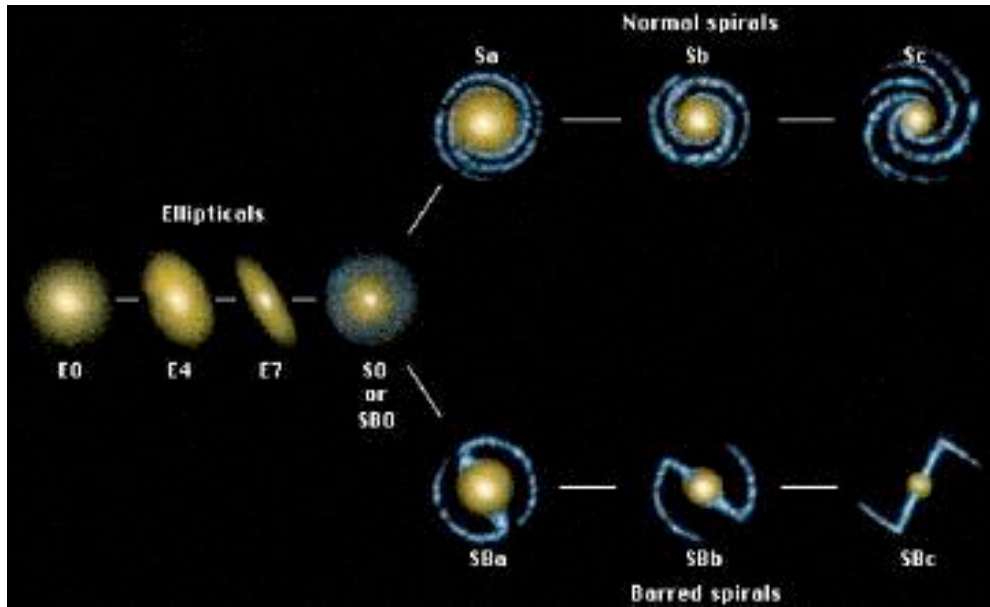




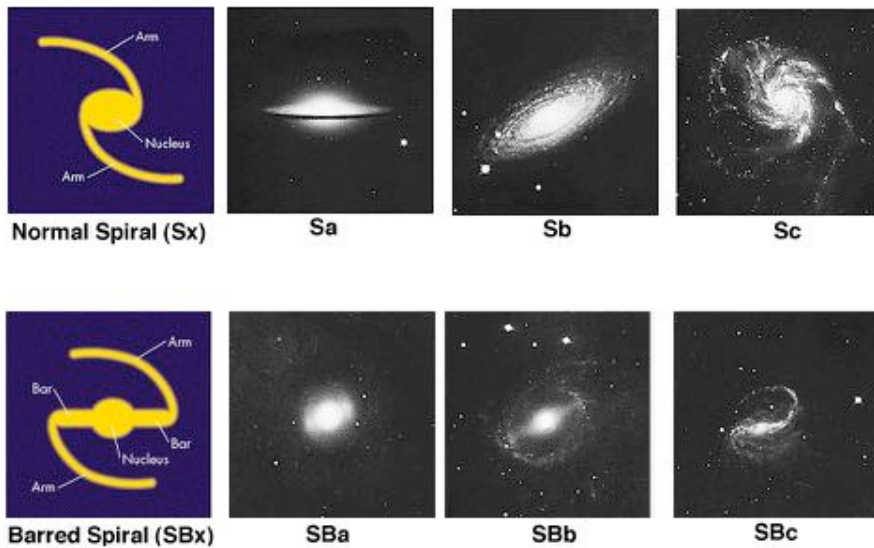
## Classifying Galaxy Types

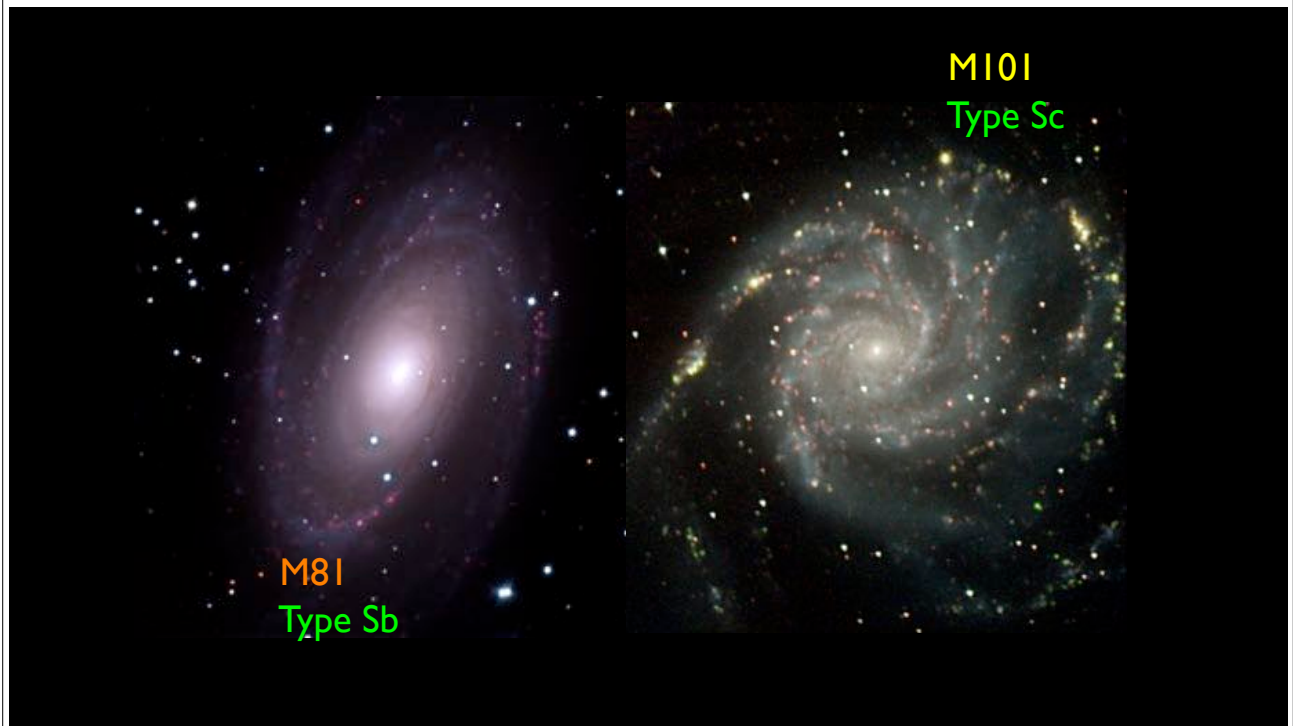


# the “Hubble Tuning Fork”



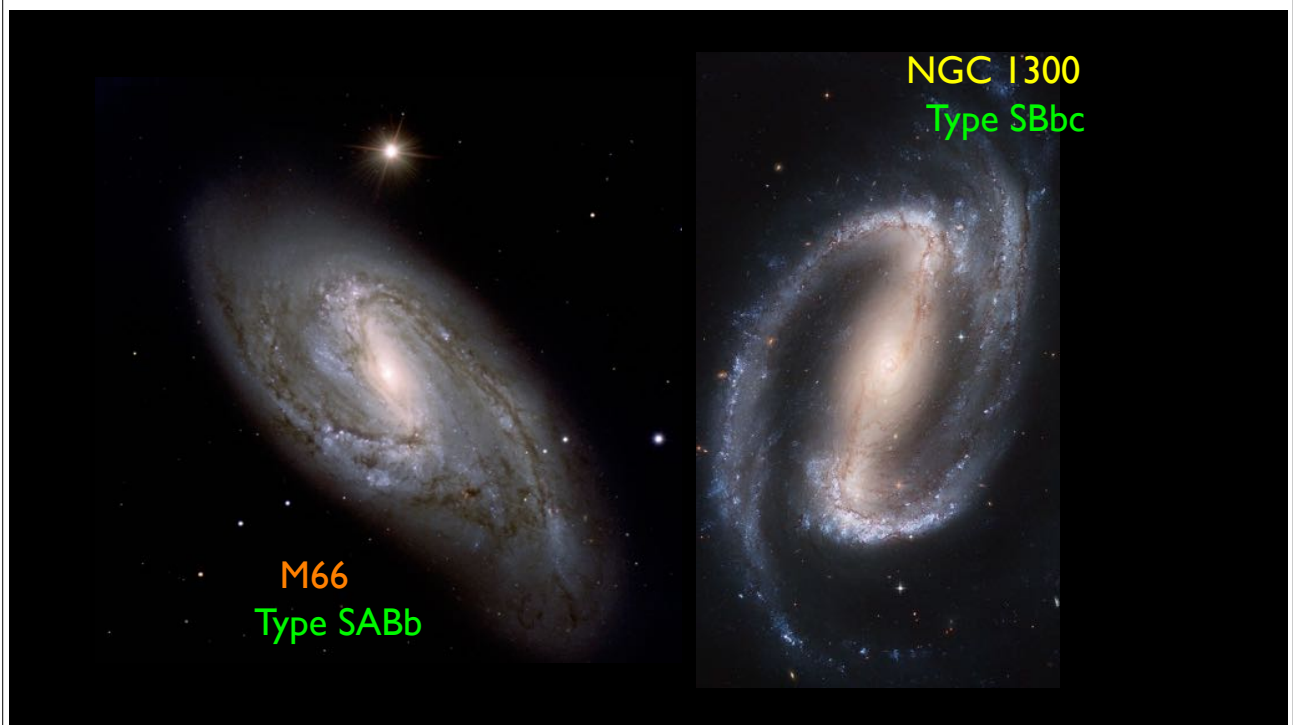
# Classifying Spiral Galaxies





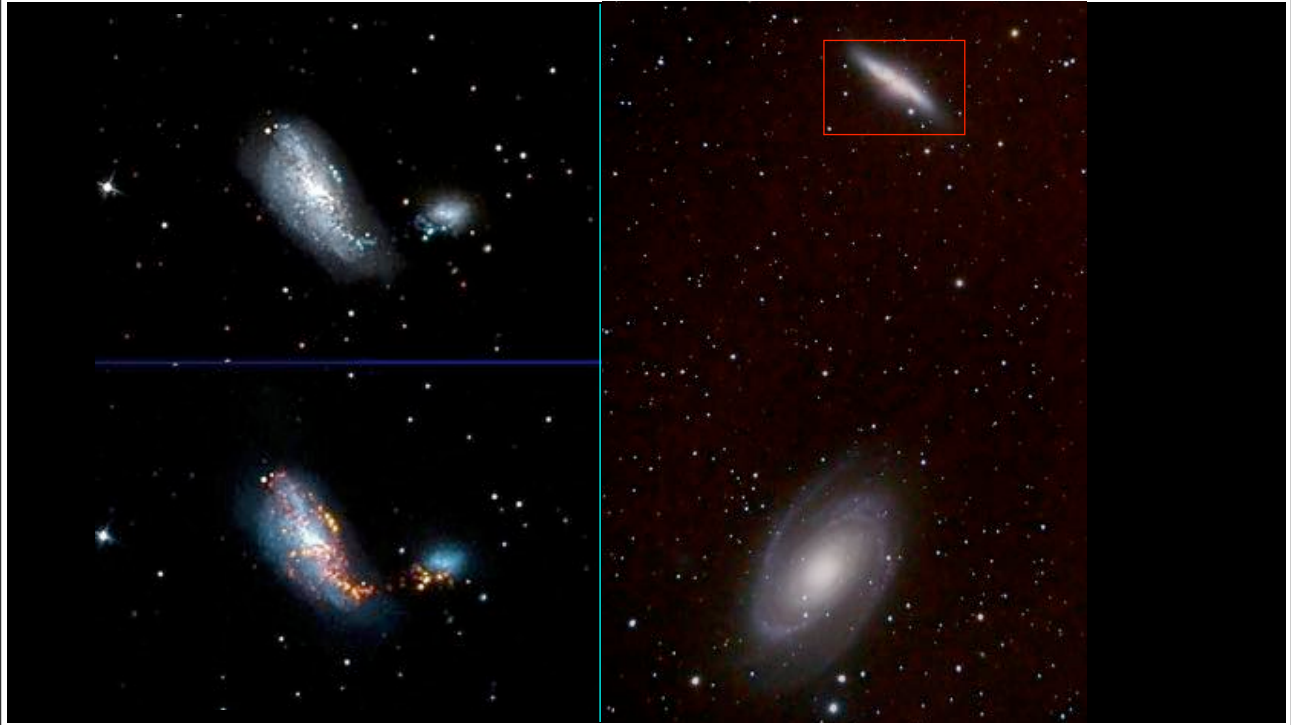
M81  
Type Sb

M101  
Type Sc



M66  
Type SABb

NGC 1300  
Type SBbc



# Today's challenge: your turn!

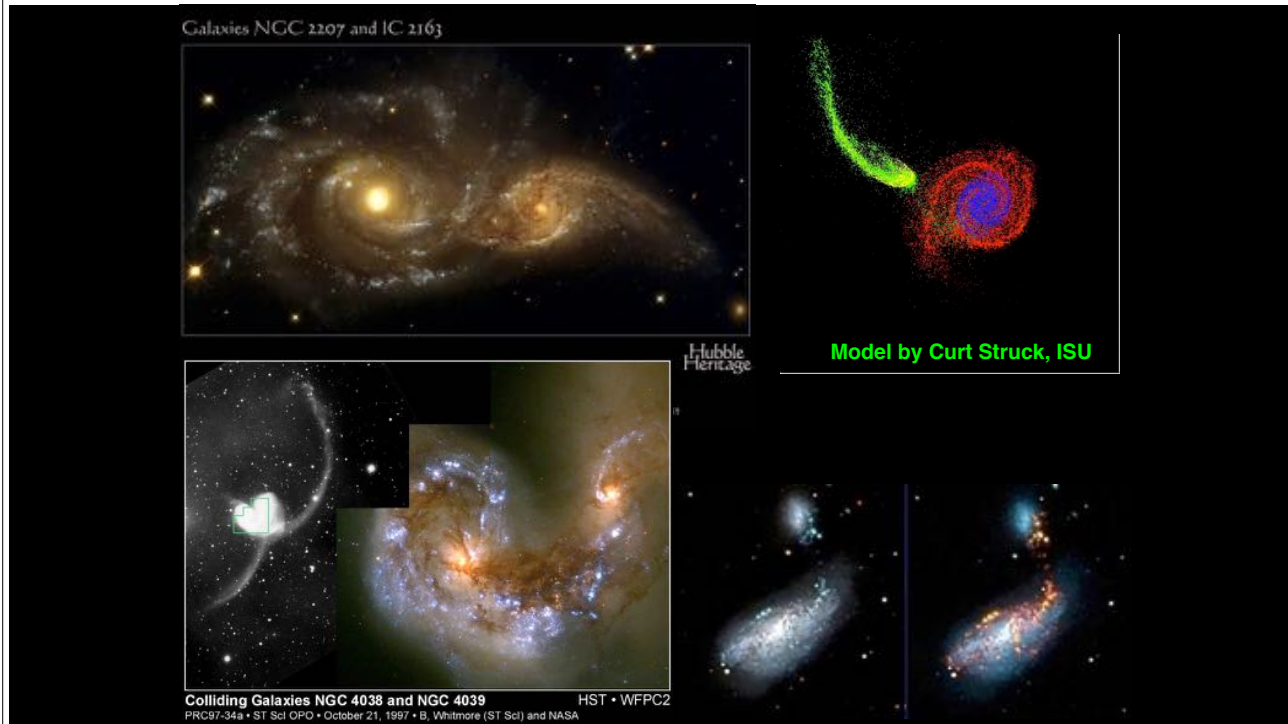


## General galaxy characteristics

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	<b>Spirals</b>	<b>Ellipticals</b>	<b>Irregulars</b>
<b>Mass (<math>M_{\text{sun}}</math>)</b>	$10^9$ - $10^{12}$	$10^6$ - $10^{13}$	$10^8$ - $10^{11}$
<b>L (<math>L_{\text{sun}}</math>)</b>	$10^8$ - $10^{11}$	$10^6$ - $10^{11}$	$10^7$ - $10^{11}$
<b>M/L</b>	2-10	10-20	1-10
<b>D (kpc)</b>	5-50	2-200	1-10
<b>Stars</b>	Pop I and II	Pop II	Pop I and II
<b>Spectrum</b>	A to K	G to K	A to F
<b>ISM</b>	gas, dust	little gas	gas, dust
<b>Enviorns</b>	small groups	rich clusters	low density
<b>Numbers</b>	20%	55%	25%

**+ Dark Matter**



## Galaxy Interactions

- Environments of galaxies
  - **spirals** found in **sparse groups** or isolation
  - **ellipticals** dominate **crowded places** (i.e. clusters)
- We see many examples of interacting (“colliding”) galaxies
  - stars (almost) never collide
  - gas clouds merge, interact, inducing star formation
  - tidal distortions
- **Elliptical Galaxies form when spiral (or other types) of galaxies collide**
  - collisions strip and/or use up gas
  - collisions may “feed the monster”



# Milky Way - Andromeda





Illustration Sequence of the Milky Way  
and Andromeda Galaxy Colliding

NASA, ESA, Z. Levay and R. van der Marel (STScI), T. Hallas, and A. Mellinger • STScI-PRC12-20b

## Galaxy interactions and their morphology

- Spiral (disk) galaxies:
  - usually found in isolation, or small groups
  - retain dust, gas, and have active star formation
- Elliptical galaxies:
  - often found in regions of high galaxy density
  - little/no dust or gas - star formation not happening
  - mostly low-mass, red stars
- Dwarf galaxies are low-mass analogs of Spirals (mostly)
- **Conclusions:**
  - spiral galaxies are 'mature' normal state of galaxies
  - elliptical galaxies form from galaxy collisions
  - evolution of galaxies are the reason for different galaxy types

## Galaxy Distances:

### The Cosmic Distance "Ladder"

