Astronomy 230

Section 1– MWF 1400-1450
106 B1 Eng Hall

This Class (Lecture 40):
Travel

Research Papers due today.

HW #8 is due on the Dec 8th!

Next Class:
Visitations

FINAL EXAM is Dec 18th.

Music: *Lucy in the Sky with Diamonds* – Beatles

Outline

- Civilization types
- The Fermi Paradox

Nikolai Kardashev: Civilization Types

Type 0: Not in complete control of planet's energy
Understand the basic laws of physics
Chemical and nuclear propulsion, solar sails

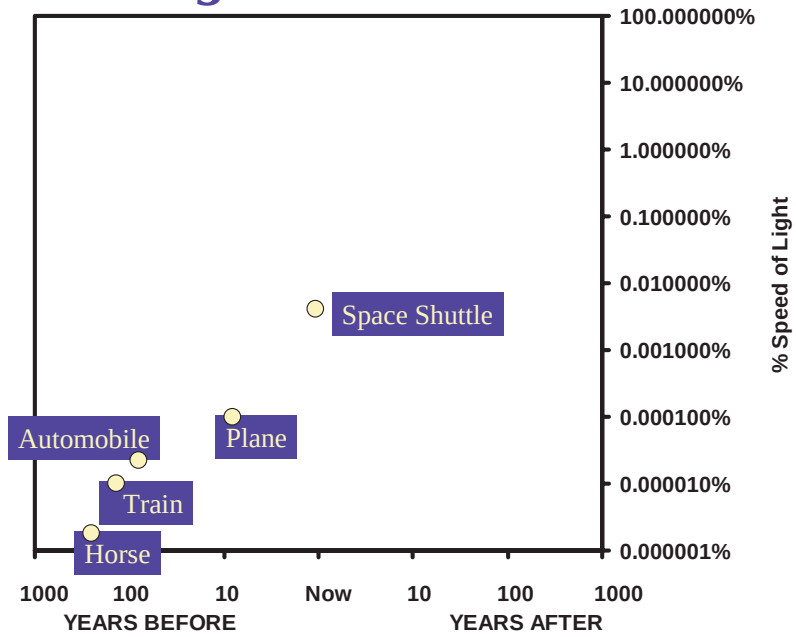
Type I: Harnesses energy output of an entire planet.
Laser sails.

Type II: Harnesses entire output of their host star
Dyson Sphere–can provide a trillion times more energy than we use on the Earth now
Antimatter drives?

Type III: Colonizes and harnesses output of an entire galaxy
Use a trillion times the energy of Type II civilizations
Use a trillion trillion times the energy of Type I civilizations

http://www.unm.edu/~astro1/ET109/types/types.html

Going Interstellar!

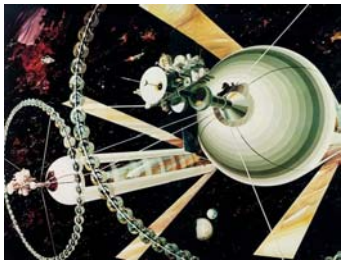


Problems to Overcome?

1. Space is Big.
   - Nothing we can probably do about this one.
2. Time.
   - Because of #1, interstellar travel would take a lot of time.
   - But arguably do-able.
     - Maybe lifetime is expanded, generation ships, suspended animation, or intelligent robots.
3. Cost
   - Right now, colossal budget of a few trillion dollars. Impossible now, but in the future?
   - Medieval blacksmiths could have made an oil tanker, but too costly. 500 years later, piece of cake.
   - In future, cost of interstellar travel may also go down.

1000 Years?

- So in 1000 years from now, we should be able to travel to other stars. But will we?
- It would be nuts to speculate on what will motivate our descendents (if any) 1000 years from now. But if interstellar travel really is easy and cheap, surely someone will give it a go?



Getting Out of Here

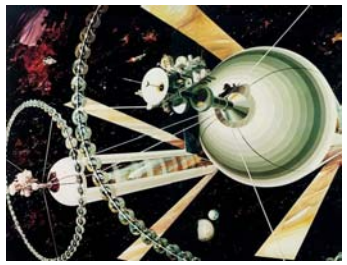
- Distances between stars are much greater than we can imagine– freaky big distances, plus difficult environment and time consuming makes interstellar travel hard to conceive.
- SciFi books and movies have dramatized space travel to make it seem possible
  - But, interstellar travel may never happen
- Even the Voyager spacecraft (one of the fastest ever flown) travels at only 20 km/s through space - not even 1% of the speed of light. They would take 60,000 years to reach even the nearest star.
- In our discussions, we discussed with foreseeable technology 10% the speed of light is possible.
- Is that enough to expect to see aliens on Earth?

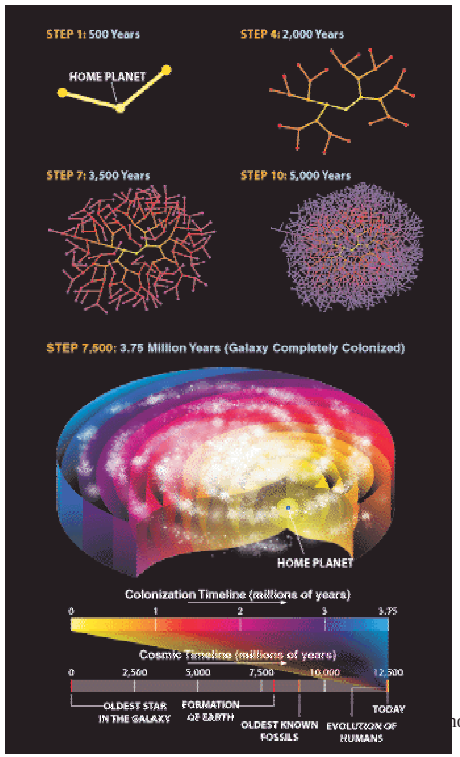
Galaxy Colonization

- If our Drake equation estimate is roughly right, there should be civilizations that are 1 billion years old!
- Think of the accomplishments.
- Even if interstellar travel is limited to 0.1c, civilizations with advanced telescopes could send colonizing craft to new planets.
- That group regenerates for 500 yrs and sends out another craft.
- An advanced civilization could colonize the entire galaxy in maybe only 5 million yrs!

How long to colonize the Galaxy?

- With 0.1c, we can travel 10 light years in 100 years
- We can reach the nearest star in 43 years
- Allow each new colony 50 years to duplicate the technology
- Colonies could spread out about 50 light years every 3,000 years





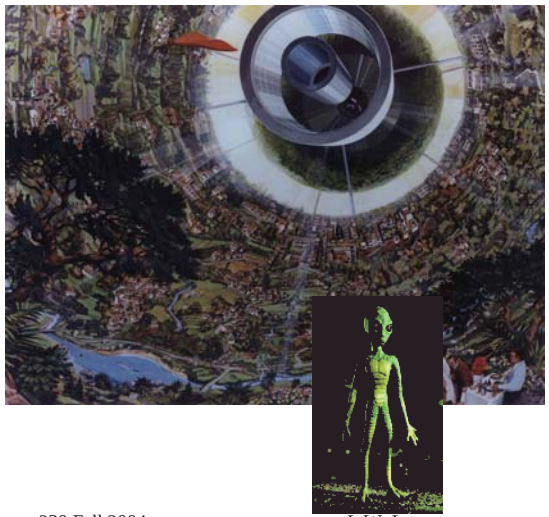
Optimistic

Every 500 years, the colonization craft makes it to the next suitable solar system– small delay.

Then, it only takes about 4 million years!

Slow Long Haul Space Travel

- Spacecraft that we can envision easily would take a lifetime to get to the nearest star.
- Colonizing missions would have to be multi-generation missions.
- Space colonies with propulsion systems would slow down things, so maybe it would take 1000 yrs for each trip.
- How many of you would sign up today?



Or how long to colonize slower?

Be even more pessimistic and use 100,000 years per 50 light years.

100,000 lyrs

Total time to cover the Galaxy:

1500 hops x 100,000 years = 150,000,000 years

The Fermi Paradox

The Drake Equation – Even for a few hundred technical civilizations.

Only 150 million years to colonize the Galaxy.

WHERE IS EVERYBODY?????

The Fermi Paradox

- Our estimate for communicable civilizations was around 70,000.
- Given such a large number, one of them must have developed earlier than we did.
- So "Where are they?"
- Even if interstellar travel is very slow and difficult, there has been a lot of time to do it.
- Furthermore, many of the objections to interstellar travel do not apply to artificial intelligence (intelligent robots.)

Life on Earth is of One Type?

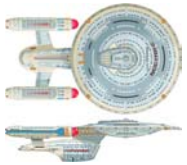
- Life got started on Earth pretty quickly. To some, this suggests that life forms easily, whenever conditions are right.
- So why are all creatures on Earth descended from the same microbe?
- You can tell from the similarities in our DNA and cells that all living things come from the same ancestors. Why?
- The average time needed to spread over the Earth was much less than the average time to evolve. Not true for the Galaxy.

Timescales

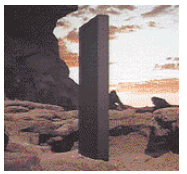
- For pessimist: 150 million years to colonize the Galaxy.
- For optimist: 4 million years to colonize the Galaxy.
- This may seem like forever, but it is actually pretty tiny compared to the time it takes evolution (about 0.1%).
- So, if we believe our condition, there should only be one intelligent family of species in our galaxy - whoever reached intelligence first should have spread everywhere before anyone else reaches intelligence.
- This is the main point of the Fermi Paradox.
- Where are they?

Limits

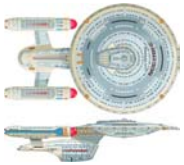
- So, if we go back to two alternatives - a galaxy packed with billions of intelligent life-forms, and a cold and lonely empty one, Fermi is suggesting that the truth lies closer to the second alternative.
- Does this seem reasonable?
- There may be a few (or a few hundred) intelligent species out there.
- But if there really were billions, we would have surely have been visited?



Where is Everyone?



- **They are around, but we can't tell yet**
  - They are too advanced or alien to recognize or detect
  - They don't bother with us (or traveling or broadcasting)
  - Do civilizations hide to avoid a "galactic scourge?"
  - They are keeping us "quarantined" (the "zoo" or prime directive hypothesis)
  - They've been here (or are here), and we don't know it
  - They are not "technical" in a way we can understand.



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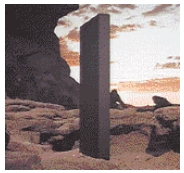


- **They are not around**
  - Some factors in Drake equation may be much smaller than we believe – life, or intelligent life, is very rare
  - They wipe themselves out too quickly
  - Other factors wipe them out too quickly
  - Life hardly ever develops technical civilizations
  - There is very little life out there
  - We are among the first to develop

Or…

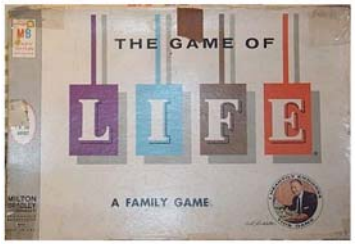
- There is no ET life on Earth, so there are only 5 possible explanations (according to Michael Hart):

1. Space travel is not feasible.
2. Other civilizations have chosen not to colonize.
3. Other civilizations have not had time to colonize the Galaxy.
4. The Earth has been visited in the past, but we do not observe any visitors now.
5. There are no other advanced civilizations in the Galaxy.

Hart argues against all but #5. He is saying that our Drake Equation result is wrong!

Maybe Life is Hard

1. Maybe colonization is much more difficult than we assume. Might expect robotic probes first, which slows down the process.
2. Maybe travelers prefer to explore more than colonize. Overpopulation is not the issue.
3. Are planets suitable for life? If one of the 20 amino acids is missing in that life system, food is a problem.
4. By colonization timescale, the space creatures may prefer to stay in space– weightlessness evolution. Comfy clothes.



1960 edition. Art Linkletter-endorsed. Shucks, that's all I need to see!


http://www.wesclark.com/am/life.jpg

Class Conclusions?

- There is no reliable evidence that leads us to believe that life exists somewhere else in the universe.
- As this class has shown, life is possible, but that is all we know now!
- May the future enlighten us!
- Still, let's use what we do know and see what sort of conclusions we can make.
- Is it possible that someone may see a UFO?

Fact 1

- It is possible that ETI life is abundant in our galaxy
  - With 300 billion stars and plenty of opportunities for life to develop.
  - Our estimate for civilizations was **70,000** right now!
  - So, there are clearly arguments for common life.

Fact 2

- If ETI is abundant in our Galaxy, then we expect that, statistically, there exist or have existed ET civilizations that have achieved a technological capability greater than that which we now demonstrate– an advanced civilization!
  - The time to reach Type 0 status was about 4.5 billion years on Earth, but it could easily be only 3.5 billion years somewhere else
  - An intelligent civilization can do a lot in a billion years

Fact 3

- The distances and times associated with interstellar travel are great, but as far as we know, it is conceivably possible that a civilization conduct significant interstellar exploration, especially with enough time.
  - At very least, a more advanced civilization could have sent out nanoprobes across the Galaxy.

Fact 4

- It is possible therefore that an ET civilization has explored our region of the Galaxy, the Sun, and even our Earth at some point in its history
  - This is not pseudo-science but real logical consequences of abundant ETI.

Fact 5

- We have no reason to believe that this has not happened
  - We also have no reason to believe that it has.
  - It is an open question.

What are we left with?

- These are two distinct but still very significant claims
  - The Earth has been visited by ETs.
  - The Earth has not been visited by ETs.
- Neither of these statements has been validated.
- So, the only statement we can make is
  - We do not know whether or not the Earth has been visited by ETs.

http://www.cgl.uwaterloo.ca/~csk/washington/graphics/logos/validated.gif