Astronomy 330

This class (Lecture 23):
Lifetime

Next Class:
Communication

HW10 is due Sunday. Not multiple choice, and will be graded harder than most HW!

Rough Drafts due tomorrow!

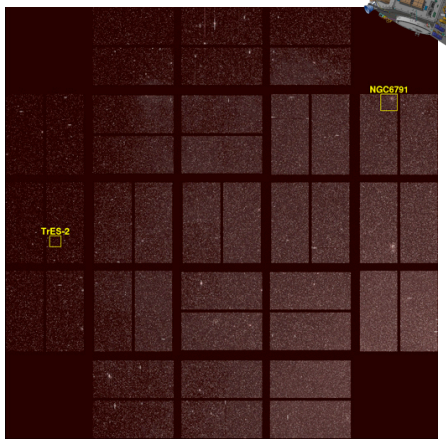
Music: *We Got the Neutron Bomb*– The Weirdos

Paper Rough Draft

- Worth 1% of your grade, but really worth more!
- Due in discussion class tomorrow (Hard date!)
- Should pretty much be the final paper.
- Will be looking for scope, ease-of-read, scientific reasoning, **proper citation**, and general style.
- 5 to 8 pages double-spaced 12-point font, not including references.
- ***Mars is a planet without an overzealous monkey population (Holt et al. 2000; James & Mann 2006; Walker 20007).***
  - ***I expect to see a few refs per page!***

Kepler

- The Earth-finding Kepler was launched March 6th.
- Finding Earth-like exoplanets by looking for transits (0.01% change)
- First images 10 degrees square!



http://www.nasa.gov/mission_pages/kepler/multimedia/images/fullFFIHot300.html

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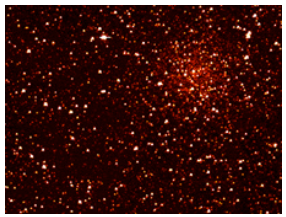
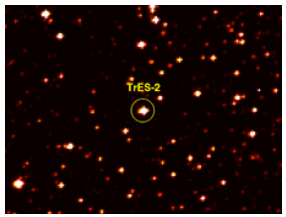




http://www.nasa.gov/mission_pages/kepler/multimedia/images/fullFFIHot300.html

Outline

- Lifetime of alien civilizations.
  - Could be a whole class (oh it is..)
  - Quick discussion
- What is L?

Drake Equation

Frank Drake

That's 1.65 Communicating life/century

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

# 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 commun-icate	Lifetime of advanced civilizations
	20 stars/ yr	0.12 systems/ star	1.25 x 0.12 = 0.15 planets/ system	0.4 life/ planet	0.23 intel./ life	0.5 comm./ intel.	yrs/ comm.

Lifetime of Civilization

- This factor pulls a lot of weight in the Drake equation. Are we alone or are there aliens everywhere?
- Easy to envision 4 cases:
  1. Communication efforts stop. Bored with lack of success or funding issues.
  2. Civilization evolves away from interest or capability. But empires rise and fall.
  3. Technological civilization collapses: exhaustion of resources and population growth,
  4. Catastrophe! Nuclear war or various natural problems.

Issues

- The last 2 items:
  - Technological civilization collapses
  - Catastrophe
- Could be caused by:
  - Resource Exhaustion
  - Population growth
  - Nuclear war
  - Natural catastrophe
  - Other…

Hiroshima

http://gawain.membrane.com/hew/Japan/Hirosh.html

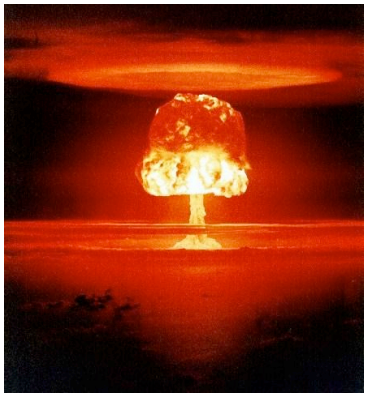
2. Population Growth

- Currently world population is around 6.7 billion (6.7×10^9).
- Population roughly doubles every 50 years–
  - 2050: 10 billion
  - 2100: 20 billion
  - 2150: 40 billion
  - 3000: ~200,000 times present population = ***1.3×10^{15}***
- In the year 3000, each person will have 4 square feet (2' by 2') of space (including the oceans!).
- A final absurdity, in 2550 years (the year 4554), the weight of humans would outweigh the Earth.
- Obviously something will have to be done!

http://w3.whosea.org/aboutsearo/88-97-7.htm

3. Nuclear War

- May be the only human activity that can catastrophically end our technological civilization.
- Effect may be seen days or years afterwards.
- Makes lots of radioactive elements with various half-lifes.
- Most destructive global nuclear war could cause a nuclear winter.



http://www.dalitstan.org/journal/recthist/nuclear/nuclear.html
http://cosmo.pasadena.ca.us/adventures/atomic/cold-war.html

3. Nuclear War

- Dust and debris thrown into atmosphere around the globe would block light and lower temperatures.
- Out of control fires would add soot to the dust layer.
- Major collapse of the world's food chain.
- Possibly extinguish our species.

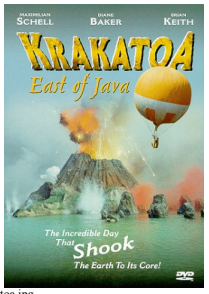
http://www.randomfate.net/MT/images/N_Korea_nuke.gif
http://cosmo.pasadena.ca.us/adventures/atomic/cold-war.html

4. Natural Catastrophes

1. Volcanoes
   - Worldwide distribution of dust. Same idea as nuclear winter, but without radioactive fallout.
   - Krakatoa eruption in 1883 near Java, blew away 75% of the island of Rakata. (Heard in Austria.)
   - Prolonged low temperatures "Year with no summer"

From Simkin and Fiske, 1983

http://www.vulkaner.no/v/volcan/indo/krakatau.html



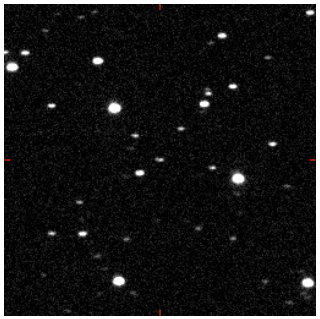
http://charm.hendrix.edu/astro/krakatoa.jpg

4. Natural Catastrophes

2. Comets and Asteroids
   - Many in Earth-Crossing orbits– NEOs.
   - Again, collision would create large amounts of dust in the atmosphere leading to global cooling.
   - Small objects can cause significant damage because the Earth's orbital velocity is 30 km/s $\Rightarrow$ KE = ½ M V^2
   - That means that a 0.25 km radius rock releases as much energy as 7200 megatons of TNT, as much as a all-out nuclear war!
   - Would make a 10 km crater a few km deep, ejecting 10^{12} tons of debris.

Killer Asteroids

- Small asteroids are often hitting the Earth's atmosphere.
- Commonly giving off around 10 kilotons of energy.
- But how often are Killer Asteroids (~ 0.5 km in diameter) expected?



Asteroid 2004 FH. 30 meters in diameter. About 1 Megaton of TNT energy in an Earth impact! Passed within 7 Earth radii of Earth. Hiroshima was 15 kilotons.

http://antwrp.gsfc.nasa.gov/apod/ap040322.html

4. Natural Catastrophes

- Common?
  - 5-10 m asteroid hits Earth every ~1 years.
  - 50 m asteroid hits Earth every ~1,000 years (Tunguska).
  - 1km asteroid hits Earth every ~500,000 years.
  - 5km asteroid hits Earth every ~10 million years.
  - >10 km asteroid hits Earth … last one was 65 million years ago
- Not a clock, just random events

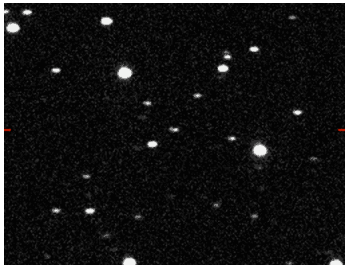
Lifetime Chances?

Cause of Death	Chances
Motor vehicle accident	1 in 100
Murder	1 in 300
Fire	1 in 800
Firearms accident	1 in 2,500
Asteroid/comet impact (lower limit)	1 in 3,000
Electrocution	1 in 5,000
Asteroid/comet impact	1 in 20,000
Passenger aircraft crash	1 in 20,000
Flood	1 in 30,000
Tornado	1 in 60,000
Venomous bite or sting	1 in 100,000
Asteroid/comet impact (upper limit)	1 in 250,000
Fireworks accident	1 in 1 million
Food poisoning by botulism	1 in 3 million
Drinking water with EPA limit of TCE*	1 in 10 million

http://www.planetary.org/html/neo/ABCsOfNEOs/FrndorFoe.html

Killer Asteroids

- In 1992 congress asked NASA to find near Earth objects.
- So far over 400,000 objects, probably all >1km objects
- The most dangerous known is 1950 DA (~1km), will get close in March 2880 (0.33% chance of collision).
- We can not predict orbits more than 20 years in advance, but 1950 DA would have 100,000 Megatons of energy.



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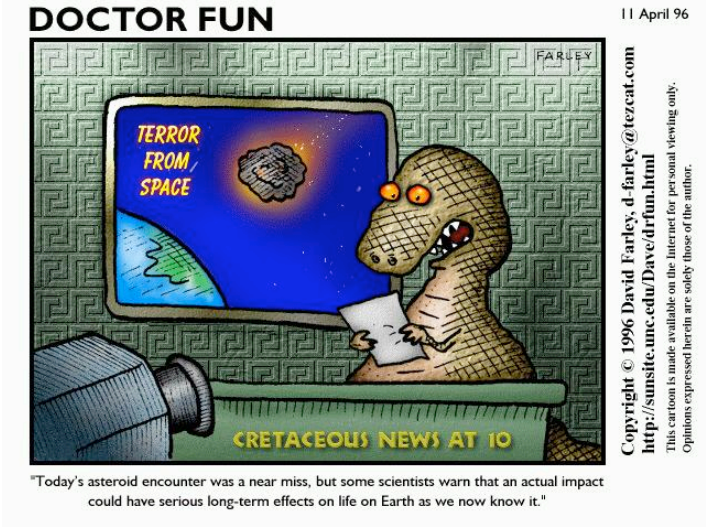
Be Aware



"Today's asteroid encounter was a near miss, but some scientists warn that an actual impact could have serious long-term effects on life on Earth as we now know it."

Killer Asteroids

- The Dino Killer was about 10 km in diameter.
- And, there are many asteroids out there that we still do not know about.
- On the long time-scale one of them will hit the Earth.
- What can we do if there is an immediate threat? There may be little time.

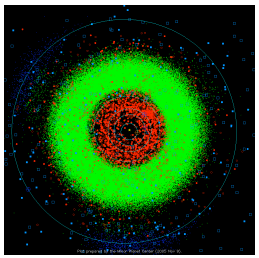
http://www2.ifa.hawaii.edu/newsletters/article.cfm?a=88&n=10

http://neat.jpl.nasa.gov/

http://www.ll.mit.edu/LINEAR/

Killer Asteroids

- Diversion or destruction of object.
- With sufficient warning it doesn't take too much to miss the Earth.
- One example is to change reflectivity of surface.
- Nuclear explosions may result in many small asteroids.
- Expensive and difficult, but advanced civilizations should be able to do it.



http://neat.jpl.nasa.gov/

http://www.ll.mit.edu/LINEAR/

Question

A larger asteroid will eventually hit the Earth again, what is the best way to avert it.

a) Bomb it.
b) Move to Mars
c) One word: lasers
d) Discover it years in advance.
e) There is already a secret project in place to avert any large asteroid– loose lips sink ships.

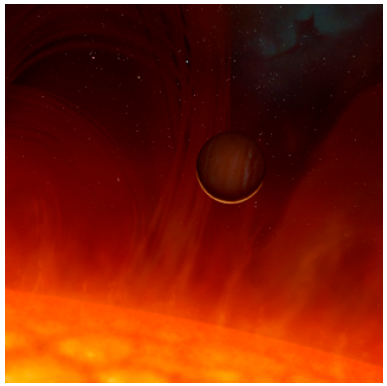
4. Natural Catastrophes

3. Stellar Evolution
   - The Sun is halfway through its lifetime on the main sequence.
   - Its luminosity will increase as it becomes a red giant in 5 billion years.
   - Sun will expand 250 times in radius
   - Earth will move outward, but likely will be eaten by the Sun.

http://www.astroimages.net/Media/SolarSys/AR03.html

4. Natural Catastrophes

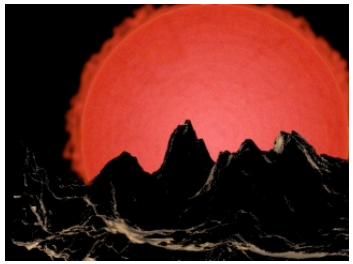
3. Stellar Evolution
   - Even earlier though, as the Sun ages, it will get bigger, hotter, and more luminous.
   - This means that even before it goes Red Giant, it will get more luminous.
   - In fact, it will get so hot at the Earth that the oceans will evaporate in 1 billion years!



http://www.sciam.com/media/inline/FA992809-E7F2-99DF-30B7058698177187_1.jpg

Natural Catastrophes

3. Stellar Evolution
   - But an advanced civilization can decrease greenhouse gases or increase dust in the atmosphere.
   - Eventually, we would have to leave the Earth, move the Earth, or move to Mars.
   - Even shorter variations in the Sun's luminosity can result in ice ages. Again, advanced civilizations can add greenhouse gas.



http://www.boulder.swri.edu/~terrell/dtart_old.htm

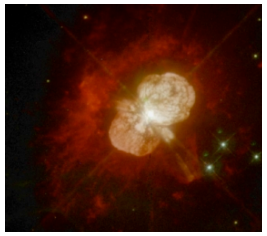
Question

In 5 billion years, our Sun will begin to turn into a red giant, on its way to a white dwarf. But never fear,

a) An advanced civ can stop the Sun from evolving.
b) We can always move to Venus.
c) An asteroid will probably hit and destroy the Sun first.
d) The Moon will be fine.
e) The Earth's oceans will evaporate before then.

4. Natural Catastrophes

4. Killer Supernovae!
   - Death of a nearby massive star would be bad news.
   - Explosion within 30 ly would destroy ozone layer.
   - Right now, no candidates.
   - Unlikely to happen in time scales of less than 2 billion years.
   - A supernova event ~2 Myrs ago may account for an extinction event.



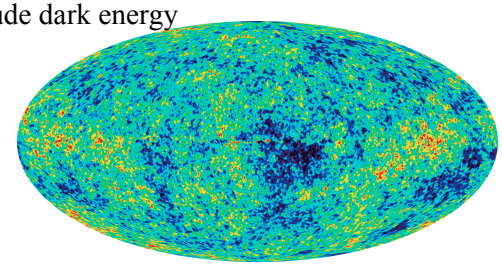
Question

A nearby killer supernova

a) is the most scary, as we won't know about it.
b) would have to be very close, but it could destroy the ozone layer .
c) is a supernova in our Galaxy.
d) would not cause any real damage, no matter how close it was.
e) will evaporate the oceans.

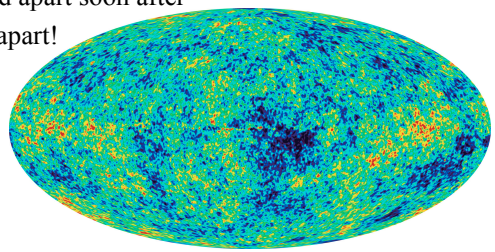
4. Natural Catastrophes

5. Ultimate limit to L!
   - Fate of the Universe.
   - A Big Crunch: 10^{12} years (a trillion years)
   - But, WMAP results from the cosmic microwave background suggest that we are in a flat universe.
   - Which does include dark energy



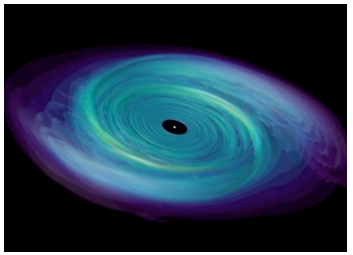
4. Natural Catastrophes

5. Ultimate limit to L!
   - The Big Rip?
     - If repulsive force increases– Brooklyn may expand too.
     - Gravity/E&M forces can not hold Galaxies rip apart
     - Could rip the MilkyWay apart in ~1 billion years
     - Earth gets ripped apart soon after
     - You get ripped apart!



4. Natural Catastrophes

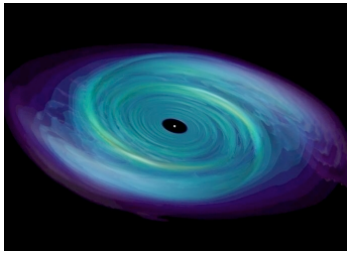
5. Ultimate limit to L!
   - Big Rip seems unlikely
   - We'll know soon.
   - If we are just in a flat Universe, then it is a matter of energy.



http://homepages.wmich.edu/~korista/web-images/accretion_ncstate.jpg

4. Natural Catastrophes

5. Ultimate limit to L!
   - Eventually all of the stars will burn out (10^{12} years).
   - Only energy source left is orbital energy.
     - Possibly extracting energy from rotating Black Holes.



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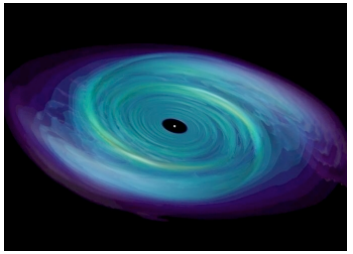
4. Natural Catastrophes

5. Ultimate limit to L!
   - Eventually, black holes evaporate (10^{100} yrs). Remember the Universe is 13.7 x 10^{9} or around 10^{10} years!
   - But half of all protons might decay by 10^{33} yrs.
   - Bottom line is that the maximum age is speculative.



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Top 10 Ways Astronomy Can Kill Humans

1. Impacts
2. Sun Evolution/Coronal Mass Ejections
3. Supernovae
4. Gamma-Ray Bursts
5. Rogue Black holes
6. Rogue White Dwarfs
7. Galaxy Collisions
8. Cosmology
9. Quasars
10. Aliens

What is L?

- How long on **average** can an advanced civilization exist?
- Again, we only have a sample of 1 from which to discuss. What is our civilization's lifetime?
  - Short Term (100-1000 yrs)
    - Give up on communication due to budgets.
    - Depletion of resources.
    - Population.
    - War.
  - Long Term (10^5 to 5 x 10^9 yrs– age of galaxy is 10^{10} yrs and we took half of that to evolve)
    - Stellar Evolution.
  - Don't forget the random volcano, asteroid, or supernova.
  - Still in many cases an advanced civilization may be prepared for many of the issues!

L-ing it

- We are talking about the amount of time that an advanced civilization (averaged over time) can communicate.
  - They may not want to for long periods of time
  - They may give up
  - They may be killed off
  - They may run out of resources
- Solving our energy problem (cheap energy) will give the largest lifetimes.