ASTR 1020: Stars & Galaxies

March 12, 2008

- Reading for Monday: Chapter 19, section 19.4; Chapter 20, section 20.1.
- *MasteringAstronomy* Homework on The Milky Way is due March 19th (Wednesday).
- Extra credit (1 pt) observing opportunities at SBO. See CULearn.
- *Exam 2 on Friday* will cover Chapters 15.3 to 19.2.

Exam Study Tips

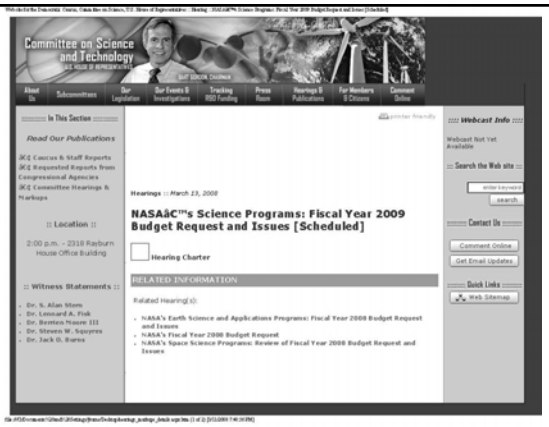
- Study with a friend!
- Check PowerPoints (on class website) against your notes, homeworks- are you comfortable with the relevant concepts?
- Do more quiz and review questions in your text and in *MasteringAstronomy.*
- Check out textbook "Learning Goals" at the beginning of each textbook Chapter and Key Concepts at end of Chapter.
- Review Clicker Questions.
- Exam is closed book but you may bring one sheet of paper (both sides) with notes.

The Day of the Exam

Bring a #2 pencil and eraser

Bring a calculator if you think you'll need one

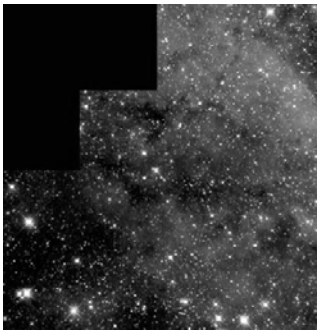
Please be prepared to get started right away at 10:00 am



http://www.science.house.gov/publications/hearings_markups_details.aspx?NewsID=2119

Astronomy in the News

Joseph Parker

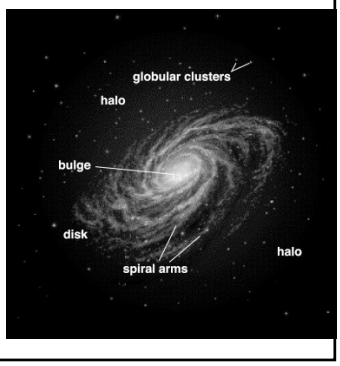


Today: More Milky Way

Disk: includes spiral arms

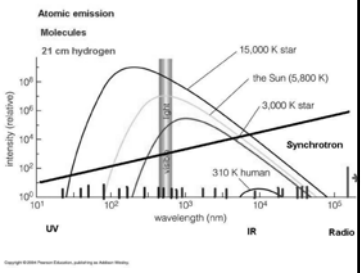
Young, new star formation

Bulge & Halo: older stars, globular clusters



Looking Across the Spectrum

- Review of ways to make light:
- Thermal (IR-> UV)
- Synchrotron (all wavelengths)
- Emission lines:
  atoms → visible/UV
  molecules → IR
  Hydrogen→
  21-cm = radio



The Milky Way Across the Spectrum

REVIEW FIGURE 19.12 in text, note symbols for telescope types

Radio
- 21 cm emission from hydrogen gas (below)
- Synchrotron emission from supernova remnants, neutron stars, black holes etc.

- Far IR
- Emission from molecules (CO)

- Infra-red (100 microns)
- Dust at a few hundred degrees K

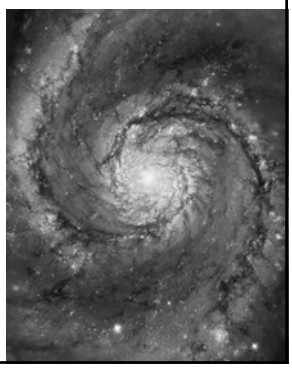
- Near infrared
- Cool stars

(low-mass main sequence stars, red giants)

- Visible and UV light:
- Sun-like and hotter stars
- Hot gas
- Dust absorbs light!!!!!!!!

Another Galaxy in Visible Light

- Star formation, molecular clouds, young blue stars and warm/hot gas and dust found in spiral arms



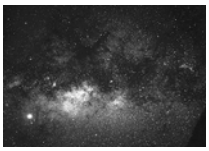
- X-rays: million degree gas, synchrotron emission
- Hot gas bubbles
- X-ray binaries (synchrotron emission)
- Some absorption by gas/dust

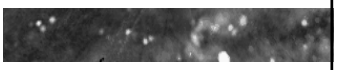
Clicker Question: We want to map out the structures of very cold gas within the dusty disk of the Milky Way. What wavelength should we be using, and why?

a) radio
b) visible light
c) X-rays

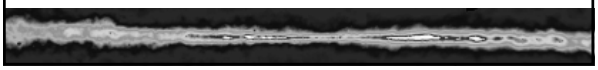
(A) Radio!

- Dust obscures our vision of much of the galaxy in visible and UV light.
- X-rays only highlight the hottest and weirdest places



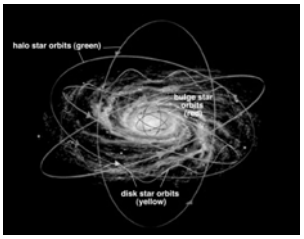


- 21 cm radio waves map normal hydrogen gas, these pass through dust unaffected



Solar Circle

- Take about 230 million years to get around
- Sun has been around about 20 times

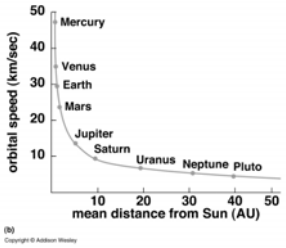


Mass in the Galaxy

- Star orbits are in response to gravity.
- Measure star speeds via Doppler shift
- Faster orbits → more mass

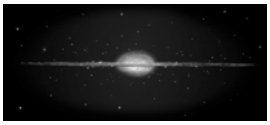
Measuring Mass: Rotation curve for gravity

- Example: Solar System
- Almost ALL the mass is in the center (Sun)
- Gravity weaker farther out
- Rotation curve falls



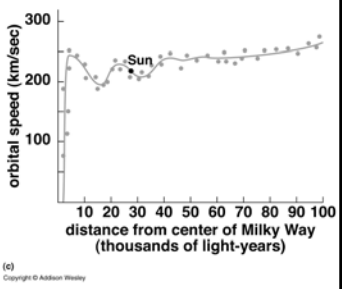
Expectation for the Milky Way

- There are a lot of stars in the center but also some outside
- Rotation curve should fall but more slowly than solar system



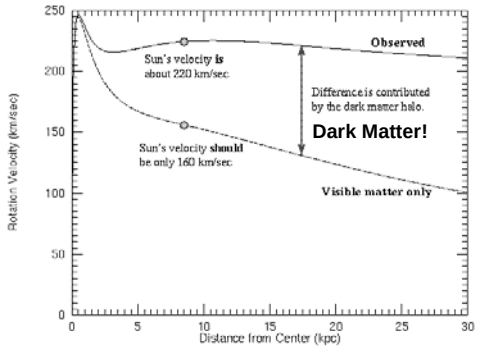
Reality for the Milky Way

- Rotation curve is flat or even rising!
- Most of the mass of the galaxy is outside the solar circle!
- But few stars, little gas there…
- DARK MATTER?!



Mass = R x V² / G

R = radius; V = orbital velocity

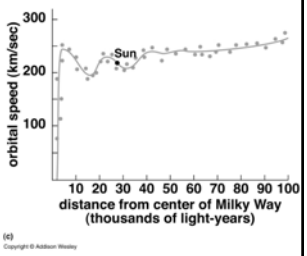


The gravity of the visible matter in the Galaxy is not enough to explain the high orbital speeds of stars in the Galaxy. For example, the Sun is moving about 60 km/sec too fast. The part of the rotation curve contributed by the visible matter only is the bottom curve. The discrepancy between the two curves is evidence for a **dark matter halo.**

Very little gas or stars at large radii → not much to measure

Still don't know the extent of the dark matter

Possibly outweigh stars by factor of 10!



- Stars and gas are embedded in a much larger Dark Matter Halo??
- Don't know what dark matter is yet….