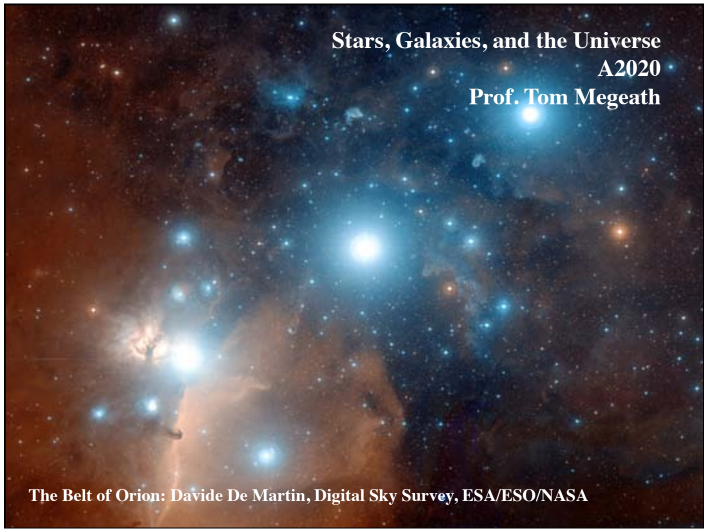


Professor Tom Megeath
Ritter 204
Phone: 419-530-7812
Email: megeath@physics.utoledo.edu
(please put A2020 in subject or the email may be unintentionally deleted as SPAM)

Office Hours: Monday 11:00AM-12
Wednesday 1-2PM
Friday 11:00AM-12
(subject to change)
or by appointment

Lectures can be found in PDF format at
http://astro1.physics.utoledo.edu/~megeath/a2020/a2020.html
(may take up to one week to post in some cases)

Book: The Cosmic Perspective, 4+th edition

Prof. Tom Megeath **MH 2002** **Spring Semester 2010**

Date	Chapter	Topic (schedule approximate; subject to change)
12 Jan	1	Intro to the class, The size of the Universe
14 Jan	1	The history of the universe
19 Jan	2	Constellations and the distances to the stars HW #1 given
21 Jan	4	Gravity and the laws of motion
26 Jan	5	Light, spectra and blackbody
28 Jan	6	Observing the universe: telescopes HW #2 given, HW #1 back
02 Feb	14	The Sun and the stars
04 Feb	15	The HR diagram and stellar clusters HW #3 given, HW #2 back
09 Feb	17	The origin of stars
11 Feb	16	Stellar evolution HW #3 back
16 Feb		Review of homework solutions and review for test.
18 Feb		**MIDTERM EXAM #1 – all material through stellar evolution**
23 Feb	18	The cosmic graveyard: white dwarfs and neutron stars
25 Feb	18, 19	Our galaxy and black holes HW#4 given
02 Mar	17, 19	The interstellar medium and cosmic recycling
04 Mar	19	Other galaxies and the expansion of galaxies HW #4 back
09 Mar		Spring Break
11 Mar		Spring Break
16 Mar		Provisional: Planetarium show – meet at Ritter Planetarium
18 Mar	20	Galaxy evolution, HW #5 out
23 Mar	21	The cosmic web
25 Mar		Review of homework solutions and review for test HW #5 back
30 Mar		**MIDTERM EXAM #2 - cosmic graveyard through the cosmic web**
01 Apr	S2	Special relativity
06 Apr	S3	General relativity HW #6 given, planetarium reports due
08 Apr	22	Dark energy and cosmology
13 Apr	S4	Quantum mechanics and fundamental particles HW #6 back, HW #7 given
15 Apr	23	The Beginning of the Universe
20 Apr	12/17/22	The future of the Earth, Sun and the Universe HW #8 given, HW #7 back
22 Apr	13/24	Other Planets and Interstellar Travel
27 Apr	24	Origin of Life and The Search for Extraterrestrial Life HW#8 back
29 Apr		Review of homework and review for test
06 May	**All**	**FINAL EXAM 10:15-12:15 - everything!!**

Course Mechanics

8 homework sets

One planetarium show – *the date is not finalized*

Attending planetarium show and writing a one page report on the show will count as two homework sets.

2 midterms

1 final

Grade: Final: 30% Midterms: 40% Homework: 30%

Policy on math in Astronomy 2010

You are expected in this class:

1. Be capable of high school level geometry and algebra

2. Know the metric system

3. Be able to use scientific notation

These skill will be needed to answer some of the midterm questions.

Scientific Notation

$10 = 10^1$
$100 = 10^2$
$1000 = 10^3$
$210{,}000 = 2.1 \times 10^5$

This is important in astronomy. For example, the mass of the Sun is:

1,988,920,000,000,000,000,000,000,000,000,000 gm = 1.988920×10^{33} gm

One year is 3.1557×10^7 seconds or approximately $= \pi \times 10^7$ seconds

The Metric System is used by all scientist without exception

Distance:

1 mile = 1.6 km
1 foot = 0.3 m
1 inch = 2.54 cm
100 cm = 1m
1000 m = 1 km
10^5 cm = 1 km

Volume:

1 gallon = 3.79 l (liter)
1000 ml = 1 l

Mass:

454 gm = 1 lb
1000 gm = 1 kg

Temperature

Fahrenheit - proposed by Gabriel Fahrenheit in 1724
no one is certain how he came up with the scale

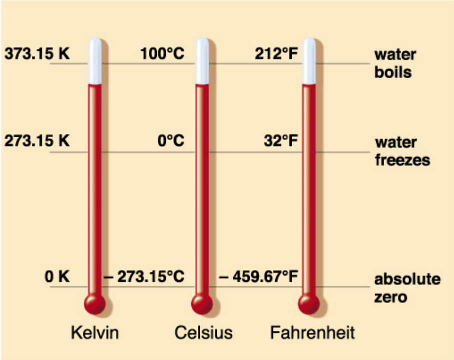
Celsius (Metric)
0 C = freezing point of water = 32 F
100 C = boiling point = 212 F

Kelvin
273 K = 0 C
273 K = freezing point of water
373 K = boiling point of water

0 K is absolute zero, the lowest temperature possible.

Astronomers use the Kelvin scale.

Thermal Energy: Temperature Scales



Special Astronomy Units

Solar Mass = mass of the sun = 2 x 10^{33} grams

Jupiter Mass = 0.001 solar masses = 2 x 10^{30} grams

Earth Mass = 0.003 Jupiter masses = 6 x 10^{27}

Astronomical Unit = distance from the Earth to the Sun

Light Year = distance light travels in 1 yr = 9.4 x 10^{17} cm

Parsec = 3.26 light years = 3.08 x 10^{18} cm

Factoid: the nearest star is 1.30 pc or 4.22 light years

Orders of Magnitude

Scientist use the phrase "order of magnitude" to indicate when something is ten times bigger, smaller, denser, older, younger, etc….. than something else.

For example:

Milky Way Galaxy is nine orders of magnitude bigger than our solar system

Measuring Distances with a Beam of Light

The Speed of Light in a vacuum:

299,792.458 km/s (kilometers per second)

The speed of light is a universal constant, it does not change over time or from place to place.

Thought Experiment: imagine two teams of scientist measuring the speed of a beam of light. One team measures the speed from a ground. The second team measures the speed from a fast moving airplane following the light beam. Do the two measurements differ?

Measuring Distances on a Cosmic Scale

Since the speed of light is constant, it makes a convenient means for measuring distances.

Distance to the nearest star:

Kilometers: 4×10^{13} km

Light Years: 4.2 ly

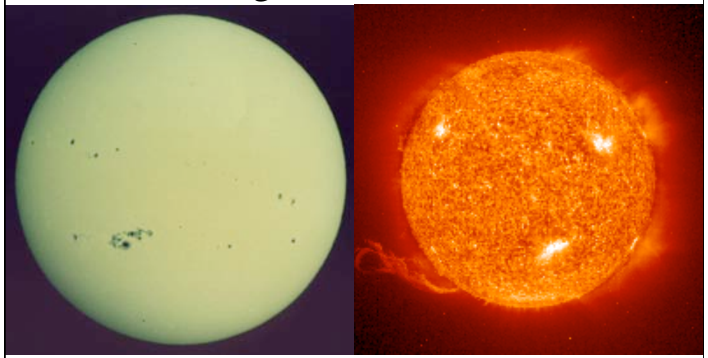
Parsecs: 1.29 pc

(I will explain why astronomers use parsecs in lecture 3)

Imagine shining a laser beam into space

Destination	Light travel time
Moon	1 second
Sun	8 minutes
Sirius	8 years
Andromeda Galaxy	2.5 million years

Starting Point: The Sun



Radius: 696000 Km 108 Earth Radii

Mass: 3.33×10^5 Earth Masses

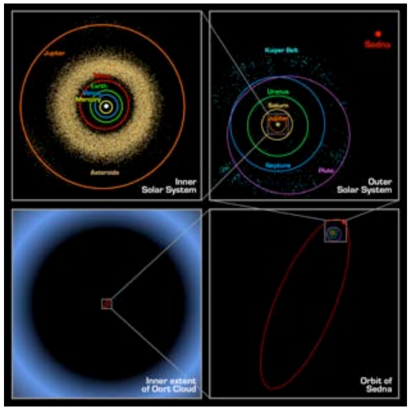
Surface Temperature: 6000 K

8 Minutes

Home Sweet Home

Distance from Sun 1.0AU
Radius:6378 Km
Mass: 1. Earth Masses
Temperature: 290 K
Orbital Period: 365.25 Days
One Moon

The Outer Solar System



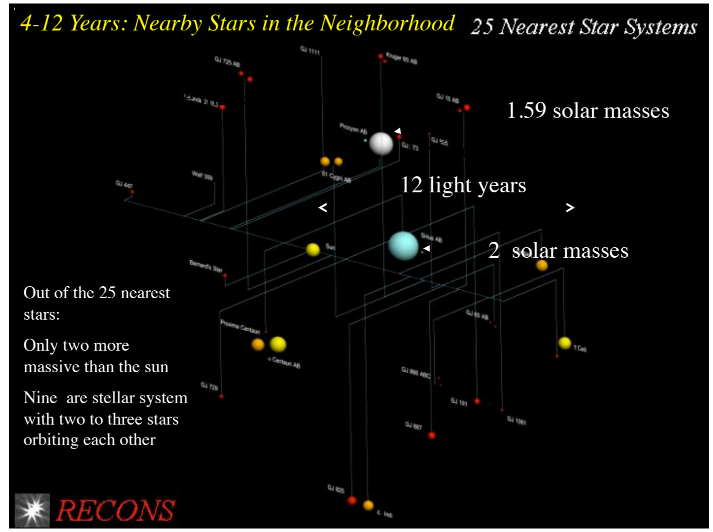
40 minutes - the planet Jupiter

4 hours - the dwarf planet Pluto

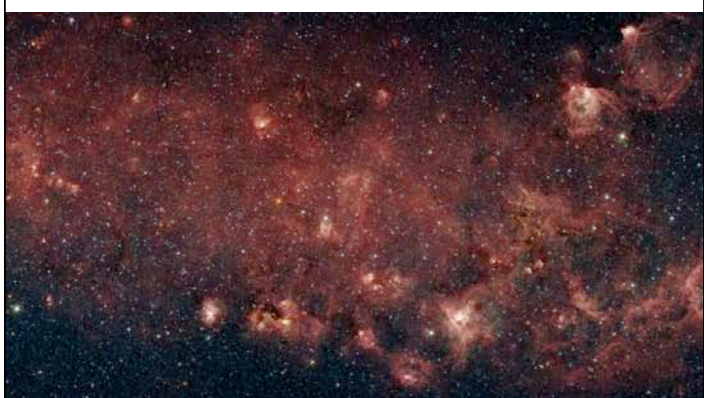
13 hours - Sedna (most distant known object)

57 days - the Oort cloud.

4-12 Years: Nearby Stars in the Neighborhood



5000 Years: The Inner Milky Way Galaxy



The Milky Way in Visible Light

The Milky Way in the Infrared

View from the Earth: *Edge On*

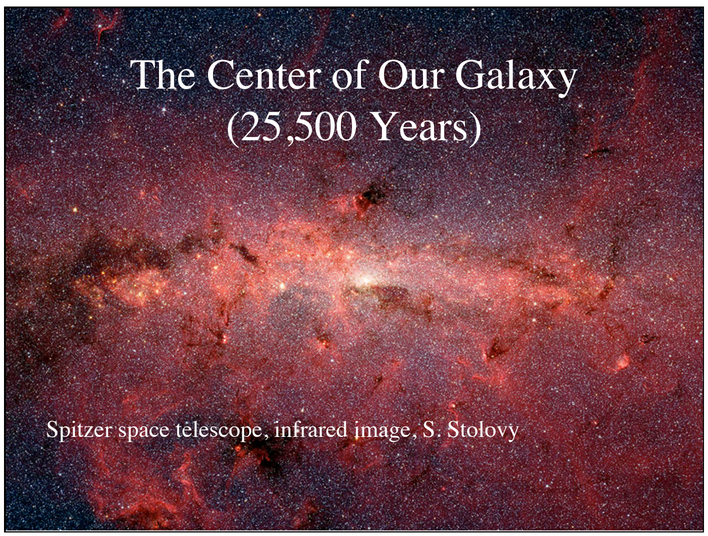
Our Galaxy: The Milky Way

For Light Beam to go to center from Earth: 25,500 years

For light beam to traverse; Galaxy: 100,000 years

Artist Conception of view from *above* the Milky Way

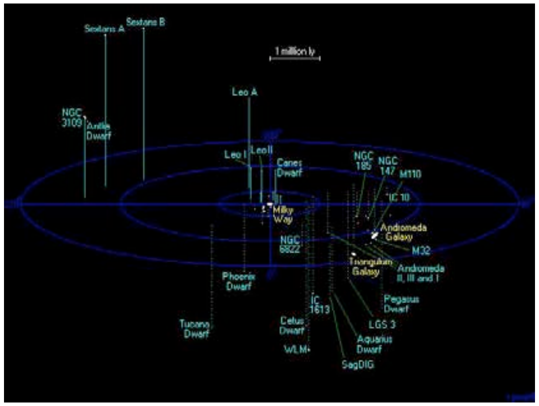
The Center of Our Galaxy (25,500 Years)



Spitzer space telescope, infrared image, S. Stolovy

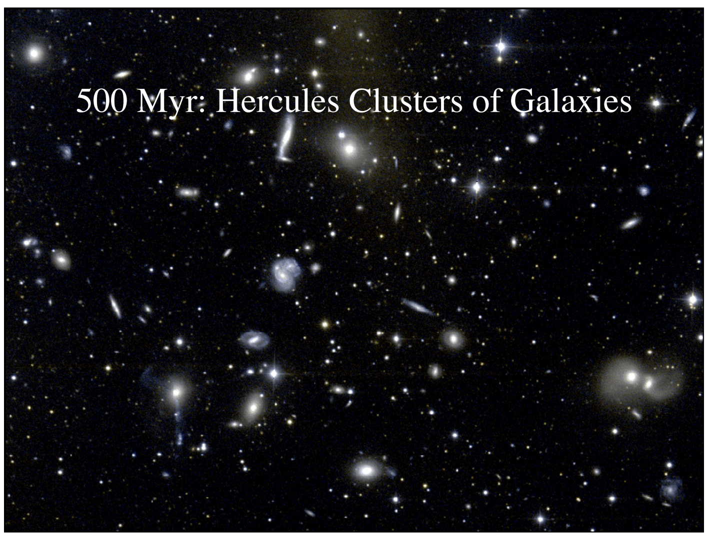
2.5 Million Years: The Nearest Galaxy Andromeda

1-10 Myr: The Local Group of Galaxies



50 Million Years: Sombrero Galaxy

500 Myr: Hercules Clusters of Galaxies



The Hubble Space Telescope Ultra Deep Field

How big is the Universe?

- The Milky Way is one of about 100 billion galaxies.
- 10^{11} stars/galaxy x 10^{11} galaxies = 10^{22} stars

As many stars as grains of (dry) sand on *all* Earth's beaches…

If you had to write your address to an alien somewhere else in the Universe, what would you put?

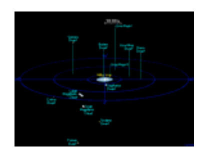
Your Cosmic Address

Earth

The Solar System

The Milky Way Galaxy

The Local Group



The Universe

How far do we travel every day?

From rotation or Earth: 29,000 km

From orbit of Earth around Sun: 2.4 million km

From orbit of Sun around Galaxy: 14 million km

Cosmic Motion

The universe is in constant motion, *for example:*

How fast are we moving:

Rotation of the Earth: 1200 km/hr

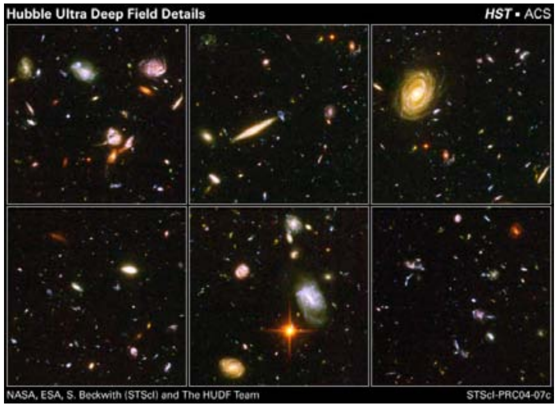
Earth going around Sun: 100,000 km/hr

The Solar System going around the Galaxy: 600,000 km/hr

Our Galaxy moving in the Local Group: 300,000 km/hr

Our galaxy moving toward the Virgo cluster: $1x10^6$ km/hr

The Universe is Dynamic! Galaxies in the Ultra Deep Field

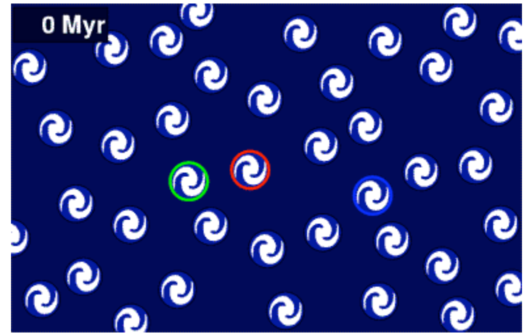


The Universe is Dynamic: Interacting Galaxies

The Universe is Dynamic: Interacting Galaxies

http://www.cita.utoronto.ca/~dubinski/antennae

The Universe is Dynamic: Expanding Universe



http://www.einstein-online.info/en/elementary/cosmology/expansion/index.html

The dynamic events occur over millions and billions of years?

How do we study the dynamic universe when things change so slowly?

Answer 1: Telescopes are Time Machines

When you look at an object 1 light away, you are looking at what it looked like 1 year ago.

When you look at an object 1 million light years away, you are looking at it 1 million years ago.

The universe is thought to be 13.66 billion years old, so when you look back 12.7 billion years - are you looking back to a time when the universe was “young”.

Cosmic evolution can be studied by looking at more and more distant objects.

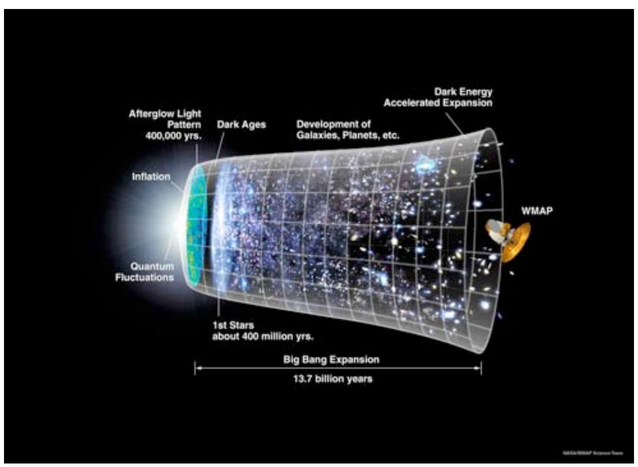
If the Sun suddenly stopped emitting light, how long before we would know it?

a. Instantaneous
b. 8 minutes
c. A few days
d. One year

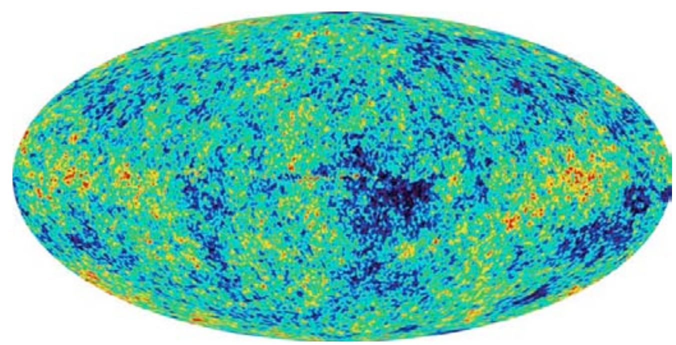
How far away is the light emitted by our Sun from the Jurassic time of the dinosaurs (150 million years ago)?

a. In our solar system
b. In our galaxy
c. In the Local Group
d. Beyond the Local Group

Cosmic Evolution

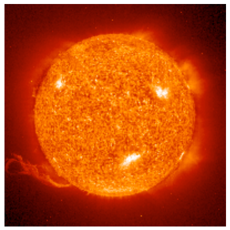


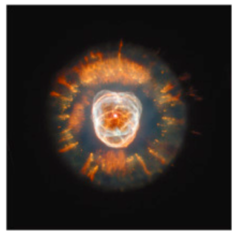
400,000 Years after the Beginning of the Universe



Answer 2: By Observing Objects at Different Stages of Evolution


Young star (pre-main sequence)


Our sun (main sequence star)


Planetary nebula (dying star)

Answer 3: By using physics

Summary

Measuring distances by travel times of light.

Traveling on a ray of light (know the relative sizes of things!)

Your cosmic address

The moving cosmos

The dynamic cosmos