# Our Place in the Universe

8-29-2005

# Opening Discussion

- What did we talk about last class?
- Have you seen anything interesting in the news?
- Do you have any questions about the reading?
- http://www.nasa.gov/images/content/125798main_pia04157.gif
- http://saturn.jpl.nasa.gov/multimedia/images/images.cfm?categoryID=4

# You, Me, and the Universe

- Our current understanding of the Universe is as follows. Roughly 14 billion years ago the Universe came into existence in the big bang.
- The Universe consisted only of hydrogen and helium plus a lot of energy (photons/light). It expanded and cooled.
- The cooled gas collapsed to form stars which were grouped into galaxies.
- In the cores or stars, nuclear fusion built the heavier elements up to iron. Supernovae produce heavier elements and spread material around.

# Scales of Distance

- In astronomy we routinely deal with very large distances. To help show you how big, let's consider a 10 billionth ($1:10^{10}$) scale model of our solar system.
- At this scale, the Sun is roughly the size of a grapefruit (13.9 cm diameter). The Earth is about the size of a small ball bearing (1.3 mm diameter).
- Where is the "edge of the solar system"? Where is the nearest star? How big is our galaxy? How does this make you feel?

# Units of Distance

- On Earth we measure distances in kilometers/miles or in meters/feet.
- Just as you don't talk about the distance between two cities in feet or how tall you are in miles, in astronomy we typically use different units for measurements.
- In planetary science the primary unit is the astronomical unit (AU). That is the average distance of the Earth from the Sun or about 150 million km.
- A light-year is the distance light travels in a year or about 9.46 trillion kilometers.

# Light

- Light is very special in astronomy for many reasons.  Some are obvious, others are less so.
- One very special feature of light is that everyone sees light traveling at the same speed, regardless of their inertial frame.  Light travels at 299,792,458 m/sec (~$3*10^5$ km/s).
- In groups, work out how far a light minute is in km.  Roughly how many light minutes are in an AU?
- What is the implication of the finite speed of light to astronomers?

# How big are these numbers?

- We will often talk about numbers that are extremely large or small in this course. Having some way to try to understand how large they are is critical.
- To help with this lets switch to time instead of distance. How many seconds are in a year? How many seconds will you likely live?
- Moving at walking speed, how long would it take you to walk a light-second? Can you walk the distance from the Earth to the Sun in a lifetime?

# Galaxies and the Universe

- Our own galaxy, the Milky Way, is roughly 100,000 light-years across and contains more than 100 billion stars.
- The Universe is vastly larger than our galaxy. In fact, there are more than 100 billion galaxies in the Universe. Following that logic there are roughly $10^{22}$ stars in the Universe, many of them much like our own Sun.
- Feel free to try to think of how big $10^{22}$ is. It is so large that it is hard for the human brain to grasp or to come up with good examples of.

# Scales of Time

- Not only are lengths in astronomy large, so are timescales. The Universe is roughly 14 billion years old. Our solar system formed about 4.6 billion years ago.
- Your book goes through a really nice "scaling argument" looking at the history of the Universe as being a single year.
- In this analogy, how many years does one second represent?
- What parts of this analogy did you find surprising? Do you think that intelligent life is common in our galaxy? Why?

# Minute Essay

- What was the most surprising thing you learned from the reading for today or in class?
- Remember to read 1.3 and 1.4 for next class.