

# A BRIEF REVIEW OF THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)

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## ABSTRACT

The Search for Extraterrestrial Intelligence (SETI) is one that began, scientifically, back in 1959 with physicists Giuseppe Cocconi and Philip Morrison. Humans have known about our place among the stars for centuries and have learned that we are not the only planet suitable for sustaining life. This knowledge, along with natural human curiosity, has incubated the grand question, “Are we alone?” The question can be answered in two ways: Yes or No. However, the answer “No” can be divided into multiple parts, but this paper will focus on the division: If there is life elsewhere in the universe, is it intelligent/technologically advanced (a.k.a. not microbial or the sort)? The SETI focuses to discover if intelligent life exists elsewhere in the universe mainly by analyzing and interpreting signals and spectra that reach Earth from space. This paper will discuss the history of the SETI and some of its aspects such as the Drake Equation and the Fermi Paradox. It will then discuss current methods being used to search for intelligent extraterrestrial life.

## 1. INTRODUCTION

The history of the search for extraterrestrial intelligence (SETI) is a fairly recent one, beginning back in 1959. Two of Cornell University’s physicists, Giuseppe Cocconi and Philip Morrison, discovered the ease at which radio signals could transverse to and between star systems. Along with the knowledge that the universe holds stars similar to our sun and planets that orbit those stars, the two physicists thought that by combining the ease of radio communication with the vast number of planets in our universe, one could potentially communicate with extraterrestrial intelligence (ETI) [1] [2]. In their paper, “Searching for Interstellar Communications” published in the Journal Nature, Cocconi and Morrison describe that searching for radio emissions frequency around 1,420 MHz (wavelength = 21 cm) would probably be the most promising way of detecting an artificially created signal as that is the frequency of natural hydrogen: a constant throughout the universe. They also claim that this frequency would be ideal because early radio-astronomers of any civilization would be aware of hydrogen and its frequency. Finally, Cocconi and Morrison state that a signal sent by ETI would be “pulse-modulated” and contain messages that only an artificially produced signal could hold [3]. A year later, astronomer Frank Drake conducted

the first SETI experiment, Project Ozma, where he used a 26m radio telescope to analyze the stars Epsilon Eridani and Tau Ceti close to the 1,420 MHz frequency. Ultimately, no signals that could be linked to ETI were discovered [4]. Later, in 1961, Drake created an equation used to estimate the possible amount of technological civilizations that exist in our galaxy. Known as the Drake Equation, it states, according to the SETI Institute website:

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

“Where,

$N$  = The number of civilizations in The Milky Way Galaxy whose electromagnetic emissions are detectable.

$R^*$  = The rate of formation of stars suitable for the development of intelligent life.

$f_p$  = The fraction of those stars with planetary systems.

$n_e$  = the number of planets, per solar system, with an environment suitable for life.

$f_l$  = The fraction of suitable planets on which life actually appears.

$f_i$  = The fraction of life bearing planets on which intelligent life emerges.

$f_c$  = The fraction of civilizations that develop a technology that releases detectable signs of their existence into space.

L = The length of time such civilizations release detectable signals into space” [5].

Eventually, NASA became interested in the search for extraterrestrial life and became an active member in the search as they believed that SETI was a legitimate scientific agenda. However, all NASA SETI programs were cancelled by 1992 [1]. In 1984, the SETI Institute was created to “facilitate scientific research and educational programs related to life in the universe” [1]. The SETI Institute created their own project (the largest SETI experiment to date), Project Phoenix, to continue parts of the then unfunded NASA SETI program. Project Phoenix ran from 1995-2004 and observed over 800 stars for more than 11,000 hours with no detected signals from ETI [6]. Today, no confirmed detection of signals from ETI exist even though over 98 SETI experiments have been conducted. Probably the most convincing evidence currently obtained consist of the “Wow! Signal” and the unusual light curve of the star KIC 8462852, also known as “Tabby’s Star.” Humans have not only sat back and waited to receive signals from space, but have sent messages into space in hopes of eventually reaching an ETI. Humans have sent physical objects on spacecraft, such as: the Pioneer Plaques on the spacecrafts Pioneer 10 and 11, and the Voyager Golden Records on the spacecrafts Voyager 1 and 2. Signals have also been sent into space such as the Arecibo Message, and Cosmic Call 1 and 2. Thorough investigation and logical thought through all the attempts of detecting signals and communicating with ETI brings to the surface a question – or rather a paradox. This being the Fermi Paradox which begs the question: If there are so many potentially habitable star systems and planets in these systems in the vast amount of galaxies in our ever-expanding universe, where is everyone? [7] By using the Drake Equation, granted it has a result range of possibly a few thousand to multiple millions of technologically advanced civilizations, one would believe that many of these alien civilizations would be more advanced than Earth and even spacefaring. However, this is obviously not the case as no confirmed detections of ETI have been made and as far as we know, humans

are the only intelligent life forms in the universe. Whether or not ETI are among the stars, possibly roaming space unnoticed by humans, the SETI seeks to resolve this paradox and answer the ultimate question: “Are we alone?”

## 2. CURRENT METHODS OF DETECTING COSMIC SIGNALS

### I. RADIO

The most commonly used method of potentially communicating with ETI is in the form of radio waves. As mentioned earlier, radio waves are good candidates for communicating as they can transverse between stars and through space with relative ease. Radio waves also travel at the speed of light while carrying information. With the speed, vast amount of information they can carry, and ease at which they travel, radio waves can be easily and effectively detected and sent by even basic technologies of an intelligent extraterrestrial civilization. Some issues that arise, however, with the use of detecting radio waves is that the waves themselves would need to be transmitted at a narrow band of frequencies to be distinguishable from the natural microwave background. Another issue is that of monitoring the entire sky, or select areas of the sky. Unless astronomers have a reason to look at one particular area of the sky, the radio waves could go undetected due to the fact that the Earth is not a massive radio dish. Not every part of the sky is being constantly monitored so signals could be missed as most of them would be intermittent. This leads to a final challenge, after receiving signals they must be deciphered. Almost every time signals turn out to be unrelated to ETI, but rather caused by astronomical phenomena, or humans ourselves. In the very rare case such that a signal cannot be connected to another anomaly, such as the Wow! Signal (whose source is still currently unknown), a source cannot usually be determined, therefore not providing sufficient evidence of and confirming the existence of ETI. However, there is very strong reason to believe that a signal from an intelligent civilization would have certain characteristics. These ultimately being the aforementioned 1,420 MHz narrow band frequency and an unusual makeup of the sent signal. This unusual makeup would consist of anything to make the signal look artificially created and

absolutely not capable of being naturally produced. Whether the signal is sent intermittently at random as to not follow any pattern and from the same place in the sky, to sending incredibly large amounts of “decipherable” data [8] [9]. Many radio telescopes are used around the world to search for potential ETI signals, such as the Arecibo Observatory in Puerto Rico and the Murchison Widefield Array in Australia.

## II. Optical

The other commonly used method of potential ETI communication is through the use of light. The observation of light emitted from star systems can relay information about that system and what is contained within it. This technique, called the transiting method, is very commonly used in the search for extra solar planets: light from a star is monitored over time (typically through a space telescope as Earth’s atmosphere can disturb that star’s light) and any fluctuations discovered in that stars light curve may indicate the presence of a planet or another object orbiting the star and transiting between the star and the telescope. When the object transits the star, the overall amount of light that is received by the telescope will decrease because part of the stars light is being blocked by the transiting object. Very unnatural distributions of a star’s light curve could possibly be explained by ETI. A perfect example of this is the star observed by the Kepler Space Telescope, KIC 8462852 (Tabby’s Star). This star underwent “irregularly shaped, aperiodic dips in flux up to  $\sim 20\%$ . The dipping activity can last for between 5 and 80 days” [10]. In short, these fluctuations are very difficult to explain through natural processes which leads many astronomers to suspect some artificial structure(s) may be causing these abnormalities. This system displays nearly all of the characteristics of a megastructure known as a Dyson Swarm [11] [12]. Another method through optics that could be used to signal the existence of ETI is that of “sending light pulses with time separations on the order of  $10^9$  -  $10^{15}$ s that could be detected in spectra” [13]. Sending multiple sporadic bursts of very intense beams of light is not an event that typically happens in nature. These bursts of light would be used to capture the attention of the receiver and signal that ETI may have been the source of the burst.

## 3. CONCLUSION

The search for extraterrestrial intelligence began back in 1959 with Cocconi and Morrison’s paper “Searching for Interstellar communications” which was published in the Journal Nature. The topic of SETI quickly began attracting attention and eventually led to NASA undertaking its own experiments and the eventual creation of the SETI Institute. Humans have made few attempts at sending our own messages and signals to be discovered by extraterrestrial intelligence, however many experiments have been conducted at detecting possible signals from ETI. The main methods of detecting these signals are through radio waves and optical observations of other star systems. There are many telescopes currently dedicated to discovering (radio) signals from space such as the Arecibo Observatory, Murchison Widefield Array and the SETI Institute’s most recent project: The Allen Telescope Array.

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