The Search for Extraterrestrial Intelligence

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1. Introduction

Throughout history, there has been the pervasive question: is anyone else out there? Technology for the search for extraterrestrial intelligence (SETI) has been advancing for decades, with radio signals, spectroscopes, telescopes, and mathematical equations pushing the progress. Most studies are based on the assumption that water is an essential ingredient for life on all planets, not just Earth. Though the true likelihood of intelligent life existing elsewhere remains unknown, the Drake Equation clarifies what variables need to be solved to get a concrete answer. Despite research providing increased knowledge of the universe, critics feel that the search for extraterrestrial intelligence is a waste of time and resources.

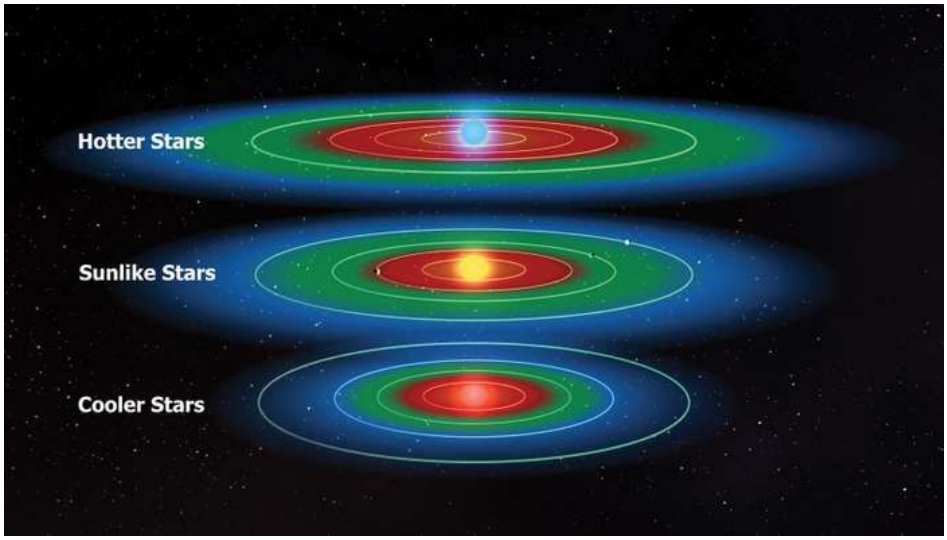
2. Radio Waves in the SETI

At the beginning of the search for extraterrestrial intelligence, it was proposed that light signals could be used as beacons to extraterrestrial societies [3]. However, in 1919, inventor Guglielmo Marconi proposed that unusual radio signals he noticed could be coming from Mars [3]. This turned researchers' attention to the prospect of using radio signals in the search for extraterrestrial intelligence. Radio waves travel at the speed of light and are not absorbed by cosmic material, giving them the ability to travel much farther than other types of waves [3]. Radio telescopes were tuned in, hoping to detect broadcasts from an extraterrestrial civilization [3]. The search began by listening to the microwave portion of the radio spectrum but this left too many frequencies unchecked [3]. Instead, attention was turned to the "portion of the spectrum between the natural emission lines of hydrogen and hydroxyl (OH), components of water, since water is assumed to be essential for life," [3].

3. Exoplanets and Habitable Zones

If extraterrestrial intelligence exists, it is logical to assume that it would be found on an exoplanet, a planet of another solar system. Despite the first exoplanet being discovered as recently as 1995, there are already approximately 3,300 confirmed exoplanets [5].The current most common method of detecting exoplanets involves observing the light emitted by stars [5]. A decrease in the amount of light indicates a planet passing in front [5].

Different qualities can indicate the likelihood of an exoplanet containing life. A planet's light signature can be viewed through spectroscopy, showing which elements are present in its atmosphere [5]. A planet with a light signature indicating the presence of oxygen or water vapor has a higher potential to support life, as those elements are considered essential [5]. Planets orbiting brighter stars are less likely to have life [5]. Brighter stars burn out faster, with the brightest burning out in a few million years in contrast to Earth's sun's total life expectancy of around 9 billion years [5]. Larger, multicellular organisms didn't appear on Earth until about 4 billion years after its formation, meaning that dwarf-stars are more likely to be compatible with intelligent life forms due to their long lifespan giving more time for them to develop [5].



Highlighted in green are habitable zones. Areas that are too hot for liquid water to exist are red and areas too cold are blue. Kepler mission/Ames Research Center/NASA.

Another criteria considered essential is for an exoplanet to be located inside a star's habitable zone, the area in the distance from the star where liquid water can exist [5]. It is often referred to as 'the Goldilocks Zone' as the planet cannot be too hot or too cold but must be just the right temperature for liquid water. Water is assumed essential for life so a planet where liquid water cannot exist is not a viable supporter of life. Mass of a star affects the distance away that the habitable zone exists due to the amount of heat emitted [5].

4. Necessity of Water

Many strategies in the search for extraterrestrial intelligence are based on the assumption that water is necessary for life. Though water is necessary for life on Earth, would extraterrestrials have the same limitation? Most likely. Water keeps cells in the necessary shape and structure by creating internal pressure to push back against external forces [4]. DNA has to be in the proper double helix shape for all necessary instructions on surval to be interpreted, such as human growth and reproduction [4]. Cell membranes allow necessary molecules into a cell and keep out harmful ones and need water to maintain their structure [4]. Water is also crucial in transporting nutrients to cells and oxygen for respiration [4]. No other known liquid possesses all of these qualities, meaning that unless extraterrestrials do not rely on these functions, water is necessary for survival [4].

5. The Drake Equation

$$N = R_* \cdot f_P \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

The Drake Equation predicts the total number of intelligent civilizations currently capable of contact [2].

The Drake Equation, developed by physicist Dr. Frank Drake in 1961, predicts the total number of intelligent civilizations currently capable of contact (N), where R* is the average rate of star

formation in the Milky Way, f*p* is the percentage of stars in the Milky Way with planets, n*e* is the fraction of planets capable of supporting life, f*l* is the fraction of planets that do develop life, f*i* is the fraction of planets with intelligent life, f*c* is the fraction of civilizations of intelligent life that develop advanced transmission technology, and L is the length of time the civilization possesses said technology [2]. Some of these variables already have approximate values. An estimated two stars form every year in the Milky Way (R*) and around 50% of stars in the Milky Way have planets (f*p*) [2]. The overall survival rate of life on a planet can be substituted for the fraction of planets with intelligent life, f*p,* as the longer life survives on a planet, the more time there is for intelligence to develop [1]. By observing trends of extinction throughout Earth's history, the survival rate for life on Earth is approximately 15% [1]. Observations have also given an estimate of 0.1 for the product of the first three variables, R*, f*p*, and n*e* [1]. However, the remainder of the variables of the Drake Equation, f*l* and L, remain unknown, meaning N cannot be conclusively determined at this time.

6. Criticisms of SETI

NASA officially began funding SETI in 1975 [3]. Biologist Ernest Mayr is one of the scientists to have vocally opposed these efforts [3]. He questioned that "[i]f intelligence has such high survival value, why don't we see more species develop it?," [3]. When observing Earth's history, it is notable that it took over 3.8 billion years since life began on Earth for intelligent life to develop [3]. Only one species out of the 50 million in Earth's lifetime have developed communication technology [3]. Mayr also argued that "if the evolutionary soup [the set of conditions on Earth when life was forming] was a few degrees hotter or colder at any point, we would not be here at all," [3]. Earth has been faced with five mass extinction events, with each one killing between 60% and 95% of all species [6]. The famous cretaceous mass extinction, which killed the non-avian dinosaurs, is not even the largest mass extinction event in Earth's history [6]. There is no reason to believe that other life-bearing planets would not have also faced mass extinctions [1]. Humans managed to evolve despite these odds but other planets' lifeforms may not have been as fortunate. This sentiment is echoed in physicist Enrio Fermi's famous Fermi Paradox; if the probability of life developing is so high, where is everyone; shouldn't Earth have been contacted by now [2]? The assumption of a high survival probability of life on other planets is not justified as another species should have contacted Earth by now [3].

Despite these criticisms, progress has been made in learning more about possible extraterrestrial life. It is important to continue the search as increasing knowledge of the universe has made it justified. One day Earth will know for sure if it is alone in supporting life.

References

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