

~~FOR OFFICIAL USE ONLY~~

Lambros D. Callimahos

Communication with Extraterrestrial Intelligence

We are not alone in the universe. A few years ago, this notion seemed farfetched; today, the existence of extraterrestrial intelligence is taken for granted by most scientists. Even the staid National Academy of Sciences has gone on record that contact with other civilizations "is no longer something beyond our dreams but a natural event in the history of mankind that will perhaps occur in the lifetime of many of us." Sir Bernard Lovell, one of the world's leading radio astronomers, has calculated that, even allowing for a margin of error of 5000%, there must be in our galaxy about 100 million stars which have planets of the right chemistry, dimensions, and temperature to support organic evolution. If we consider that our own galaxy, the Milky Way, is but one of at least a billion other galaxies similar to ours in the observable universe, the number of stars that could support some form of life is, to reach for a word, astronomical. As to advanced forms of life—advanced by our own miserable earth standards—Dr. Frank D. Drake of the National Radio Astronomy Observatory at Green Bank, West Virginia, has stated that, putting all our knowledge together, the number of civilizations which could have arisen by now is about one billion. The next question is, "Where *is* everybody?"

The nearest neighbor to our solar system is Alpha Centauri, only 4.3 light years away; but, according to Dr. Su-Shu Huang of the National Aeronautics and Space Administration, its planetary system is probably too young for the emergence of life. Two other heavenly friends, Epsilon Eridani and Tau Ceti, about 11 light years away, are stronger contenders for harboring life. Nevertheless, if superior civilizations are abundant, the

nearest would probably be at least 100 light years away; therefore it would take 200 years for a reply to be forthcoming, a small matter of seven generations. This should, however, make little difference to us, in view of the enormous potential gain from our contact with a superior civilization. Unless we are terribly conceited (a very unscientific demeanor), we must assume that the "others" are far more advanced than we are. Even a 50-year gap would be tremendous; a 500-year gap staggers the imagination, and as for a 5000-year gap. . . (By the way, if they are as much as 50 years *behind* us, forget it!) It is quite possible that "others" have satellite probes in space, retransmitting to "them" anything that sounds nonrandom to the probe. But they have probably called us several thousand years ago, and are waiting for an answer; or worse yet, they have given up; or, more probably, they have reached such impressive technological advances that they have destroyed themselves. In this connection, Professor Iosif Shklovsky, Russia's greatest radio astronomer, has cited the profound crises which lie in wait for a developing civilization, any one of which may well prove fatal:

(1) Self-destruction as a result of a thermonuclear catastrophe or some other discovery which may have unpredictable and uncontrollable consequences;

(2) Genetic danger;

(3) Overproduction of information;

(4) Restricted capacity of the individual's brain, which can lead to excessive specialization, with consequent dangers of degeneration; and

(5) A crisis precipitated by the creation of artificial intelligent beings.

Epsilon Eridani and Tau Ceti were the targets on which Dr. Drake focussed his attention in the spring of

This article was given as a lecture at the Cosmos Club in Washington earlier this year.

detect); if so, "they" may have to wait a century or two before we learn how to build a neutrino receiver.

The growing presumption that life exists in other worlds led, in 1971, to a six-nation multidisciplinary conference held in Soviet Armenia on Communication with Extraterrestrial Intelligence. The U.S. delegation of about two dozen scientists was headed by Dr. Carl Sagan of the Center for Radiophysics and Space Research at Cornell University. The report of this conference, published in 1973 by MIT, deals with such subjects as the evolution of intelligence, the lifetimes of technical civilizations, and the number of advanced galactic civilizations. Last November a group of scientists at Arecibo Observatory in Puerto Rico sent a three-minute message beamed at Messier 13, and this represented man's first attempt to take the initiative in communicating with another civilization. The project was conducted by the National Astronomy and Ionosphere Center, which operates the Arecibo Observatory for

[illegible]

~~FOR OFFICIAL USE ONLY~~ 5

~~FOR OFFICIAL USE ONLY~~

Cornell University and the National Science Foundation. Messier 13 is a cluster of 300,000 stars on the edge of the Milky Way, 24,000 light years away, so if the message is received and answered promptly, unless we happen to hit them on one of their three-day holidays we should have their answer in 48,000 years, give or take a day or two. Actually, the main purpose of the experiment was to dramatize the capabilities of the world's largest antenna at the Arecibo Observatory.

If another civilization were trying to establish communication with us, it would first embark on attention-getting signals of such a nature that we could distinguish them from random cosmic noise; once we receive a recognizable signal, we have a good chance of understanding the message. For example, they could start with trains of signals corresponding to the natural number 1, 2, 3, . . ., followed perhaps by prime numbers. They might continue with equal-length extended signals consisting of start and stop impulses, with occasional pulses in between; when these signals are aligned flush over one another, they would show a circle, the

Pythagorean Theorem, or similar geometric design. These attention-getting signals would be followed by what amounts to early "language lessons," interspersed with items of technical information to help bring us up to the level of our superiors, "them."

It may be assumed that the sense of sight, or an equivalent, is possessed by all higher forms of life; the problems of communication could thus be greatly simplified through the medium of a "raster" representation such as that of a television screen. After a conference held at Green Bank in 1961 to discuss the possibility of communication with other planets, one of the participants, Bernard M. Oliver, made up a hypothetical message on the raster principle. The message, consisting of 1271 binary digits or "bits," is shown in Figure 1. Since 1271 has but two prime factors, 31 and 41, we would naturally be lead to write out the message in raster form, in 41 lines of 31 bits each, or in 31 lines of 41 bits each; the latter case reveals a greater nonrandomness in the patterns disclosed, indicating that these are the correct dimensions. In Figure 2 is shown the

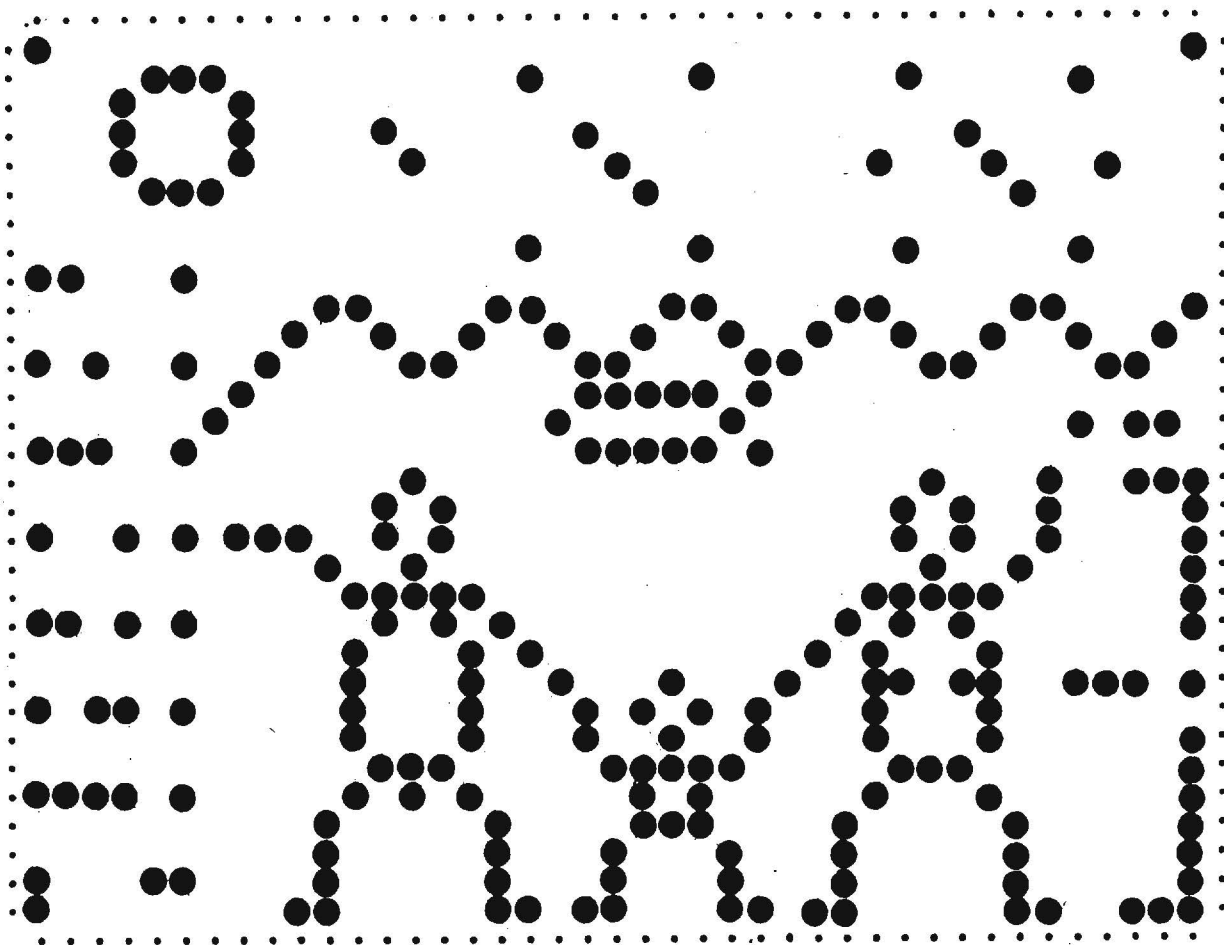


Figure 2

write-out of the message, in which the binary 1's have been replaced by a dot and the 0's left as blank spaces. Now for its interpretation.

There are dots at the four corners of the pictogram as reference points, marking the outlines of the rectangle. At the upper left is a representation of the sun; directly underneath in a column are dots representing 8 planets, identified by the appropriate binary coding to their left, preceded by a binary point as a marker. The erect, two-legged beings illustrated are obviously bisexual and mammalian; one hand of the male figure points to the fourth planet where they apparently reside. At the top of the pictogram may be seen representations of hydrogen, carbon, and oxygen atoms, indicating that the chemical structure of life on their planet is similar to ours. From the third planet there emerges a wavy line, showing that it is covered with water; the fish shows that they must have visited us and therefore have space travel. One hand of the female figure points to a six (preceded by the usual binary point), perhaps implying that there are six fingers on each hand; we could therefore assume that their number system is probably to the base 12. At the right of the female figure may be seen a bracket, in the middle of which is eleven in binary form (preceded by a binary point): this implies that the beings are 11 units high. A reasonable interpretation is that the unit is 21 cm., the wave length of the transmission, making them about $7\frac{1}{2}$ feet tall, which should be all right for average Martians.

In 1952 the British scientist Lancelot Hogben delivered an address before the British Interplanetary Society entitled "Astraglossa, or First Steps in Celestial Syntax." Hogben pointed out that *number* is the most universal concept for establishing communication between intelligent beings, therefore mathematics forms the basis for the first steps in extraterrestrial communication; he then illustrated how he could transmit pulses representing integers, and distinctive signals or "radioglyphs" representing "+", "-", "=", and so on. Morrison later carried out the basic idea a little further, using different pulse shapes to represent elementary mathematical symbols. An entirely different approach was developed by Hans Freudenthal, Professor of Mathematics at the University of Utrecht, who in 1960 published a book entitled *Lincos: Design of a Language for Cosmic Intercourse*. "Lincos," an acronym of "lingua cosmica," tries to establish a communication of ideas through symbolic logic, but the general consensus of those who have taken the trouble to study his book is that his plan is too difficult. After all, the object of the exercise is getting ideas across to another party, whose thinking processes may be entirely different from our own. In other words, what we need to develop is an "inverse cryptography," or

communication symbolism specially designed, not to hide meaning, but to be as *easy* as possible to comprehend. Cleverness on the part of the *sender* is then the important factor, not reliance on ingenuity of the recipient. The inverse cryptographer—somehow, this term doesn't sound quite right—must make his meaning clear to the recipient, even if the latter does not possess a cosmic equivalent of the Rosetta Stone.

As an illustration of how much information could be conveyed with a minimum of material, and as an example of facile inverse cryptography, let us consider a message I have devised to be typical of what we might expect of an initial communication from outer space. In Figure 3 is shown a series of transmissions which could have come from another inhabited planet, many light years away. The 32 arbitrary symbols are representations for the 32 different signals (combinations of beeps, or distinctive pulse shapes) heard on a frequency of 1420.4 megacycles. The punctuation marks are not part of the message, but here represent different time lapses: adjacent symbols are sent with a short pause (1 unit) between them; a space between symbols means a longer pause (2 units); commas, semicolons, and periods indicate pauses of 4, 8, and 16 units, respectively. Between transmissions (numbered here for reference purposes) there is a time lapse of 32 units.

The first transmission, (1), is obviously an enumeration of the 32 different symbols which will be used in the communications; in transmission (2) is the clear implication that A represents the integer 1, B the integer 2, and so on to J being the integer 10. In transmission (3), the symbols K for a plus sign and L for "equals" are introduced; in (4), the symbol M stands for "minus"; in (5), the symbol N stands for the concept and sign for zero. In (6), the concept of decimal notation is introduced; in (7), the symbol O must stand for the multiplication sign; in (8), the symbol P must stand for the sign for division; in (9), the symbol Q must represent a sign for the reciprocal; and in (10), the symbol R must stand for a decimal point. In the next ten transmissions there are introduced the concepts and symbols for inequalities, approximations, nested parentheses and brackets, powers and roots, factorials, and infinite series defining pi and *e*. Transmission (21) adds nothing new to the 31 symbols recovered thus far, but it does quote one of the most beautiful concepts in pure mathematics, Euler's identity, $e^{i\pi} + 1 = 0$. With this they are telling us that, if they can teach us such a complex notion at this early stage, we will be staggered by what they will teach us by the 200th or 2000th transmission.

Beginning with transmission (22), words and word-cluster concepts are introduced, so that by the time we come to transmission (30) we are now understanding, in a

~~FOR OFFICIAL USE ONLY~~

- (1) A. B. C. D. E. F. G. H. I. J. K. L. M. N. O. P. Q. R. S. T. U.
V. W. X. Y. Z. *. &. \$. ¢. #. @. A. B. C. D. E. F. G. H.
I. J. K. L. M. N. O. P. Q. R. S. T. U. V. W. X. Y. Z. *. &. \$.
¢. #. @.
- (2) A A, B; A A A, C; A A A A, D; A A A A A, E; A A A A A A, F;
A A A A A A A, G; A A A A A A A A, H; A A A A A A A A A, I;
A A A A A A A A A A, J.
- (3) A K A L B; A K A K A L C; A K A K A K A L D. A K A L B;
B K A L C; C K A L D. B K C L E; E L B K C; F K D L J;
J L D K F. E L K E; K E L E.
- (4) C M A L B; D M A L C; G M E L B; E M G L M B.
- (5) D K N L D; G K N L G; F M F L N; E M E L N.
- (6) J L A N; J K A L A A; J K B L A B; A A K A L A B. J K J L B N;
J K J K J L C N; I N K C L I C.
- (7) B O C L F; D O B L H; E O B L A N; D O A N L D N.
- (8) F P C L B; H P B L D; J P B L E; J P E L B.
- (9) A P J L Q J; A P A N N L Q A N N; Q J, P J L Q A N N.
- (10) Q J L R A; Q J O B L R B; A R E M A L R E L E O Q J.
Q A N N L R N A; Q A N N O B L R N B.
- (11) H L H; G S C, C S G. D K A L C K B; D K C S E K A;
E K A S D K C.
- (12) D T A; D T B; D T C; D L D; D U E; D U F; D U G. J T I;
J U A A.
- (13) F I R I I V G N; A N N N K C V A N N N; A N P C V C R C.
- (14) W E K A X L E K A; B W E K A X L W B O E X K W B O A X L B O F.
- (15) C Y B L I; E Y B L B E; B Y E L C B; W D K A X Y B L B E.
- (16) B E Z B L E; F D Z B L H; B G Z C L C; A B E Z C L E.
W A I K F X Z B L E. B E Z B L M E; M A B E Z C L M E.
B E Z B L K M E.
- (17) D * L D O C O B O A L B D; E * L E O D O C O B O A L A B N;
H * L D N C B N.
- (18) & P D L A M Q C K Q E M Q G K Q I M. & V C R A D A E I.
- (19) \$ L A K Q W A * X K Q W B * X K Q W C * X K Q W D * X K.
\$ V B R G A H B H.
- (20) ¢ E K A # L W E K A X; B ¢ E K A # L B W E K A X;
B ¢ E K W D K C X # L B W E K G X.
¢ B # ¢ D # L W B X W D X L B O D.
- (21) \$ Y ¢ & O W M A X Z B # K A L N.

Possible Communications from Another Planet

Figure 3

~~FOR OFFICIAL USE ONLY~~

- (22) B K C L € @ NNA #; B K C L E. C O D L € @ NNA #; C O D L AB.
D Y B L € @ NNA #; D Y B L AF.
- (23) B K C L E; € @ NNB #. B K D L E; € @ NNC #. E Y B L BE;
€ @ NNB #. F Y B L C E; € @ NNC #. I T E; € @ NNB #. H U C;
€ @ NNC #. & V BRGAHBH; € @ NNC #.
- (24) B L € @ NND #. C L € @ NND #. E, G, AA, AC, AG, € @ NND #.
ANA € @ NND #.
- (25) € @ NNE # L B O & € @ A #; € @ NNF # L & € @ A # Y B.
€ @ A # L € @ NNG #. € @ NNE # L B & € @ NNG #;
€ @ NNF # L & € @ NNG # Y B.
- (26) € @ NNH # L D O Q C O & € @ NNG # Y C.
- (27) Q B K Q D K Q H K Q AF K Q CB V A;
Q B K Q D K Q H K Q AF K Q CB K € @ NNI # L A.
- (28) C K € @ A # L G; € @ A # L D. I K € @ A # L AB;
€ @ A # L C. FD Z € @ A # L H; € @ A # L B.
€ @ A # L A, R GG, M R GG, J P C, &, K, M, € @ NNI #.
€ @ B # L A, R GG, M R GG, J P C, &, K, M, € @ NNI #.
€ @ C # L A, R GG, M R GG, J P C, &, K, M, € @ NNI #.
- (29) € @ NNE # L B & € @ B #; € @ NNF # L & € @ B # Y B.
€ @ NAN # LB € @ C # K B € @ D #;
€ @ NAA # L € @ C # O € @ D #.
- (30) € @ NNE # L € @ NAB #, € @ NAC #; € @ NNF # L € @ NAD #,
€ @ NAC #. € @ NAN # L € @ NAB #, € @ NAE #;
€ @ NAA # L € @ NAD #, € @ NAE #.

Figure 3 (Continued)

manner of speaking, pure Venerean sentences. Furthermore, we can now see how we could recover the code they are using on us, and which will obviously consist of thousands upon thousands of code groups with different meaning; this is easily appreciated by anyone who takes the trouble to fathom the meaning of all 30 transmissions in the foregoing example.

Even right after this first series of transmissions, if we are in direct communication with that planet, we shall have questions to put to "them": the proof of Fermat's Last Theorem, Goldbach's conjecture, and many other unsolved problems in mathematics and the natural sciences. By the way, Goldbach's "notorious" conjecture is called by that adjective only because other mathematicians weren't imaginative enough to make the conjecture themselves; it states that every even number

greater than 2 can be expressed as the sum of two primes. It will not be difficult for "them" to demonstrate their intellectual and technological superiority (first of all, don't forget it was *they* who were able to call *us*!). If "they" but know the *seventh* digit of the "fine structure constant," they are ages ahead of us (we know only the first five for sure, suspect the sixth). This number, 137.039. . ., is the ratio, among others, of the speed of light to the speed of the hydrogen electron; it may take a century to calculate this constant to 9 digits. And after we resolve our pressing scientific questions, it might be appropriate to make discrete inquiries as to how we could live in harmony and peace with our fellow man—that is, if we aren't eaten or otherwise ingested by the superior civilization that had the good fortune to contact us. But as far as the cryptologist is concerned, he (and generations of

~~FOR OFFICIAL USE ONLY~~ 9

~~FOR OFFICIAL USE ONLY~~

his descendants who might experience the supreme thrill of their lives when we hear from "them") must keep a level head, not get excited, and be prepared to cope with problems the likes of which he has never seen—out of this world, so to speak.

Mr. Callimahos won world renown as a flute virtuoso before serving in the Army cryptologic unit in World War II. The author of many textbooks, monographs, studies and articles, including the ones on cryptology in the *World Book Encyclopedia*, *Collier's Encyclopedia*, and the *Encyclopaedia Britannica*, he has for twenty years taught NSA's senior course in cryptanalysis.