A Theoretical Astro-biological Solution for Femi’s Paradox

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Abstract. The Great Filter Theory is a commonly accepted solution for Fermi’s Paradox, indicating that there is a huge wall preventing the intelligent species from achieving Level III Civilization, Galactic Civilization, which has the ability to control the energy on the scale its entire galaxy. There are many forms of hypothesis about what the Great Filter is, such as unbreakable light speed limit. Here we analyze the hypothesis that the Great Filter is the irreconcilable predicament between advanced technology and limited lifespan, which inevitably leads to stagnation in technology development.

Introduction

The Fermi paradox, or Fermi’s paradox is the apparent contradiction between the lack of evidence and high probability estimates for the existence of extraterrestrial civilizations. The basic reasoning line, made by physicists Enrico Fermi (1901–1954) and Michael H. Hart (born 1932), are:

• There are at least 100 billion planets in our Galaxy alone (Cassan et al. 2012), and about 20% are of habitable zone (Petigura et al. 2013).
• With high probability, some of these stars have Earth-like planets, and if the Earth is typical, some may have developed intelligent life.
• Some of these civilizations may have developed interstellar travel, a step the Earth is investigating now.
• Even at the slow pace of currently envisioned interstellar travel, the Milky Way galaxy could be completely traversed in a few million years.

The theoretical framework and estimation of extraterrestrial life is described by Drake Equation given by Walters et al (1980):

\[ N = R_\ast f_p n_e f_l f_i f_c L \]

• \( N \) = the number of civilizations in our galaxy with which communication might be possible (i.e. which are on our current past light cone)
• \( R_\ast \) = is average start formation rate
• \( f_p \) = the fraction of those stars that have planets
• \( n_e \) = the average number of planets that can potentially support life per star that has planets
• \( f_l \) = the fraction of planets that could support life that actually develop life at some point
• \( f_i \) = the fraction of planets with life that actually go on to develop intelligent life (civilizations)
• \( f_c \) = the fraction of civilizations that develop a technology that releases detectable signs of their existence into space
• \( L \) = the length of time for which such civilizations release detectable signals into space

According to this reasoning, either we should have found the evidence of other intelligent civilizations in observable universe since spacefaring means leaving significantly change in the universe, or, despite that \( R_\ast \) is astronomically large, \( N \) is actually very small.
The Great Filter

According to Robin Hanson’s theory, the best-guess of evolutionary path would be the following:

1. The right star system (including organics)
2. Reproductive something (e.g. RNA)
3. Simple (prokaryotic) single-cell life
4. Complex (archaeatic & eukaryotic) single-cell life
5. Sexual reproduction
6. Multi-cell life
7. Tool-using animals with big brains
8. Where we are now
9. Colonization explosion

The concept of the Great Filter is brought up to explain the lack of evidence of intelligent life in observable universe, indicating that at least one of the steps is extremely improbable. In other words, there is a “great filter” somewhere along the path. We argue that one of the great filters lies between step 8 and 9, and such a great filter is the lifespan which may lead to the stagnation of science and technological development so that we, or other extraterrestrial lives, are very unlikely to make into step 9.

Predicament between Limited Life and Infinite Knowledge

It is obvious that technology is the key if we hope that we become spacefaring civilization someday, but the increasing volume of knowledge and so slow-growing, if not constant, human life span become the irreconcilable predicament. The chain of argument is:

1. We develop new theory based on existing theories and knowledge.
2. Every technology breakthrough or discovering new theory requires that scientist previously knows certain existing knowledge. Without loss of generality, we name the knowledge $A$, and the minimum required previous knowledge $pre-A$.
3. There is a maximum speed for people to get information or knowledge.
4. People are born with no existing knowledge and the knowledge cannot be inherited.
5. There is a maximum limit to human lifespan.
6. If there exists a knowledge $A$ such that the minimum time to learn $pre-A$ is longer than or equal to human’s maximum lifespan, then we’ll never discover knowledge $A$.

The assumptions in this logic lines are:
- People obtain information/knowledge by reading and verbal communication, and there is a maximum speed for human to absorb information.
- People are born with no knowledge or memory.
- There is a maximum lifespan of human or other alien creatures if they exist.
- There is infinite knowledge.
- Extraterrestrial lives also share similar biological mechanism with creature on earth and also obey the law of nature selection.
Evidence of Limited Lifespan

Figure 1. Trends in life expectancy and late-life survival (Dong, X., Milholland, B., & Vijg, J. (2016)).

a. Life expectancy at birth for the population in each given year. Life expectancy in France has increased over the course of the 20th and early 21st centuries.

b. Regressions of the fraction of people surviving to old age demonstrate that survival has increased since 1900, but the rate of increase appears to be slower for ages over 100.

c. Plotting the rate of change (coefficients resulting from regression of log-transformed data) reveals that gains in survival peak around 100 years of age and then rapidly decline.

d. Relationship between calendar year and the age that experiences the most rapid gains in survival over past 100 years. The age with most rapid gains has increased over the century, but its rise has been slowing and it appears to have a plateau.

It is true that the average lifespan of human keeps increasing since the nineteenth century, as seen in the figure (Dong, Xiao; Milholland, Brandon; Vijg, Jan), because of technological progress and improvement of public health. Demographic evidence also shows a reduction in old-age mortality and increasing maximum age of death. Together with the evidence that the maximum of life span of animals in lab can be greatly extended with pharmaceutical interventions, some people argue that one day people can live forever. However, as shown by the data from Human Mortality Database, most of the increase of human lifespan expectation is attributed to decrease in early-life mortality. That is, we are less likely to die early because of disease or accident, but the maximum lifespan did not increase since 1990. The evidence that improvements in survival with age tend to decline after age 100, and that the age at death of the world's oldest person has not increased since the 1990s (Dong, Xiao; Milholland, Brandon; Vijg, Jan) also strongly suggests that the maximum of lifespan of human is fixed. According to Dong's Paper, “Evidence for a limit to human lifespan” that was published in Nature Vol. 538 (October 13, 2016), the authors concluded that human lifespan is limited to 115 years and the probability of a lifetime exceeding 125 in any given year is less than 1 in 10 000.

The maximum of human lifespan has always been a controversy topic. According to Olshansky and Carnes, there are three types of viewpoints: “Futurists,” “Optimists,” and “Realists.” Futurist believe in continuous extension of human lifespan without upper limit, with the help of biotechnological equipment, achieving eternal life some day in the future. Optimist believe that the human lifespan will be greatly increased by biomedical technology at the speed of 2.5 years per decade and remains open towards whether human will achieve external life. Realist believes that the lifespan is biologically determined and cannot be increased. More and more evidence in biology and chemistry support the “Realists” view that it is the progressive accumulation of molecule damage inside the cells that play an influential role in aging. In DNA Damage Theory of Aging, aging is due to irreversible unrepairred accumulation of naturally occurring DNA damages (Freitas AA, de Magalhães JP (2011). "A review and appraisal of the DNA damage theory of ageing".
Therefore, we have reasons to assume that the maximum ages of individual’s lifespan of both human and alien civilizations are determined and cannot be arbitrarily increased.

**Longer and Longer Study Period**

It is obvious that with the increase of existing amount of knowledge, averagely it takes longer and longer time for somebody to learn before starting doing research and forming new theory. Form the graph, we can see that the average age of Nobel Prize winner in fundamental subjects, Physics, Chemistry and Medicine, is upward increasing.

![Figure 2. Awarded age of Nobel laureates (Dong, X., Milholland, B., & Vijg, J. (2016)).](image)

![Figure 3. Prize-winning age of Nobel laureates (Dong, X., Milholland, B., & Vijg, J. (2016)).](image)

Henri Poincaré was accredited as the last versatile genius in mathematics; Enrico Fermi was accredited as the last genius in both theoretical physics and experimental physics…Today, it is nearly impossible to know all the knowledge in certain subject, not mention to make great contribution in different subjects like Newton or Aristotle. The history of mathematics is longer than that of other subject, so what happens today in mathematics is a good reference to the future of other subjects. Today, mathematics has been divided into more than a hundred sub-subjects, and mathematicians usually have great difficult in understanding papers of different sub-subject. According to Ronald Solomon, the co-author of *The Classification of Finite Simple Groups*, there are less than five people who understand the proof of “Enormous Theorem”—the proof of this theorem is longer than 15000 A4 pages.

**Darwin’s Aliens**

According to a recent study, *Darwin’s Aliens*, published at *International Journal of Astrobiology* by a group of scientists from the University of Oxford, it is very likely that extraterrestrial lives behave
like earth creatures and also evolve through nature selection. That is, the aliens also have a limited lifespan and we have reason to believe that the best guess of alien is us. Therefore, we can expand our aforementioned theory and the logic chain of arguments to the entire universe until new evidence was discovered.

**Conclusion**

The limited lifespan indicate that we can only absorb limited knowledge in one’s life time. Therefore, if the minimum time to learn Pre-A exceed human’s, or any extraterrestrial’s, maximum lifespan, then we, or that species, will never discover the new knowledge A. In Robin Hanson’s theory, spacefaring is the last step of any civilization and our physics and astronomic theories also indicate that it requires extremely advance technology to achieve spacefaring. Therefore, it is very likely that the limited lifespan serves as a great filter that prohibit most life from spacefaring.

**Objection Considered**

The chain of argument is based on several aforementioned assumptions, which may become the target for potential counter-arguments. However, we can still show that this theory is very reliable though not perfect.

1. Infinite lifespan

   It is true that lifespan wouldn’t be the barrier if some alien has infinite lifespan. However, according to the study of *Darwin Alien*, the best assumption for alien is human until further evidence.

2. Subject Dividing

   Subject dividing is what we have been doing through human history. Facing with increasing knowledge, each PhD nowadays only focus on a tiny area, and it seems to work very well since we still make progress in science and technology every year. However, the problem is that such a method didn’t solve the problem. However, this method cannot solve the problem in interdisciplinary areas. Moreover, all subjects rely on mathematics and statistics. Therefore, no matter how small a subject is divided, people still need the same amount of time to study relevant math and statistics, which may be longer than human’s lifespan.

**Reference**


