Astronomy 330:

Extraterrestrial Life

TR 11:00-12:20
Astronomy 134

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by appointment or email

This class (Lecture 2):

Astronomy Highlights

Next Class:

Pseudoscience Smackdown

http://eeyore.astro.illinois.edu/classes/astro330h/spring15/

https://learn.illinois.edu/course/view.php?id=10593

Horoscope Song: Weird AL

ASTR 330: Extraterrestrial Life

Astronomy Highlights

Poor Pluto

More Highlights

HW 1 due Sunday night

(simple Drake equation estimate)

"My horoscope says I'm due for a surprise today."

One slide to summarize this class

Are we alone?

How can we address this question in a scientific manner?

Drake Equation

Frank Drake

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

N	R_*	f_p	n_e	f_l	f_i	f_c	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 commun-icate	Lifetime of advanced civilizations
	stars/yr	systems/ star	planets/ system	life/ planet	intel./ life	comm./ intel.	yrs/ comm.

Course Goals

Drake Equation:

Central theme of course

Naive View: # Alien Civilizations with which might be able to communicate

Course View: Quantifies ignorance and guides our thinking about this question.

And have fun doing it!

Are we alone?

Yo, the Drake Equation ...

a) calculates the exact number of advanced civilizations in the Universe!

b) means nothing, its a fake equation. It is only meant to guide our thinking about the relevant questions.

c) It gives us an exact number of alien lifeforms (intelligent or not) in the Galaxy.

d) calculates the number of advanced civilizations in our Galaxy today.

e) allows us to estimate the age of the Universe.

iClicker

Basic Astronomy Highlights

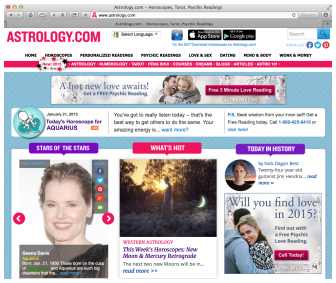
Why?

Easy refresher ...

in case you've forgotten ...

or, Dude, what time is it?

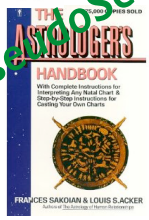
Astronomy is not Astrology!

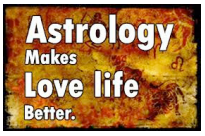


Astronomers used to make living with horoscopes, but did research too! Maybe we should go back to that model? Now, despite F&S questions, no relation! We don't do horoscopes. And do not call the Astronomy Dept the Astrology Department. You would be surprised how often this happens!

Astronomy is not Astrology!

Pseudo Science





Nevertheless, more people earn income by casting horoscopes than doing astronomical research

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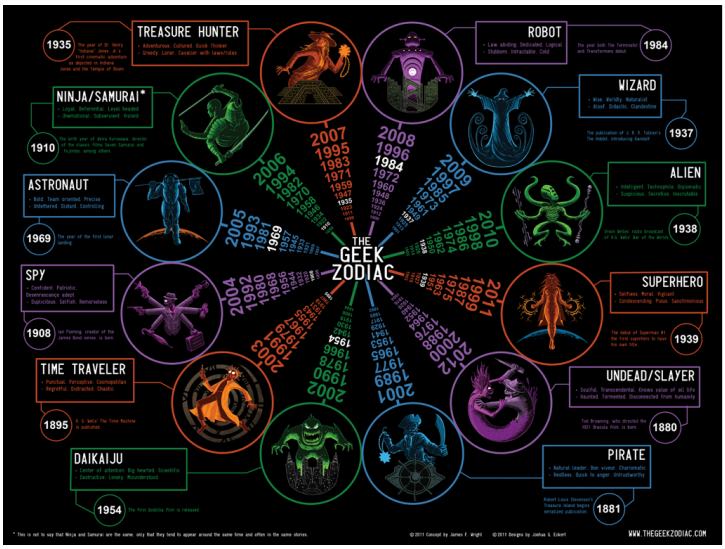
Group Think

Astrology

What do you think? Why?

Find the best Astrology-Astronomy confusion!



http://www.geekzodiac.com/index.html

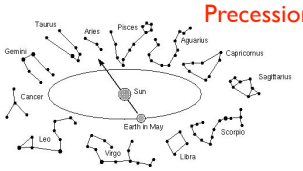
Astronomy is not Astrology!

Check out how the new zodiac configuration affects the various signs.

Sign	Old Dates	New Dates
Capricorn	Dec. 23-Jan. 20	**Jan. 9- Feb. 15**
Aquarius	Jan. 21-Feb. 19	**Feb. 16-Mar. 11**
Pisces	Feb. 20-Mar. 20	**Mar. 12-Apr. 18**
Aries	Mar. 21-Apr. 20	**Apr. 19-May 13**
Taurus	Apr. 21-May 21	**May 14-June 19**
Gemini	May 22-June 21	**June 20-July 20**
Cancer	June 22-July 22	**July 21-Aug. 9**
Leo	July 23-Aug. 21	**Aug. 10-Sept. 15**
Virgo	Aug. 22-Sept. 23	**Sept. 16-Oct. 30**
Libra	Sept. 24-Oct. 23	**Oct. 31-Nov. 22**
Scorpio	Oct. 24-Nov. 22	**Nov. 23-Nov. 29**
Ophiuchus	Not a Part of the Zodiac	**Nov. 30-Dec. 17**
Sagittarius	Nov. 23-Dec. 22	**Dec. 18-Jan. 8**

Zodiac defined ~2000 years ago

Hello McFly!
Precession ...



Ophiuchus: The 13th sign

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Babylonians Wanted 12 signs, dropped Ophiuchus.

Astronomy

Highlights

Highlights of the Week

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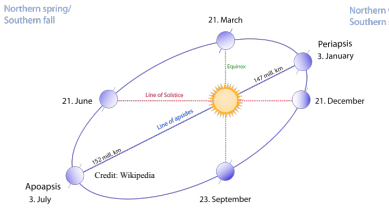
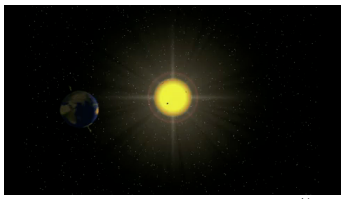
Basic Astro



Sky rises in East
Sky sets in West

Northern summer/
Southern winter



Northern fall/
Southern spring

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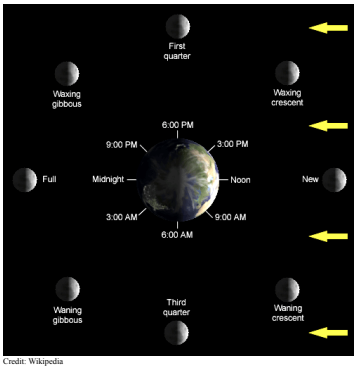
Earth orbits the Sun— once per year. It is a slightly elliptical orbit with the Sun at one foci. Every 24 hours, the Earth rotates and that gives the daily motion of the Sun rising in the East and setting in the West.

The reason for the Seasons: The Earth has a slight tilt (23 degrees). That tilt makes the Sun higher in the summer with longer days, and the Sun lower in the winter with shorter days.

The seasons have nothing to do with distance differences.

Basic Astro



Credit: Wikipedia

Moon is tidally locked

Far Side
not a
Dark Side

Lunar Phases

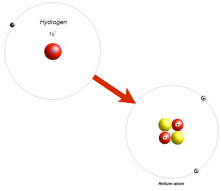
Occultation

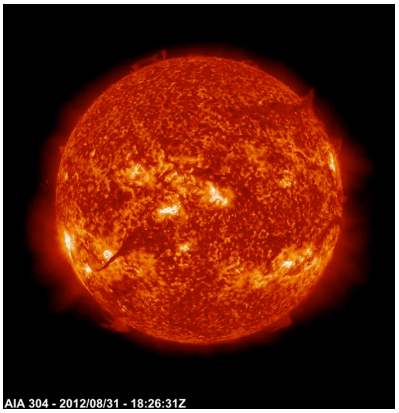
About once per Moonth (get it?), the Moon orbits around the Earth. The relative position of the Moon, Earth, and Sun causes the Moon to have phases.

Stars

Nearest star is ...

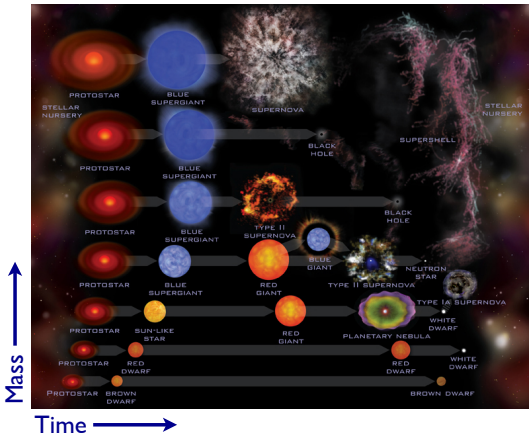
Thermonuclear Reactors:





A huge ball of hydrogen gas (much of it ionized). Mostly turning hydrogen into helium, which makes energy.

Stellar Lifetimes



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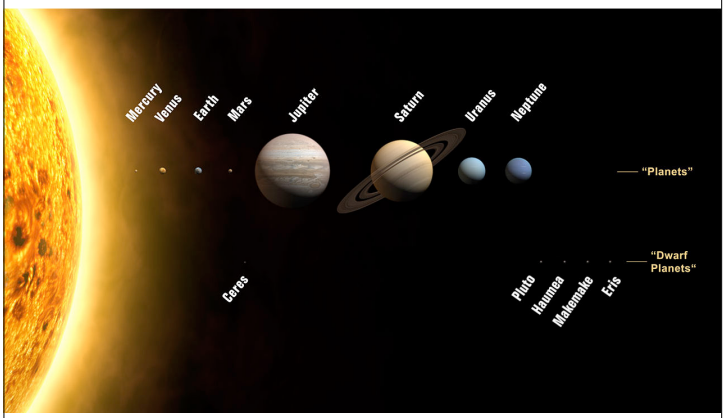
Some stars can burn (thermonuclear speaking) for 10's of billions of years (<0.5 solar masses), and some only burn for a few million years (>25 solar masses)

Solar System



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What happened to Pluto?

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

Traditionally there are 9 planets: 4 rocky, 4 gaseous, 1 "misfit"Scientists are arguing over the status of some of the solar system's smaller bodies

Also worth pointing out: (1) planets shine primarily by reflecting light from their star rather than by generating their own light like a star. (2) Until today, there was never an official definition of a planet. It was like art – "we know it when we see it"Today the IAU is voting on the definition of a planet!

What kicked off the ruckus? Xena!

The War of "What is a planet?"

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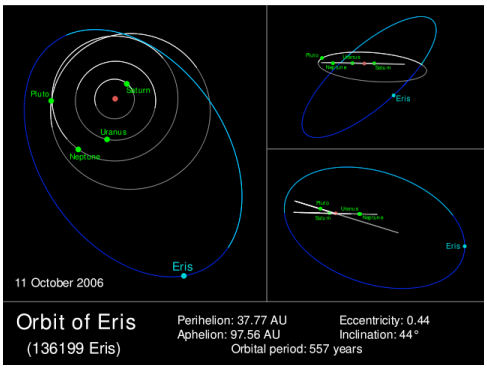
The Planet Eris?

Discovered in 2005



Potentially bigger than Pluto

Discovered in 2005 from images taken in 2003 at the Mount Palomar

About 2400 km across, slightly bigger than Pluto!

Orbits the Sun in about 560 years, at an average distance of 68 AU (varies from 38–98 AU)

On September 10th 2005, astronomers at the Keck Observatory on Mauna Kea discovered Xena has a "moon", Gabrielle!

Because its bigger than Pluto, if Pluto is a planet, what about Xena?

Two Dozen Planets???

Could these bodies also be inducted into "planetdom"?

Time for a *NEW Definition*

A planet is a celestial body that

(a) has sufficient mass for its self-gravity to assume a nearly spherical shape, and

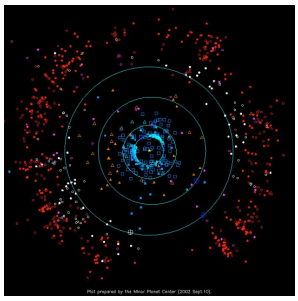
(b) is in orbit around a star, and is neither a star nor a satellite of a planet, ***and***

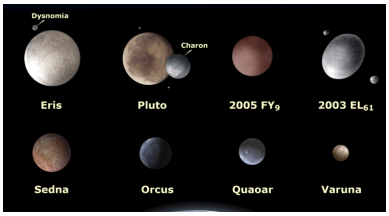
(c) has cleared the neighborhood around its orbit

New stuff in bold

Now, lets take a look at the consequences of this proposal

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

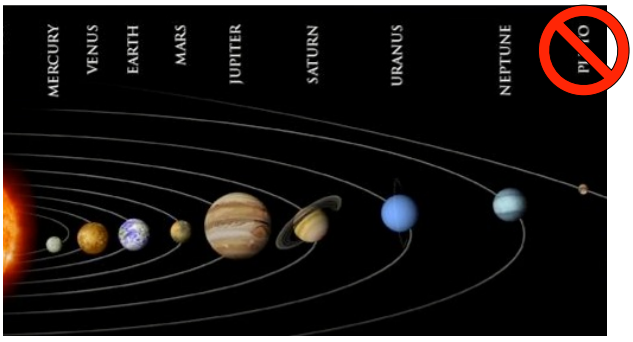
Pluto lies in a region beyond Neptune containing many (perhaps thousands or even millions) of small, icy/rocky bodies called the Kuiper Belt.

The Results...

Poll class...

Should Pluto remain a planet?

~~Nine~~ 8 Planets



My Very Excellent Mother Just Served Us Noodles!

This excludes Pluto, Charon, Ceres, and Xena from planetdom.

They are in "crowded areas".

There are hundreds of asteroids bigger than 100 km between Mars & Jupiter.

Pluto crosses Neptune's orbit, and it is part of a region of icy/rocky objects beyond Neptune, of which we already know dozens – and there may be thousands!

Whither the status of Pluto?

What do we call Pluto now?

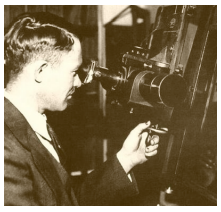
Planet-ish objects that meet the earlier definition, but fail to make the grade because of the new criterion would be called *dwarf planets*

Pluto is not a dog... its a dwarf!

Has a planet ever been demoted before? YES!

Not in Illinois!

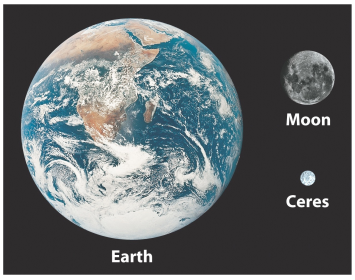
- Clyde Tombaugh, who discovered Pluto, was from Illinois, so the Illinois State Senate made a resolution
  - RESOLVED, BY THE SENATE OF THE NINETY-SIXTH GENERAL ASSEMBLY OF THE STATE OF ILLINOIS, that as Pluto passes overhead through Illinois' night skies, that it be reestablished with full planetary 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

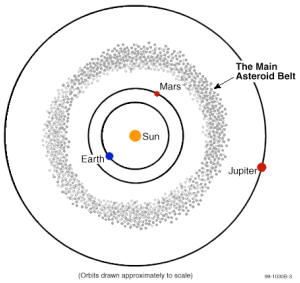


  - Luckily for us, it never passes overhead in Illinois!

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

Misery Loves Company





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

On january 1 1801, Ceres was discovered (after uranus, before neptune and pluto).

It was celebrated as a "new planet" between Mars & Jupiter

Ceres was listed as a planet in astronomy books and tables for about half a century

Ceres turned out to be disappointingly small, only 1000 km across

When other, similar but smaller, objects were found in the same area between Mars and Jupiter, Ceres was demoted from planethood and re-christened an "Asteroid" (small rocky body orbiting the Sun), of which it is the largest of millions.

Dude, what the hell happened to Pluto?

a) It's rotational energy decreased, which pushed it out of the solar system.

b) We found out that Pluto was never a planet.

c) The definition of Planet was modified.

d) A trans species mutation.

e) Aliens.

iClicker

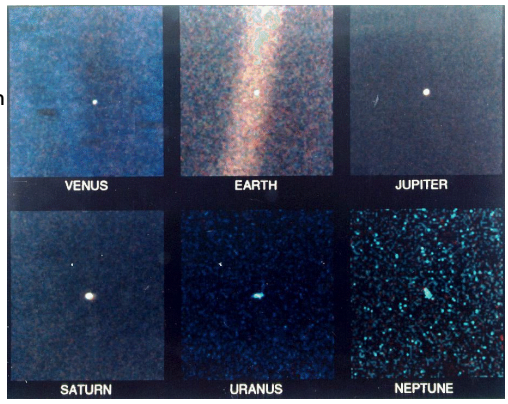
One of

We are:

- 1 planet out of ~~8~~ 9 in our solar system.

Perspective of Scale

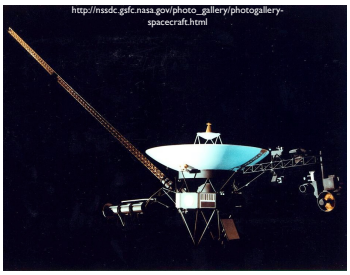
Images from Voyager (launched in 1974) at 4 billion miles out. Moving at 100 times faster than a speeding bullet (38,000 mph!). And just recently made it into interstellar space. It took 36 years!



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?

Nothing faster than the speed of light….

nothing!

Let's look into the constant speeder– light!

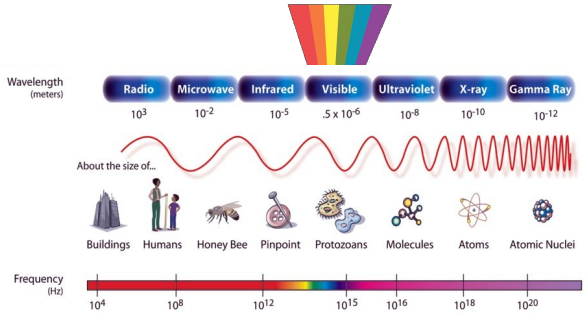
We'll be talking about it a lot.

Fastest thing out there.

Nothing faster allowed– we'll talk more about this later.

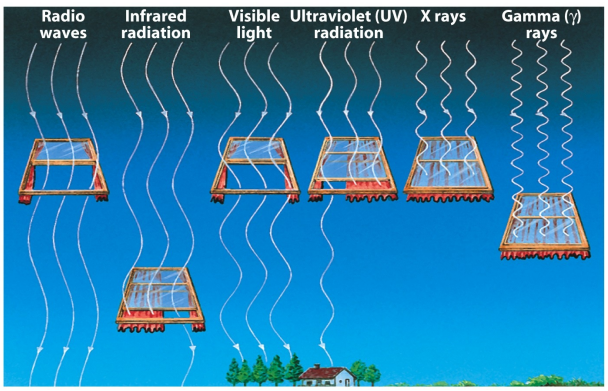
What is Light?

Light comes in many colors that you can not see! The color x-ray or color radio or color microwave. It is still 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 x 10^{10} microns

Or 285120 paces

Or 2 hours at car speed

Or 1 movie-unit at car speed

Or 0.7 ms at light speed

A Light Year

The **light-year**

- The **DISTANCE** that light travels in one year

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

peed of light: roughly 3.00×105 km/sec

3.16 × 1017 seconds in one year

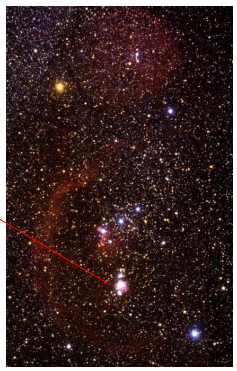
so 1 light year = (3.00×105 km/sec) × (3.16×107 sec) = 9.42×1012 km

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.

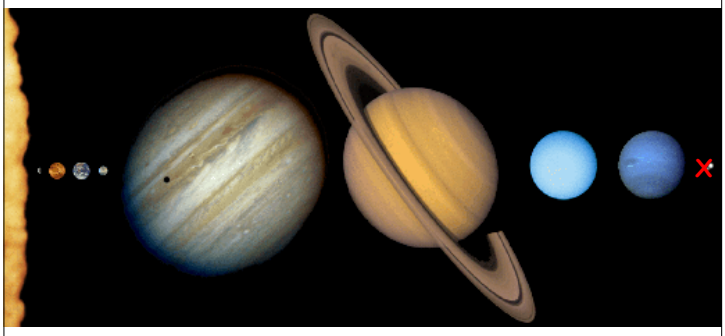


Other Distances

- 1 light year is 9.42×10^{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 This Class

In groups:

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

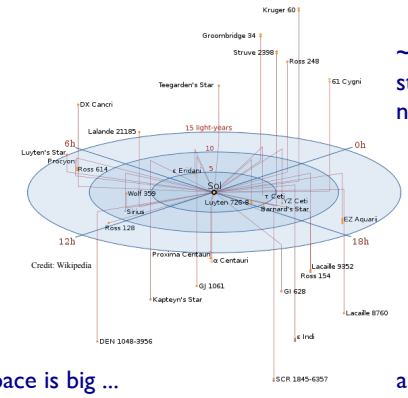
1)Calculate the distance from the softball to the "Earth". Then show that distance to me.

2) What would be the distance to the Moon from the Earth?

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!

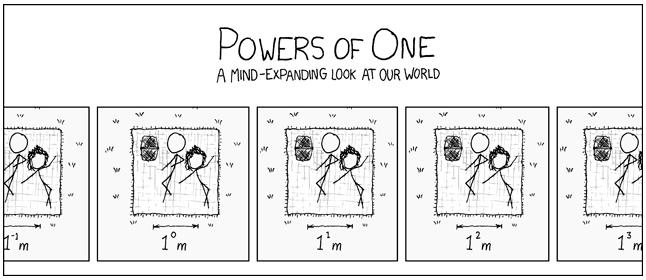
Nearby Stars



~6000 ***Naked Eye*** stars are primarily nearby

Space is big ... and mostly empty.

Scale it:
Powers of 10

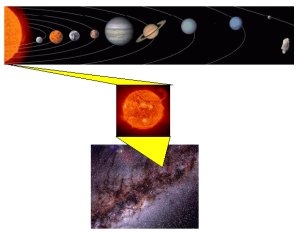


http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/

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
- What's next? This took until the 1920s to suss.



Next Time

A Pseudoscience Smackdown!