AN INFRARED SEARCH IN OUR SOLAR SYSTEM AS PART OF A MORE FLEXIBLE SEARCH STRATEGY

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ABSTRACT. One of several explanations for the Fermi Paradox is that the whole Galaxy, including our Solar System, has already been colonized, but that for a variety of reasons the extraterrestrials have chosen not to reveal their presence. In a universal search for extraterrestrial intelligence, it seems prudent to check-out also our own backyard. IRAS has obtained a large volume of infrared data at 12, 25, 60 and 100 microns from which a special working group at JPL, of which the author is a member, is trying to establish a special catalogue of Solar System objects, the vast majority of which are asteroids. A careful search through this data bank for objects with peculiar infrared spectra would be the first step in the search for major artificial objects, such as space stations or materials processing plants, in our Solar System. The asteroid belt is an ideal source of raw materials for space colonies, which could have easily escaped detection lost among the many thousands of natural asteroids. Checking them out for excesses in the infrared is an ideal screening test for artificial objects in our Solar System.

1. INTRODUCTION

The possibility that life, and especially life with intelligence, might exist in other parts of the Universe has puzzled the minds of people for thousands of years. Nearly 2,400 years ago the Greek philosopher Metrodorus of Chios (Diels, 1422) was writing: "It seems impossible, in a large field only one shaft of wheat to grow, and in an infinite Universe to have only one living world". The rapid progress of science and technology during the 20th century made it finally possible to undertake actual searches for extraterrestrial life. The first radio search for other civilizations in nearby Sun-like stars was undertaken by Frank Drake in April 1960 in his celebrated Project OZMA, while the landmarks in the search for primitive forms of life in our Solar System were the retrieval of lunar rocks in 1969 by the Apollo missions, and the landing of the two Viking biological laboratories on Mars in 1976.

The chances of finding extraterrestrial life, primitive or advanced, depend on how common they are and on how easy it is to detect

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them. Judging from how common complex organic compounds are both in interstellar space and in our Solar System (the Earth, carbonaceous chondritic meteorites and asteroids, Jupiter, Titan, etc), and from the early appearance of life on Earth (3.5-3.8 billion years ago), i.e., as soon as the Earth could hold it after it underwent heating, melting, chemical differentiation, outgassing of its secondary atmosphere, cooling, formation of a solid crust and of extensive oceans, and finally the cessation around 3.9 billion years ago of a harsh meteritic bombardment, one may guess that primitive life is probably quite common in our Galaxy. At the present state of the art, however, we can search for it only inside our own Solar System, where in the apparent absence of any other planet or large moon with liquid water the chances of finding any primitive life appear to be very slim.

Galactic civilizations, on the other hand, are much easier to detect either from intentionally transmitted signals, where our current technology allows us to detect Arecibo-like transmissions from any of the 200 billion stars of our Galaxy, or from radio signals leaking out unintentionally from their planet, as they do from Earth, where our present capabilities limit us only to stars in the immediate vicinity of our Sun. In the past 25 years we have carried out close to 50 different radio searches and have accumulated more than 120,000 hours of observations. Our instrumentation is constantly becoming more sophisticated and the prospects for the next 10 - 20 years are very promising with the implementation of the bimodal NASA SETI Program of targeted and all-sky surveys over a wide frequency range, and the coming into the scene of the new generation of the 8-million channel spectrum analyzers. It appears, therefore, that by the turn of the century we would have devoted a substantial effort in the radio search for extraterrestrial intelligence in other solar systems. But is there anything else we could do that is within our present capabilities?

2. GALACTIC COLONIZATION

In the 50's and in the 60's interstellar travelling was believed to be out of the question, primarily because round trips even to the nearest stars within a reasonable fraction of a human life-time require velocities of the order of 0.5 c. This made them indeed unrealistic even with a matter-antimatter propulsion fuel. In the 70's and in the 80's, however, the idea evolved that large, self-sufficient space colonies could undertake interstellar trips of several centuries and many generations to the stars at much lower speeds of 0.01-0.05 c, which seem like a realistic possibility even with nuclear fusion. Some scientists have advocated the idea that interstellar travelling is a natural extension of the conquest of space, which our civilization initiated as soon as we had the necessary technology. Consequently, civilizations far more advanced than ours will be undertaking rather routinely missions to other stars establishing initially some outposts which in time will grow into blossoming new colonies. These space-faring civilizations would be totally accustomed to living in space colonies, which would eliminate the need for Earth-like planets, and therefore would make practically all solar systems candidates for colonization.

In this manner the entire Galaxy could be colonized in only about 10 million years (Jones, 1976), which is a very short interval when compared to the 10 or so billion year history of our Galaxy. If interstellar traveling is indeed an inevitable consequence of technological progress, then either the entire Galaxy, including our Solar System, must have been colonized since long ago, or we must be one of very few if not the only advanced civilization in the entire Galaxy. This presumably was also the conclusion that had been reached by the famous Italian physicist Enrico Fermi when in a luncheon meeting with Emil Konopinski, Edward Teller, and Herbert York, at the Fuller Lodge of the Los Alamos National Laboratory in the summer of 1950 (Jones, 1985), he asked the now legendary question "Where is Everybody?" This argument was formalized in 1975 by Michael Hart (1975) in a classic paper in the Quarterly Journal of the Royal Astronomical Society, which ignited a series of long debates, both in conferences and in the scientific literature, during the late 70's and early 80's (Papagiannis, 1980; Hart and Zuckerman, 1984). The absence of any scientifically verifiable past or current contacts with extraterrestrials on Earth has become known as the "Fermi Paradox" and is also referred to as "The Great Silence."

Some scientists (Hart, 1975; Tipler, 1980; Shklovsky) have adopted the extreme position that The Absence of Evidence (of Extraterrestrials on Earth) is Evidence of Absence (of Extraterrestrials from the whole Galaxy). Hence we must be alone, and therefore there is no point in searching. Most of the scientists, however, tend to believe that the Absence of Evidence is not Evidence of Absence, and therefore have tried to find logical explanations for the so called Fermi paradox. These explanations may be grouped into three general categories: I. Interstellar travel, even at V~0.02 c is too expensive and possibly also too hazardous to be undertaken by advanced civilizations which can communicate very easily by radio (Drake, 1980). II. Interstellar colonization is possible but advances very slowly so that it might have not yet blanketed the entire Galaxy (Newman and Sagan, 1981). III. The colonization of the Galaxy has been completed long time ago but for a variety of reasons they have chosen not to reveal their presence. These reasons include the "zoo hypothesis" (Ball, 1973) (we are being treated like a zoo or wild life preserve) and the "galactic quarantine hypothesis" (Papagiannis, 1978, 1984), (before admitting us into the galactic society, they are waiting to see whether we will be able to overcome our technological crisis, or we will self-destruct).

3. A NEW APPROACH

It is obvious that there are strong and weak points in practically all of these arguments, which is the reason why the concept of galactic colonization makes such a great subject for debates. It is clear, however, that in the absence of any actual data these debates lead to nowhere. Debates are useful in sharpening our understanding of a certain problem, but they are no substitute for action. They did, however, have in this case another beneficial effect. After we debated for years until we were all red in the face, we finally began to realize that none of us could claim to know exactly how civilizations far more advanced than ours are likely to behave and act. Would they want to communicate with new, still rather primitive civilizations? Would they keep sending radio messages for millions of years? Would they undertake interstellar trips? Would they let us know if they were here? and so on.

The result has been that all of us have become less doctrinairial and more willing to accept the idea that other alternatives are also possible. It has also made us realize that only the actual searches are capable of either bringing a clear answer with the discovery of one or more extraterrestrial civilizations, or of narrowing down the potential explanations to certain limits. From this new understanding a new approach has developed, which essentially says the following: Let us undertake systematic, well planned and hopefully internationally coordinated searches for extraterrestrial civilization, but let us also keep our search strategy flexible enough to include also the experimental testings of other theoretical alternatives. This, by the way, is also the approach we are following in other global problems, such as the search for new energy sources or the search for a cure for cancer, which too have a wide range of potential answers.

As a result we are now proceeding with a multi-path search strategy centered on the comprehensive SETI program of NASA, now in the development stage, supplemented by several other more specialized radio searches, such as project Sentinel of Paul Horowitz and the Serendip project of Werthimer and Bowyer, but which will also include some other less conventional searches such as the optical search for artificial objects at the L4 and L5 Langrangian points of the Earth-Moon System by Valdes and Freitas (1983), and my own search for space colonies and material processing plants in the asteroid belt using the IRAS data.

4. THE ASTEROID BELT AND THE IRAS DATA

If galactic colonization will ever take place, it will most probably be in the form of space colonies simply because it is highly unlikely that the extraterrestrials, television programs and movies notwithstanding, will ever find a planet where they could freely breathe the air (Papagiannis, 1981). In addition, after long interstellar trips they would probably become unaccustomed to the strong gravity on the surfaces of planets, and if the planet has already life, its viruses and bacteria might also pose grave dangers for their health.

Space colonies need only energy and raw materials. The fact that they were able to travel from one star to another implies that they have in their possession high sources of energy, probably from nuclear fusion, and therefore they are not very dependent on solar energy. Hence it seems logical to assume that they will establish their space colonies or at least their materials processing plants in the asteroid belt (Papagiannis, 1978a,b, 1980, 1982), which is an ideal source of raw materials including metals in almost pure form, organic compounds in the carbonaceous asteroids, and possibly even pure water in the forms of ice.

There are now catalogued nearly 3,200 asteroids ranging from the largest, Ceres (1025 km), Pallas (583 km) and Vesta (555 km), to some of the smallest, like Geographos (2.2 km), Icarus (1.9 km) and Atem (1.1 km), of which there must be many, many thousands more than the relatively few we have catalogued so far. Most of the asteroids are concentrated in the asteroid belt, which extends roughly between 2.3 and 3.3 A.U., but there are some others, like the Apollo and the Amor families, that penetrate into the inner region of the Solar System, and some of them have passed quite close to the Earth (Hermes in 1937, 400,000 miles). Their chemical composition varies greatly and therefore when properly identified they will be able to provide practically all the raw materials needed by a civilization living in space colonies, including our own if we ever establish a permanent presence in space.

The Infra-Red Astronomy Satellite (IRAS) was launched into a 900 km altitude, near-polar orbit on January 26, 1983 and its active life ended on November 22, 1983 when its supply of cryogenic helium was exhausted. Its orbit had an inclination of 99° with respect to the Earth's equator and precessed so as to remain always close to the plane of the terminator. The observing strategy involved "seconds", "hours", "weeks" and "months" confirmations indicating that a source that was confirmed must have been detected at least twice with the above mentioned intervening periods between successive sightings. Seconds-confirmations occurred because every source on the field of view passed always over two different rows of detectors of the same wavelength. Scans of the same area were made in pairs, which produced the hours-confirmation. These pairs of scans were repeated within 7-11 days providing the weeks-confirmations, and in most instances another pair of scans of the same area was made after several months to provide the months-confirmation. When the IRAS mission ended, 72% of the sky had been observed with three or more hours-confirming scans and 95% of the sky with two or more hours-confirming scans. About 2% of the sky was not observed at all, while another 3% was observed with only one hours-confirming scan. These different time confirmations have made it possible to separate Solar System objects from galactic and extragalactic sources, because the Solar System objects are likely to show a considerable change in location within these time intervals. In addition, they tend to display a considerably different infrared spectrum because of their generally lower temperatures, which was also used as a criterion in the identification of Solar System objects.

The IRAS carried a Ritchey-Chretien telescope with an apperture of 57 cm and beryllium mirrors cooled to less than 10 K with liquid helium. The focal plane assembly, which was cooled to less than 3 K, consisted of an array of 62 infrared detectors, 15 or 16 for each one of the four observing wavelengths, arranged in such a way that each source crossing the field of view would be seen at least by two detectors in each one of the four observing wavelengths. The four wavelength bands of the system were centered at 12, 25, 60, and 100 microns and extended respectively over the ranges 8-15, 20-30, 40-80, 80-120 microns.

The initial idea was to study only galactic and extragalactic sources, but a group of Solar System scientists met in April 1980 at the Asilomar Conference Grounds near Monterey California, formed an active group, and convinced NASA to allow for a parallel study of Solar System objects (mostly asteroids) in the IRAS data. An IRAS Asteroid Advisory Group was set up at JPL under the chairmanship of Dennis Matson, which has held so far four IRAS Asteroid Workshops (May, 1983; Nov. 1983; May 1984; Feb. 1985) chaired by Tom McCord of the University of Hawaii, and with Ed Tedesco of JPL being the secretary and report editor (1984). Thirty to forty scientists, including the author, from NASA, JPL and a variety of other institutions have been participating in these workshops which are preparing a detailed listing of Solar System objects observed with the IRAS, after passing the original list through a variety of filters to separate the Solar System objects from galactic and extragalactic sources. The final product is expected to be ready by the end of 1985.

My personal objective is to search through this final list, which is expected to contain more than 10,000 objects, for objects with an unusual infrared spectrum, one, e.g., that would indicate a temperature considerably higher than what is justified by the distance of the object from the Sun. It is possible that I might also have to search in some of the earlier and larger data banks for objects that were not included in the final catalogue because of a serious anomaly in their infrared spectrum. It is going to be a complicated, but exciting hunt, which I hope to start early in 1986, i.e., as soon as the final catalogue becomes available.

5. CONCLUSIONS

The wealth of infrared data obtained by the IRAS, and the labor provided by the IRAS Asteroid Workshops and the JPL Asteroid Advisory Group to separate the Solar System objects from the much larger number of galactic and extragalactic infrared sources, offer a unique opportunity for a comprehensive search for large space colonies and materials processing plants in our Solar System predicted by one of the possible explanations (they have colonized our Solar System but have chosen not to reveal their presence to us) of the Fermi Paradox. This effort is in resonance with a more flexible search strategy which tries to provide experimental tests for different theoretical alternatives. If indeed the case is that our Solar System has already been colonized, we would look rather foolish to future generations searching for extraterrestrials in far away stars and galaxies when all we had to do was to look in our backyard. This project will address this possibility and will allow us to place some upper limits to this alternative theory.

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