Astronomy 122

TR 1300-1350

112 Chemistry Annex

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

This Class (Lecture 2):

Size Scales and the Sky

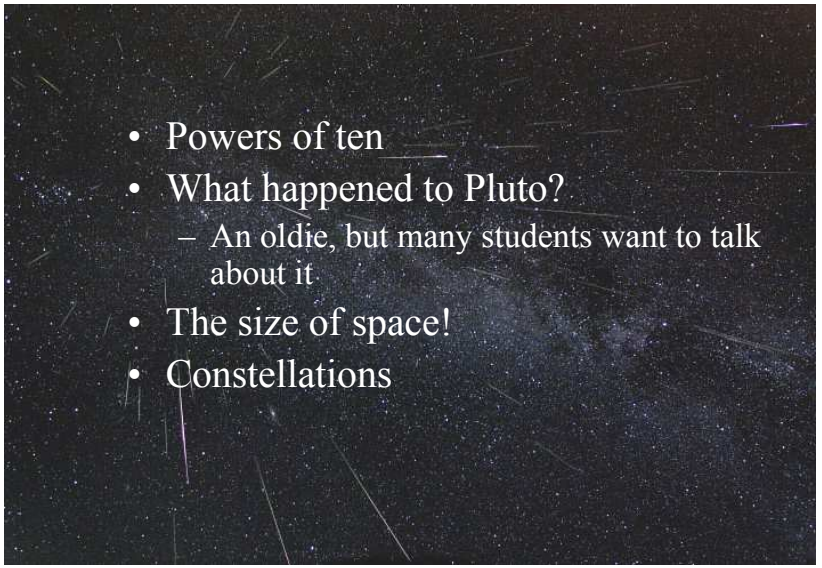
Next Class:

The Glorious Dance

http://eeyore.astro.uiuc.edu/~lwl/classes/astro122/spring08/

Music: *Fly Away* – Lenny Kravitz

Outline



- Powers of ten
- What happened to Pluto?
  - An oldie, but many students want to talk about it
- The size of space!
- Constellations

To understand the universe, astronomers use the laws of physics to construct testable theories and models

Scientific Method: based on observation, logic, and skepticism

Hypothesis: a collection of ideas that seem to explain a phenomenon

Model: hypotheses that have withstood observational or experimental tests

Theory: a body of related hypotheses can be pieced together into a self consistent description of nature

Law: theories that accurately describe the workings of physical reality, have stood the test of time and been shown to have great and general validity

Power of Tens: Adding another Zero

http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html

http://www.youtube.com/watch?v=LnqXcK4YPM0

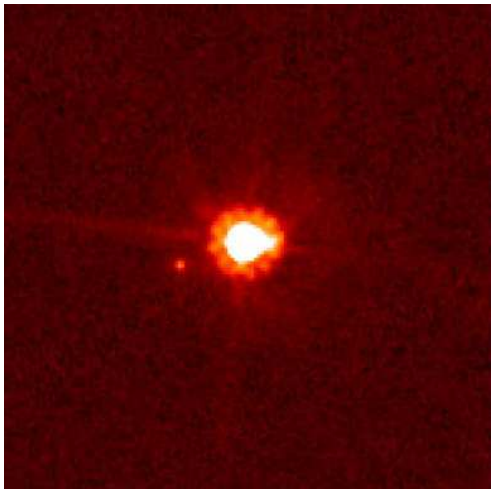
http://www.youtube.com/watch?v=RHkOQFF5ewk

http://www.youtube.com/watch?v=1QPll-TKaEE

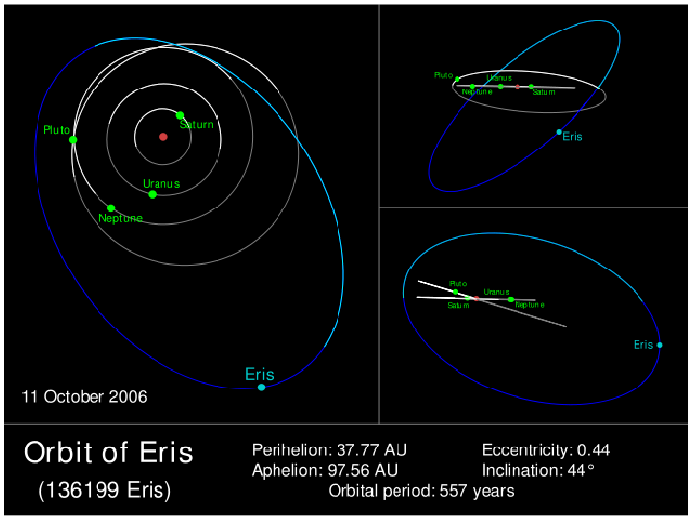
What is a planet?

The Planet Eris?

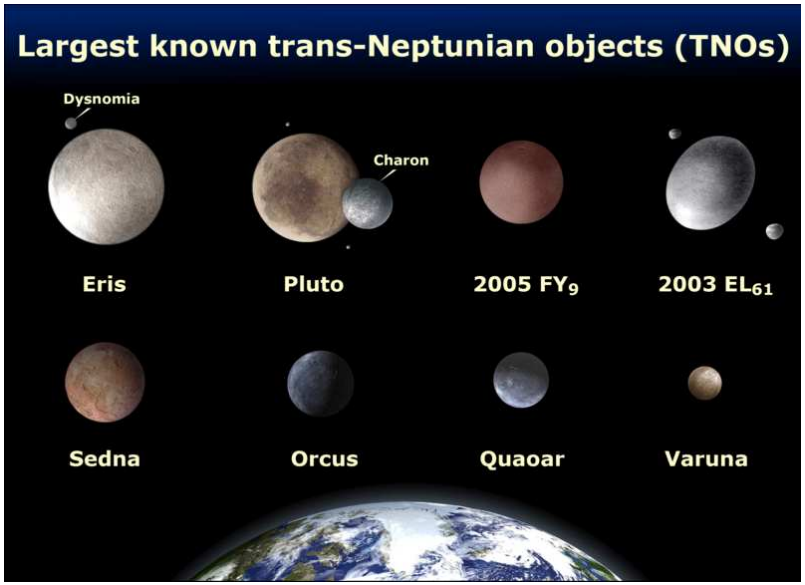
- ~20% larger than Pluto
- ~30% more massive than Pluto
- Has a moon (Dysnomia)
- Weird orbit



The Planet Eris?



Planet or Plan-not?



The Initial 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

12 Planets?

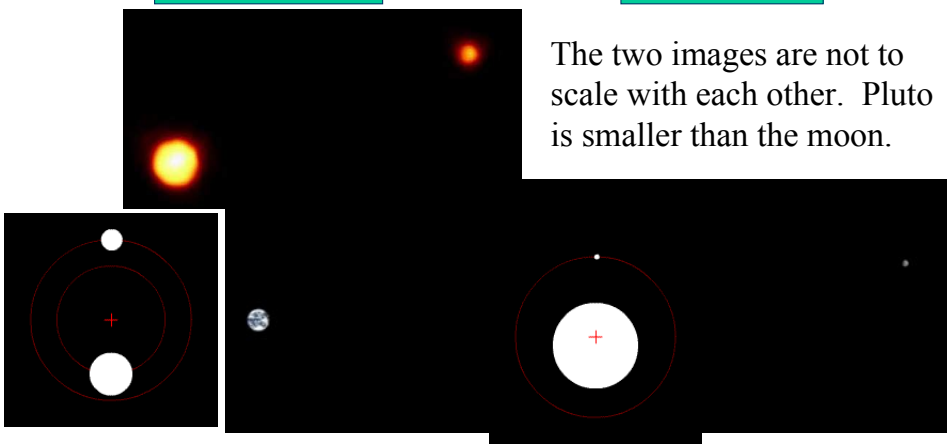
My Very Eccentric Mother Curiously Just Showed Us Nine Planters Conducting Encores

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

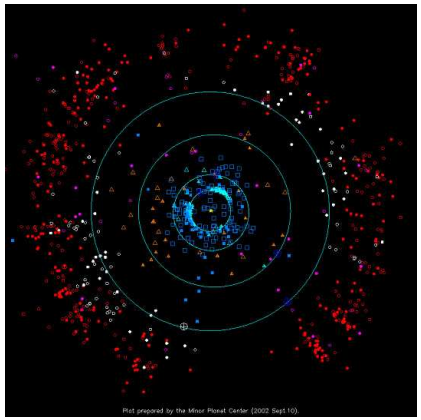
A planet is a celestial body that

(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

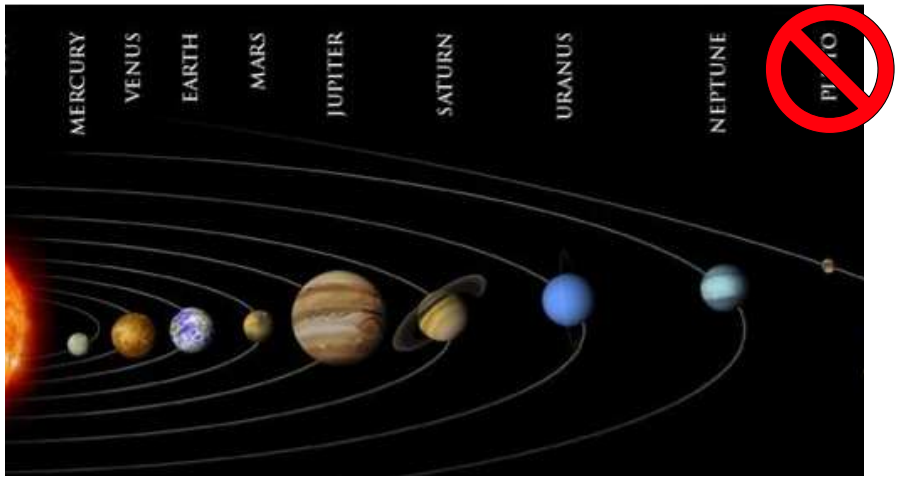
This definition would exclude Pluto (and others) because it's one of many...



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

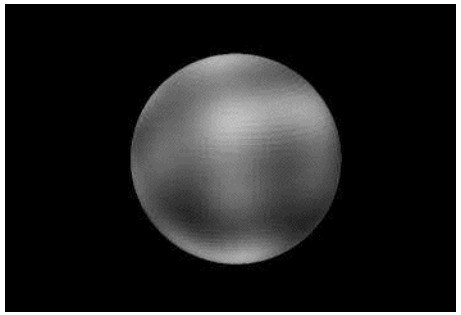
The Results...

8 ~~Nine~~ *Planets*



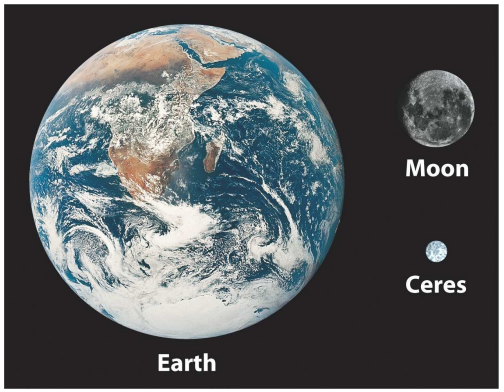
My Very Excellent Mother Just Served Us Noodles!

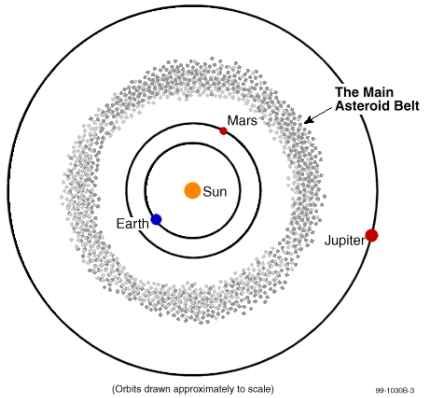
So what do we call Pluto now?



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

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**

Size Scales

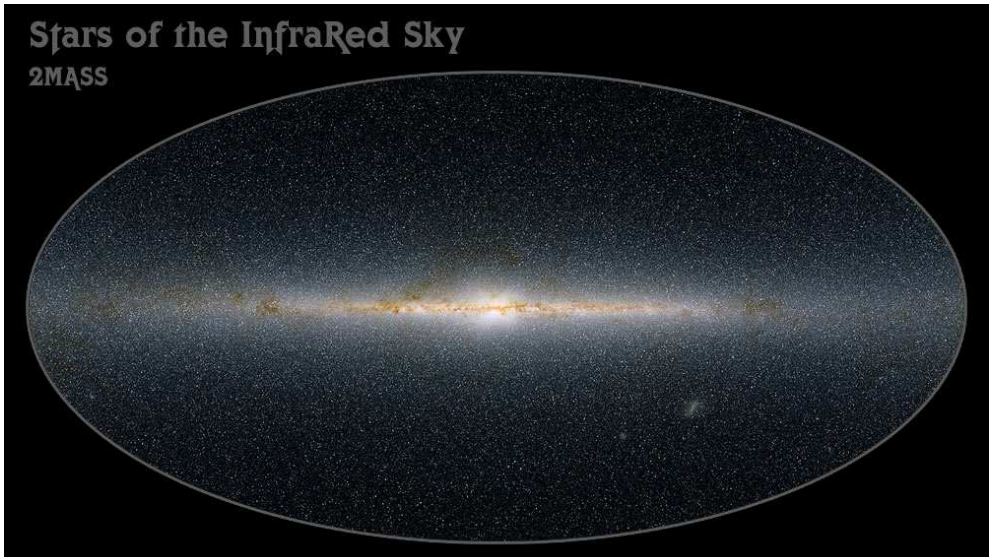
- The size scale of astronomy does not fit into one's head.
- First just look at the number of stars in our Galaxy…
- How many can you see with the naked eyes (a small fraction)?

A Sky Full of Stars

On a clear night at a dark site (away from city lights), about how many stars can we see with the naked eye?

a) **Hundreds**
b) **Thousands**
c) **Millions**
d) **Billions**

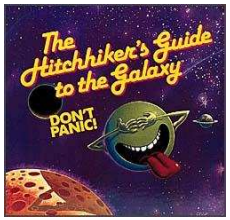
It's Full of Stars!



http://coolcosmos.ipac.caltech.edu/image_galleries/legacy/2m_allsky_stars/

A Sky Full of Stars

- **The average person on a clear night can see about 3000 stars**
  - 6000-8000 total visible (about half are below the horizon)
  - All in our Galaxy and relatively close to us
- **In late July 2003, the total number of stars in the observable Universe was estimated to be:**
  - 70 sextillion (70 thousand million million million or 7×10^{22})
  - About 10 times the number of grains of sand on all of the Earth's beaches and deserts



Space is Big!

"Space is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist, but that's just peanuts to space…

To be fair though, when confronted by the sheer enormity of the distances between the stars, better minds than the one responsible for the Guide's introduction have faltered.

The simple truth is that interstellar distances will not fit into the human imagination."

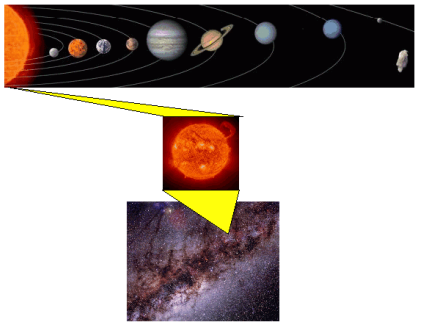
--Douglas Adams

The Hitchhiker's Guide to the Galaxy

One of

We are:

- 1 planet out of ~~9~~ 8 in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way



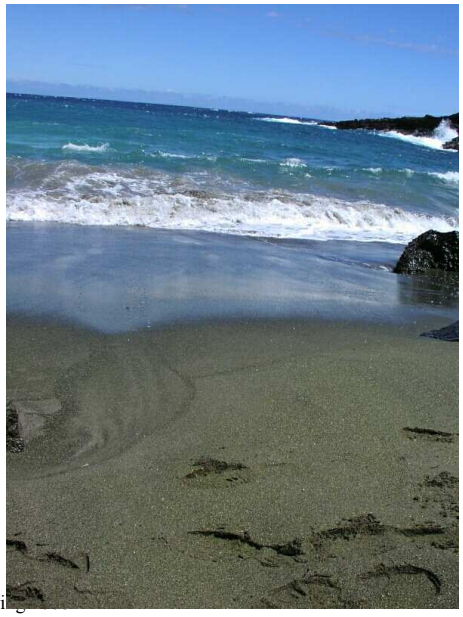
So what?

If you were to count every star in the Milky Way at one star a second, how long would it take you to count all the **visible** stars?

a) 3 years
b) 30 years
c) 300 years
d) 3000 years
e) 30,000 years

So?

- In the Universe, the number of stars is greater than the number of grains of sand on all of the beaches of the Earth.
  (Paraphrasing Carl Sagan.)
- Each of these stars may have planets.
- Is it sensible to think that life only exists on Earth?



Speed of Light

- Light has a finite speed that is the same for all observers. Regardless of the observer's speed. (Special relativity—later).
- Nowadays we **define** the speed of light to be

  2.998×10^8 m/s

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**

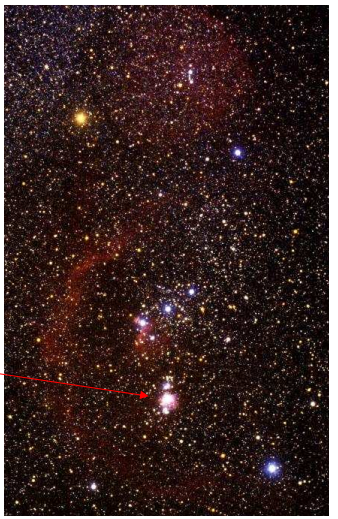
- Distance that light travels in one year
- Speed of light: roughly 3.00×10^5 km/sec
- 3.16×10^{17} seconds in one year

so 1 light year = $(3.00\times10^5$ km/sec) × $(3.16\times10^7$ sec) = 9.42×10^{12} km

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

First Contact?

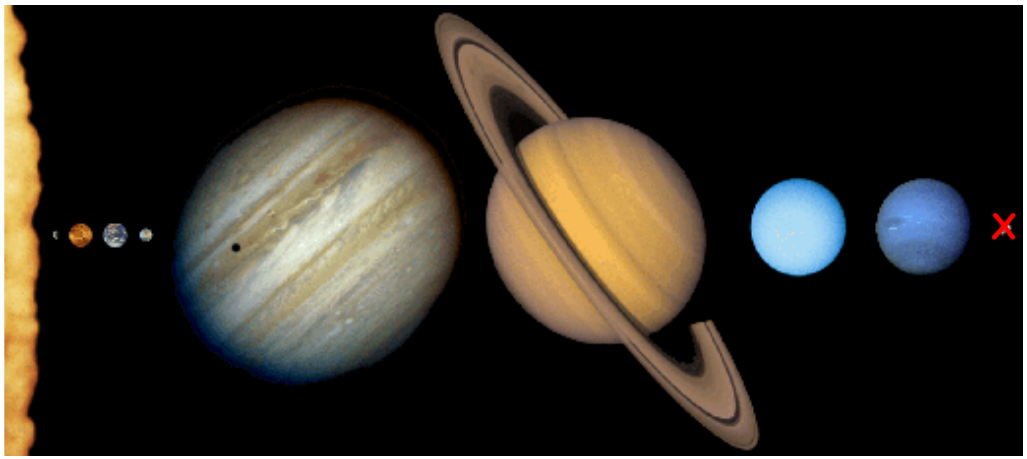
- Let's assume that there is life in the Alpha Centauri stellar system.
- It will take 100,000 years to travel on a Voyager-like spacecraft.
- It will take 8.4 years to send out a radio message and get a response.
- For stars in the sword of Orion, it would take 3000 years.



Other Distances

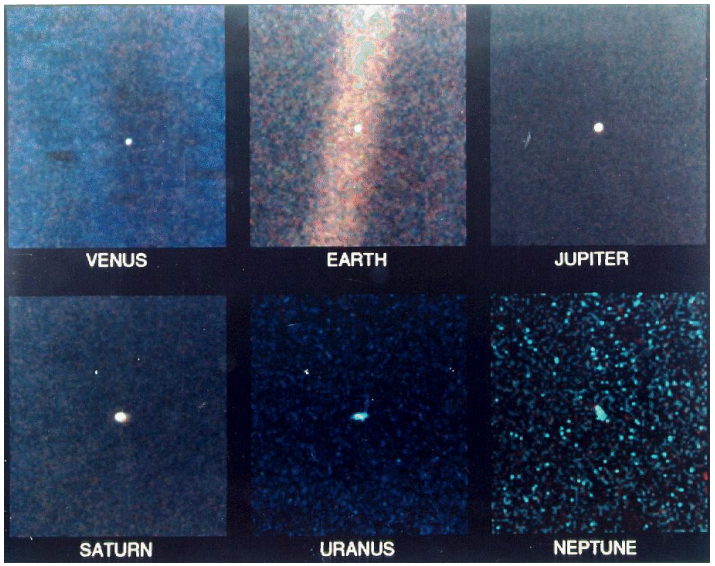
- 1 light year is 9.42×10^{12} km
- AU: the distance from the Sun to the Earth = 149,570,000 km = 1.58×10^{-5} light years
- pc: the distance away that a star would have a parallax of 1 arcsec = 3.086×10^{13} km = 3.26 light years

Size Scales



Perspective of Scale

Images from Voyager (launched in 1974) at 4 billion miles out. Moving at 100 times faster than a speeding bullet. And arguably just in interstellar space last year.

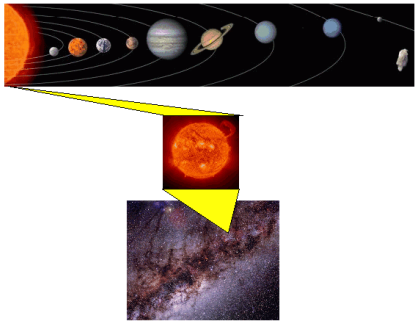


http://seds.lpl.arizona.edu/nineplanets/nineplanets/overview.html

One of

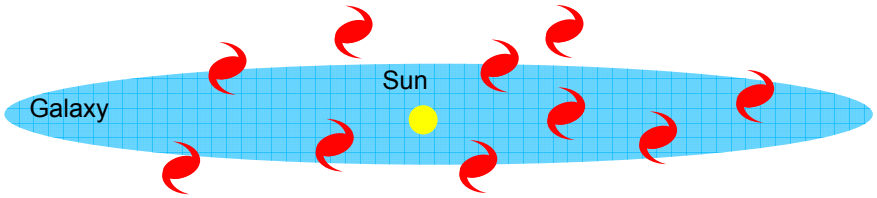
We are: 8

- 1 planet out of ~~9~~ in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- What's next? This took until the 1920s to suss.



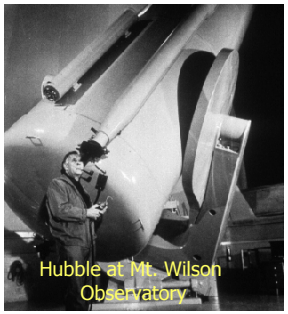
Those weird Spiral Nebulae?

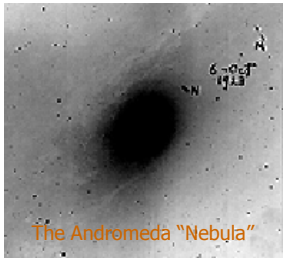
- Dim, diffuse, "interstellar" nebulae with spiral structure were seen in the 17th century.
- Some disagreement on what they were.
  - "A galaxy is a spiral "island universe" and the other spiral nebulae are the same and far away"
  - "Milky Way is all there is in the Universe, and the spiral nebulae 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 300,000 parsecs (modern estimate is 700,000)
- Andromeda is an "island universe" like our own Galaxy.

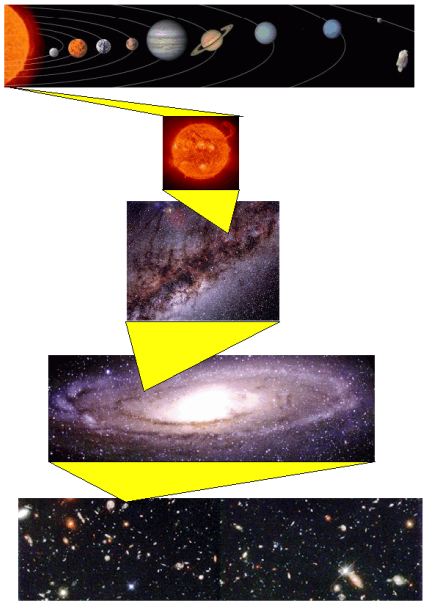




One of

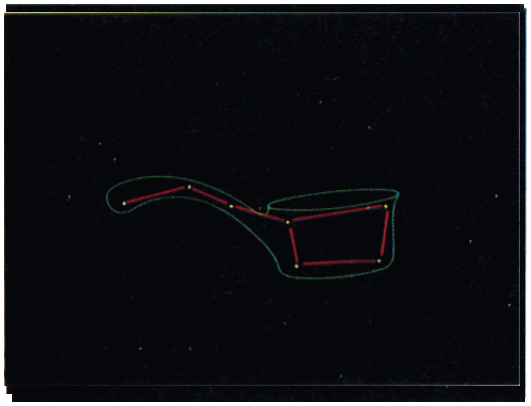
We are:

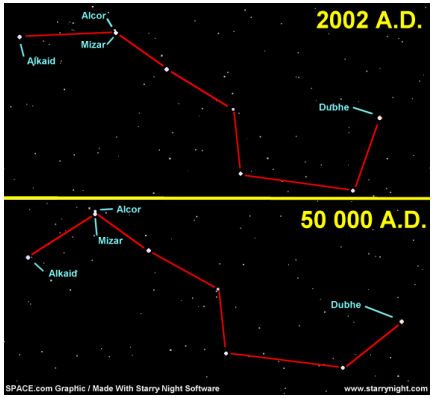
- 1 planet out of 8 in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- 1 galaxy of the 100 billion galaxies in the observable Universe.



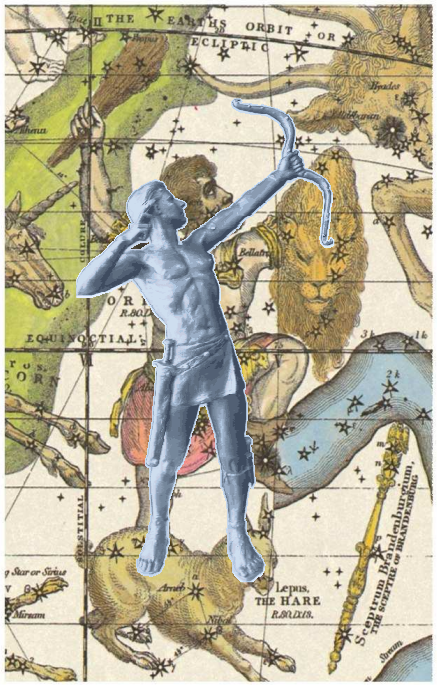
Constellations

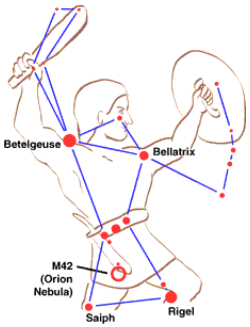
- **Constellations** -- a <u>visual</u> grouping of stars
  - named after gods, heroes, and animals





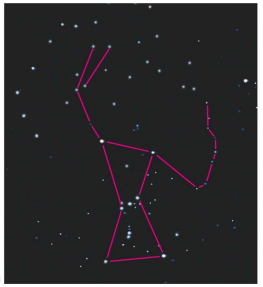
Orion: The Hunter

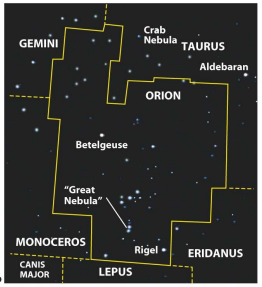




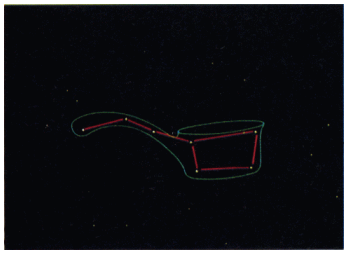
Constellations & Asterisms

- Today we have 88 "official" constellations
  - 50 ancient, 38 modern
  - Every region of the sky "belongs" to an official constellation





- Commonly recognized, but "unofficial" patterns are called **asterisms**
  - Parts of constellations
    - Big Dipper, Great Square, etc..
  - Cross-constellation patterns
    - The Summer Triangle, etc..



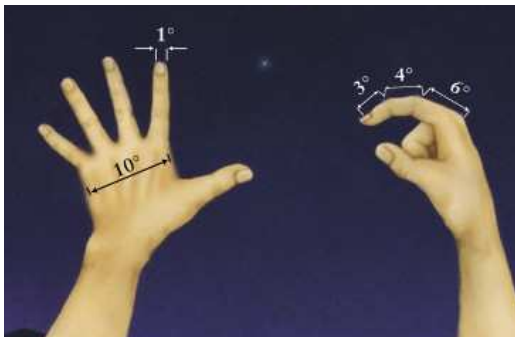
In Astronomy it's all about Angles

- As you know, to do a 360 is to go around in a circle

- 1 degree = 1° = 1/360 of a circle
- 1 arcminute = 1' = 1/60 of a degree
- 1 arcsecond = 1" = 1/60 of an arcminute
  = 1/3600 of a degree

Angular Sizes on the Sky

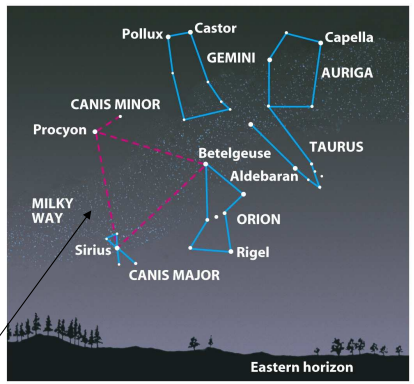
- Diameter of Sun or Moon roughly half a degree
- Jupiter is about 45 arcseconds
- Earth rotates at 360 degrees/24 hours or 15 degrees per hour
- 1 arcsecond is the angular size of a dime from about 2.5 miles away



2.5 miles!

Star Names

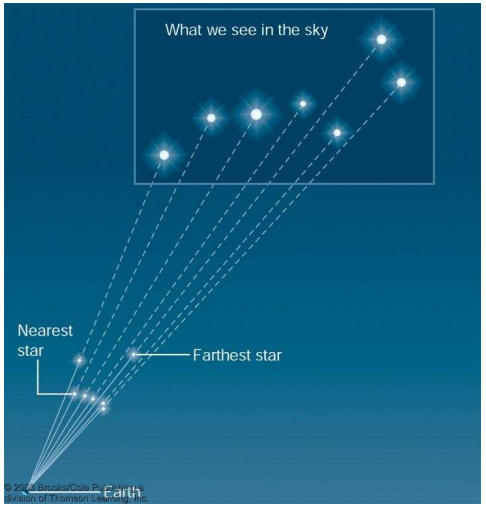
- Many bright stars have **proper names**
- Examples
  - Sirius – from Greek for "scorching"
  - Betelgeuse – from Arabic for "the armpit of the central one"



The winter triangle

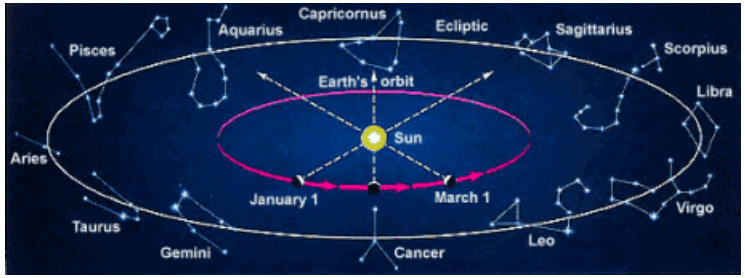
Constellations Are Patterns

- Remember, the constellations are *patterns*
  - Usually not physically associated
  - Stars in a constellation can be *very* far away from each other
- The sky would look very different from another solar system



The Zodiac

- The most famous of ancient constellations
  - Origins deep in our agricultural past
  - Many constellations symbolize planting or harvesting
  - 12 constellations (sort of), one for each lunar cycle per year.



The Real Zodiac

Table 1-1
The 13 Constellations of the Zodiac

Constellation	Dates of Sun's Passage Through
Pisces	March 13–April 20
Aries	April 20–May 13
Taurus	May 13–June 21
Gemini	June 21–July 20
Cancer	July 20–August 11
Leo	August 11–September 18
Virgo	September 18–November 1
Libra	November 1–November 22
Scorpius	November 22–December 1
Ophiuchus	December 1–December 19
Sagittarius	December 19–January 19
Capricorn	January 19–February 18
Aquarius	February 18–March 13