

Astronomy 330



This class (Lecture 22):
Lifetime

Next Class:
Communication

Rough Drafts due next Discussion!!

Music: *It's the End of the World as We Know It* – R.E.M.

Apr 16, 2009

Astronomy 330 Spring 2009

Outline



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

Paper Rough Draft



- Worth 1% of your grade, but really worth more!
- **Due next discussion class (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 2007).*
 - *I expect to see a few refs per page!*

Drake Equation



Frank Drake

That's 3.3 intelligent systems/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 communicate	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	comm./intel.	yrs/comm.

f_c Your Guess!



- Given that an intelligent civilization exists, what is the likelihood that it can (technologically advanced) and will want to (knows astronomy and thinks that its chances are good) communicate?
- Cultural evolution to **technology** and **worldview** are essential components of f_c
 - Extra-somatic storage of info crucial.
 - Technology and innovation– quantum mechanics
 - Copernican revolution played an important role.
 - ET has to realize that they are not the center of the Universe and that there might be other life.
 - How fast were these accomplishments? What is fast?

Big Questions for f_c



- Our capacity for interstellar communication arose at the same time as our interest in it. Coincidence?
- Can a society have a highly developed technology with an incorrect astronomy?
- What if the skies were constantly cloudy?
- What if their solar system had no other planets?
- What if they lived in a molecular cloud?
- What if they lived in a huge cluster of galaxies?

f_c Development



- Are we typical?
- Is it inevitable f_c = 100% or a fluke 1/10000?
- Remember civilizations come and go, but in general the gains (technology/worldview) aren't lost.
- Picked up by the next civilization.
- Even if one civilization goes dark for centuries, eventually another rekindles the technology/worldview.
- We are talking about the ability to communicate, not that the civilization is communicating.

Drake Equation



Frank Drake

That's 3.3 x ? Communicating life/century



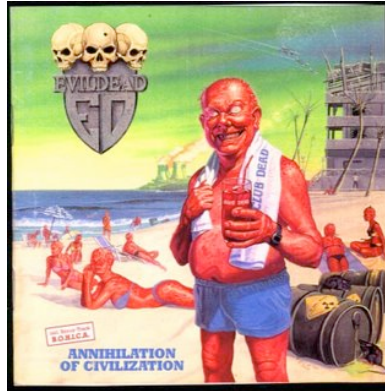
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Lifetime of Civilization



- If a civilization can communicate with other life forms, and wants to, how long can it last?
- We are talking about the long haul here, not necessarily short time scales.



Lifetime of Civilization



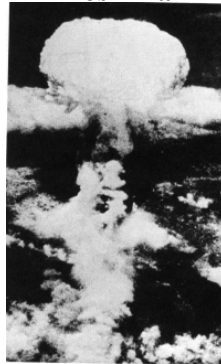
- This factor pulls a lot of weight in the Drake equation. Are we alone or are there aliens everywhere?
- Easy to envision 4 cases:
 1. Communication efforts stop. Bored with lack of success or funding issues.
 2. Civilization evolves away from interest or capability. But empires rise and fall.
 3. Technological 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

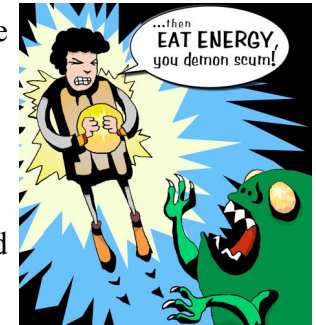


<http://gawain.membrane.com/bew/Japan/Hirosh.html>

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>

1. Depletion of Resources



- Energy allows us to recycle, remove salt from the oceans, grow more crops, and generally convert material into the form we need.
- So, energy is our **greatest** concern.
- Remember that energy is not depleted, rather converted from useable form to less useable form (2nd law of Thermodynamics).



<http://europa.eu.int/comm/mediatheque/photo/select/energy/p-009892-00-8h.jpg>

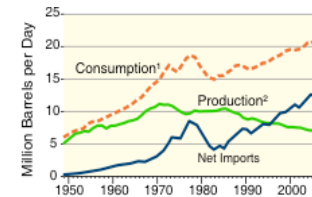
Energy



- Majority from chemical means– fossil fuels– electricity and gasoline (92% in the U.S.).
- Really are from fossils, representing millions of years of life.
- And how are we spending it?
- The average US citizen uses twice that of a European, and 5 times the world average.



<http://www.orps.state.ny.us/sas/graphics/oilwells.jpg>



¹Petroleum products supplied is used as an approximation for consumption.
²Crude oil and natural gas plant liquids production.
 Source: Energy Information Administration, Annual Energy Review 2007-Table 5.1. (June 2008)

http://tonto.eia.doe.gov/energy_in_brief/foreign_oil_dependence.cfm

Energy

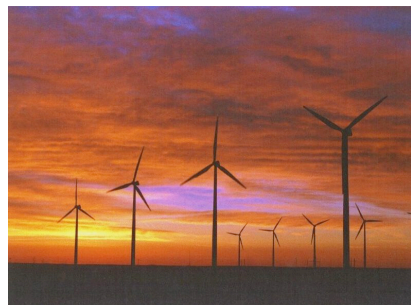


- Easy to obtain fossil fuels should last 50-100 yrs, coal 300-600 yrs.
- We will have to change! But US spending on renewable energy sources dropped by factor of 10 in the 1980s.
- SUVs do not help.



<http://www.orps.state.ny.us/sas/graphics/oilwells.jpg>

<http://www.astrosurf.org/lombry/Documents/windfarm.jpg>



http://www.dealerimpact.com/downloads/desktop_imgs/800x600-hummer.jpg

Nuclear Fission



- Breaking apart heavy (heavier than iron) unstable elements into lighter ones. Like an Un-Sun.
- Most widely used is ²³⁵U– formed from supernovae– so limited amount on Earth.
- Supplies are limited and length of use controversial.

Nuclear Fission Chain Reaction

- — ²³⁵U
- — Neutron
- — Fission Product



<http://library.thinkquest.org/17940/texts/images/chainreactionanim.gif>

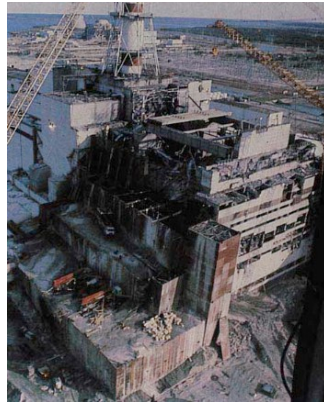


<http://www.capefeare.com/seasonone.php>

Nuclear Fission



- A large reactor power plant uses 26 tons of fuel and 25 tons of waste per year.
- What do we do with the waste?
- How to prevent accidents: Three Mile Island or Chernobyl?

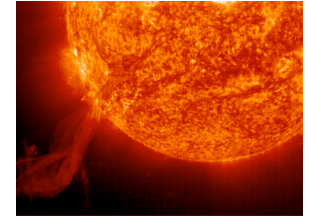


<http://www.ourtimelines.com/hist/chernobyl.jpg>

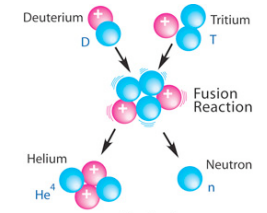
Nuclear Fusion



- What the Sun does for energy— $H \Rightarrow He$.
- Requires high density and temperature.
- How to contain it on Earth—Sun uses gravity.
- Put the Sun in a box, but how to build that box?



<http://antwrp.gsfc.nasa.gov/apod/ap051109.html>
<http://www.cnn.com/SHOWBIZ/9712/24/teletubbies/>
http://www.pppl.gov/fusion_basics/pics/fusion_dt_reaction.jpg



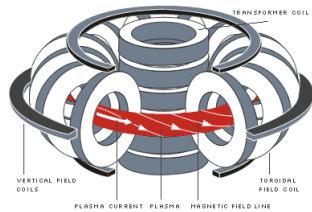
Payback
About 450 : 1
Diagram of deuterium-tritium reaction.

Nuclear Fusion



- Magnetic confinement, but not easy.
- Research continues, but unlikely to play a large role in the next 50 yrs.
- And on Earth requires deuterium (heavy hydrogen) not as abundant as hydrogen, nonetheless very promising!

Tokamak Fusion Reactor

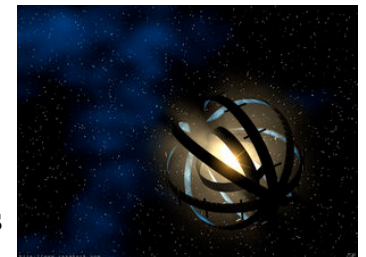


<http://www.ipp.mpg.de/ippcms/eng/pr/exptypen/tokamak/magnetspuen/index.html>

Long-Lived Civilizations



- Require renewable energy supplies, all Sun related.
- Hydroelectric (requires rain), windmills (winds), and solar power.
- Solar power is used today, but currently expensive because of manufacturing and tax subsidies for fossil fuels.
- Future example, could imagine a power plant that completely surrounds the Sun— e.g. Dyson sphere.

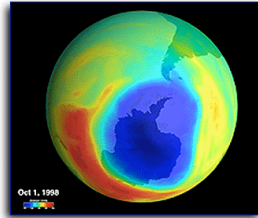


<http://capnhack.deviantart.com/art/Dyson-Sphere-11008136>

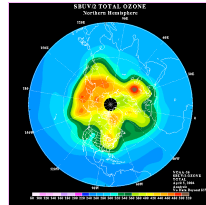
Pollution from Civilization



- Ozone layer (O_3) is formed from O_2
 O_2 broken up by ultraviolet light
- Ozone protects life against harmful Sun rays.
- Chlorofluorocarbons (CFCs) destroy the ozone.



ANTARCTIC OZONE HOLE
 PHOTO COURTESY OF NASA

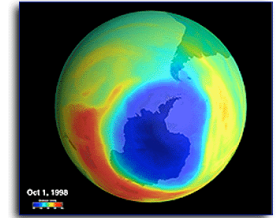


http://www.epc.ncep.noaa.gov/products/stratosphere/sbuv2to/gif_files/sbuv16_nh_latest.gif
<http://www.ngdc.noaa.gov/paleo/globalwarming/images/ozone.gif>

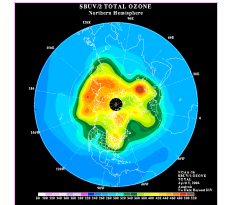
Pollution from Civilization



- CFCs were used in A/C and refrigeration.
- Governments did not do much until a large hole appeared over Antarctica and N. America.
- Finally, being phased out, but the CFCs take about 20 yrs to reach stratosphere.
- The problem was predicted 25 years ago.



ANTARCTIC OZONE HOLE
 PHOTO COURTESY OF NASA

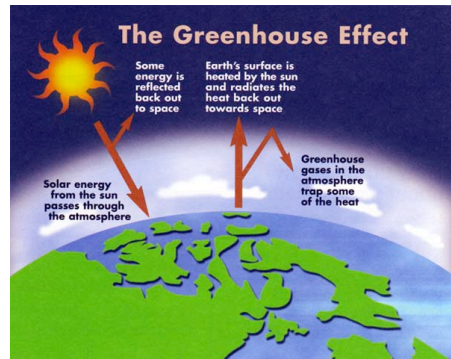


http://www.epc.ncep.noaa.gov/products/stratosphere/sbuv2to/gif_files/sbuv16_nh_latest.gif
<http://www.ngdc.noaa.gov/paleo/globalwarming/images/ozone.gif>

Global Warming



- Burning of fossil fuels releases CO_2 .
- This is a greenhouse gas.
- Humans add more CO_2 to the atmosphere (50-100x) than natural sources—25 billion tons each year!

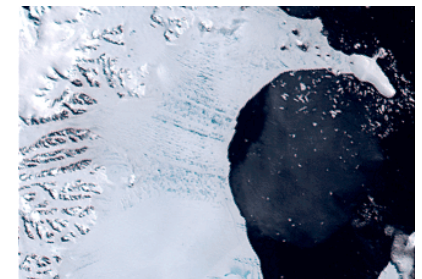


http://www.climatechange.gc.ca/english/climate_change/images/ghg_effect_lg_e.jpg

Global Warming



- Why hasn't the temperature rise been more dramatic?
- The burning of coal releases sulfates form a haze that increases the albedo of Earth.
- So the effect is less than expected, but predictions suggest that CO_2 content will begin to dominate in this century.
- Already, large slabs of the Antarctica ice shelf have melted.



Destruction of Larsen ice shelf 2002. 3250 km^2 over 35 days. That's bigger than Rhode Island! Existed for at least 400yrs maybe 12,000yrs.

<http://www-nsidc.colorado.edu/iceshelves/larsenb2002/animation.html>

Question



Although depletion of resources is a major issue for long term survivability of an advanced civilization, resource depletion really highlights a larger issue,

- a) energy.
- b) population growth.
- c) global warming.
- d) pollution.
- e) asteroids.