Astronomy 330

This class (Lecture 21):
Lifetime
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Next Class:
Communication
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Presentations

- **Christine Fleener**
- **Emmanuel Arredondo**

Outline

- How long can a civilization last?

Drake Equation

That's 0.77 intelligent 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 commun-icate	Lifetime of advanced civilizations
	15 stars/ yr	0.5 systems/ star	2.7 x 0.134 = 0.36 planets/ system	0.95 life/ planet	0.3 intel./ life	comm./ intel.	yrs/ comm.

Lifetime of Civilization

- If a civilization can communicate with other life forms, and wants to, how long can it last?
- 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

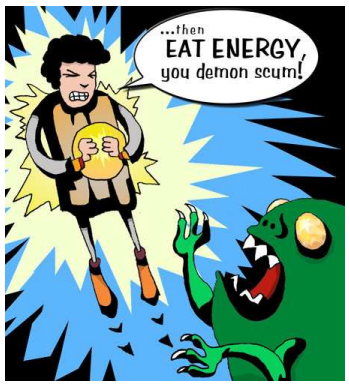
- The last 2 items:
  - Technological civilization collapses
  - Catastrophe
- Could be caused by:
  - Resource Exhaustion
  - Population growth
  - Nuclear war
  - Natural catastrophe

Hiroshima

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

1. Depletion of Resources

- Modern life depends on metals and rare elements.
- Recycling can delay the depletion.
- Pollution of our water or air supply is still a problem.
- But, many of these issues can be solved with sufficient ***energy***.



http://www.timboucher.com/portfolio/eat-energy.jpg

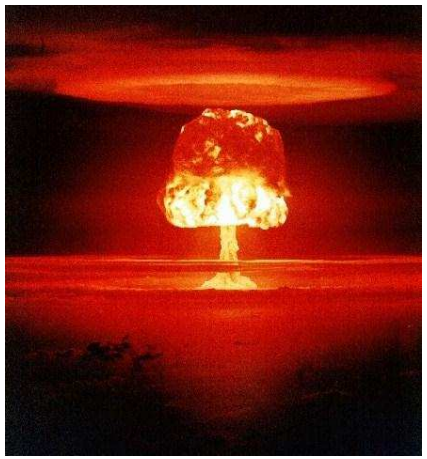
2. Population Growth

- Currently world population is around 6.6 billion (6.6×10^9).
- Population roughly doubles every 50 years–
  - 2050: 10 billion
  - 2100: 20 billion
  - 2150: 40 billion
  - 3000: 2.6×10^5 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

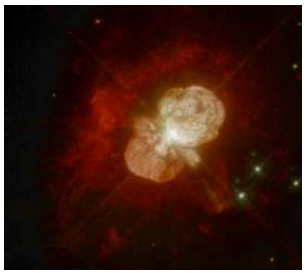
4. Natural Catastrophes

1. Volcanoes
2. Comets or asteroids
3. Stellar evolution
   (Sun becomes Red Giant)

http://www.vulkaner.no/v/volcan/indo/krakatau.html http://charm.hendrix.edu/astro/krakatoa.jpg

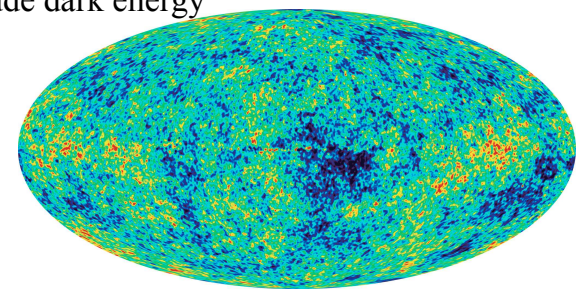
4. Natural Catastrophes

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 a mass extinction event.



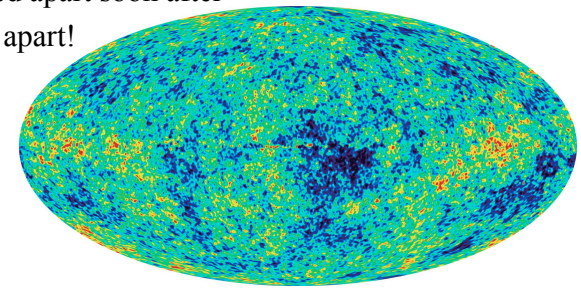
4. Natural Catastrophes

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



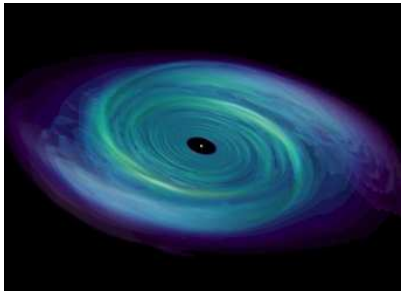
4. Natural Catastrophes

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

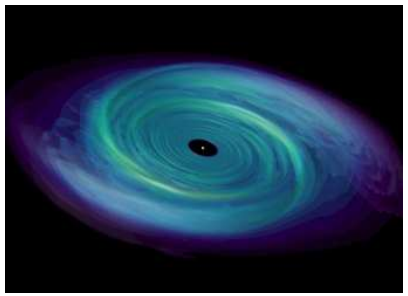
5. Ultimate limit to L!
   - Big Rip seems unlikely
   - We'll know soon.
   - If we are just in a flat Universe, then it is a matter of energy.



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.
   - 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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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!