2/24/19 Sermon “The Aestivation Hypothesis”

There is a Google Data Center out in Douglas County, Georgia that some of you may know about or even have been to. It’s about 20 miles away from here, a little ways out I-20 West. I have a friend who works for Google and a few years ago he was telling me about coming to Georgia to do some work at the Data Center. One of the things that was really interesting was that he said it cost much more to have a Data Center in Georgia than in Alaska. This surprised me, because I have family in Anchorage and I have been to Alaska several times and most things are definitely more expensive up there. A two-liter bottle of Coke costs twice as much on average there as it does in Atlanta, although I admit that may not be a totally fair comparison. But overall, the cost of living is noticeably higher, so I wondered how it could be cheaper to run a data center there.

My friend explained to me that one of the primary costs of running a data center, is keeping it cool, keeping its temperature down so that the servers don’t overheat. In a 2017 paper entitled “Data Center Energy and Cost Saving Evaluation,” scientists from a Swedish university estimated that 40% of the energy consumed by operational data centers is used to cool the equipment. Obviously, keeping things cool is a simpler proposition in Alaska than in Georgia. There are plenty of other factors, of course, but cooling cost is the one most relevant to our topic this morning.

You see, physicists Anders Sandberg, Stuart Armstrong, and Milan M. Cirkovic have extended this idea about cooling costs to its logical, if extreme, conclusion. They said that once an alien civilization is sufficiently advanced, computing power becomes its primary concern. That seems like a reasonable assumption, given that the advancements in human evolution and civilization that have gotten us to where we are today are things like our voice boxes, written communication, and the internet, all of which substantially enhance our abilities to transfer information, to transfer data.

If we accept that the direction of future growth and evolution of our civilization is going to be toward greater capacity for transmitting information, then the question of how to do that most efficiently, takes on a great deal of importance. Sanders and his fellow physicists posit that if efficient data transmission becomes more and more the goal of advanced civilizations, and if temperature control is the primary limiting factor for efficient data transmission, then such civilizations will logically seek out the coldest possible conditions. They will choose Alaska over Georgia for their data center needs, but on an even more extreme scale.

In fact, they will look at the temperature of outer space, and say even that's not cold enough. The cosmic background temperature, the temperature of most parts of space in our Universe, is 3 degrees Kelvin, which is minus 455 degrees Fahrenheit and minus 270 degrees Celsius. Not even taking refuge inside a Tauntaun will keep you warm in those conditions; it is unimaginably cold! And yet, if you are putting most of your eggs in the "let's get as cold as possible" basket, it actually makes sense to **wait** for things to get even **colder**. You see, as our Universe expands and cools, that 3 degrees Kelvin background temperature is going to keep decreasing, to the point where it will be a small fraction of a degree Kelvin.

How much of a difference can 2-3 degrees make? In this context, it can make a logarithmic, exponential difference! Sanders and his fellow physicists estimate that compared to super-efficient, outer space-cooled computers running right **now**, ones that operate with that lower cosmic background temperature in the **future** will be 10^{30} times more efficient. They will be able to do a million trillion trillion times more computations than can be done for the same energy expenditure right now.

In short, they are waiting for things to get colder, so that they can compute to their heart's content while using as little of the limited energy available to them as possible. Waiting for things to get colder before you become more active is called aestivation, which is like hibernation, but the opposite; instead of emerging when the summer comes, like bears, these hypothetical aliens are waiting for cosmic winter, for things to get even colder than they are right now before they become more active. Those colder conditions won't happen for billions of years, so for right now we probably wouldn't see any signs of those civilizations in our observations of the cosmos.

So, that's why the Aestivation Hypothesis is an explanation for Fermi's Paradox. Fermi's Paradox is the quandary that Enrico Fermi raised about why, given the incredible vastness of our galaxy and our Universe, we have not yet discovered evidence of intelligent extraterrestrial life. Maybe they're all aestivating. Maybe they've all gained digital consciousness, and decided that if they wait billions of years, they'll be able to do a lot more computing in their lifetimes.

If you're feeling uncertain or unconvinced about this theory, don't worry, you're not alone. I think this is one of the more creative, but less plausible, possible explanations for Fermi's Paradox, for why we have not observed evidence of extraterrestrial intelligence. Even the primary author, Anders Sandberg, wrote on his own website last year: "I . . . personally think the likeliest reason we are not seeing aliens is not that they are aestivating, but just that they do not exist or are very far away."

I thought that was a cop-out until I read another paper that Sandberg was the lead author of last year, entitled "Dissolving the Fermi Paradox." In that paper, he talks about the Drake Equation, which is the equation that probabilistically calculates the number of actively communicating intelligent civilizations in the Milky Way galaxy. The full equation is that the likely number of such civilizations is determined by multiplying seven factors together, including the rate of stellar formation, the fraction of habitable planets on which life has arisen, the fraction of times when life has arisen that intelligence has evolved, the length of time over which such civilizations transmit detectable signals, and other factors. Sandberg takes issues with the traditional estimates about the fraction of habitable planets where life has emerged, and the fraction of times that life has evolved intelligence, saying basically that we have no frame of reference beyond Earth for such estimates, and that using even really, really low estimates could be overdoing it. If you allow for a wider range of fractional estimates, including much lower possibilities than have been inputted previously, there's actually a better-than-even probability that there is no other intelligent life in the galaxy.

According to this paper, we are probably the only intelligent life in the galaxy. And that's actually a really good sign! The rarity of extraterrestrial intelligence tells us that there is probably at least one universally applicable very important reason why the evolution of intelligent life doesn't happen very often. That reason, whatever it might be, is called the Great Filter. It filters out most would-be intelligent species, whether by preventing life from emerging in the first place, or preventing intelligence from evolving very often. And since we don't see evidence of extraterrestrial life in our galaxy, there is a good chance the Great Filter is actually BEHIND us! We can hold out hope that whatever prevents the wide-scale spread of detectable intelligent life in the Milky Way has already taken its shot at us, and we have survived. It's not looming over us. Maybe. We'll see!

One theme that emerges from the papers that have been written about Fermi's Paradox in the last 10-15 years is that we are living in **highly** uncertain times. The physicist Anders Sandberg himself has written that his approach to analyzing the odds in question provides only a range of possible probabilities, and is far from giving any definite answers. There are many other hypotheses out there about our lack of detection of extraterrestrial intelligence, beyond just that it's not there or that it's aestivating.

The Dark Forest theory says that any civilization that transmitted its location to the cosmos would be inviting imminent annihilation from advanced civilizations wary of interstellar aggression. We could be living in a small galactic habitable zone due to supernova gamma-ray bursts heavily restricting the ability of life to emerge and evolve for long periods of time in most of the galaxy. There is the Gaian Bottleneck Hypothesis, that says Earth's primordial conditions that supported life were very, very rare among the planets in our galaxy. These last two are from Charley Lineweaver, a physicist from New Zealand who's been kind enough to answer my questions about them over email.

Part of the reason for all this uncertainty is the limited detection capabilities we currently have. Gavin Schmidt and Adam Frank pointed out in a paper this year in the *International Journal of Astrobiology* that we probably wouldn't even be able to detect an industrial civilization on our own planet if it had existed many millions of years ago. The title of the paper is "The Silurian Hypothesis: Would it be possible to detect an industrial civilization in the geological record?" Can anyone guess why they called this the Silurian Hypothesis? **(Look/listen for raised hands or shouts)** This is my favorite footnote ever in a physics paper, they say: "We name the hypothesis after a 1970 episode of the British science fiction TV series *Doctor Who* where a long buried race of intelligent reptiles 'Silurians' are awakened by an experimental nuclear reactor. We are not however suggesting that intelligent reptiles actually existed in the Silurian age, nor that experimental nuclear physics is liable to wake them from hibernation." Glad we cleared that up!

There is great spiritual wisdom to be found, if we can face uncertainty with honesty and courage. Theologian James Carse tells us: healthy religion encourages a "higher ignorance" which enables openness to continual learning and growth. My hope is to be able to use the case of extraterrestrial intelligence to practice the kind of healthy religion that encourages a "higher ignorance." A religion that enables openness to continual learning and growth. After all, learning about astrophysics and its implications represents most of the control I can exercise over the situation. Beyond that, it will be good to remain curious but not anxious, and remember this is not about me as an individual one way or another. My hoping that we do or do not find signs of intelligent life on other planets ultimately has little or no effect on whether that actually happens. But there are plenty of areas in my life that are filled with uncertainty, where if I can embrace **that** uncertainty then I will be able to be open to continual learning and growth.

Several institutions that play a major role in my life, directly and indirectly, are facing greater uncertainty than they ever have in my lifetime. I'm going to keep doing everything I can to influence them in positive ways. But ultimately, control of those institutions rests beyond my hands. Once I've done what I can to influence things in a helpful direction, I hope to embrace their uncertain outcomes in a way that allows me to be open to learn and grow no matter what happens. May we all learn and practice the cultivation of a higher ignorance that keeps us open to the possibilities of the future!

May it be so, and may we be the ones to make it so!