

Life beyond our Solar System

What follows is at least somewhat speculative!

Lecture 3 of Planets Everywhere

Feb 2020, Richard Edgar @ Wind Crest

- Drake equation, intelligent/civilized life vs. microbes.
- Fermi Paradox
- SETI institute and Breakthrough grant
- Tide-locking
- Radial Velocity method
 - Nobel prize for Michel Mayor and Didier Queloz, 2019
 - Gives “minimum mass” of the planet, depending on unknown inclination angle of the system to the line of sight.
 - words about biases and limits
 - Upsilon Peg, Proxima Centauri
- Transit method
 - gives size of the planet (relative to the star)
 - Kepler and TESS spacecraft; Mearth program, others. CHEOPS spacecraft.
 - Multi-planet systems including TRAPPIST-1, TOI-700

The Drake Equation

- Frank Drake, Princeton, wrote it down in 1961.
- Probabilistic argument about how many civilizations there might be in the Milky Way galaxy we could communicate with.
- Wikipedia: https://en.wikipedia.org/wiki/Drake_equation?oldformat=true

- The equation: $N = R_{\star} \times f_p \times n_e \times f_l \times f_i \times f_c \times L$
- N = number of civilizations in our Galaxy with whom communication might be possible
- R_{\star} = Number of stars forming per year in our Galaxy
- f_p = Fraction of those stars with planets
- n_e = number of planets per star that might support life
- f_l = fraction of those planets which actually do develop life.
- f_i = fraction of life-bearing planets developing intelligent life
- f_c = fraction of civilizations sending signals into space
- L = lifetime of such communication/civilization

- R_* is the star formation rate; it's about one solar mass per year, averaged over our entire Galaxy. Most likely stars smaller than the sun form, so perhaps 2-3 such stars form in a year.
- We'll be talking about f_p and n_e , the astronomical factors. Wild guesses: 0.8 and 1.5?
- What fraction of potentially life-friendly planets develop life is completely unknown (in my opinion). Say 50%, very optimistically.
- Intelligence is a biological ponderable. Guess 10%?
- Radio signals need not be intentional. Guess 10%?
- How long civilizations last is a sociological question. Maybe 1000 years?
- Multiply to get 18, but with huge uncertainties (factors of at least 100).
- Note if you care about "life" and not "communication" you get back a large factor (100 million?). But the probability of developing life at all is... unknown.

The Fermi Paradox

- While we're talking about civilizations and intelligent life...
- Enrico Fermi over lunch with Edward Teller and others at Los Alamos in 1950 estimated how long it would take a space-faring civilization to spread across the Galaxy.
- Interstellar distances (few light years) and plausible speeds (100 km/sec ?) give 10,000 year travel time between nearest neighbors.
- The Galaxy is much older than that (10-13 billion years)
- ***Where are they?*** Why haven't they visited us?
- Maybe this argument bears on the Drake equation unknowns.

- Maybe they have visited, and moved on before we arose from the slime. Maybe they even planted life on the earth. If so, no other footprints or evidence remain.
 - Lesson: if you get abducted by aliens, bring back souvenirs!
- A more detailed recent simulation including motion of stars, etc. suggests we might be alone even if there are dozens of civilizations out there among the stars. See Sci Am, Jan 2020, p32, by Caleb Scharf, link here: [https://
www.scientificamerican.com/article/alone-in-a-crowded-milky-
way/](https://www.scientificamerican.com/article/alone-in-a-crowded-milky-way/)
- Two interstellar comets / asteroids have cruised through the Solar System in the last couple years, so if one is patient, interstellar travel is possible.

SETI: the Search for Extraterrestrial Intelligence

- Searching the radio sky for artificial signals (not from earth-made transmitters)
- There's an expanding sphere in space now 70 light years in radius, filled with reruns of *I Love Lucy*.
- If we don't look, we won't find anything.
- Often done in parallel with other radio astronomy. Some targeted searches toward “interesting” planetary systems.
- Custom-built spectrum analyzers help
- Russian oligarch Yuri Millner has funded a few astronomical projects including “Breakthrough Listen” to search for extraterrestrial radio signals... \$100M.
- SETI@Home... a screen saver for PCs that uses your computer to search through radio signals for anything suspicious.



Have you ever noticed that all the instruments searching for intelligent life are pointed away from earth?

- The “Wow!” signal... Ohio State University Big Ear radio antenna saw this on Aug 15, 1977, pointed toward Sagittarius
- Never seen again
- Unknown what the source was. No nearby sun-like stars in the error box
- Unclear if it was modulated or just a continuous wave (carrier)
- 1420.54 MHz (near but not quite on the hydrogen spin-flip line)

