

(Continued from Oct-Nov issue)

The Songs of the Distant Earths

"...her knees drawn up to her chin, thought about the inside of the radio. Are all those tubes really necessary? What would happen if you removed them one at a time? Her father had once called them vacuum tubes. What was happening inside a vacuum tube? Was there really no air in there? How did the music of the orchestras and the voices of the announcers get in the radio? They liked to say, "On the air". Was radio carried by the air? What happens inside the radio set when you change stations? What was 'frequency'...." -Ellie's thoughts in Carl Sagan's science fiction 'Contact'.

The possibility of the existence of advanced living creatures in the other planets of our own solar system has now been almost ruled out. Of the eight other planets in our solar system, life can theoretically exist only on Mars and Venus, but even if they exist, they must be too primitive to communicate with us! These might be microscopic organisms, which would of course be of immense interest to the scientific community. On the contrary, there are many scientists who believe that advanced civilizations must exist elsewhere in the universe if not in our solar system. They have been employing radio telescopes for the purpose of searching or listening to radio transmissions sent to us from outer space by those hypothetical advanced civilisations. But where do they search for these hypothetical advanced civilizations in this vast incomprehensible universe with billions of galaxies? Would it prove to be fruitful to search for them randomly in all the different star systems?

Planets around other stars have never been observed directly with telescopes because of the great brightness difference between the star and planet. Indirect evidence for the existence of other planetary system has however been obtained. After the discovery of planets orbiting far away stars like the 47 Ursae Majoris, 70 Virginias, and PST B1257+12 systems with the advent of new radio astronomy technology, the belief about the possibility of the existence of civilizations of extra-terrestrial intelligence took a firm root. In 1998, Geoffrey Marcy of San Francisco State University, announced the existence of a planet around the star Gliese 876, which is only 15 light years distant from Earth.

It has been observed that things necessary to support life are uniform throughout the universe. According to the science on Earth, certain substances are needed to support life. Water is one of those key substances. Also needed for life to develop are the materials like methane, hydrogen, carbon monoxide and ammonia, which are abundant throughout the universe. For these materials to turn just from a small group of organic elements to life, an energy source is required. This energy source can be anything from lightning, to volcanic eruptions to even solar radiation from their own sun. It is believed that chemical evolution leading to life on Earth began in such an environment some 4.5 billion years ago as a result of amino acids synthesis from these chemicals. The amino acids mix with each other and form the nucleic acids DNA and RNA, and protein. These materials combine and form life. This combination creates single-celled organisms that reproduce. Eventually during the process it mutates. Good mutations create new species which reproduce it's more advanced self. The basic mechanism underlying biological evolution is mutation, the modification of the structure of the genetic material, and retention in the gene pool of favourable traits.

In a deliberate experimental simulation of the hypothetical primitive Earth conditions carried out in 1953 by a U.S. graduate student, S.L. Miller, under the guidance of the eminent chemist H.C. Urey, methane and ammonia

were continuously circulated between a simulated lower "ocean", which was heated, and an simulated upper atmosphere", through which an electric discharge was transmitted. At the end of 24 hours, 95 percent of the methane was converted to amino acids, the building blocks of proteins, and other organic molecules.

Scientists, however, differ in their opinion on the primitive earth atmosphere. According to the theory of Miller and Urey, the make up of primitive Earth atmosphere came from the interstellar gas clouds (which is known as a 'reducing atmosphere', where, when chemicals combine, hydrogen is added, rather than oxygen). But Harrison Brown (1952) of University of Chicago was against this theory, because of the fact that the rare gases like neon, argon, krypton and xenon are a million times more common in interstellar gas clouds than they are in the Earth's atmosphere and the Earth's atmosphere has no resemblance to this. A reason to believe that any gases from interstellar gas-clouds would have been lost into the space very early in the Earth's history, and the primitive Earth atmosphere was formed mainly by volcanic out-gassing. But the Earth's atmosphere has an abundance of oxygen (20%) which were probably not released into the Earth's atmosphere from the volcanic eruptions. Volcanic eruptions at present release water vapour, carbon dioxide, nitrogen and small amounts of hydrogen. They believe that the ancient volcanoes were no different from the volcanoes of the present day. Where from such a vast amount of oxygen came to the Earth's atmosphere? Another theory says that some of the water vapours broke down to hydrogen and oxygen catalysed by the ultraviolet radiation from the Sun. Hydrogen being very light would have escaped into space, leaving the oxygen behind. Though they are not sure on the amount of oxygen present in the primitive Earth atmosphere, they found that there is little evidence for primitive methane-ammonia Earth atmosphere on Earth. At present all the scientists agree that most of the oxygens in Earth atmosphere has come from photosynthesis by plants-but not all of them. In 1996, biologist Kenneth Towe (of the Smithsonian Institution) reviewed all the available evidence and he also concluded that the early Earth very likely had an atmosphere that contained free oxygen.

Now, a team of scientists including SETI Institute and NASA researchers announced on March 26, 2002 that they were successful in creating amino acids, chemicals essential to life, in a laboratory simulation of conditions found in deep space. At NASA's Ames Research Center, Moffett Field, CA, the team reproduced the freezing conditions that exist in the gigantic interstellar clouds of dust, gas, and ice that are the birthplaces of new stars and planetary systems. NASA scientists simulated space-like

conditions in the laboratory by freezing mixtures of common molecules found in interstellar clouds and then exposing them to ultraviolet radiation resulting in the formation of glycine, alanine, and serine, amino acids that play central roles in all living organisms on Earth. According to Dr. George Cooper of Ames, a variety of amino acids were previously detected in certain primitive meteorites, which proves that amino acids are in fact made in space. However, a general belief about their formation in the solar system was that within asteroids, which are the sources of most of the meteorites. According to Dr. Scott Sandford of Ames, at least some of the amino acids found in meteorites may predate our solar system. The findings that certain meteorites contained amino acids and the fact that amino acids can be made in interstellar clouds suggests that the Earth may have been seeded with amino acids from space

reported listening to strange Morse Code like signals. This was done to enable various wireless monitoring stations to pinpoint the strange radio signals. The result remained inconclusive owing to the very broad spark signals emitted by European radio transmitters who were not signatories to the American silence period.

The human search for extra-terrestrial radio message in the appropriate (presumably) frequencies began only a few decades ago (not even a century!). In fact the scientific advancement of the human race is also a recent phenomenon, compared to the millions of years of our torturous evolution (our planet is about four and a half billion years old)! Radio astronomers have been listening for radio signals of extra-terrestrial origin only for the last 43 years using the largest and most sophisticated modern radio telescopes. They listen to certain selected ranges of radio frequencies, which might be used by extra-terrestrial civilizations. For example, Giuseppe Cocconi and Philip Morrison (Massachusetts Institute of Technology) believed that any extra-terrestrial civilization, who might have reached our level of technological development, would recognize hydrogen as a kind of cosmic common denominator and use its frequency for interstellar communication. As mentioned earlier, the vast clouds of hydrogen in the inter stellar space also emits radio frequencies of 21 cm wavelength (i.e. 1420 MHz or 1.4 GHz) contributing to considerable amount of natural radio noise hampering the reception of any possible artificially generated radio signals sent to us by extra-terrestrial civilization; to receive weakest of these radio signals, we also need to develop more sensitive radio receivers and ingenious computerized data-processing systems (Carl Sagan, 1979). Dixon and Cole (1977), at Ohio State University Radio Observatory, were making an all-sky survey near 1.4 GHz hydrogen line.

Now it is hypothesized that the extra-terrestrial broadcaster would be transmitting a little away from the hydrogen line, say, a wide bandwidth of several hundred Mega hertz near 1.5 GHz. The frequency range from 1420 MHz (frequency of hydrogen) to 1660 MHz (frequency of Hydroxyl) is called the "water hole", because, hydrogen and hydroxyl are the disassociation products

Star Spectrum Character by Class	
Spectral Class*	Spectral characteristics
O	Very hot stars with He absorption
B	He I absorption; H developing later
A	Very strong H, decreasing later; Ca II increasing
F	Ca II stronger; H weaker; metals developing
G	Ca II strong; Fe and other metals shown; H weak
K	Strong metal lines; CH and CN bands developing
M	Very red, TiO bands developing

* Sequence of letters remembered by generations of beginning astronomy students by mnemonic: "Oh, Be A Fine Girl, Kiss Me!"

in its earliest days."The infall of these materials on the early Earth may have facilitated the origin of life on our planet," said Dr. Jason Dworkin of the SETI Institute and Ames. "Furthermore, since new stars and planets are formed within the same clouds in which new amino acids are being created, this probably increases the odds that life has evolved elsewhere."

Over 3 billion years, the primitive organisms on Earth slowly evolved into a vast array of living systems we see today. Man appeared very late in this sequence of events. Scientists have now almost been coming to the conclusion that life develops the same way everywhere in the universe. Dr. Frank Drake puts it like, "We've witnessed a shift in our perceptions about the prevalence of biology. I am sure that life is not a rare occurrence at all, but is as natural throughout the universe as the formation of planets and stars. The chances that some of this life has evolved to the point of intelligence are perhaps greater than previously thought."

Can we detect them with our existing technology? As described earlier, radio is the best medium for this kind exploration. But would it make any sense to listen to all the radio frequencies starting from, say a few kilohertz to thousands of Megahertz? The first search for artificial radio signals of extraterrestrial origin is said to have began in the US, when, on August 21, 1924, all commercial radio stations, including the high power Navy radio transmitters, were silent for a period of five minutes each hour for eight hours, after Guglielmo Marconi



The Arecibo Radio/Radar Telescope in Puerto Rico (Caribbean Sea)

of water. It was a rather poetic term coined by Bernard M. Oliver of NASA who headed SETI (Search for Extraterrestrial Intelligence) during 1971s. According to Oliver, it is the "water hole", where species have always gathered and we need to seek out "our kind" near this "water hole"! The "water hole" has a band-width of 240 MHz meaning 24 million channels when scanned in 10 Hz steps! To cope with this problem, the Digital Signal Processing (DSP) system has been emerging with the capability of

recognizing very weak coherent signals. Sweeping the enormous band-width of radio spectrum, even with much smaller precision, say, in steps of extremely narrow band-width of 0.1 Hz, would pay much better result to the investigator. Unfortunately, the cost factor involved in the manufacture of such radio receivers is putting a restriction on their wide scale use among the amateur radio astronomers. Scientists have also been listening to a narrow band of frequencies centred at the 4830 MHz (4.8 GHz) formaldehyde line.

The radio message of extra-terrestrial origin may necessarily be a beacon. A beacon is a radio signal, usually in coded form transmitted from a particular radio station to identify itself. The most primitive of the beacons may sound like Morse Code (combination of short and long tones or 'dot' and 'dashes'). According to Carl Sagan (1979), "it is easy to create an interstellar radio message that can be recognized as emanating unambiguously from intelligent beings. A modulated signal ("beep," "beep-beep,"...) comprising the numbers 1, 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, for example consists exclusively of the first 12 prime numbers-that is, numbers that can be divided only by 1, or by themselves. A signal of this kind, based on a simple mathematical concept, could only have a biological origin....The beacon signal might also note a particular frequency where the main message is to be found."

The first serious attempt to listen to possible radio signals from other civilizations was the setting up of National Radio Astronomy Observatory in Greenbank, West Virginia, in 1959 by Dr. Frank Drake. This project was called Project Ozma (after the princess of L. Frank Baum's Land of Oz, a place exotic, distant and difficult to reach), which was established at a cost of 2000 US dollar only. Dr. Frank Drake (1960) estimated 10,000 advanced civilizations in the Milky Way galaxy. Milky Way galaxy is however, only one of a 100 billion galaxies in the universe! As per Carl Sagan (1979) the total number of individual stars in the Milky Way galaxy, which have been examined for artificial radio signal, was only 1,000. This, he said, was just one-tenth of one per cent of the required effort. Carl Sagan had predicted an astounding one million technical civilizations in our own Milky Way galaxy out of a total of about 2,50,000 million stars in it. This makes each star we survey in the Milky Way galaxy a 20 million-to-one long shot! It has been estimated that with a million technical civilizations in the Milky Way galaxy, the average separation between civilizations would be about 300 light-years. Thus a two-way communication to establish, it would require at least 600 years. Thus, even to receive a radio transmission of extraterrestrial origin, 43 years is too small a time!

The vast incomprehensible distance between our solar system and the other stars has been putting a direct restriction to our effort. The astronomical distances are measured in light years. A light-year is the distance which light travels (at the speed of 3,00,000 km per second) in one year, i.e. approx. 9,461,000,000,00 km.

The acronym SETI (Search for Extraterrestrial Intelligence) was coined by Dr. Frank Drake in 1960s to describe the use of radio telescopes to seek out electromagnetic signals of possible extraterrestrial intelligent origin. One of the requirements of SETI was to target Sun like stars, i.e. stars having surface temperatures of 4500 to 6500 K and luminosity of 0.3 to 3 of the Sun. These stars belong to the classes F, G and K (please see *table* at page no. 7).

It might have been considered that the stars nearest to us if given birth to earth like planets in their solar system, their evolutionary period would have been almost compatible to that of ours! The nearest stars to us are the Alpha Centauri and Proxima Centauri whose light takes 4 and a half years to reach the earth. The same applies to radio signals, which also travel at the speed of light. Tau Ceti and Epsilon Erdani are two other constellations located 11 light years away from us. A possible two-way radio communication to take place, it would need 22 years! But if the civilizations in these nearest star systems have not yet reached our level of technical development, it would be useless to concentrate on them. A civilization thousand of years behind us would mean that they had just come out of bow and arrow stage!

A few scientists in fact have tried to attract the attention of any possible extraterrestrial broadcasters. In November 1974, the first "aimed" radio signal, a complex radio message was transmitted from the Arecibo Radio/Radar Telescope in Puerto Rico, with its antenna 1000 feet in diameter (the largest radio telescope ever built on the Earth); 500 feet deep; and a 500-ton feedhorn that is 200 feet long. The 2380 MHz radio signal of 500 kW power was beamed towards a collection of stars called M13, a globular cluster comprising about a million separate suns. It would take 24,000 years for the radio signal to reach M13 and if any one is listening, we have to wait for 48,000 years for their answer! Though it was not a serious attempt, the experiment was carried out by Cornell University for National Science Foundation to demonstrate the human advancement in terrestrial radio technology. Since then, scientists have been working on improving this huge radio telescope. According to Arecibo transmitter engineer Bob Zimmerman, "the earlier 0.5 MW output power klystron transmitter has been completely removed, dismantled, and used in the construction of our new 1.0 MW output power transmitter, which is now at Continental Electronics in Dallas." The University of Washington scientists calculate that a strong 5 megawatt (5 million watts) Ultra High Frequency (UHF: the frequency range from 300 MHz to 3000 MHz or 3 GHz) television station could be detected by a radio receiver of the Cyclops type (An antenna system, which would consist of a thousand array of 100-metre antenna dishes proposed to be built under project Cyclops in the US covering an area of 10 km in diameter on the darker side of the moon) up to 25 light-years away.

According to Carl Sagan (1979), "It might seem remarkably selfless for a civilization to broadcast radio messages with no hope of knowing, at least in the immediate future, whether they have been received and what the response to them might be...A civilization which had been aided by the receipt of such a message in its past might wish to benefit other emerging technical societies.... And such radio transmission services could be an activity either of an entire planetary government or relatively small groups of hobbyists, *amateur radio operators* and the like."

Large dish antennas (like the Arecibo type) provide quite narrow beamwidth for sky survey with greater sensitivity and suitable for targeted search, whereas smaller dishes, though have lesser sensitivity, can be suitably employed to sweep the entire sky as seen from a given location. They can be fitted on a virtual transit mount aiming due south, letting the Earth turn them, and varying only their elevation. The SETI League Executive Director H. Paul Shuch, who is an amateur radio operator (Call-sign: N6TX), in 1995, appealed to the international amateur radio operator community to volunteer for such an all-sky-survey programme. Dr. Shuch had estimated that if a single amateur radio operator gears himself with a TVRO (Television Receive-Only) type dish

antenna of 3 degree beamwidth fitted on a transit mount, letting the Earth be his antenna rotator, the dish would be rotating at 15 degree per hour, allowing any star to be within its beamwidth for about 12 minutes, it would take him 46 years (16,667 days) to survey the water hole frequencies of 240 MHz wide, and that too only 3 degree swath of the sky at a single elevation. To cover the range of declinations covering southern to northern horizon, he would need to conduct 60 such surveys, which brings the time required to about 2760 years! And that only covers the one hemisphere of sky he can see from his part of the world. Dr. Shuch had estimated an astounding 6000 years for a single amateur radio operator to complete such a survey covering both the hemispheres! On the other hand, if 5520 amateur radio experimenters located at different parts of the world can coordinate in such an effort, they can complete the enormous sky survey in just one year!

In fact the US Congress, in 1993, stopped funding the SETI because of the enormous amount of money (10 billion dollar) to be involved in implementing a search facility of Cyclops type. As a result of which the responsibility of "full sky survey" is being gradually shifted to the non-profit, membership supported SETI League, which is now involved in privatising the effort. Some amateur groups are promoting SETI by non-professionals, justifying the viability of such an enterprise by citing the astounding communications range of Earth's largest radiotelescopes. According to SETI League Executive Director Dr. H. Paul Shuch, if such "big guns" like the Arecibo radio telescope exist at the other end of the communications path, even small amateur radio stations have a reasonable probability of success in detecting their signals. As Dr. Shuch puts it-" It has been said that if we integrate long enough, we can detect a flashlight across the universe. Trans-Galactic communications between two Arecibos is almost within our grasp. Given, for example, Drake's assumed 500 kW CW transmitter at 2380 MHz, his 10 milliHertz receiver bandwidth, and integrating for an hour, our signals will reach easily to the center of the Milky Way. Detection may be possible, but this should not be confused with communication, since our data rate would be limited to something like 278 microBaud. This is tens of millions of times slower than even the most sluggish PC modem. And since we presume the distant station is also situated on a rotating planet, we are faced with the challenge of making two antennas track each other for hours on end. Though the system works on paper, such communication requires great coordination, which is not likely to be present for SETI."

For now, a two-way radio communication with any possible intelligent civilization of extraterrestrial origin remains a distant dream. But would it be justifiable to stop our search for radio messages of the extraterrestrial intelligent origin? This would amount to stop looking at the sky at all! In fact when we look into the sky, we look into the past. The light reaching us, from, a star located thousands of light years away is in fact the light from the past. That star might have exploded and become a supernova during the time the light took to reach us. Similarly, any radio message of extraterrestrial intelligent origin, which we may intercept, may be a message from a civilization, which did not any longer exist! So what? The mankind had explored and learnt so many things only by studying their past! As Carl Sagan pointed, "The search for extraterrestrial intelligence (SETI) is the search for a generally acceptable cosmic context for the human species. In the deepest sense the search for extraterrestrial intelligence is a search for ourselves." According to Sagan, even if we fail in our search, we will not have wasted our time. We will have developed

an important technology, with applications to many other aspects of our own civilization. And this enormous noble task should, obviously, be carried on by all our generations to come till our Sun turns into a supernova or we decimate ourselves prematurely with an atomic holocaust!

□ Sandeep Baruah, VU2MUE

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queries of the participants in Hindi. In the interactive session, that followed the demonstration, many written queries from the audience were replied.

A lecture cum demonstration programme on ham radio was organized on November 21, 2003 at Vishwa Bharati Public School, Noida. 70 students participated in the programme. A demonstration on *computer-to-computer digital communication* was given to the children using two computers (interfacing one computer to a transceiver and using a communication receiver at the other computer) kept at two different places in the school. Two hams (Shri Sunil U.K., VU2UKR and Shri Gaurav Sharma, VU2GTI) located at Noida also personally came to the school and participated in the interactive session answering to the questions of the children. VHF and HF communication were demonstrated to the children by contacting VU2NCT, which was operated by Shri Kapil Tripathi, VU3POF.



SSTV demonstration at Sardar Patel Vidyalaya, New Delhi

A lecture cum demonstration programme was organized at Sardar Patel Vidyalaya, Lodhi Estate on December 16 (from 08:30 AM 12:30 PM), on the occasion of the school's annual activity week. The programme was attended by the students of *class VII and VIII*. Mrs. Kusum Warikoo, *Principal*, Sardar Patel Vidyalaya, was also present in the programme. She got enthused to see the SSTV picture transmission technique using walkie-talkie and computers. This programme was initiated by Shri Sunil U.K. (VU2UKR) and Shri C.K. Raman, (VU3DJQ). Three VHF stations (VU2MUE, VU2UKR and VU3DJQ) equipped with Notebook computers were installed at different locations of the lecture hall and demonstrations of some of the new digital modes of communications were given. Students got thrilled to see the transmission of images using radio waves, when crisp clear pictures were received using the VHF walkie-talkie sets.