

ASTR 101
Introduction to
Astronomy:
Stars & Galaxies

Prof. Rosalba Perna

TA: Cameron Clarke

<http://amalfi.astrosunysb.edu/rosalba/ast101/ast101.html>

MAKE SURE TO **GO OVER THE SYLLABUS** (if you haven't already done so)
AND
CHECK THE TIMETABLE after each class for the **READING ASSIGNMENT**

Goals of the day

- **Order of Magnitude Astronomy**
 - Reasonable estimates
- **Size Scales**
 - getting used to astronomy
- **Light year**
 - Measuring distances in astronomy



Clickers

GRADED clicker questions will start NEXT WEEK.
Remember to bring your clicker to class always.



Order of Magnitude Astronomy

- Astronomy frequently deals with very BIG numbers
- When dealing with really big quantities, the small details become trivial
 - For example, when we say that the nearest galaxy is 2 million (2,000,000) light-years away, does it really matter if its actually 2,000,001? 2,000,100?
 - How far is it to drive from here to Los Angeles?
(centimeters won't matter...)

What's a factor of π between friends?

*More on order of magnitude
Astronomy*

*How many piano tuners are
there in Boulder County?*

- A. 2
- B. 20
- C. 200
- D. 2000
- E. Too many to count!



Start with known facts and reasonable guesses

Population of Boulder County?

- ~300,000 people
- How many people have a piano?
 - 1 in 30?
 - Could be off but probably not by much!
- How many pianos?
 - ~10,000 pianos in Boulder County
- How often do you need to tune a piano?
 - Once a year??

10,000 piano tunings/year

Other needed estimates

- How long does it take to tune a piano?
 - 3-4 hours?
 - = 2 tunings per day

$$\frac{2 \text{ piano tunings}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{50 \text{ weeks}}{\text{year}} = \frac{500 \text{ piano tunings}}{\text{year}} \quad \text{/ tuner}$$

$$\frac{10,000 \frac{\text{piano tunings}}{\text{year}}}{500 \frac{\text{piano tunings}}{\text{year}} \text{ / tuner}} = 20 \text{ tuners}$$

Scales in the Universe: our Cosmic Address

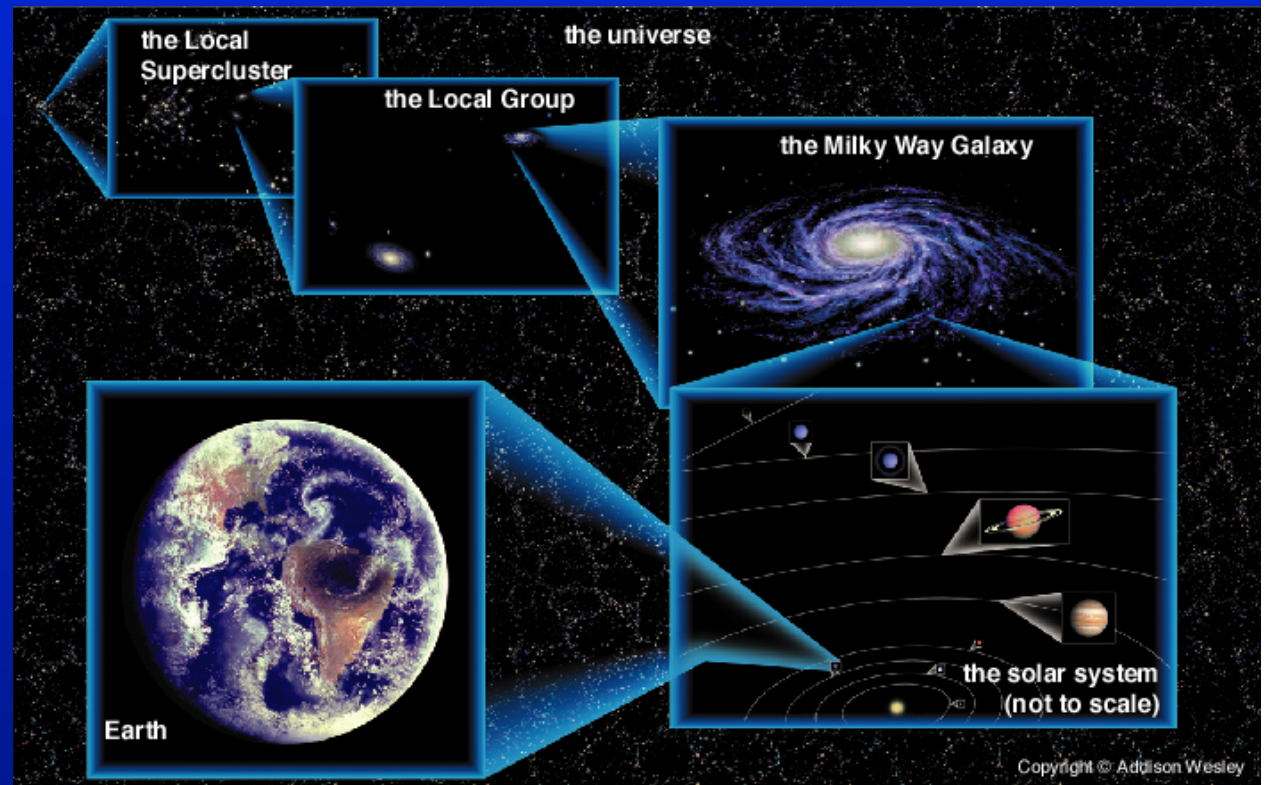
Earth

Sun/Solar
System

Milky Way
Galaxy

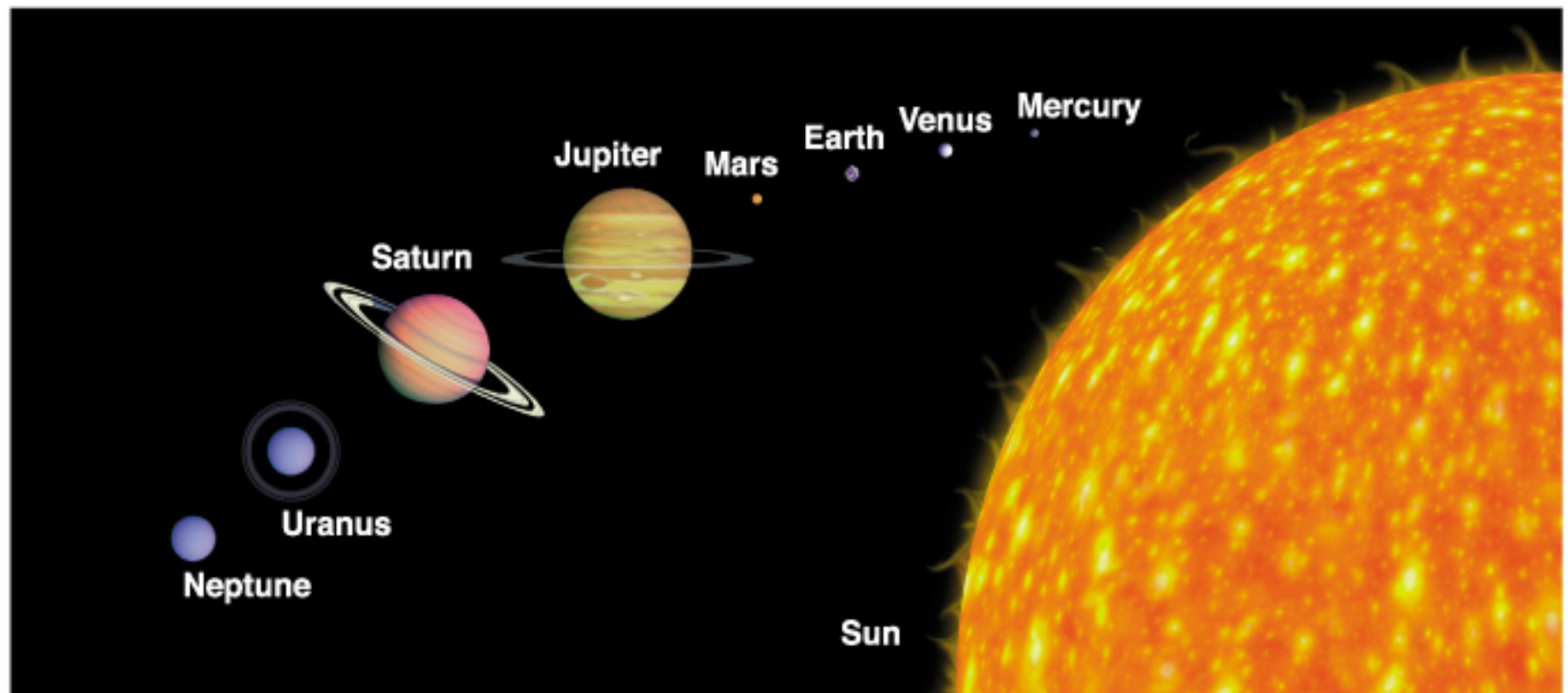
Local Group

Local
Supercluster



Scale models of the Universe

- Scale Sun as a grapefruit (1:10,000,000,000)



What about distances from the Sun on the same scale?

- Earth = tip of ball point pen, 15 meters (49 feet)
 - Moon = 4 cm away from earth
- Mars = tip of ball point pen, 23 meters (75 feet)
- Jupiter = marble, 78 meters (255 feet)



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Moving out of the solar system

- On this scale, the nearest stars would be a system formed by a cantaloupe, a small apple and a kiwi fruit, located in the middle of Alaska (with solar system in middle of Colorado)
- There is essentially nothing in between!!

New Scale for the Galaxy:

- Stars are microscopic - located a few mm apart
- Milky Way galaxy is 100 meters in diameter, contains 100,000,000,000's (100's of billions) of stars

1 to 10^{19} scale - MW=100 m



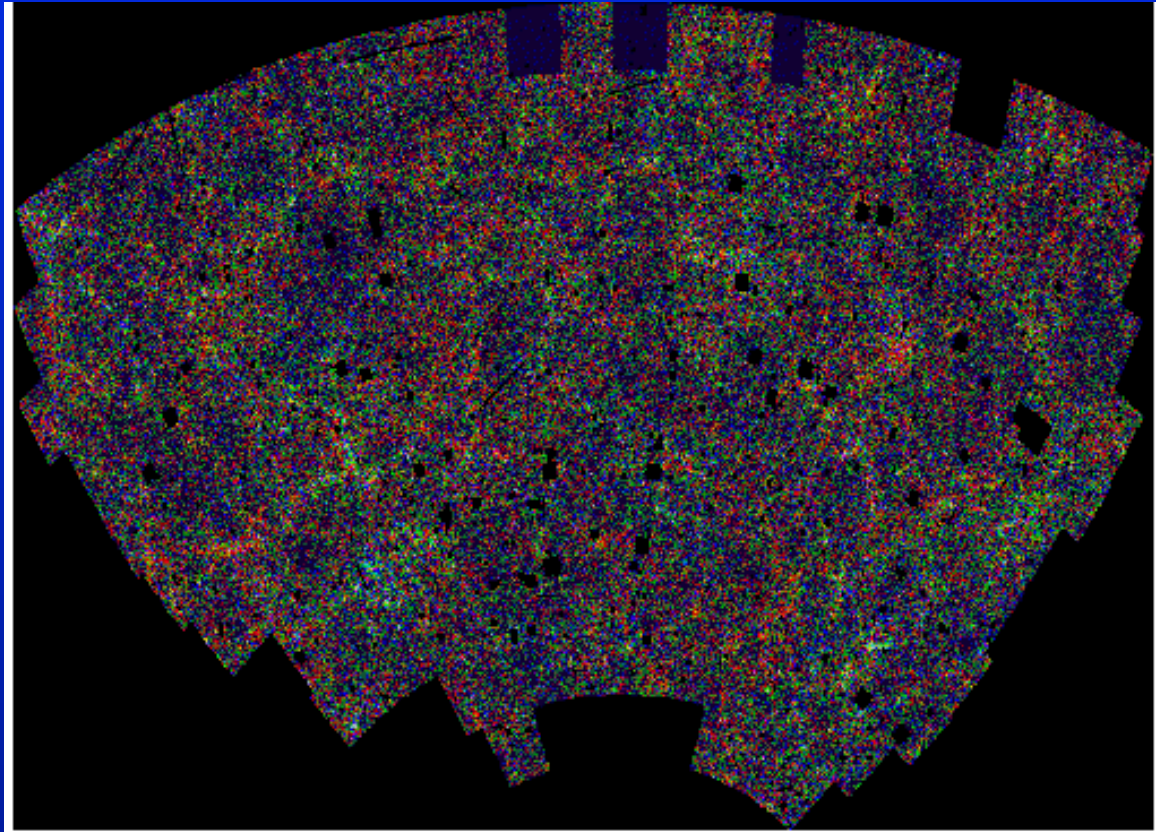
Solar system: dot ~20 meters away from center

Yet Another Scale for Everything Else

- Galaxies are 10" paper plates
- Milky Way and nearest neighbor Andromeda) are 5 meters apart
- Galaxy groups and clusters contain 10's to 1000's of galaxies



- Superclusters 50 meters across (size of buildings in our scale model) are the largest structures we see
- Observable universe is about size of our county on this scale



In this image, each dot is an entire galaxy

Sample Clicker Question

Which of these are the most likely?

- A. Two planets colliding
- B. Two stars colliding
- C. Two galaxies colliding
- D. None of the above... there's too much space!

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Milky way and Andromeda Galaxy in local group predicted to collide in about 4 billions years

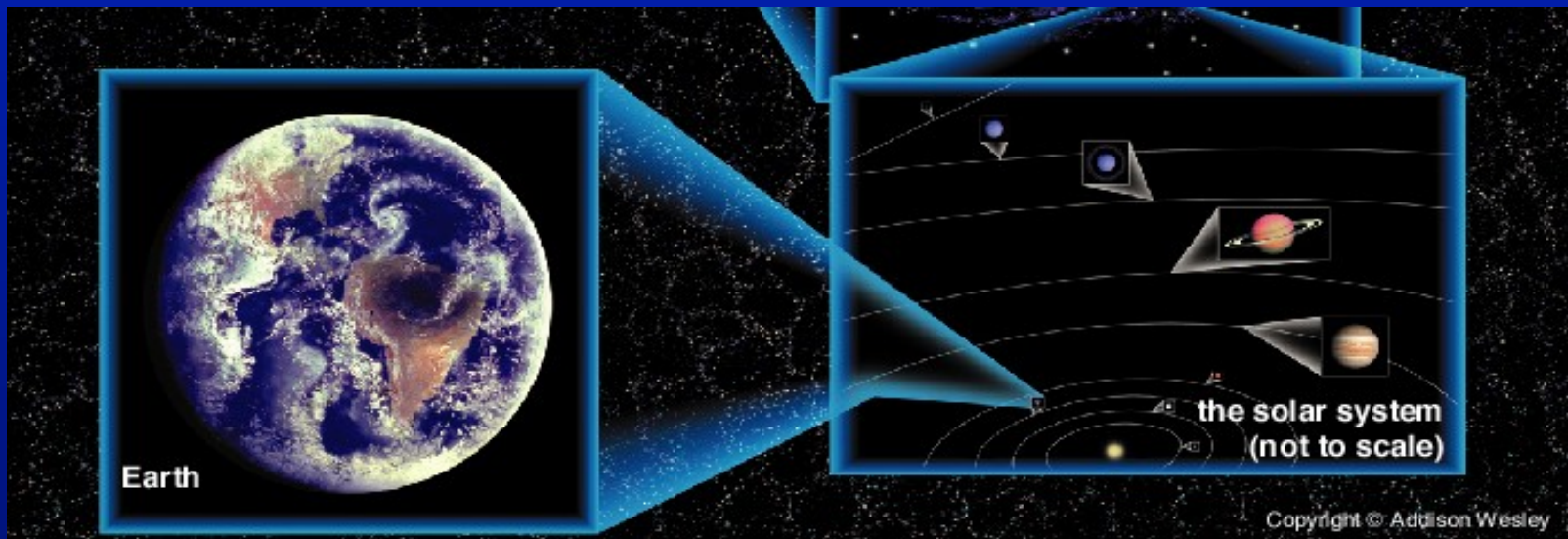


Measuring cosmic distances

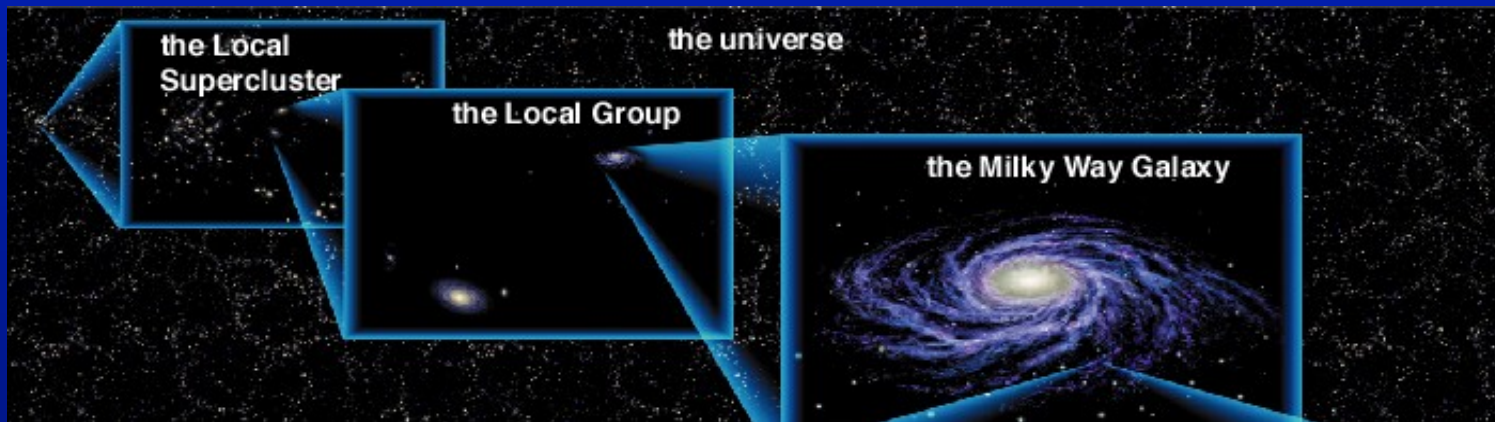
- Most useful measure is based on the speed of light = 300,000 km/sec
 - Light-year = the distance light travels in a year
= ~ 10 trillion kilometers = 10^{16} m
- Like saying “I live 30 min from Stony Brook”
- Constant speed for light traveling in space
- Nothing travels faster through space

Measuring Distances with Light:

- Earth-Moon = 1.5 light-seconds
- Earth-Sun (a.k.a. astronomical unit, or AU) = 8 light-minutes
- Solar system = light-hours



- Nearest stars = several light-years
- Milky Way= 100,000 light-years = 10^5 ly
 - Galactic Center is 28,000 light-years away
- Local group = several million light-years = 10^6 ly
- Observable universe = 14 billion light-years = 1.4×10^{10} ly



Sample Clicker Question

- A radio message from outer space arrived today which was sent from planet Buff on the day you were born. The friendly aliens sending you the birthday message live:
 - A. In the Solar System
 - B. From a close-by star in the Milky Way
 - C. In Andromeda, the nearest major galaxy
 - D. In a galaxy outside the local group

Answer B:

- You are probably between 10 and 90 years old. Objects at distances between 10 and 90 light-years away from us are relatively close-by stars in the Milky Way.
- The solar system is light-hours in size
- The Local group is millions of light-years in size

Over astronomical distances, even light takes a lot of time (from a human's perspective!) to travel between the stars

This means that what we SEE in the distant universe is light that has traveled a long time.

Our image of the universe is a delayed image.

In looking out into space, we are looking back in time!

Look Back Time

What we SEE is always delayed by the speed of light. In the classroom, our view of each other is only about 10^{-5} seconds old, so we barely notice (10^{-5} sec = 0.00001 sec)

Satellite communications - noticeable delays

The image of the Sun is _____ old?

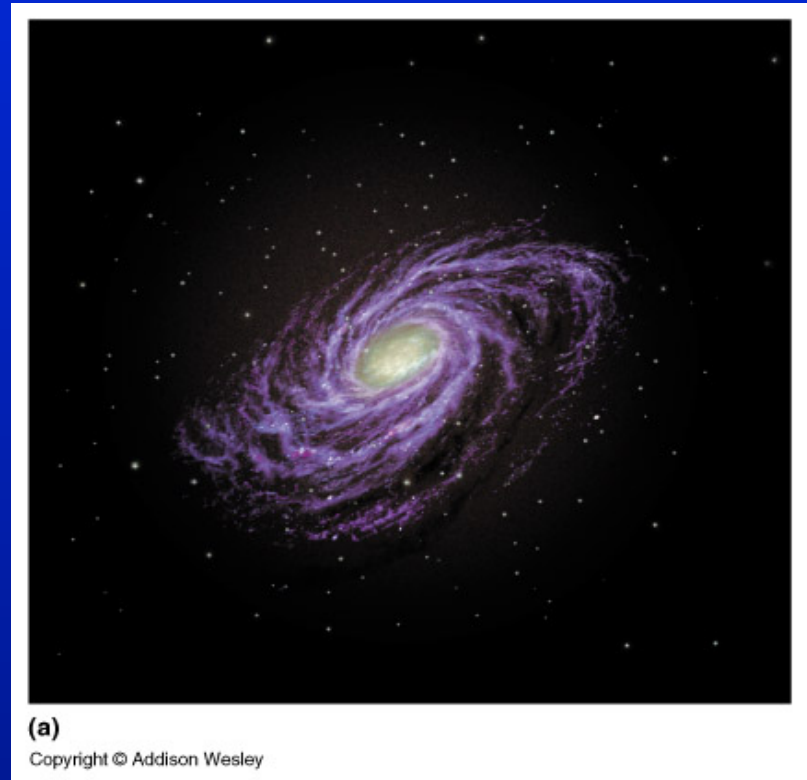
Analogy: what we “hear” is delayed by the speed of sound - more familiar in our everyday lives (e.g. lightening-thunder delay)

Image of the Orion nebula, 1500 ly away



When studying the Universe, it is impossible to separate space and time

- The image of a galaxy spreads across 100,000 years of time
- Try to think of what we SEE NOW as different from what may EXIST now



Sample Clicker Question

Last night we saw a bright supernova explode in the Andromeda galaxy (the other big galaxy in the local group). The remnants from such explosions disperse in about 10,000 years.

- A. The supernova remnant still exists now, and we will watch it disperse over the next 10,000 Earth years.
- B. In reality, the supernova remnant has already dispersed, but we will watch it disperse over the next 10,000 Earth years.
- C. The image of the supernova dispersing will not reach us for another 2 million years.
- D. We will never see the supernova remnant because it has already dispersed.

- Answer: **B**
- This galaxy is millions of light-years away from us. The light left the galaxy millions of years ago and only arrived yesterday. In the intervening time, the supernova remnant has dispersed and no longer exists today.

But the light that left on the day after the explosion will arrive here today and we can see that.

Discussed so far

- Cosmic Distances
- Light-Year vs Year
- Look Back Time



Make sure to become familiar with these concepts!

For next class meeting, reading..

....remains on the entire Ch. 1

IF you have problems, please let us know!