

Astronomy 330:

Extraterrestrial Life



This class (Lecture 12):

Planets for Life

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Next Class:

Planets for Life



Music: 3rd Planet – Modest Mouse

HW #4 due Sunday night.

HW #2



Brandon Murchison

<http://www.chron.com/news/nation-world/space/article/Were-aliens-watching-Apollo-12-astronauts-on-the-6018034.php#photo-7378978>
Apollo 12 mission to the moon were most likely being observed by aliens

Obinna Onyemepu

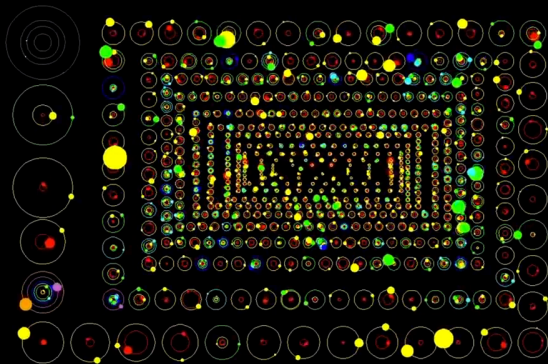
<http://www.ufoevidence.org/documents/doc119.htm>

The Dogon tribe was a West African tribe who knew some precise information about the Sirius star system.

2

The Kepler Orrery III

$t[\text{BJD}] = 2455255$



3

Group Think



In small groups discuss issues with the methods and estimate f_p .

Circumstellar disks

Starspots

Binary stars

Multiple planets

Detection limits

Orientation

Unknowns

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About 2/3 of all stars are in multiple systems. Is this good or bad? Disks around stars are very common, even most binary systems have them. Hard to think of a formation scenario without a disk at some point- single or binary system. Disk formation matches our solar system parameters. We know of many brown dwarfs, so maybe some planets do not form around stars. There might be free-floating planets, but...

Extrasolar planet searches so far give an absolute lower limit of about $f_p \sim 0.34$! Some estimates of total planets give an average of $f_p = 1$!!!! Maximum is 1 and lower limit is probably around 0.30.

A high fraction also assumes that the disks often form a planet or planets of some kind. A low fraction assumes that even if there are disks, planets do not form. f_p is not Earth-like planets, just a planet or many planets.

Drake Equation

That's 24 planetary systems/year

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

30 stars/yr

0.8 systems/star

planets/system

life/planet

intel./life

comm./intel.

yrs/comm.

Earth-like Planets?



What does this term mean?

$$n_e = n_p \times f_s$$



n_p = number of life-possible objects/system

f_s = fraction of star systems that can support life



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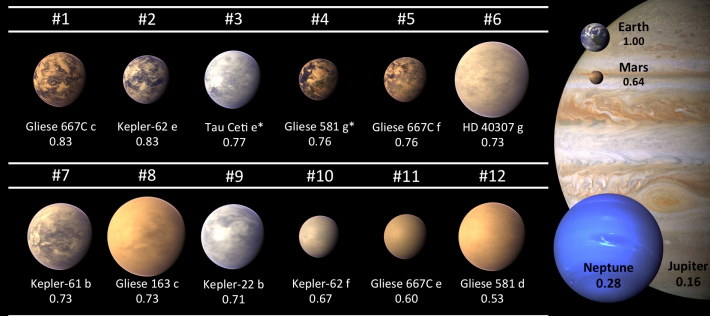
Terrestrial planets and Gas Giants... but how many are valid planets/moons for n_p ?

Habitable Planets?



Current Potentially Habitable Exoplanets

Ranked in Order of Similarity to Earth

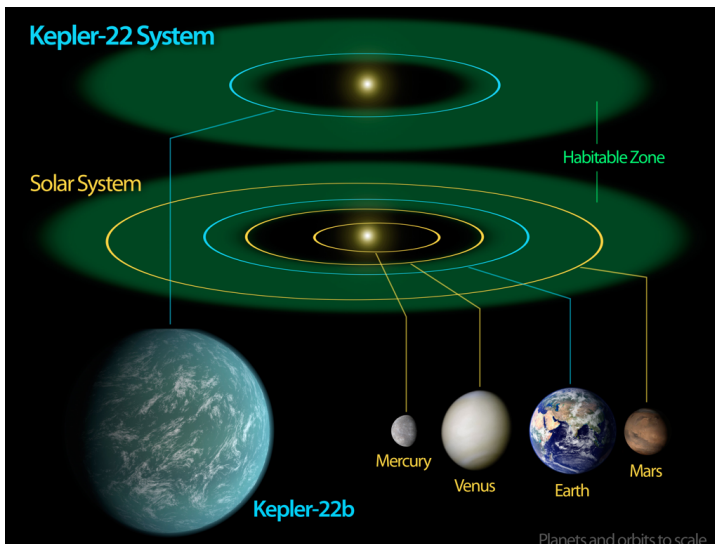


*planet candidates

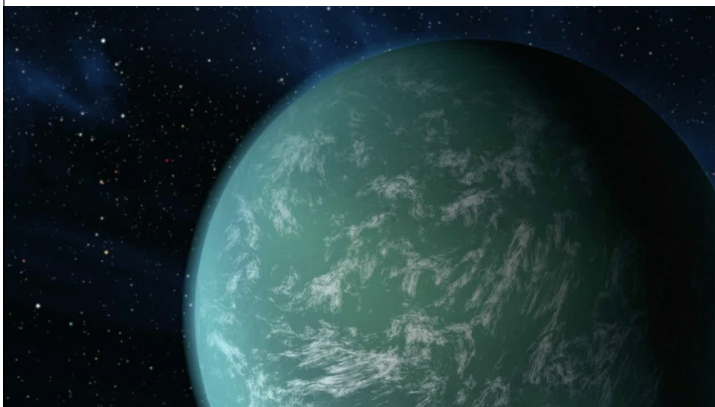
Number below the names is the Earth Similarity Index (ESI)

CREDIT: PHL @ UPR Arcibo (phl.upr.edu) December 5, 2013

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Kepler 22b



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More Habitable Planets?



~3 minutes



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Exomoons



Gas giants in other planetary systems likely have moons.

Massive Exoplanets in habitable zone?

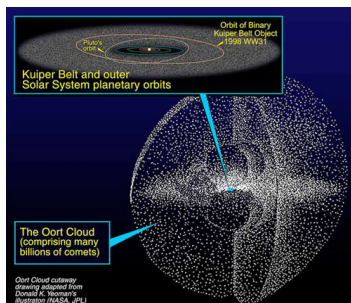
Gliese 876 b, 55 Cancri f, Upsilon Andromedae d, 47 Ursae Majoris b, HD 28185 b, and HD 37124 c

Other heating mechanisms?

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Extrasolar planet Upsilon Andromedae d lies in the habitable zone and if it has moons large enough, they may be able to support liquid water, as the image shows. On the horizon of this hypothetical earth-like moon can be seen Upsilon Andromedae d, possibly a class II planet (Sudarsky classification): since it is too warm to form ammonia clouds this one's are made up of water vapor, white in colour instead of the characteristic yellow-reddish clouds of Jupiter and Saturn.

Exocomets



How big is Oort Cloud?

Have we captured comets from other star systems?



Comets detected around Beta Pictoris



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Stars are born in clusters, did we share comets early on? Beta Pic had 100's of comets detected by seeing absorption lines against the star.

Question



What do the discovery of exocomets and the suggestions of exomoons mean?

- a) Other solar systems are likely similar to ours
- b) Aliens have the same killer sky anxieties that we do
- c) Astronomers should get more NASA funding
- d) Nothing
- e) Aliens stole our comets and moons.

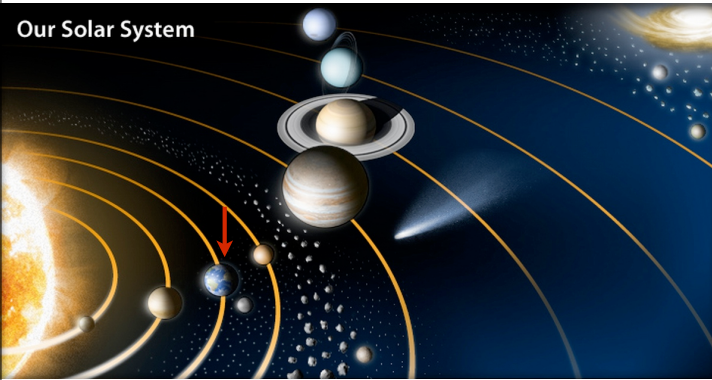
iClicker

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Life Supporting Objects



Our Solar System



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Life



Life on Earth



Liquid Water



- Primary role as a solvent
 - Dissolves molecules to bring nutrients and remove wastes. Allows molecules to "move" freely in solution.
 - Must be in liquid form, requiring adequate pressure and certain range of temperatures.
- This sets a requirement on planets, if we assume that all life requires water.
- Does it?

Water is a key to life on Earth. Primary constituent of life- "Ugly bags of mostly water" Life is about 90% water by mass.

http://www.youtube.com/watch?v=LA1qp0_a0tE

Life on Earth



Liquid Water



Temperature



Metals on Surface



Atmosphere



All good stuff for life!

Question



Which of the following items is not a feature of Earth that is important for life?

- a) Liquid Water
- b) Atmosphere
- c) Temperature
- d) Heavy Elements on surface
- e) Length of day/night

iClicker

E

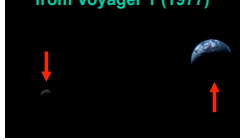
Formation of Earth



Planetesimals from the circumstellar disk.



Earth and Moon together from Voyager 1 (1977)



We find we live on an insignificant planet of a humdrum star lost in a galaxy tucked away in some forgotten corner of a universe in which there are far more galaxies than people

Carl Sagan

Earth formed from planetesimals in the circumstellar disk. Was hot and melted together. The biggest peculiarity, compared to the other planets, is the large moon.

Earth-Moon Comparison



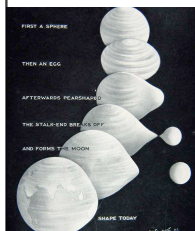
Radius 6378 km
Surface gravity 9.8 m/s²
Mass 6.0x10²⁴ kg
Distance to Sun 1.5x10⁸ km
Year 365.2422 days
Solar day 1 day

Radius 0.272 Earth
Surface gravity 0.17 Earth
Mass 0.012 Earth
Distance to Earth 384,000 km
Orbital Period 27.3 days
Solar day 27.3 days

Why a "double world"? Most moons are tiny compared to the planet. The Moon is over 25% the diameter of Earth. Jupiter's biggest moons are about 3% the size of the planet. The Moon is comparable to the terrestrial planets. About 70% the size of Mercury. Nearly the same density as Mars.

The Moon's surface is barren and dead. No water, no air, some water ice. No life!!

Moon Origin



Theories:

- 1) Ejected from Earth
- 2) Captured Object
- 3) Impactor Origin

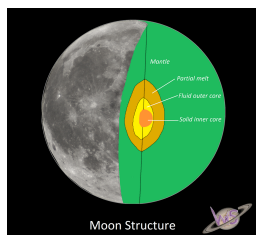


Fe Core
5.5 gm/cm³

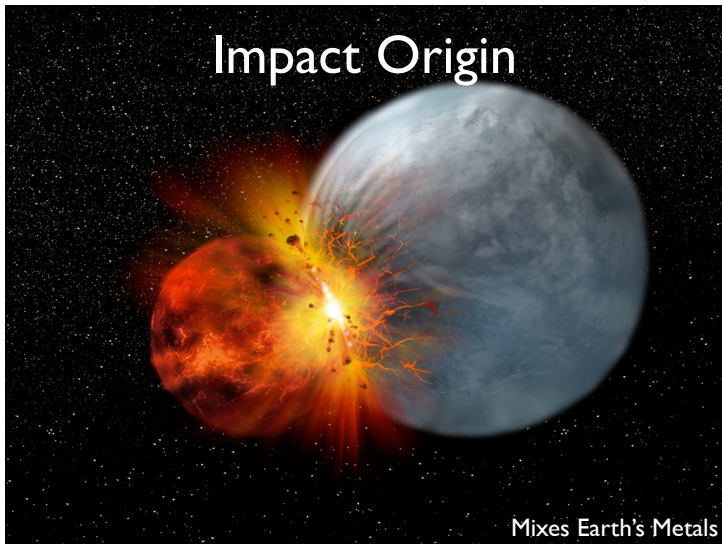


No Fe Core
3.3 gm/cm³

Ejecta from Rocky Mantle



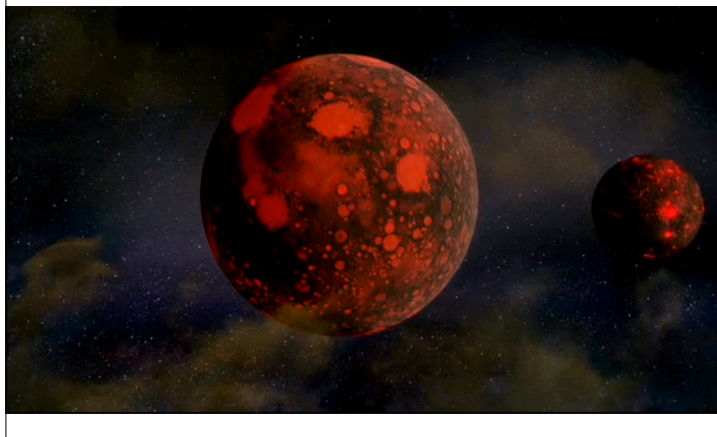
Impact Origin



http://physicsgg.files.wordpress.com/2011/09/moon_earth.jpg

Collision of Earth with a Mars-sized body early in the solar system's history. Iron-rich core of the impactor sank within Earth. Earth's rotation sped up. Remaining ejecta thrown into orbit, coalesced into the Moon.

Formation of the Moon



<http://www.youtube.com/watch?v=jbV4MdN5wo0&feature=related>