Is there life in outer space?

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for

Astronomy 302

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May 16, 1961

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Is there life in outer space? For centuries this question has been contemplated by philosophers, daydreamers, and storytellers. Only with a passive interest did anyone think he might live to see the day that scientists would begin a rational search for other celestial beings. Even after Darwin it was universally thought that although human life might have evolved from less complicated forms of life on this planet, certainly we represent the ultimate of biological development in the known universe. The reasons behind the recent change in philosophy concerning the prospect of higher life on other worlds, and the project launched by the United States in April 1960 to attempt establishing communication with such civilizations are the subjects of this paper.

In scientific circles, according to classical beliefs, life elsewhere in the universe was considered quite improbable. This idea was a natural consequence of the then prevailing theory concerning the origin of the solar system and other planetary systems. Our solar system was thought to have been born as a result of a near collision of the sun with another star which, because of the strong gravitational attractions, pulled some of the sun's matter from the main star body. This matter was supposed to have contracted into the planets from its gaseous, spiral-like state around the sun, again do to gravitational interactions. Assuming this "near collision" theory for the formation of all planetary systems, it is then possible to compute from observational data the probability of the existence of another system like ours. The odds are so much against such an occurrence, that there could only be one or two other planetary systems in the remainder of the visible universe. And the chance of life on one of these planets would be almost zero due to other physical considerations to be discussed shortly.

What happened, then, to change the course of scientific thinking on the subject to the degree that the United States Government has allocated funds for the express purpose of trying to discover one or more of these so-called exo-civilizations? This question can best be answered by looking into a recent astronomical analysis of the phenomenon of star formation. It is experimentally confirmed that when stars evolve from gaseous clouds or nebulae a certain amount of angular momentum (rotation) is almost always exhibited by the system. As the gases contract and stars evolve, this inertia usually manifests itself as axial rotation or an orbital motion in the case of multiple star systems. In about one of every thousand star births, however, this momentum appears to be measurably reduced, according to studies made by Harlow Shapley of Harvard. There is only one obvious conclusion: some of the rotational inertia has been hidden in the orbital motion of invisible object, i.e., planets. With this new theory now generally accepted, the number of stars with planets in the Milky Way alone could exceed 10^8, even by conservative estimates.[6]

But even if there is a multitude of planets in outer space, what indications are there that life exists on any of them? An experiment conducted by Stanley Miller of the University of Chicago lends evidence to a popular theory that the phenomenon we know as life is a logical consequence of evolutionary developments involving non-living matter.[1] Into a mixture of chemicals such as originally composed the earth's atmosphere (hydrogen, methane, ammonia, and water vapor) Miller passed high voltage sparks that approximated lightning. After many of these electrical discharges the chemical mixture was found to contain amino acids and other complex molecular structures that are the building blocks of proteins. Sidney W. Fox, a Florida State University biochemist, carried Miller's experiment one step further and developed substances actually resembling proteins, as well as tiny spheres which looked and acted like bacteria.

Thus, evidence is accumulating toward the idea that life in some form is possible in other areas of the universe. Just how frequently life occurs we cannot be sure. However, there are certain limiting factors which restrict considerably the number of planets on which life as conceived by us is feasible. The first limitation is on the size and temperature of the parent star. One of our potential "life" planets must remain always in a region surrounding the star known as the "zone of life." This zone is characterized by an intensity of light and heat radiation comparable to that which we experience on earth. It is only within this zone that life can survive. Extreme cold stifles evolution and extreme heat destroys complex chemical bonds. Planets surrounding small, cool stars are ruled out as possibilities because the zone of life is so narrow that it would be highly improbable for a planet to have both an almost perfectly circular orbit and the necessary mean distance to stay within the zone. Large, hot stars have enormously wide zones; however, they are inherently unstable and would engulf their planets before advanced biological beings would have appeared. This requirement would also eliminate planets of double and triple stars because stable orbits could not remain within the complex zones. The search for life is consequently reduced to single stars approximately the size and temperature of the sun and therefore members of spectral classes F, G, K, and maybe M.[3]

In addition to having circular or moderately elliptical orbits, the planets themselves would have to have surface gravities not much different from the earth's. The reason behind the gravity restriction concerns the planet's atmosphere. The original atmosphere would most likely be the typical hydrogen, methane, ammonia, and water vapor mixture. Ultra-violet rays from the star would break up the water to hydrogen and oxygen starting a chemical chain reaction. Oxygen would combine with methane forming carbon dioxide and water, and with ammonia forming more water and freeing nitrogen. Now, if the gravity were too strong, hydrogen could not escape and would remain to recombine with the carbon, nitrogen, and oxygen, thus leaving the atmosphere in a stable state without much, if any, free oxygen to support life. If the gravitational forces were too weak the whole atmosphere would escape. If gravity were in the proper earth-like range, only hydrogen and the lighter gases would escape, leaving the familiar nitrogen, oxygen, carbon dioxide atmosphere after a period of two or three billion years.

Throughout this discussion it has been tacitly assumed that the beings for which we are looking are similar to us in environmental requirements and biological development—not necessarily look-alikes, but of similar chemical and functional nature. Chemical systems departing from the carbon life cycle with its inherent temperature and radiation restrictions are, however, extremely improbable. Within the carbon cycle itself, it is true that certain earth-bound germs thrive on pure sulfur, that species of microbes generate in boiling Yellowstone Springs, and that the water cooled reactors at Los Alamos are sometimes clouded with Pseudomonas which successfully take 10,000 times the lethal radiation dosage for humans, but such examples are rare on earth and must be assumed to be rare on similar planets.[6] A feasible variation of the carbon cycle is one with a hydrogen peroxide atmosphere, whereby the organisms would simultaneously satisfy oxygen and water needs. This concept is remote, though, unless the atmosphere were clouded sufficiently to prevent breakup of the peroxide molecules from radiation, and if that were the case, life would probably not have developed at all. Fluorine atmospheres might sustain life, but inasmuch as there is only one-thousandth as much fluorine in the sun as oxygen, this possibility is ruled out.[6] A silicon cycle would necessitate the expulsion of silicon dioxide (quartz) or silicon tetra-fluoride (a colorless gas.) The quartz exhalation would involve severe physical problems and the silicon-fluorine basis, although quite possible, must also be rejected as an object of earth-bound search because of its low probability of occurrence.

Many guesses have been made as to what types of beings might be found in outer space. No one can say for sure what their physical appearance would be, but a few assumptions about their nature are reasonable. Sense organs such as visual perceptors, similar or analogous to our eyes, would necessarily be close to the primary nerve center or brain. If they were not, neural messages signaling danger would take too long in arriving at the brain and such species would likely perish. Vital organs would appear internal to a gravity-opposing skeletal system so that they would not be lopped off by accidents. In a Life magazine article,[6] Krafft Ehricke is quoted making a comparison indicating why he thinks these other beings would be basically like humans. He stated that when airplanes were first developed, there were many varieties. Now that the early stages of airplane manufacture have been passed, only one best design for a given size and speed range exists. Would not the evolution of life also proceed toward one optimum design?

Admittedly, some of the foregoing assumptions cannot be substantiated by our limited history of scientific observations. The very nature of the subject places it within the realm of speculative inquiry. At present all that our scientists really have as material basis for further study is a series of calculated and assigned probabilities and a wealth of astronomical information. However, the inquisitive mind has produced many scientific breakthroughs against much greater odds, and our space philosophers are surprisingly confident of establishing a communications link with one of these exo-civilizations.

If contact were to be achieved, there is little doubt as to what the medium of communication would have to be. Radio is the only realistic possibility. Radio would certainly be familiar to advanced civilizations because of similarities to the light radiation emanating from their own star. Other media of long distance communication are much inferior. Optical means, for instance, could at best tell us if planets exist around some of the stars. Even if observations were made from the atmosphereless moon, there would no hope of detecting an advanced society. Inasmuch as the sun is only of average age, in all probability many of these societies are technologically much superior to us and possess a knowledge of radio techniques perfected to the degree that any interference in signals transmitted by them would be externally caused. Since the transitional period of learning about radio is a very small lapse of time compared to the eons of an evolutionary process, exo-civilizations are classed into those with a complete mastery of radio and those with complete ignorance of electronic methods. We are now one of the rare exceptions in the transitional stage. Maybe somewhere it has even been discovered how to modulate a beam of neutrinos or some other wave/particle we have not yet found, thus permitting even better communication. We have no way of knowing. Actual transportation is out of the question because even with the use of the "perfect" matter/anti-matter engine, a space vehicle would need 200 tons of each (assuming we could isolate and contain anti-matter) just in order to traverse the distance to the nearest sun-like star and back at 99% the speed of light. Our only choice is exploration by radio.

Once the radio medium has been decided, where do we look, and how? Conservative estimates based upon these theories place the number of inhabited planets in the Milky Way alone at 100,000! If we radiated energy aimlessly, it would be 10.8 years before our first transmissions even reached the nearest sun-like star, and the program would be hopelessly expensive. It is much wiser for us just to listen, and for this interstellar eavesdropping, we call on the services of the radio astronomers.

Radio astronomy had an unusual beginning in 1931 when Dr. Karl Jansky, employing a crude apparatus, tried to determine the cause of interference in trans-Atlantic radiotelephone transmissions. His conclusion that the primary disturbances were due to solar activity launched a science that has progressed to the stage where it is a very useful supplement to the optical twin. Many phenomena that have not been observed using optical equipment have been "heard" with big radio telescopes.

The United States program to study interstellar life was begun on April 8, 1960, and is called Project Ozma after the Queen of Oz who governed that far away, difficult to reach, mythical land inhabited by exotic beings. The project is centered on activities at the National Radio Astronomy Observatory in Green Bank, West Virginia, and is directed by Dr. Frank D. Drake. The telescope at Green Bank has a parabolic antenna eighty-five feet in diameter, but it will soon be overshadowed as larger, more sensitive telescopes are built. A 140 foot telescope is under construction, a 400 foot 'scope of new design is planned, a 600 foot unit is being constructed by the Navy in Columbus, Ohio, at a cost of $80 million, for installation at Sugar Grove, West Virginia. Designs for a 2000 foot antenna are being studied. Signals that are transmitted with the power of high intensity U. S. radars can be picked up by the Green Bank telescope at a distance of 5×10^{13} miles and the Sugar Grove to 3.6×10^{14} miles and within a listening range of more than 10^{20} stars.[7]

Larger telescopes have another major advantage in addition to increased range—resolving power. If the resolving power is expressed in the usual dimensionless ratio of diameter of telescope divided by the wavelength of a typical received signal, then larger telescopes are proportionally better at star separation, a very necessary quality when close double stars are examined. Large radio telescopes still lag behind large optical telescopes in resolving power by a factor of 10^5, but the Sugar Grove unit will still be good enough to examine individual sunspots.

The Green Bank telescope is an electronic marvel. When a signal arrives at its parabolic antenna the electromagnetic wave is reflected to the focus and is strengthened by the newly invented reactance amplifier, soon to be replaced by a maser suspended in liquid helium at a temperature of –269°C. the new maser will make the telescope's radiometer (the device that changes radio waves into graphical patterns) 10^{18} times more sensitive than a television set.[7] From the reactance amplifier the signal travels to the first mixer and intermediate frequency amplifier, and is further processed in the superheterodyne circuitry as indicated in Figure 1 below.[7]

The signal from the focus of the 85 foot parabolic antenna enters the circuitry symbolically in the third box of the first row below for mixing with the internally generated signal………..

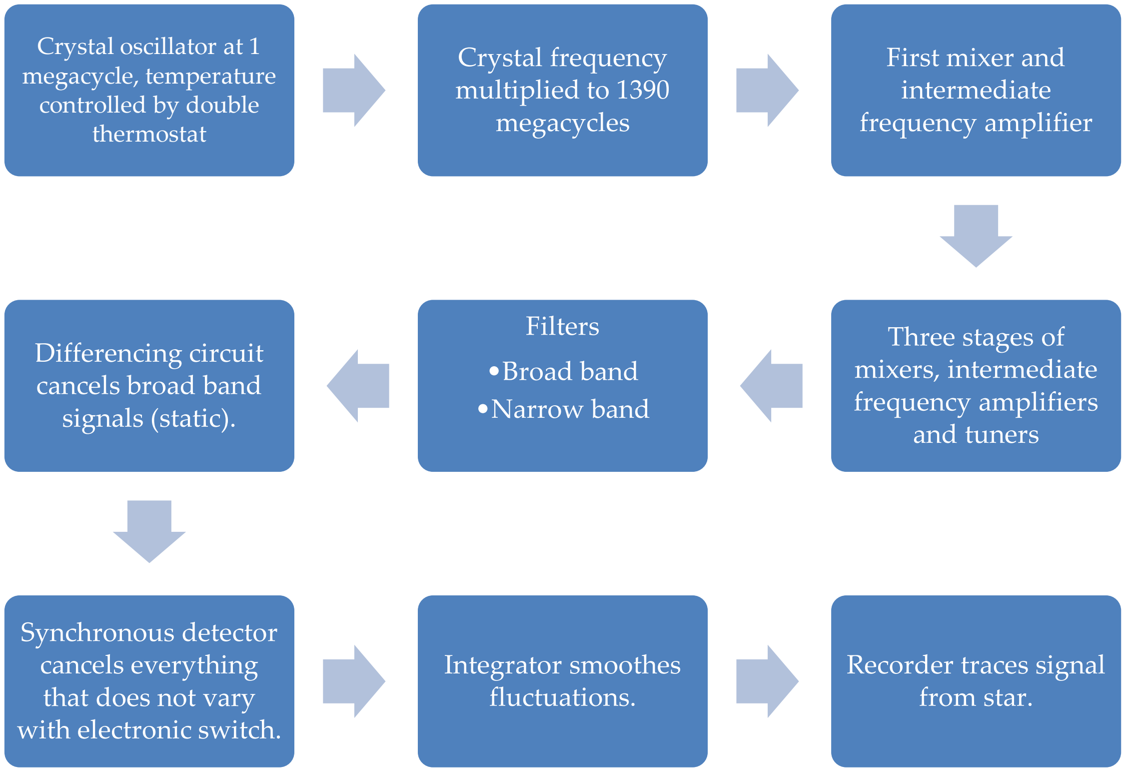

Figure 1

Several items need explanation. The telescope sensor placed near, but not at, the focus is aimed at a blank part of apace. An electronic switching circuit changes the input back and forth between the two sensors to that the radiometer can compare the two inputs and eliminate all signals that are repeated, i.e., interference. The static and other "noise" appear in the broad band filter inasmuch as the frequencies are not at all constant, and are canceled in the next stage. Star transmissions have very small frequency variations, enter the narrow band filter, and are eventually graphed. The crystal oscillator is double enclosed and accurately controlled for temperature and humidity so that its frequency will not vary by more than one part per billion. The zero to two hundred cycles per second frequencies following the intermediate frequency stages are quite low as a consequence of the close band width tolerances.

If other societies were to send radio messages it is thought that the frequencies employed would be in the 1000 to 10,000 megacycle band. Frequencies below 1000 megacycles are subject to extreme interference from cosmic noise. Frequencies above 10,000 megacycles have difficulty penetrating an atmosphere. Specifically, the hydrogen emission frequency of 1420 megacycles, discovered in 1951 by two Harvard physicists, is considered to be the most likely for interstellar communication, and it is this wavelength that is being studied with close attention by the Green Bank Observatory. Only one minor problem sometimes occurs. A large red shift in the case of a star receding with high velocity puts the hydrogen frequency in the noise band. Since the narrower the band width of transmissions, the greater the range, only close tolerance signals are being analyzed, under the assumption that exo-civilizations would desire the greatest possible range.

The search has been localized to six stars within fifteen light years of the sun: tau Ceti, omicron-2 Eridani, epsilon Eridani, epsilon Indi, 70 Ophiuchi, and 61 Cygni. Dr. Su-Shu Huang of the University of California suggested epsilon Eridani and tau Ceti as the best prospects, and these two are getting the most attention now. Tau Ceti is 10.8 light years away and is the closest candidate.

Even at these relatively short distances on the astronomical scale, it would be over twenty years before an exchange of communication could take place. What kinds of messages would be sent to us and how would we respond? Considering the great time lags, any message we received would most likely be lengthy and in a logical sequence independent of verbal languages. Once the sequence had been recorded we could sit back and attempt to decipher it. One of the first things noticed would undoubtedly be that the carrier wave itself was characterized by a Doppler shift due to the orbital motion of both the earth and the other planet. The initial items of the text would contain simple statements of universal scientific truths such as pulses arranged in the prime number series according to Drs. Giuseppe Cocconi and Philip Morrison of Cornell. Also, wave forms depicting the standard arithmetic operators would appear and π, with its universal significance, might be transmitted as the series: $\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots$. As the message progressed, the Pythagorean Theorem might appear, as well as more involved physical constants, such as the fine structure constant, 137.039, representing several fundamental atomic ratios among which are

1. the ratio of the principal hydrogen wavelength (in the visible spectrum) to the circumference of the orbit of simple hydrogen's only electron,
2. the velocity of light to the velocity of hydrogen's electron, and
3. the number of uranium atoms necessary to sustain a chain reaction.

Scanning lines that could be put together in the form of a picture, like television, would emerge, and eventually clues to the nature of their language, life, and society would be revealed.

Our first response would be to send back a similar sequence with a few obvious alterations so that they would not think they were hearing an echo. We could add to their message and insert ideas of our own, like symbols for units of distance, time, and mass, for example. Who knows? — Maybe after thousands of years an interstellar "party line" could be established and a wealth of knowledge exchanged.

As new problems are solved, the search for intelligent beings trillions of miles away quickens in pace. With each new success, though, comes a new question to be pondered. What if high exo-civilizations have had an ear turned our way for a hundred million years or so and have already decided there is no one here? What if advanced societies want no part of underdeveloped people who are just learning the fundamentals of radio? What about our own existence? Could we all have evolved from matter brought to the earth billions of years ago by a stray meteorite from a life-sustaining planet of that era? Melvin Calvin of the University of California has found nucleotide fragments in meteorite specimens. Nucleotides are substructures of desoxyribonucleic acid, better known as DNA!

There are wide areas of uncertainty, but the quest for scientific knowledge and the romantic appeal of maybe finding an equal or superior civilization in the far reaches of outer space make one want to forget that we might not find anything. Astronomer Drake himself wryly suggests, “We might get a better feeling for the situation if we could first answer the question: ‘Is there intelligent life on earth?’” The odds are uncertain, but the search continues.

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