

Astronomy 150: *Killer Skies*

MWF 1300-1350
141 Wohlers Hall



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Office Hours:

R: 10:00-11:00 a.m.

or by appointment or email

This Class (Lecture 2):

Poor Pluto

Next Class:

Astro-Death is very unlikely

<http://eyore.astro.illinois.edu/~lwl/classes/astro150/spring10/>
(simpler to google-me, then click on 150 link)

Music: *Millions of Miles from Home* – Dune

Outline



- What the hell happened to Pluto?
- The speed of light!
- Scale of the Solar System
 - Freaky Big!

Question



Is Pluto a planet?

- Yes! Very much so.
- Yes, but not a strong opinion.
- No, but not a strong opinion.
- No! Not at all.

What happened to Pluto?



The War of “What is a planet?”



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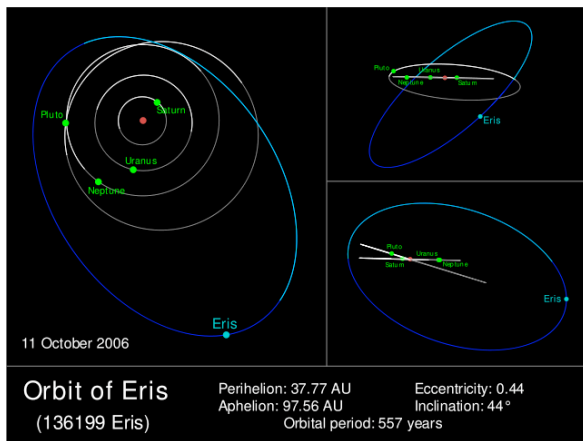
What's Changed?



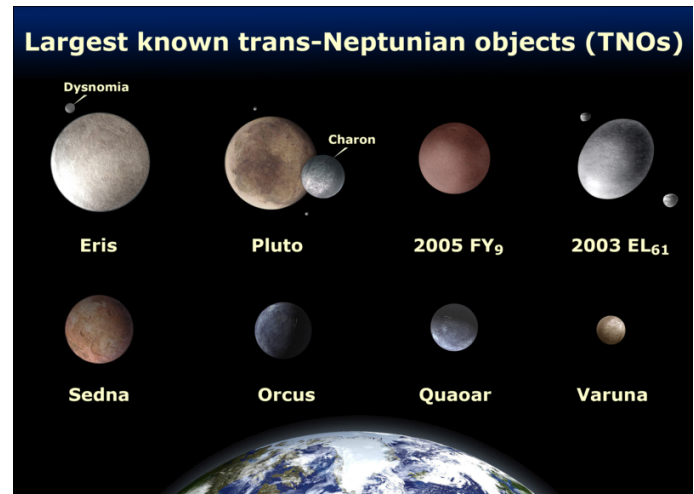
- The object Eris discovered in 2005
- ~20% larger than Pluto
- ~30% more massive than Pluto
- Has a moon (Dysnomia)
- Weird orbit
- Planet?



The Planet Eris?



Planet or Plan-not?



What is a Planet?

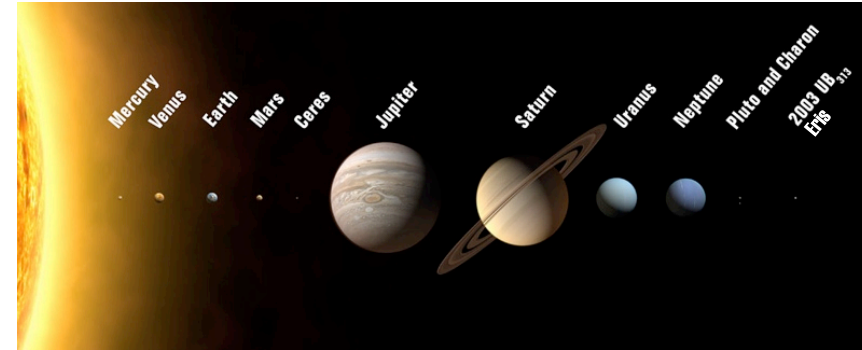


A planet is a celestial body that

(a) has sufficient mass for its self-gravity assumes a nearly round shape, and

(b) is in orbit around a star, and is neither a star nor a satellite of a planet

12 Planets?



My Very Eccentric Mother Curiously Just Showed Us
Nine Pianists Conducting Encores

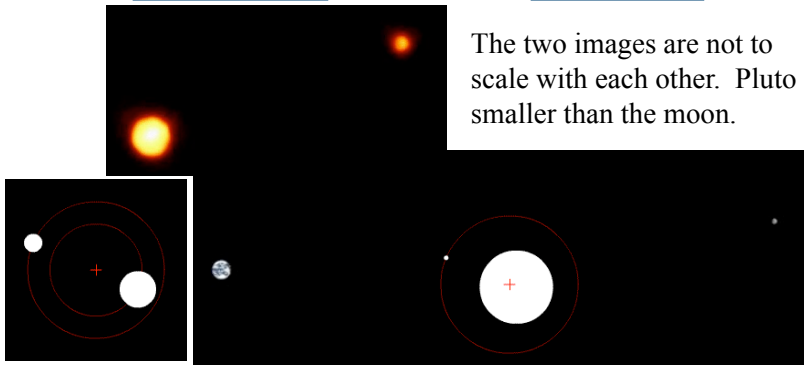
My Very Excellent Mother Just Served Us Nine Pizzas

Why Charon and not our Moon?



Pluto-Charon

Earth-Moon



The two images are not to scale with each other. Pluto is smaller than the moon.

When a moon orbits a planet, or a planet orbits a star, both bodies are actually orbiting around their *center of mass*

Two Dozen Planets???

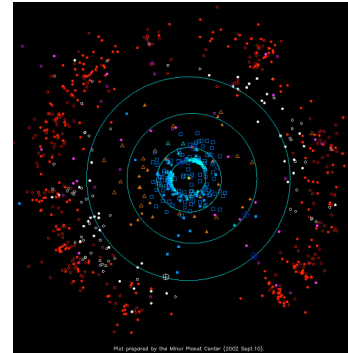


The Alternate Proposal



A planet is a celestial body that
 (a) has sufficient mass for its self-gravity assumes a nearly round shape, and
 (b) is in orbit around a star, and is neither a star nor a satellite of a planet, **and**
 (c) has cleared the neighborhood around its orbit

This definition would exclude Pluto (and others) because it's one of many...



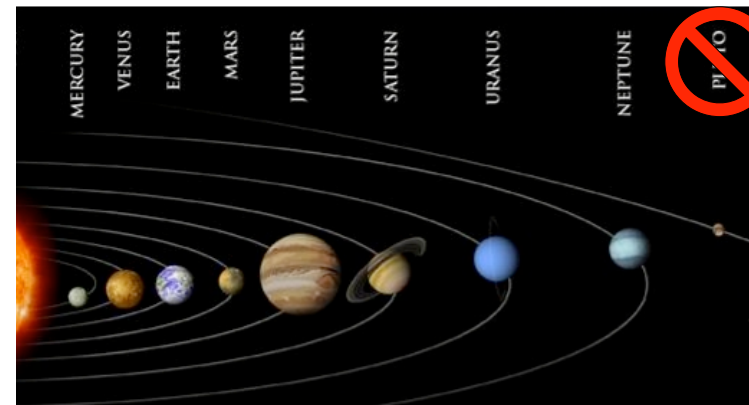
Red & white dots show other Pluto-like objects discovered around & beyond Neptune's orbit



~~8~~
~~Nine Planets~~

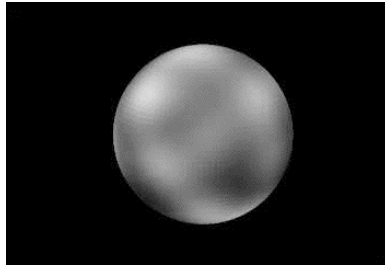


The Results...



My Very Excellent Mother Just Served Us Noodles!

So what do we call Pluto now?



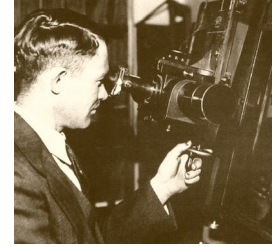
Planet-ish objects that meet the earlier definition, but fail to make the grade because of the new criterion would be called **dwarf planets**



Not Here in Illinois!

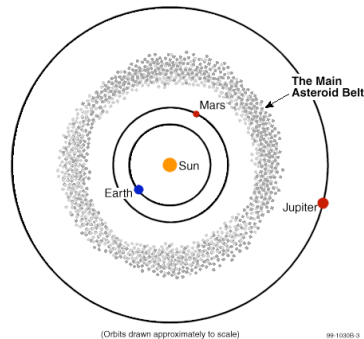
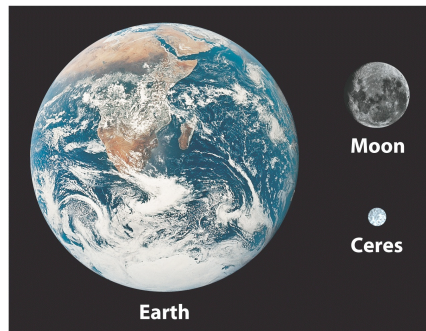


- Clyde Tombaugh, discovered Pluto, was from Illinois, so the Illinois State Senate made a resolution
 - RESOLVED, BY THE SENATE OF THE NINETY-SIXTH GENERAL ASSEMBLY OF THE STATE OF ILLINOIS, that as Pluto passes overhead through Illinois' night skies, that it be reestablished with full planetary status, and that March 13, 2009 be declared "Pluto Day" in the State of Illinois in honor of the date its discovery was announced in 1930
 - Luckily for me, it never passes overhead in Illinois!



<http://ilga.gov/legislation/fulltext.asp?DocName=&SessionId=76&GA=96&DocType=SR&DocNum=46&GAID=10&LegID=40752&SpecSess=&Session=>

Ceres, Another Former Planet



- Ceres was considered a planet for 50 years after its discovery in 1801
- Demoted after similar bodies were found
- Now, called an **asteroid**

Question



So, what the hell happened to Pluto?

- It's rotational energy decreased, which pushed it out of planetary orbits.
- We found out that Pluto was never a planet.
- The scientific definition of Planet was modified.
- Other objects that may be bigger than Pluto were found.
- It just plain ran out of luck.

Question



We know what the astronomers voted for, but in your opinion is Pluto a planet?

- a) Yes! Very much so.
- b) Yes, but not a strong opinion.
- c) No, but not a strong opinion.
- d) No! Not at all.

What's this Universe All about Then?



- Planets are now defined
- Stars – Nuclear burning machines, usually turning hydrogen into helium
 - Colors (temperatures: cold/red to hot/blue),
 - Sizes (Jupiter-sized to 1000x the Sun)
 - Masses (80x Jupiter to 100x the Sun)
 - Ages (Just born to nearly the age of the Universe)



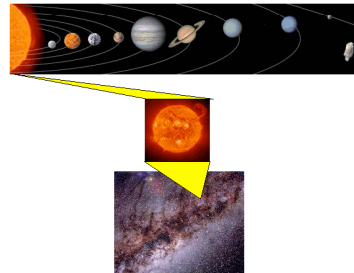
<http://www.thurs.net/dan/piggyback/piggyback.html>

One of



We are:

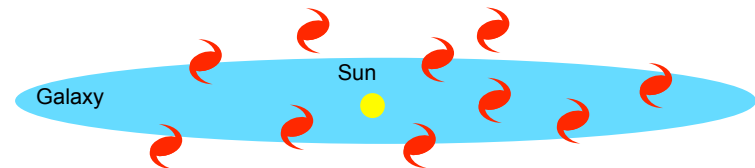
- 1 planet out of ⁸ in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- What's next? This took until the 1920s to suss.



Those weird Spiral Nebulae?



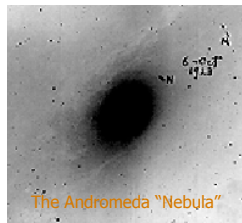
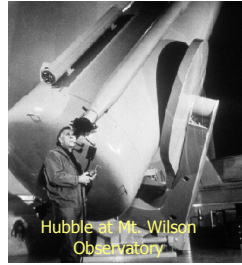
- Dim, diffuse, “interstellar” nebulae with spiral structure were seen in the 17th century.
- Some disagreement on what they were.
 - 1) “A galaxy is a spiral “island universe” and the other spiral nebulae are the same and far away”
 - 2) “Milky Way is all there is in the Universe, and the spiral nebulae are nearby.”



Edwin Hubble: Solved It



- In 1923, Hubble resolved M31, the Andromeda “Nebula”, into stars
- If these stars were like the stars in our Galaxy, then M31 must be far away!
- Estimated the distance to M31 to be 1 million light-years (modern estimate is 2.5 million light years)
- Andromeda is an “island universe” like our own Galaxy.



What's this All about Then?



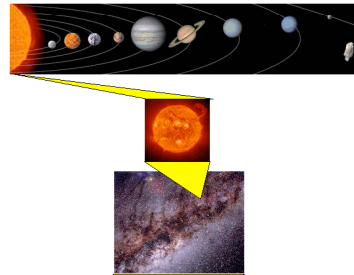
- Planets are now defined
- Stars – Nuclear burning machines, usually turning hydrogen into helium
 - Colors (temperatures: cold/red to hot/blue),
 - Sizes (Jupiter-sized to 1000x the Sun)
 - Masses (80x Jupiter to 100x the Sun)
 - Ages (Just born to nearly the age of the Universe)
- Galaxies
 - Collection of stars, gas, and dust (huge!) that are very far away.

Special?



We are:

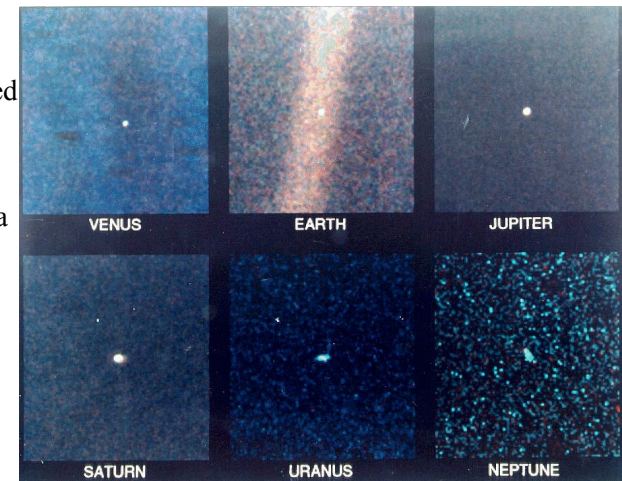
- Not, the center of the Solar System.
- Not, the center of the Galaxy.
- Not, the center of the Universe.
- Not special?



Perspective of Scale



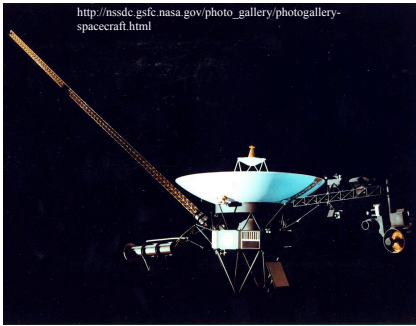
Images from Voyager (launched in 1974) at 4 billion miles out. Moving at 100 times faster than a speeding bullet. And just recently made it into interstellar space.



Interstellar Travel



Don't forget that the Voyager spacecraft are about the fastest vehicles made by mankind. Even so, Voyager would take over 100,000 years to reach some of the closest star systems.



What's the Fastest Way?



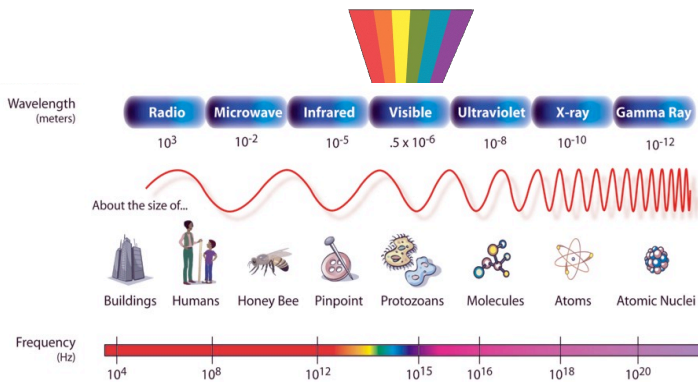
- Let's look into the constant speeder— light!
- Fastest thing out there.
- Nothing faster allowed—we'll talk more about this later.



What is Light?



- Visible light is only a tiny portion of the full electromagnetic spectrum
- Light comes in many colors that you can not see! The color x-ray or color radio or color microwave.
- Divisions between regions are really only from biology or technologies.



Distances



How far is it to Chicago?

Around 135 miles

Or 217 km

Or 712800 feet

Or 8.7×10^{10} microns

Or 285120 paces

Or 2 hours at car speed

Or 1 The Matrix DVD units at car speed

Or 0.7 ms at light speed

A Light Year



The light-year

- Distance that light travels in one year
- Speed of light: roughly 3.00×10^5 km/sec
- 3.16×10^{17} seconds in one year

so 1 light year = $(3.00 \times 10^5 \text{ km/sec}) \times (3.16 \times 10^7 \text{ sec}) = 9.42 \times 10^{12} \text{ km}$

- Nearest star (Proxima Centauri) is about 4.2 light years away.
- Analogous to saying: Chicago is about 2 hours away.

Question



I want to send a signal to the nearby star Alpha-Centauri (there might be ETs), which is 4.2 light years away, as quickly as possible. What wavelength of light do I use?

- Radio waves
- X-rays
- Optical light
- Infrared light
- They are all the same speed.

Question



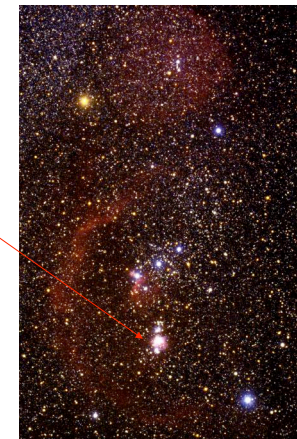
I want to send a signal to the nearby star Alpha-Centauri (there might be ETs), which is 4.2 light years away. How long will it take to reach Alpha-Centauri?

- 4.2 years
- 4.2 years times two = 8.4 year
- Forever
- 42 years
- 4.2 years divided by two = 2.1 years

First Contact?



- It will take 8.4 years to send out a radio message and get a response.
- It will take 100,000 years to travel on a Voyager-like spacecraft.
- For stars in the sword of Orion, light takes 3000 years, but that is still nearby!



Other Distances

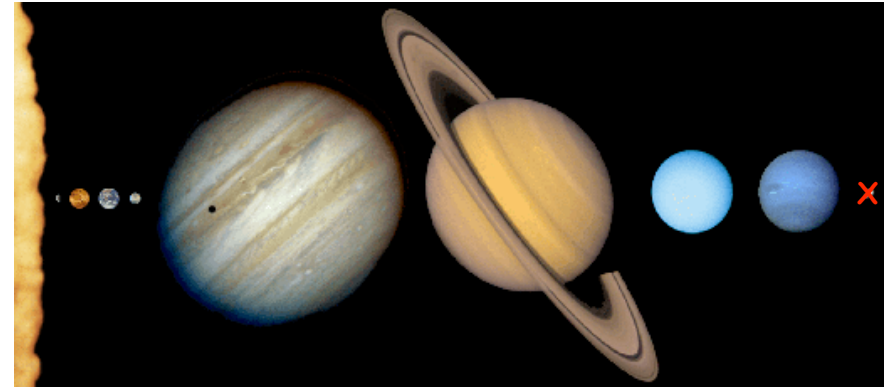


- 1 light year is 9.42×10^{12} km
- AU: the distance from the Sun to the Earth = 149,570,000 km = 1.58×10^{-5} light years
- pc: the distance away that a star would have a parallax of 1 arcsec, so 1 pc = 3.086×10^{13} km = 3.26 light years

Size Scales



To put astronomical scales into a reference, imagine a model of our Solar System.



Scale it:

The Most Math You'll Do in Class



In small groups:

Assume the Sun is almost the size of my softball (diameter = 4 inches) to make a scaled model of the Solar System.

Calculate the scaled distance from the softball to the "Earth". (Hint use ratios to figure out the answer.)

- 4.29 feet
- 129.5 feet
- 35.8 feet
- 32.2 inches
- 49.6 feet

Sun's diameter = 1,391,900 km
 distance from Earth to Sun (1 AU) = 149,570,000 km
 distance from Earth to Moon = 385,000 km
 1 km = 1000 meter = 3279 ft = 0.621 miles 1 mile = 5280 feet
 1 light year = 9.46×10^{12} km = 5.87×10^{12} miles

Note: A million miles away from home is actually quite close!



Scale it:

The Most Math You'll Do in This Class



In small groups:

Assume the Sun is almost the size of a softball (diameter = 4 inches) to make my scaled model of the Solar System.

Calculate the scaled distance from the "Earth" to the "Moon".

- 1.1 inches
- 11.0 inches
- 38.8 inches
- 0.9 inches
- 0.1 inches

Sun's diameter = 1,391,900 km
 distance from Earth to Sun (1 AU) = 149,570,000 km
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