Statistics of One

What the history of Earth can tell us about life in the cosmos

Eric J. Korpela

Space Sciences Laboratory University of California

http://setiathome.berkeley.edu/~korpela

SETI@home

Extratemestrial Intelligence





Extrapolating from the History of Earth

Earth is our only example of a planet where intelligent life has developed.

Earth is also our our only example of a planet where life is known to have developed.

Earth may be our only example of a planet where life could develop.

What else can we do but extrapolate from the history of life on earth?





History of Life on Earth

Life on Earth developed shortly after the planet cooled enough to have a solid surface/liquid water. (For appropriate definitions of shortly)

After N evolutionary steps of varying timescales we evolved. definitions of N)

From this point we tend to make inferences based upon our understanding of statistics.

Common Assumptions:

The length of time a step took is an indicator of the intrinsic timescale.

The total time is dominated by the longest intrinsic timescales.

Sometimes Forgotten:

Uncertainties are dominated by the longest intrinsic timescales The timescale measurements are not statistically independent



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The Usual Conclusions

Life is easy because it arose quickly.

- The timescale for abiogenesis is of order a hundred million years
- Life could be common in the universe

Intelligent life is hard because it took a long time.

- The timescale for evolution of intelligent life is around 4 billion years
- The fraction of planets with lifetimes > 4 Gyr in the CHZ that develop intelligent life is >> 0%





Anthropic Bias

However, there is a bias involved that must be corrected for:

It is impossible for an intelligent being that evolved upon a 4.5 billion year old planet to measure a summed abiogenesis and evolutionary timescale for that planet of greater than 4.5 billion years.

Similar to Anthropic Principle:

We can only observe a universe where it was possible for us to evolve.





Similar problem...

Bob won the lottery for the first time when he was 47 years old. What is the probability of winning the lottery?

Questions you can't ask:

- How many people played?
- How many times did Bob play?
- How many tickets did he buy?
- How many other people have won?





Correcting for the Bias

Start with a question we can answer:

For given values of the abiogenesis timescale (τ_{bio}) and the timescale for evolution of intelligence (τ_{evo}), what is the probability that a species that has evolved on a 4.5 Gyr old planet will obtain our measured values, t_{bio} and t_{evo} ?

Then invert it:

Given a species that evolved on a 4.5 Gyr old planet measures the values t_{bio} and t_{evo} , what is the likelihood distribution of the values of the intrinsic timescales τ_{bio} and τ_{evo} ?

This is essentially the same problem that we always face in error analysis.





The Easy Method...

- In your basement, create an large number of universes with values of the timescales (τ_{bio} , τ_{evo}) distributed according to the appropriate prior distribution. $P_0(\tau) = d\tau/\tau = d \log \tau$
- Place an exact duplicate of the Earth in each universe.
- For each Earth determine the time at which life arises and intelligence evolves.
- Calculate for each (τ_{bio}', τ_{evo}) the normalized distribution of measurement values that can take place prior to 4.5 Gyr





Results















Results







Conclusions

- The anthropic bias is very likely to lead us to underestimate the timescale for evolution of intelligence.
- The early origin of life on Earth leads to a well defined peak in the likelihood distribution for τ_{bio} . However, the distribution flattens to a constant value at large τ_{bio} , which indicates a significant probability that the origin of life on earth was unusually rapid.
- Without further examples of life, or analytical reasons to restrict long duration timescales, no upper limit can be placed on the timescales required for abiogenesis and evolution of intelligence.
- It is likely that the universe we inhabit is barely capable of supporting life. To assume it is finely tuned for supporting life presupposes that there is no more finely tuned set of parameters.



