Search for Extraterrestrial Intelligence

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We, the human beings believe that we are civilised and intelligent although some of our actions make one doubt if this is really true. We wonder, whether intelligent or not, as living beings we are alone in the whole universe. Traditional astronomy looks at only inanimate objects. In recent times astronomers are beginning to talk about a subject called "Exobiology', which deals with life outside our Earth. It is an interdisciplinary subject with inputs from various branches of science. The subject of Search for Extra-Terrestrial Intelligence (SETI) is also only 2o to 25 years old. Biologists are now trying to understand what is the basis of a living system and how living and nonliving objects differ. Life on Earth is known to be based on the complex and giant molecule called the DNA molecule, which has the structure of a double helix or a spiral staircase. It is still not known how exactly life originated from these giant molecules.

Inanimate objects proceed always from order to disorder. Those who are familiar with the laws of thermodynamics know it. If you drop a china plate on the ground it will break into pieces. But you cannot have a situation in which the pieces come together and join themselves to form a plate. The situation is just the other way round in living systems, which are very orderly, but which presumably grew out of disorder.

It has been known for a long time that the vibrations of atoms in molecules produce radiowaves of wavelengths of the order of a millimetre or so. The frequencies of these waves are well-defined for a particular molecule. We can therefore identify the molecule from the radiowaves it emits just as policemen identify criminals from their fingerprints. Radiotelescopes on the ground began searches for molecules in space since the early 1960's. Gradually bigger and bigger molecules were discovered in interstellar space. Organic molecules like formaldehyde, methanol, dimethyl ether, aminoacids and some building blocks of the DNA molecules were discovered. Is was clear that these constituents somehow came together to form life. Exobiology wants to know the conditions under which the molecules combine.

Frank Drake wrote the following simple equation to answer the question: "How many advanced civilizations are there in our Galaxy ?"

Lecture delivered under the auspices of the Sky-watchers' Association of Bardhaman on 24th May, 1990.

$$N = Rf_s f_p n_e f_l f_i f_c L$$

where N is the total number of advanced communicating civilizations in our galaxy, R is the average rate of star formation in our galaxy i. e. the number of new stars formed per year, f_s is the fraction of those stars that are "good suns" i. e. those that are neither too big nor too small and are bright enough for a sufficiently long time to supply the energy necessary for sustaining life, f_p is the fraction of these good stars that have planetary systems. Life cannot originate on a star as it is too hot. We need planets for the formation of life. n_e is the fraction of the planets which are ecologically suitable for the development of life. It should not be too near the star (like, Mercury) nor too far away (like pluto in our solar system). In our solar system Earth and Mars are the only two planets which are ecologically suitable. f_l is the fraction of such planets where life actually starts. f_i is again the fraction of them where intelligent beings develop. f_c is the fraction of such intelligent species who communicate using radio-waves. L is finally the lifetime of the communicative phase of these civilisations. Lifetime is an important issue, for they may develop destructive things like nuclear weapons and finally destroy themselves after a few centuries.

The values of all these factors are not definitely known. All these questions do not fall within the purview of astronomy. We must have inputs from many branches of science like biology, artificial intelligence, social sciences etc.

Let us first see how stars form. They condense from clouds of interstellar gas clouds and dust. Astronomers are familar with the cloud forming the Orion nebula, which is believed to be the site of star formation at present. Initially the stars are not hot enough to emit visible light but they radiate in the infraed region. The Infrared Astronomical Satellite (IRAS) has detected infrared radiation from "baby stars" in the Orion nebula which is the maternity home for stars. By "baby stars" I mean stars about 3 lakh years old. Although this may appear a long time to us, it is very short compared to timescales in astronomy. For example, our sun is 5 billion years old and has come of age. One star on the average is born every year in our Galaxy.

Now we ask the next questions as to how many stars have planets. Planets of other stars are not visible even with the largest optical telescope available on the Earth. However, IRAS has detected infrared radiation from the neighbourhood of some stars like Beta Pictoris probably emitted by the protoplanetary disc which will eventually break into planets.

I shall now tell you about an experiment performed by Urey and Miller in 1953. They

took a mixture of four gases—methane, ammonia, water vapour and nitrogen and liquid water in a flask. This was supposed to stimulate the conditions on the earth before life originated. By passing electric discharges inside the flask they were able to produce aminoacids which are the building blocks of proteins. However, we still do not know how these proteins formed living cells.

By and large the astronomers are optimistic and believe in the existence of life elsewhere in our Galaxy. Our Galaxy has 100 to 200 billion stars. If 10% of them are "good suns" and even if we allow for the rarity of planets suitable for life, we may infer that about a million advanced civilizations exist in our Galaxy. However, biologists are not so optimistic. They doubt if so many special condltions necessary for the correct combination of molecules to originate a living cell can be satisfied at more than one location in our Galaxy. If we assume that more advanced civilizations are present in our Galaxy, they must have tried to colonise other planets and a time of 100 million years is estimated to be required by them to colonise the whole Galaxy. Our Galaxy is estimated to be 10 billion years old, which allows them sufficient time for the purpose. Biologists then ask as to why we do not find them visiting us. One answer to their question is what is known as the "zoo hypothesis." When we go to a zoo, we do not shoot the lion in the cage. We have also prohibited the shooting of lions in a sanctuary like the Gir forest. Just as we do not disturb wild life in the sanctuaries, the extraterrestrials may have decided to treat the earth as one such sanctuary, where they may be studying how intelligent life evolves in isolation. Thus they may be observing us from a distance bnt are not disturbing us. Whether one believes this or not depends on one's taste.

Let us now come to the other aspect of the problem. Since the extraterrestrials have not visited us, we should think of ways to contact them. The only place outside our Earth that man has so far visited is the Moon. The mission Apollo 11 went to the Moon in 1969 and our Earth was photographed from there. The whole journey to the Moon and back took about a week. But light takes only $1\frac{1}{4}$ seconds to go to the Moon (one way). Let us now look at it in the cosmic context. The nearest star Proxima Centauri is $4\frac{1}{4}$ light years away. If the ratio of our travel time to that of light be the same in this case, then we arrive at an incredibly long time for a returntrip to this star. No human being can undertake such a long journey. These estimates are however based on the technology about 20 years old. As association of scientists, engineers and technicians, called the British Interplanetary Society made a project estimate about the maximum velocity of space

travel that can be attained in the foreseeable future using nuclear fuel. They came to the conclusion that the maximum possible velocity is $\frac{1}{8}$ times the velocity of light, which is much faster than Apollo 11. If we consider Barnard's star which is 6 light years away then 96 years or roughly a century will be necessary for the total journey. The only way out is to send astronauts who will reproduce themselves in space so that children or grand children of the astronauts going out will come back ! The reason why we chose Barnard's star is that we have some indications that it has a planetary system. If we estimate the total nuclear fuel necessrry for making the journey, then we find all the fuel available in the whole Earth will be used up. The fuel makes the rockets very heavy. About 50 tons of fuel will be necessary for a payload of only 3 tons. The whole project is impracticable under the present circumstances. Thus it seems impossible for human beings to go to the planet of a neighbouring star in the foreseeable future. Can unmanned spacecrafts do the exploration ?

A search was made for microorganisms on Mars by the Viking spacecrafts which landed instruments that automatically scooped out Martian soil and tested it for the presence of microorganisms. The results were negative. Later, however, the same experiment was repeated in the Antarctica where the soil is known to contain microorganisms. The results were again negative, implying that we cannot draw any definite conclusions about the existence of life on Mars. Voyager 2 has photographed four outer planets, Jupiter, Saturn, Uranus and Neptune where the environments are far less friendly than on Mars. The Red Spot on Jupiter is a huge anticyclone, not at all friendly from any consideration. Voyager 2 could not go too near the planets for fear of being trapped in their gravitational fields. Then it would need a rocket booster to come out, which was not available. Future spacecrafts may go nearer these planets and try to find evidence of life. Even if they find life there, it would definitely be of a primitive kind. For, we expect advanced life to establish its communications technology.

Let us then send information about our whereabouts to the distant civilizations and wait for them to visit us. So a plaque was placed on the Pioneer 10 spacecraft launched in 1972 containing information including picture of a man and a woman. Their average heights were expressed in the binary system used by computers. Since the units metre, centimetre etc. are not known to them, the heights were expressed in terms of the wavelength of 21 cm radiowaves emitted by hydrogen. Because hydrogen is the most abundant element in the universe, we assume that the extraterrestrials are familiar with its characteristic

wavelength. Further, the earth has been drawn as the third planet of the sun and its direction has been indicated relative to the directions of some pulsars the ratios of whose frequencies remain the same for all observers. No language on the earth could be used as the extraterrestrials are definitely not familiar with any of our languages. We hope that if they know good astronomy and are very advanced technologically, they will be able to find out our tiny planet after deciphering the coded message sent to them. This spacecraft has now left the solar system. More recently Voyger 2 is carrying a large number of pictures of various places and records of various sounds of Earth on its way out of the solar system.

Finally, we come to waht is perhaps the most practical way of communicating with aliens. If two extraterrestrials are communicating with each other using radiowaves then, we may eavesdrop on them in the same way as illegal wiretapping is done by people on Earth. We may pick up random radiosignals and analyse them to find out if some sense can be made out of them. This may be done at the wavelength of 21 cms. The 1000 ft radio dish at Arecibo has been used for the last twenty years for sending coded messages towards possible extraterrestrials. Nowadays we have million channel analysers which can listen at a million different wavelengths at one go. No intelligible message has been received so far. A suggestion had been made to build an array of a taousand 100 metre dishes, which when pointed in the same direction would be able to receive very weak but detectable signals from civilizations around nearby stars. The project was nicknamed Cyclops but was not funded by the authorities because of its enormous cost. Bigger antennae may be used for this purpose in future. This is the quickest and most practical way in which we may communicate with extraterrestrial civilizations, if they exist.

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