

Sex in Space: Astronomy 330

TR 1230-1350
Astronomy 134



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Office Hours:
W: 11:00 a.m. – noon
or by appointment

This class (Lecture 2):

Pluto & Size Scales

Next Class:

Cosmology and the
origins of elements

HW1 due on Tuesday!
(grace period until Feb 3rd)
Make sure to follow directions!

Music: *Astronomy*– Metallica

Outline



- The Pluto thing (it's old but still many students want to talk about it)
- Let's take some time to get our bearings around the Universe.
- We live in the Milky Way.
- Size Scales

Basic Astronomy Highlights



The following are some astronomy facts for those who have not had any astronomy before.



Astronomy is not Astrology!



- In the ancient world, astronomy and astrology went hand-in-hand
- Many ancient astronomers were also astrologers
- Today, they are not connected.



Astronomy is not Astrology!



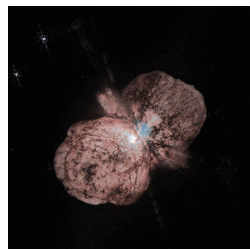
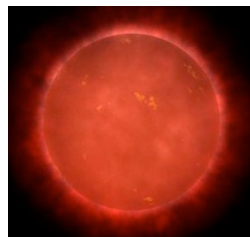
- Scientific tests of astrology show it's predictions are no more accurate than random chance
- Nevertheless, more people earn income casting horoscopes than doing astronomical research
- Pseudo-science, not science
- And the zodiac signs were picked 2000 years ago.
- Since then the Earth has precessed, and someone born "in" Virgo is actually a Libra.



What is a Star?



- A huge ball of mostly ionized hydrogen gas
- Mostly turning hydrogen into helium, which makes energy.
- Some stars can burn (thermonuclear speaking) for 10's of billions of years (<0.5 solar masses), and some only burn for a few million years (>25 solar masses)
- Our Sun is the closest star.



http://www.daviddarling.info/images/red_dwarf_art.jpg
HST of Eta Carinae

Basic Astronomy



- Earth rotates on its axis, takes about 1 day.
- Sky rises in the East, sets in the West, due to our rotation motion.
- Earth orbits the Sun, takes 1 year.
- Reason for the seasons is the 23 degree tilt of the Earth. It's Summer in Australia now!
- Moon orbits the Earth, takes about 1 month.
- No such thing as the "Dark Side" of the Moon, but there is a "Far Side" of the Moon.
- Moon phases are from relative position of Earth, Moon, and Sun.

Basic Astronomy



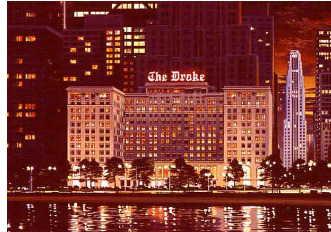
- Stars are "freaky far" far away from us!
- All the stars you can see with your naked eye (about 6000), are "nearby".
- A bunch of stars + gas + dust + stuff together make up a galaxy.
- Galaxies are usually separated by "freaky far" distances.



Course Goals



- This class is designed to be fun.
- This course will revolve around the "Drake Equation".
- The Drake Equation *looks* like an attempt to calculate how many intelligent extraterrestrial civilizations exist with whom we *might* be able to communicate in our Galaxy.
- However, the equation actually helps us understand our ignorance about the subject and illuminates the various topics and issues worth thinking about when we ask the question, "Are we alone?", with an open mind.



Drake Equation

Frank Drake



$$N =$$

of advanced civilizations we can contact in our Galaxy today

Drake Equation

Frank Drake



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

| | | | | | | | |
|--|---------------------|--------------------------------|-----------------------------------|-------------------------------|-----------------------------------|---------------------------|------------------------------------|
| # of advanced civilizations we can contact in our Galaxy today | Star formation rate | Fraction of stars with planets | # of Earthlike planets per system | Fraction on which life arises | Fraction that evolve intelligence | Fraction that communicate | Lifetime of advanced civilizations |
| | stars/yr | systems/star | planets/system | life/planet | intel./life | comm./intel. | yrs/comm. |

Question



What does the Drake equation really tell us?

- It calculates the exact number of advanced civilizations in the Universe.
- It means nothing, a fake equation. It is only meant to guide our thinking about the relevant questions.
- It gives us an exact number of alien lifeforms (intelligent or not) in the Galaxy.
- It calculates the number of advanced civilizations in our Galaxy.
- It allows us to estimate the age of the Universe.

What happened to Pluto?



http://orbitingfrog.com/blog/wp-content/uploads/2008/07/poor_pluto_mathias_pedersen.jpg

The War of "What is a planet?"

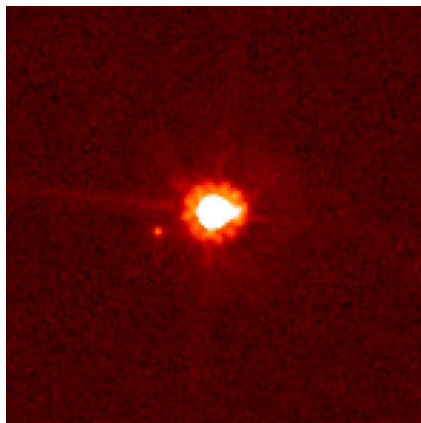


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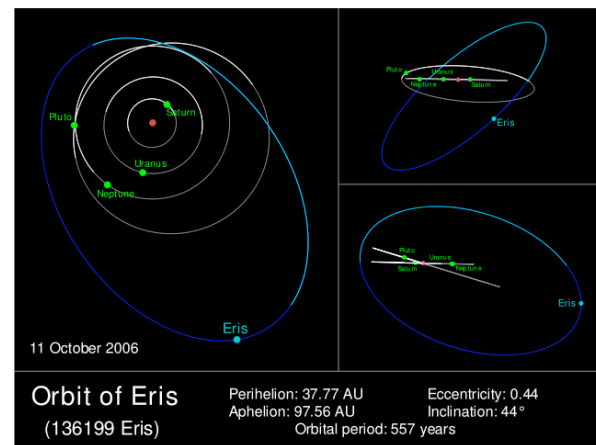
What's Changed?



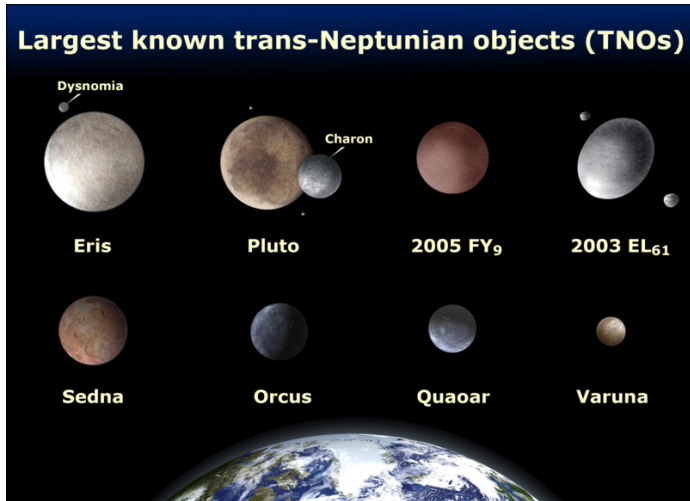
- The object Eris discovered in 2005
- ~20% larger than Pluto
- ~30% more massive than Pluto
- Has a moon (Dysnomia)
- Weird orbit
- Planet?



The Planet Eris?



Planet or Plan-not?

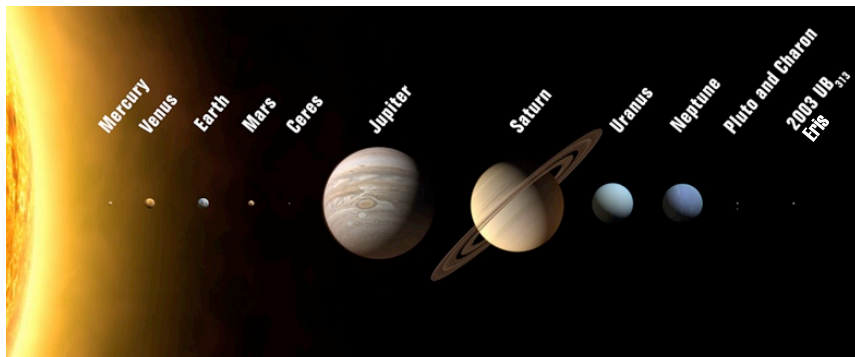


What is a Planet?



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**

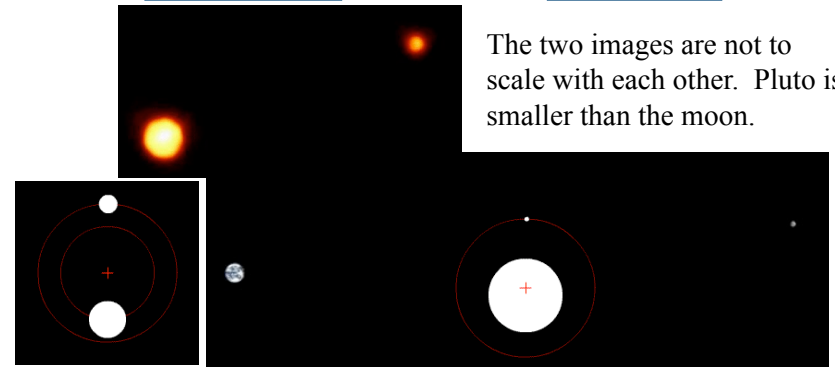
My Very Excellent Mother Just Served Us Nine Pizzas

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???

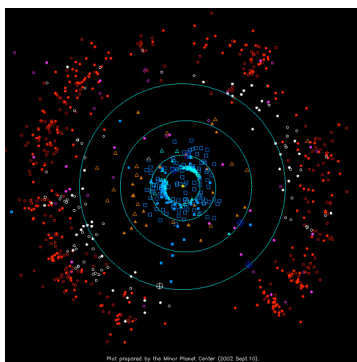


The Alternate Proposal



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...

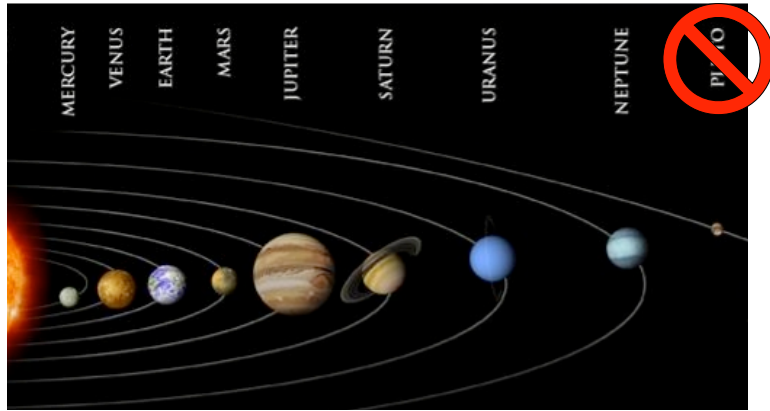


Red & white dots show other Pluto-like objects discovered around & beyond Neptune's orbit

The Results...

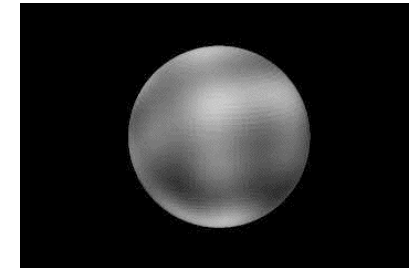


~~8~~ Nine Planets



My Very Excellent Mother Just Served Us Noodles!

So what do we call Pluto now?



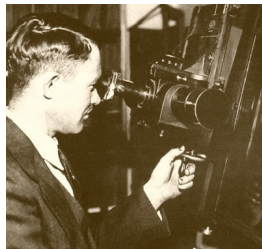
Planet-ish objects that meet the earlier definition, but fail to make the grade because of the new criterion would be called *dwarf planets*



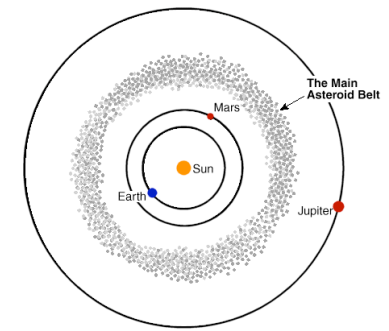
Not Here in Illinois!



- 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!



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



What the hell happened to Pluto?

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

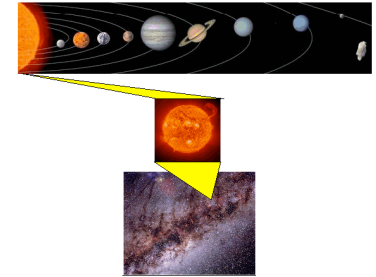
One of



We are:

8

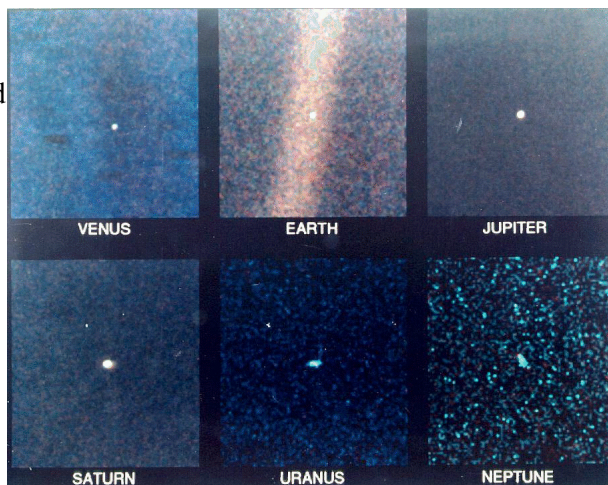
- 1 planet out of ~~9~~ in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way



Perspective of Scale



Images from Voyager (launched in 1974) at 4 billion miles out. Moving at 100 times faster than a speeding bullet (38,000 mph!). And arguable just recently made it into interstellar space.

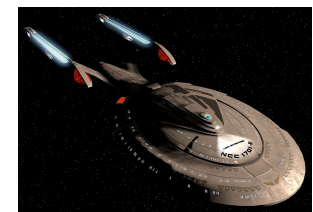
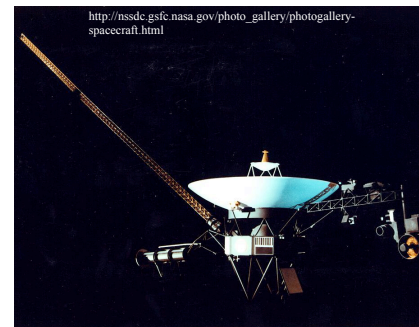


<http://seds.lpl.arizona.edu/nineplanets/nineplanets/overview.html>

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?



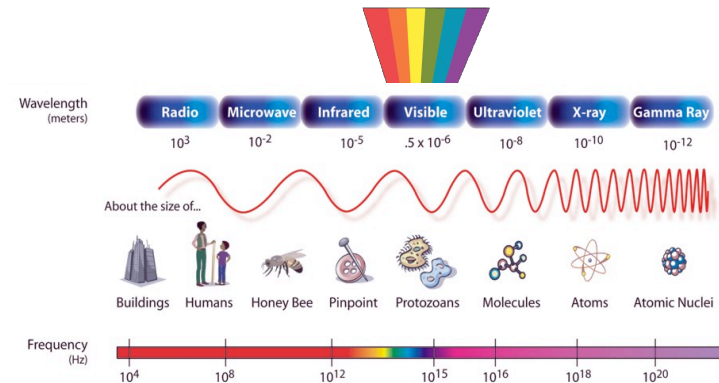
- Let's look into the constant speeder– light!
- We'll be talking about it a lot.
- Fastest thing out there.
- Nothing faster allowed– we'll talk more about this later.



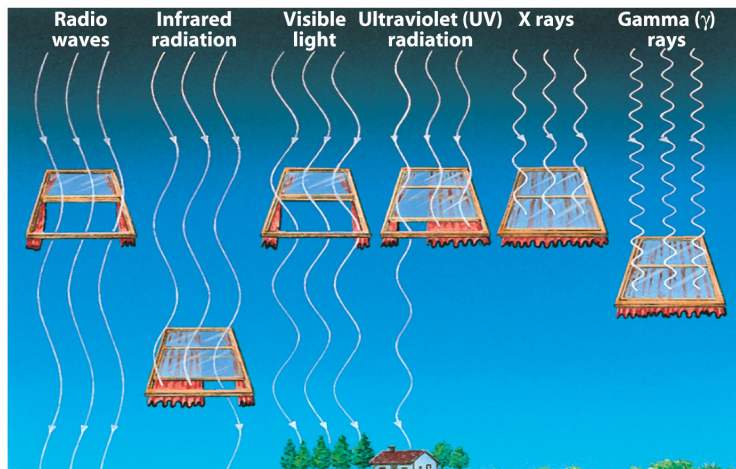
What is Light?



- 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.



The atmosphere absorbs some wavelengths and not others



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 ETI), which is 4.2 light years away.
- I want to communicate quickly.
- So what wavelength of light do I use? Radio? X-rays?
- How long will it take to reach Alpha-Centauri?

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, it would take 3000 years.



Other Distances

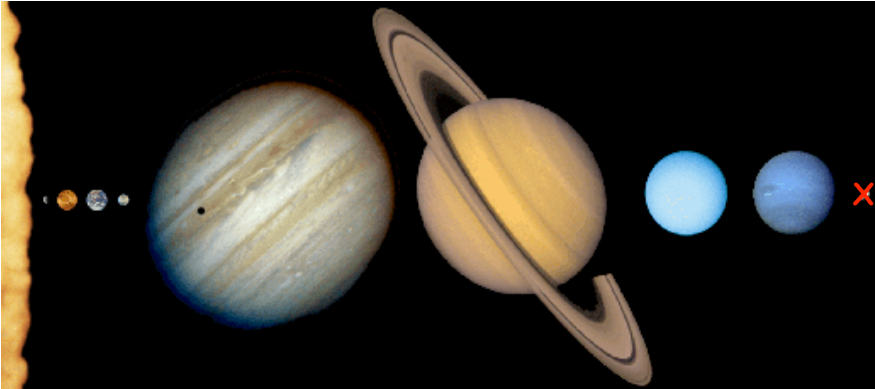


- 1 light year is $9.42 \times 10^{12} \text{ km}$
- AU: the distance from the Sun to the Earth = $149,570,000 \text{ km} = 1.58 \times 10^{-5} \text{ light years}$
- pc: the distance away that a star would have a parallax of 1 arcsec, so $1 \text{ pc} = 3.086 \times 10^{13} \text{ km} = 3.26 \text{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

Size Scales



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

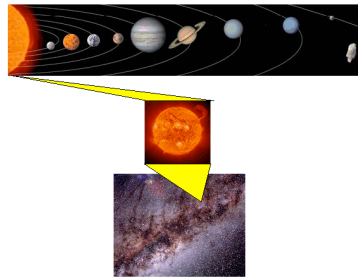


One of



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.



Scale it: The Most Math You'll Do in This Class



In groups:

Assume the Sun is the size of a softball
(diameter = 4 inches).

- 1) Calculate the distance from the softball to the "Earth". Then show that distance to me.
- 2) What would be the distance to the Moon?
- 3) What is the distance to Proxima Centauri (4.2 light years away)?

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

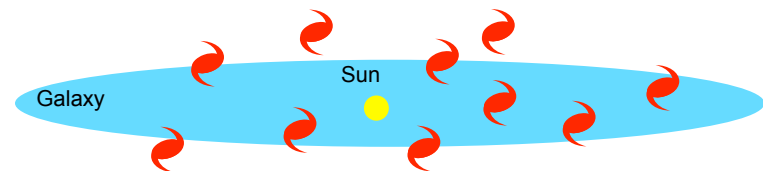
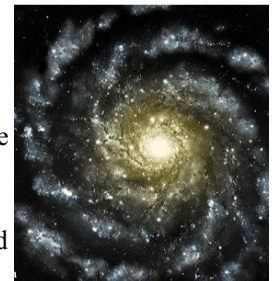
1 light year = 9.46×10^{12} km = 5.87×10^{12} miles

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

Those weird Spiral Nebulae?



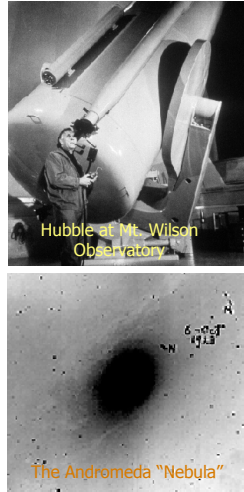
- Dim, diffuse, "interstellar" nebulae with spiral structure were seen in the 17th century.
- Some disagreement on what they were.
 - "A galaxy is a spiral "island universe" and the other spiral nebulae are the same and far away"
 - "Milky Way is all there is in the Universe, and the spiral nebulae are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



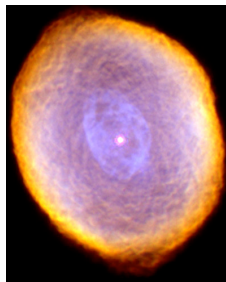
- Planets are now defined
- Stars – Nuclear burning machines, usually turning hydrogen into helium
 - Colors (temperatures: cold/red to hot/blue),
 - Sizes (Jupiter-sized to 1000x the Sun)
 - Masses (80x Jupiter to 100x the Sun)
 - Ages (Just born to nearly the age of the Universe)
- Galaxies
 - Collection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

Where do we Live? And What is our Fate?



- Our Sun is an average star, halfway through its lifespan.
- Will evolve to a Red Giant in about 5 billion years.
- Thousand years after that, it will eject its outer layers forming a planetary nebulae and a central white dwarf.

But our Solar System is located in our Galaxy– The Milky Way.



<http://spaceflightnow.com/news/n0009/07hubble/>

One of



We are:

- 1 planet out of 8 in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- 1 galaxy of the 100 billion galaxies in the observable Universe.

