AST 104
Milky Way Galaxy
Prof. Ken Nagamine
UNLV
Our Milky Way Galaxy

- Above average size Spiral Galaxy
- More than 100 billion stars
- Galaxy Components:
  - Bulge
  - Disk
  - Halo
• **Bulge** – Center of the galaxy
• **Disk** – Thin disk around bulge
• **Halo** – Spherical distribution of stars surrounding the galaxy

$kpc = \text{kiloparsec} = 10^3 \text{ pc}$
Which is our view of the Milky Way?
Which is our view of the Milky Way?

A is what we see from Earth inside the Milky Way, while B is what the Milky Way “might” look like if we were far away looking back at our own galaxy from some other galaxy.
The Milky Way is made of gas, dust and stars. Most of the gas, dust and stars are located in the disk.

There are between 100-400 billion stars in the Milky Way. All the stars you can see in the sky with your eye are in our own Galaxy.
Where in the disk are we?
To answer our question, we want to imagine being able to look at the Galaxy from above or below, where dust is not a problem!

If we look at the Galaxy from an edge-on view across the disk, dust is in the way of seeing across the galaxy.
• Globular clusters (~$10^6$ stars that were all born from the same cloud at the same time) are distributed uniformly around the Milky Way.

• The center of this distribution is located at the galactic center.
In 1917, **Harlow Shapley** plotted the distribution of globular clusters in the Milky Way in an effort to learn our location within the Galaxy.

The center (maximum) of the distribution of globular cluster shows us where the center of the galaxy is.
What do the disks of other spiral galaxies look like? **M83** observed in both visible light and radio wavelengths.
Although the visible light from stars is blocked by dust we can still observe the disk of our Galaxy by looking at Doppler shifted radio wavelength light emitted from hydrogen gas.

The Milky Way galaxy observed using Doppler shift and radio wavelengths
Observed spiral arms of Milky Way

- 4 major spiral arms
- We are here
• We know **we are not** in the center of our solar system

• AND we know **we are not** in the center of our Galaxy

• (We are also **NOT** in the center of the Universe)

• We are located in the disk about **25,000 ly (~8 kpc)** out from the center
Sun's orbital motion (radius and velocity) tells us mass inside the Sun's orbit:

\[ \sim 1.0 \times 10^{11} \, M_{\text{Sun}} \]
Imagine that you could travel at the speed of light. Starting from Earth, how long would it take you to travel to the center of the Milky Way Galaxy?

A. It would happen in an instant.
B. ~250 years
C. ~2,500 years
D. ~25,000 years
E. ~250,000 years
Quiz

Answer the following question using the image below, which represents the Milky Way Galaxy.

Approximately how large is the diameter of the white dot?

A. 4,000 light years
B. 10,000 light years
C. 50,000 light years
D. 100,000 light years
Lecture-Tutorial (LT): Milky Way Scales (pp.135-138)

- Work with a partner!
- Read the instructions and questions carefully.
- Discuss the concepts and your answers with one another.
- Come to a consensus answer you both agree on.
- If you get stuck or are not sure of your answer, ask another group.
- If you get really stuck or don’t understand what the LT is asking, ask for help.
Galactic Recycling

start here

atomic-hydrogen clouds
Fig. 19.12a

molecular clouds
Fig. 19.10

hot bubbles
Fig. 19.6

returning gas: supernovae and stellar winds
Fig. 19.5

stellar lives: nuclear fusion/heavy-element formation
Fig. 19.13

star formation
Fig. 19.11
We observe a star-gas-star cycle in Milky Way’s disk using many different wavelengths of light.
Infrared light reveals stars whose visible light is blocked by gas clouds.
X-rays are observed from hot gas above and below the Milky Way’s disk.
21-cm radio waves emitted by atomic hydrogen show where gas has cooled and settled into disk
Radio waves from carbon monoxide (CO) show locations of molecular clouds.
Long-wavelength infrared emission shows where young stars are heating dust grains.
Gamma rays show where cosmic rays from supernovae collide with atomic nuclei in gas clouds.
Summary of Galactic Recycling

- Stars make new elements by fusion
- Dying stars expel gas and new elements, producing hot bubbles (~$10^6$ K)
- Hot gas cools, allowing atomic hydrogen clouds to form (~100-10,000 K)
- Further cooling permits molecules to form, making molecular clouds (~30 K)
- Gravity forms new stars (and planets) in molecular clouds
What are Spiral Arms?

Spiral arms are waves of star formation

1. Gas clouds get squeezed as they move into spiral arms
2. Squeezing of clouds triggers star formation
3. Young stars flow out of spiral arms
• It is easy to create spiral pattern with differential rotation

• But, if stars are moving together with the spiral arms, then it would soon look like this....

• But the true arms are not that tightly wound. Why?

Differential rotation: stars near the center take less time to orbit the center than those farther from the center. Differential rotation can create a spiral pattern in the disk in a short time.

Prediction: 500 million years

Observation: 15,000 million years
Nature of Spiral Arms

• Stars are not moving with the arms!

• propagation of density wave

• analogy: traffic jam

Spiral density waves are like traffic jams. Clouds and stars speed up to the density wave (are accelerated toward it) and are tugged backward as they leave, so they accumulate in the density wave (like cars bunching up behind a slower-moving vehicle). Clouds compress and form stars in the density wave, but only the fainter stars live long enough to make it out of the wave.