

Astronomy 330



This class (Lecture 21):

Cultural Evolution

Clara Mount

Next Class:

Lifetime

Ryanne Ardisana

HW #9 due Thursday

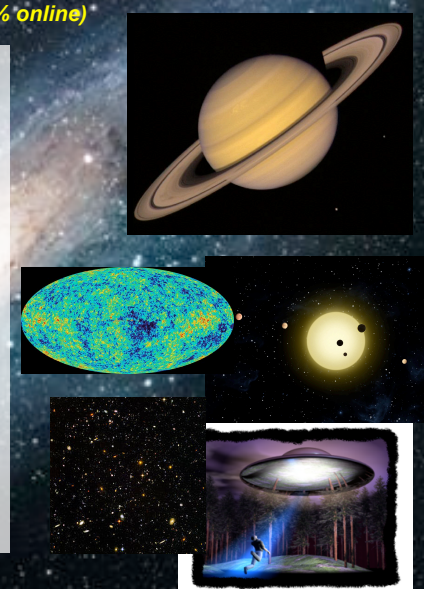
Paper Draft due next Tuesday

Music: *Concerning the UFO Sighting near Highland, Illinois*
– Sufjan Stevens

Online Astronomy 100

(Summer 100% online)

- Want more Astronomy?
- This summer, learn about the night sky, planets, stars, galaxies, and the beginning/end of the Universe by taking the 100% online Astronomy 100 summer course.
- As a self-guided narrative, you will learn astronomy while saving the Earth from alien enslavement by the evil Overlord. The Overlord is quizzing you to find out how much astronomy Earthlings know, and luckily for the Earth, you happened to have a thumb drive with your friend's Astro 100 lectures and notes from last semester.
Can you save the Earth?
- Counts as a Physical Sciences course.



Paper Rough Draft



- Worth 1% of your grade, but really worth more.
- **Due on or before April 17th! (Hard date!)**
 - Beginning of class, else considered late.
- Should pretty much be the final paper.
- Will be looking for scope, ease-of-read, scientific reasoning, **proper citation**, and general style.
- 6 to 8 pages double-spaced 12-point font, not including references.

Paper Rough Draft



Mars is a planet with an overzealous monkey population (Holt et al. 2000; James & Mann 2006; Walker 2007; Wikipedia: Mars).

– *I expect to see a few refs per page!*

- Holt, W., Smith, E., Rowe, T., & Jones, A. B. 2000, The Astronomical Almanac for the Year 1994, Vol. 2 (2nd ed.; Washington, DC: GPO)
- Smith, A. B., Thomas, J. R., Major, W., & Peebles, P. J. E. 2006, Astrophysics Journal, 450, 12
- Wikipedia: Mars, <http://en.wikipedia.org/wiki/Mars>, Accessed: March 25, 2012, Updated: March 24, 2011

Or?



- If you find a wikipedia article(s) (related to class) that has citation problems or missing content, you can edit for credit.
- First, in discussion section on Compass claim ownership of the article(s), first come/first serve.
- Must demonstrate 6-8 significant edits or improvements (print a before and after)– and email me the link to the history page so I can verify updates.

Wiki-fixes



- Grade is determined on improvement quality and citations are important.
- Must show a draft of improvements by April 17th.

HW 2



- Jennifer Bora
<http://www.dailymail.co.uk/news/article-1378400/Body-dead-alien-Siberia-claims-UFO-hurling-earth.html>

Presentations



- Clara Mount
[The War of the Worlds: Human Responses to Extraterrestrial Contact](#)

Outline



- Will a civilization develop that has the appropriate **technology** and **worldview**?
- What is f_c ?
- What is the lifetime of a civilization that can communicate?

Drake Equation



Frank Drake

That's 1.38 intelligent systems/year



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

# 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	0.8 systems/star	$2 \times 0.11 = 0.22$ planets/system	0.775 life/planet	0.505 intel./life	comm./intel.	yrs/comm.

Extrasomatic Storage Leaps



- Printing press (1456) – number of books jumped from 10,000 to 10 million in 50 yrs.
- Telegraph (1844)
- Radio (1895)
- Television (1936)
- Computers (1950s)
- Internet (1970s)
 - Huge extrasomatic storage: Well above brain storage



Does all of this increase the “intelligence” of our species?

From Rocks, to Metal, to Rocks



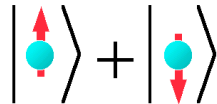
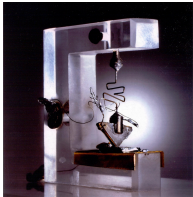
- Next real step was developing energy sources.
- The industrial revolution.
- Modern technology based on electronics, crucial to our ability to communicate with ET.



<http://www.learnhistory.org.uk/cpp/industrial-revolution-children-labor.jpg>

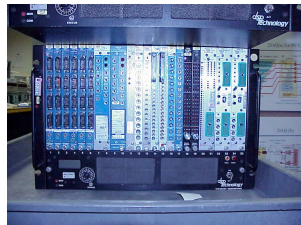
From Rocks, to Metal, to Rocks

- Transistor in 1948.
- Microchip in 1959.
- We went back to rocks— silicon!
We are arguably in the “silicon age”.
- This implies knowledge of electromagnetisms and quantum mechanics.



Cultural Evolution

- What do we mean by cultural evolution?
- Is that like evolution's natural selection?
- Since technology has developed out of it, we can conclude that technology was a desirable trait that is likely to develop on any planet with competition between cultures.



Question

Which of the following is **not** an example of an extrasomatic storage technique?

- a) Brain synapses
- b) Wikipedia
- c) Printing press
- d) Language
- e) None of the above.

Cultural Evolution

- Or can we?
- If so, then would have to say that cultural evolution follows a punctuated equilibrium model.
- Or, episodic progress with long periods of dark ages.
- Like species, the fate of civilizations has been extinction, but their technology was adopted by others (cultural diffusion).

Evolution?



- The main point is how likely is it that technological civilizations exist on other planets?
- Hard to determine from Earth data, but there are some points:
 - Agriculture arose independently in Mexico and probably China, Andes (potatoes), and eastern US (sunflowers).
 - Written language independently in Sumer, China, and the Americas, maybe India and Egypt.
 - But, the wheel was not invented outside of Sumer– were examples of toys in South Americas
 - For recent developments, the world was in too much contact to distinguish.

Technology Development



- Our sample of one makes it difficult to determine if technological development (to communication ability) is a fundamental step from intelligence.
- Does it depend on the planet– water/desert dominated?
- How would metal poor planets develop?
- Does the competition of civilizations matter?
- Is there a dependence on psychology of the intelligence life?

Questions: Variations of Civilization



- What if the Americas had invented gunpowder?
- What if the Americas had large animals of burden?
- What if the germs of Europe were less dangerous than the germs of the Americas?
- Similar examples of cultural devastation in the Pacific Islands.
- Often cultures are wiped out from *Guns, Germs, and Steel* (by Jared Diamond)– manifestations of geography.

Technology



- Cultural evolution was fast.
- Especially after agriculture freed civilizations.
- Development of language.
- Increase of extra-somatic storage.
- We're living in a silicon age.
- Does the development of technology also include a correct worldview?

Next Step



- Besides needing technology, intelligent life must have a **want** to communicate with extraterrestrial life.
- That means that it **MUST** believe in the possibility of other life.
- Requires civilization to undergo three steps:
 1. A correct appreciation of the size and nature of the Universe
 2. A realization of their place in the Universe
 3. A belief that the odds for life are reasonable. The beings of Q'earth must have taken their Q'astro 330 class and came up with a good number of communicable civilizations in the Q'drake equation.



<http://www.bybeeweb.com/cats/amelia-step.jpg>

Big Questions



- 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?

Copernican Revolutions



1. We are not the center of the Solar System.
2. We are not the center of the Galaxy.
3. We are not the center of the Universe.

Our First View



- The first concepts of the Universe were Earth-centered.
- How did we come to this point– Astro 330?
- First recorded cosmology was from the Babylonians.
 - The Universe is a large oyster, and we are inside.
 - But other aspects of their astronomy was advanced.
 - Regularity of astronomy for crop planting, harvesting, and accurate calendars back to the 3800 BC.



Our First View



- The Mayans computed the length of year to within a few seconds (0.001%).
- So early humans had a weird mixture of precise calendar astronomy with primitive concept of the Universe and mythological systems incorporating magic.



<http://www.mayasites.com/equinox.html>

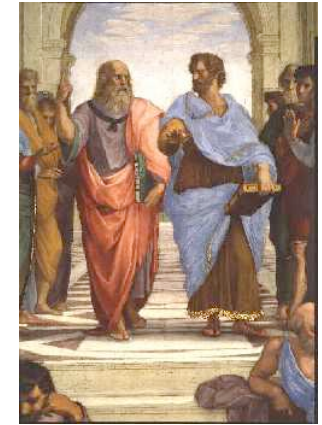


<http://ephemeris.com/history/mayan-calendar.jpg>

Greek Astronomy



- Greeks were excellent Astronomers
 - Cataloged star positions & brightness.
 - Systematic, quantitative observations.
 - Natural philosophers.
- They observed that the stars, Sun, and planets revolved around the Earth.
- So Earth is center of Universe- **geocentric cosmology** (mostly from Plato and Aristotle).
- Even though other philosophers (Aristarchus) argued for a heliocentric cosmology.



Power of Ignorance



- Geocentric model was absorbed by Christianity.
- If Geocentric, then of course no ET life.
- St. Augustine (420 AD) incorporated Neo-Platonism. He listed science as a temptation to avoid: “a mere itch to experience and find out”
- Also said, “Nor do I care to know the course of the stars.”



http://www.fhlocaustmuseum.org/history_wing/assets/room1/St_Augustine.jpg

Power of Ignorance



- The European worldview degenerated for years.
- No one in Europe mentioned the supernova of 1054 (Crab Nebula), unlike China or Americas. People were afraid to notice it and be described as a heretic.
- Could an ET civilization reach technology with that sort of attitude?

<http://www.pbs.org/deepspace/timeline/t114.html>

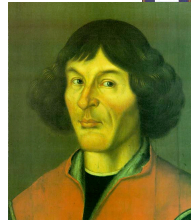
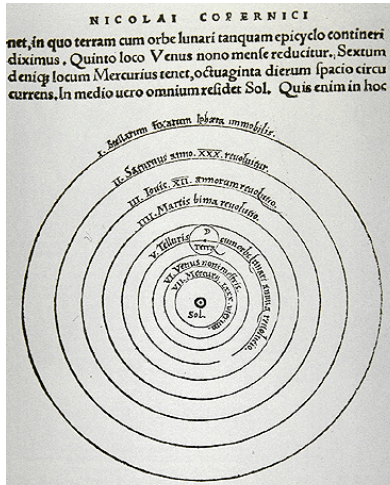


<http://www.tulane.edu/~danny/southwest.html>



<http://www.godandscience.org/images/crabnebula.jpg>

Copernicus (1540) resurrected the heliocentric model



- If Earth moves, then stars have to be very far away.
- Was rejected on theological and philosophical grounds.
- 1616, the Catholic Church listed it as heresy.



Giordano Bruno



- Took this one step further.
- Thought that the stars were all little Suns.
- Possibly with planets of their own.
- Maybe life on those other planets.
- Maybe more advanced than those on Earth.



Giordano Bruno



- These are some of the reasons why he was tortured then burned at the stake around 1600.
- One of his crimes of heresy: "Claiming the existence of a plurality of worlds and their eternity."
- He became a martyr for free-thought in the 19th century.



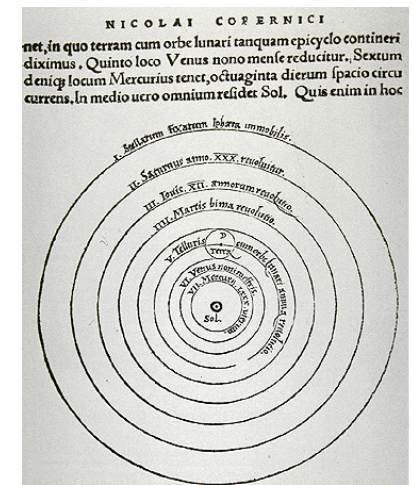
Copernicus (1540) Heliocentric Model



BUT, keep in mind that the geocentric model was still valid. Both models explained the observed motion.

Heliocentric is NOT obvious!

IT was determined a philosophical argument for 50 years! New observations from Galileo finished the argument,



Implications



- Kepler showed that ellipses needed to explain heliocentric model movement.
- New Twist– even the Sun isn't at the center of the solar system now. How does that change our view of the Universe and our place in it?



<http://antwrp.gsfc.nasa.gov/apod/ap010101.html>

Galileo (1609) 402 Years!



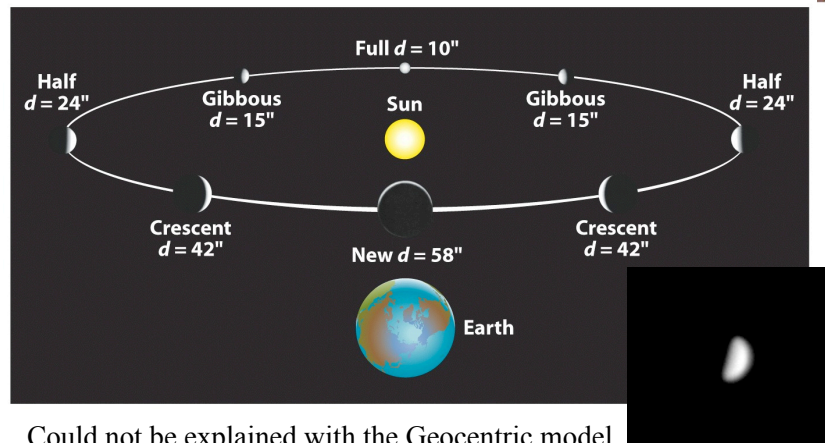
First to systematically use the telescope (but did not invent it).

- Moon has mountains and valleys
- Milky Way consists of faint stars
- Saturn is elongated
- Venus shows phases
- Jupiter has moons (now called Galilean moons)

Wow! Big stuff. The moons of Jupiter did not orbit the Earth!



The Phases of Venus



Could not be explained with the Geocentric model

<http://www.astro.ubc.ca/~scharein/a310/SolSysEx/phases/Phases.html>

<http://www.calvin.edu/academic/phys/observatory/images/venus/venusb.html>

Galileo (1610)



- Disproved Ptolemaic system
- Rome bullied him into recanting (cleared in 1992)
- Now we understand the motions and the fact that the solar system MUST be Heliocentric, but now we need a reason why?
- Need something with predictive power– Newton and gravity!



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?
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- What if the skies were constantly cloudy?
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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 0.96 Communicating life/year



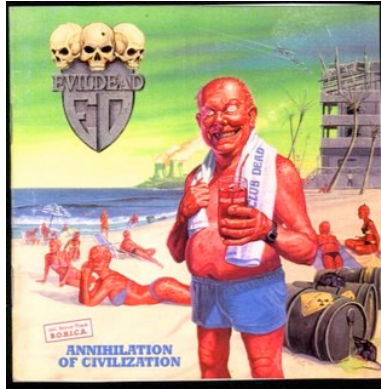
$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

# 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	0.8 systems/star	2 x 0.11 = 0.22 planets/system	0.775 life/planet	0.505 intel./life	0.7 comm./intel.	yrs/comm.

Lifetime of Civilization



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



Lifetime of Civilization



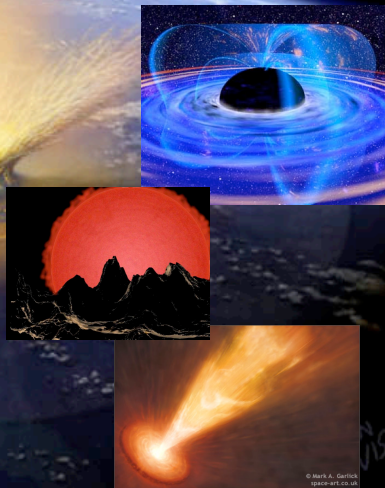
- This factor pulls a lot of weight in the Drake equation. Are we alone or are there aliens everywhere?
- Easy to envision 4 cases:
 1. Communication efforts stop. Bored with lack of success or funding issues.
 2. Civilization evolves away from interest or capability. But empires rise and fall.
 3. Technological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

Killer Skies: Astro-Disasters

(Top 10 Ways Astronomy Can Kill You or Your Descendants)

Astro 150

- Are you scared? Should you be?
- Exploration of the most dangerous topics in the Universe, such as meteors, supernovae, gamma-ray bursts, rogue black holes, colliding galaxies, quasars, and the end of the Universe, to name just a few.
- A fun class that does not require any prereqs, except an open mind!
- Counts as a Physical Sciences course.



Issues



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

Hiroshima

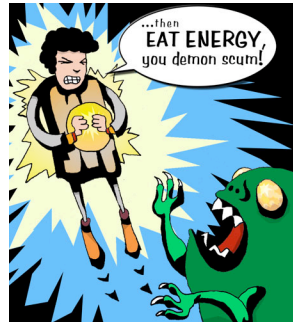


<http://gawain.membrane.com/hew/Japan/Hirosh.html>

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>

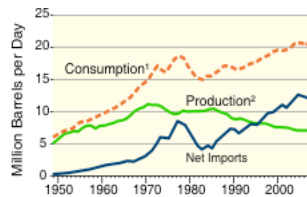
Energy



- 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.ops.state.ny.us/sas/graphics/oilwells.jpg>



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

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)

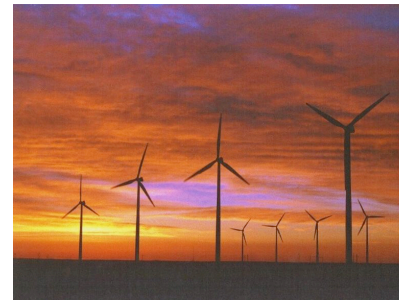
Energy



- 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.ops.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

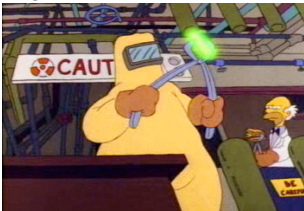
Nuclear Fission



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

Nuclear Fission Chain Reaction

- — ^{235}U
- — Neutron
- — Fission Product



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



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

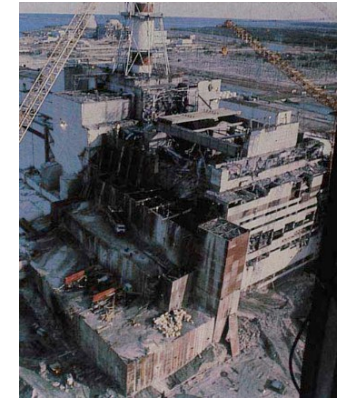
Nuclear Fission



- 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 or Japan?



<http://www.ctv.ca/CTVNews/TopStories/20110322/japan-fukushima-nuclear-plant-containment-effort-110322/>

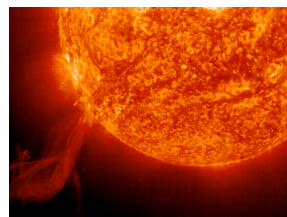


<http://www.ourtimelines.com/hist/chernobyl.jpg>

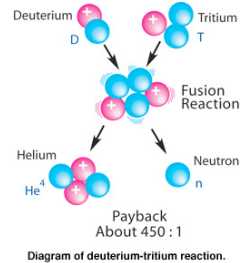
Nuclear Fusion



- What the Sun does for energy— $\text{H} \Rightarrow \text{He}$.
- 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

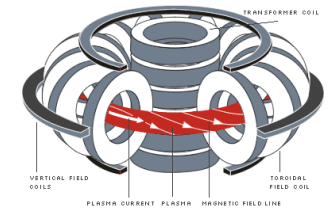


Nuclear Fusion



- 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

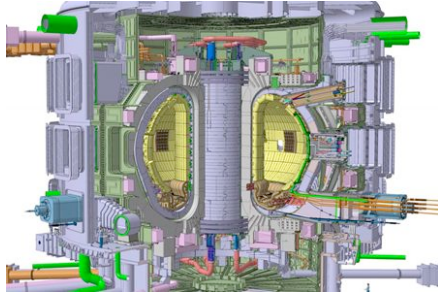


<http://www.ipp.mpg.de/ippcms/eng/pr/exptypen/tokamak/magnetspulen/index.html>

International Thermonuclear Experimental Reactor

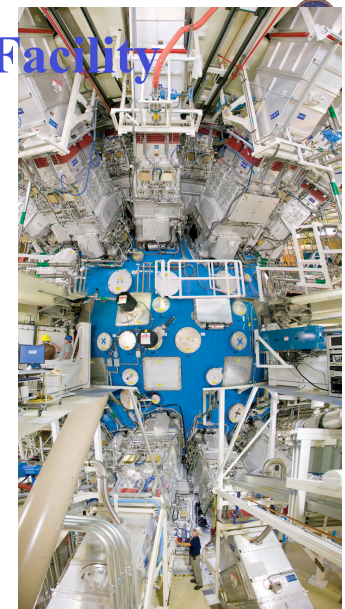
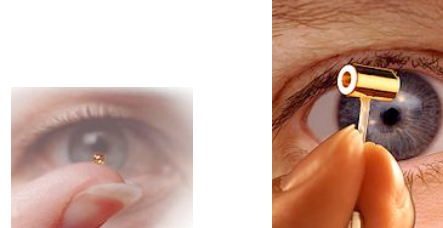


- 5+ billion Euro project
- Designed to produce 500 megawatts of output power for 50 megawatts of input power
- Construction underway
- Fusion starting in 2019



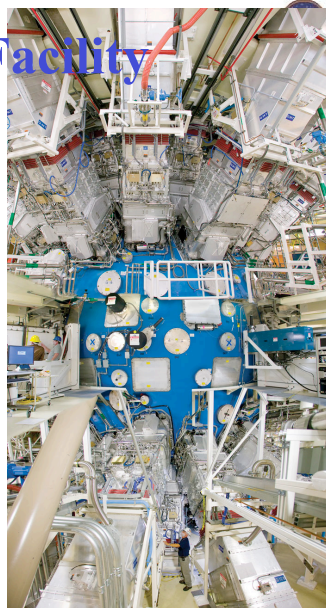
National Ignition Facility

- National Ignition Facility (NIF) is a large, laser-based inertial confinement fusion (ICF) research device in California
- 192 lasers used to compress deuterium-tritium at a small point to induce fusion.



National Ignition Facility

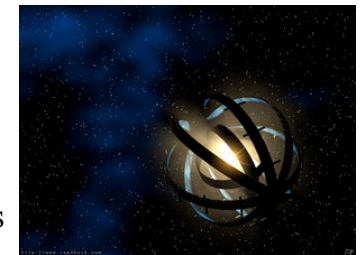
- In March 2012, 192 lasers fired with 411 trillion watts of peak power - 1,000 times more US uses at any one moment.
- Total laser energy was 2.03 million Joules— about 100 times more powerful than any other laser.
- National Ignition Campaign in Oct 2012 to get more energy out than put in.



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.



Long-Lived Civilizations



If you have “free-energy” might be more likely to have automated SETI transmission experiments for 1000s of years.

