THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

To consider Earth the only populated world in infinite space is as absurd as to assert that in an entire field sown with millet, only one grain will grow.

—*Metrodorus of Chios, 4th century B.C.*

Is There Intelligent

by Guillermo A. Lemarchand

Making first contact is equivalent to finding a needle in a haystack 35 times the size of Earth. Actively sending announcements to introduce ourselves may be the best way

Life Out There?

The land lies sleeping under the enveloping mantle of night. Bright stars gleam like jewels from the velvet darkness. Beyond, in depths frightening in their sheer immensity, the Milky Way trails its tenuous gown of stardust across the heavens, and well beyond that billions of stars, galaxies and planets dance in a cosmic symphony.

From our earliest days, humans have strongly sensed that this endless majesty is too huge to be contemplated by a single intelligent species, and one thread that links the ancient Greek philosophers to modern space scientists is the desire to know whether other inhabited worlds exist. Vast and old beyond understanding, the universe forces us to ponder the ultimate significance of our tiny but exquisite life-bearing planet and to long for the knowledge that somewhere out there, someone like us is gazing toward the heavens and having similar thoughts.

We have the means to test the possibility that advanced extraterrestrial civilizations exist. This is the search for extraterrestrial intelligence, known as SETI.

The Chances of Intelligent Life

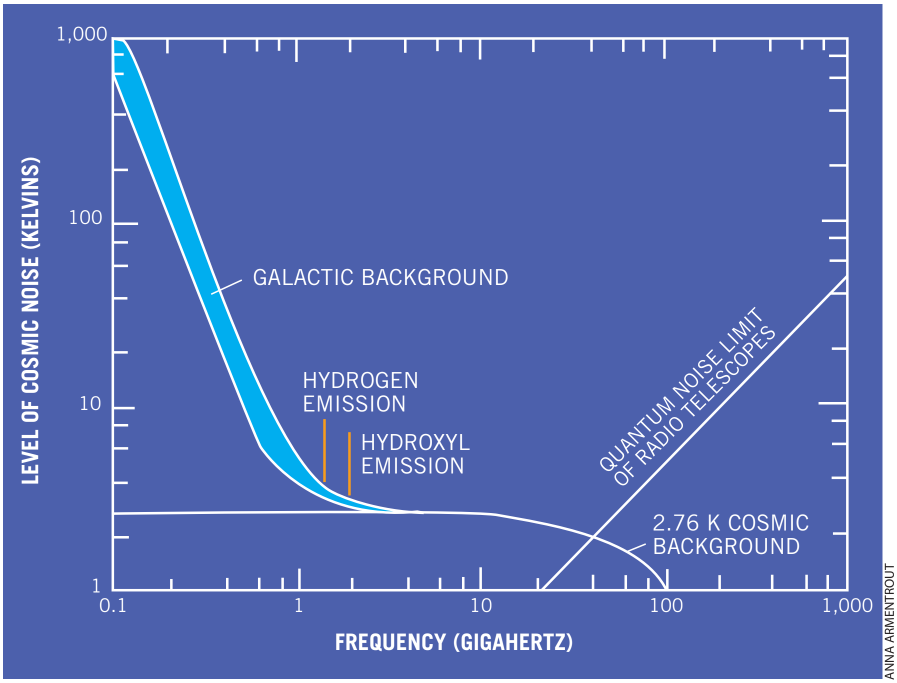
Despite its roots in some of our most profound questions, the goal of SETI is not to fulfill a spiritual longing. Instead it is a realistic, practical response to the statistical likelihood that the evolution of life is a natural occurrence everywhere across the universe.

SETI operates under a two-pronged hypothesis. The first assumption, known as the principle of mediocrity, is that the development of life is an unexceptional consequence of physical processes taking place in appropriate environments—in this case, on Earth-like planets. Because our galaxy has hundreds of billions of stars and the universe has billions of galaxies, many habitable Earth-like planets should exist, and life should be common.

The second assumption is that on some planets that shelter living creatures, at least one species will develop intelligence and a technological culture. They will have an interest in communicating with other sentient beings elsewhere in the cosmos and will beam signals into space with that goal. Assuming that these cultures would use electromagnetic signals to communicate and that their signals would have an artificial signature we could recognize, it should be possible to establish contact and exchange information.

Life as we know it could only exist on Earth-size planets because liquid water—apparently a prerequisite for organisms similar to terrestrial ones—seems to occur only on planetary bodies that size. Recent astronomical observations indicate that planetary systems are common. In just the past three years, researchers have detected 13 planetary systems orbiting sunlike stars. Current detection methods prevent us from knowing how sim-

MEG CRANE



RADIO SPECTRUM OF SPACE has a "quiet" area between one and 100 gigahertz, in which noise comes only from the cosmic background radiation. The "magic frequencies" in this area include the frequency at which hydrogen emits energy, at 1,420 megahertz, and that of the hydroxyl radical (oxygen and hydrogen), at 1,667 megahertz. The combination of both substances yields water—possibly a universal signature of life.

ilar these new systems are to our own solar system. At best, we know the new planets to be gas giants like Jupiter.

Based on these discoveries, SETI pioneer Philip Morrison of the Massachusetts Institute of Technology has estimated that the number of planetary systems just in our own galaxy could range from as few as 10 million to as many as 100 million. From this estimate, I believe we can realistically speculate about the number of Earth-like planets.

The most important determining factors are how frequently Earth-like planets are formed when a planetary system develops and how soon afterward life would appear. The best current estimates of the number of planets close in mass to Earth, combined with the best current estimates of the long-term stability of oceans, suggest that one or two possible worlds around every sunlike star have environments suitable for life—essentially the profile of our own solar system.

Based on Earth's history, life emerges relatively quickly. When Earth formed some 4.6 billion years ago, it was a lifeless, inhospitable place. Only one billion years later the whole planet was teeming with one-celled organisms resembling blue-green algae. The principle of mediocrity suggests a logical progression: the emergence of life will lead to the emergence of intelligence, which will give rise to interstellar communications technology. Viewed from one angle, it may be said that SETI is simply an attempt to test this theory.

There are no guarantees, though, that life everywhere will develop along the path followed on Earth and lead to intelligence. For example, Ernst Mayr of the Museum of Comparative Zoology at Harvard University notes that out of some 50 billion species that have arisen on Earth, only one achieved the kind of intelligence needed to establish a civilization. Intelligent life on Earth occupies less than 0.025 percent of the total history of life here. Mayr believes that such high intelligence may simply not be favored by natural selection: after all, every other species on Earth gets along fine without it.

Another possibility is that high intelligence is extraordinarily difficult or dangerous to acquire. For example, two or more competing intelligent species could destroy each other before either could give rise to a technological civilization. If this is so, we probably cannot expect more than one intelligent species to exist on any planet.

Technological civilizations must also survive long enough to be discovered. The late Carl Sagan referred to our period as "technological adolescence," when technology brings the civilization-ending threats of ecological catastrophe, exhaustion of natural resources and nuclear war. There may be 100 million suitable planets in our galaxy, and if even a small fraction of civilizations survive technological adolescence, then the possible number of galactic civilizations may still be very large. Sagan considered an estimate of one million of them in the galaxy to be conservative.

Making Conversation

SETI researchers also assume that the physical laws governing the universe are the same everywhere. If so, then we should be able to communicate through our common principles of mathematics, physics, chemistry and so on.

Not all researchers, however, agree. Nicholas Rescher, a philosopher at the University of Pittsburgh, argues that extraterrestrials would be organisms with different needs, senses and behaviors. So despite sharing universal laws with us, they are extremely unlikely to have any type of science we would recognize.

But artificial-intelligence pioneer Marvin Minsky of M.I.T. argues that intelligent extraterrestrials will think like us, in spite of different origins, because all intelligent problem solvers are subject to the same ultimate constraints: limitations on space, time and resources. According to Minsky, in order for intelligent life-forms to evolve powerful ways to deal with such constraints, they must be able to represent the situations they face and to manipulate those representations. To do this, every intelligence will inevitably discover the same basic principles. As a result, he says, aliens will have evolved thought processes and communications strategies that will match our own to a degree that will enable us to comprehend them. SETI proponents largely concur.

As a tool that cuts across cultural and linguistic boundaries, mathematics would seem to be a "cognitive universal" that could be used to communicate with extraterrestrial intelligences (ETIs). As early as 1896 Sir Francis Galton, a cousin of Charles Darwin, published an essay describing a mathematical language he developed for extraterrestrial communication.

In 1960 Dutch mathematician Hans Freudenthal created a language for a cosmic dialogue, known as Lincos (Lingua Cosmica), based on mathematical principles for exchanging concepts of time, space, mass and motion. Recently Louis E. Narens of the University of California at Irvine noted that many kinds of cognitive universals can be surmised by considering pragmatic requirements—for example, what the extraterrestrials must know to build sending and receiving equipment.

Efforts in First Contact

Since the first formal SETI efforts, researchers have used the microwave region of the electromagnetic spectrum for detecting interstellar communications, because microwave signals require little energy to exceed natural background radiation and are not deflected by galactic or stellar fields. Moreover, they are easy to generate, detect and beam and are not absorbed by the interstellar medium or by planetary atmospheres. A quiet cosmic frequency window exists in the microwave region, between one and 100 gigahertz.

In September 1959 Giuseppe Cocconi and Morrison, both then at Cornell University, proposed the first realistic strategy for searching for ETIs. It would use radio-astronomy telescopes to scan the nearest sunlike stars for artificial signals at or near the 21-centimeter wavelength (1,420 megahertz), which corresponds to the frequency of microwave energy that neutral hydrogen emits. (Hydrogen is the most abundant element in the universe, so presumably radio astronomers in any technological civilization would scan at this wavelength to study the substance.) Independently, Frank D. Drake, an astronomer then at the National Radio Astronomy Observatory (NRAO) in Green Bank, W.Va., was planning an actual search. On April 8, 1960, he turned the 26-meter-wide Howard Tatel radio telescope toward the nearby solar-type stars Tau Ceti and Epsilon Eridani. Drake dubbed the search Project Ozma, in reference to a princess who appeared in sequels to L. Frank Baum's book *The Wonderful Wizard of Oz*.

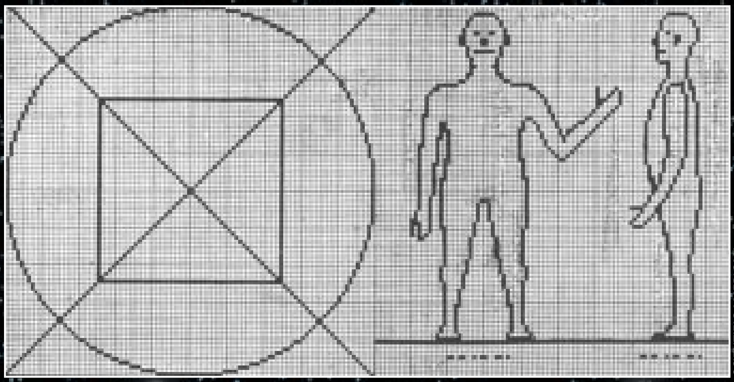
With $2,000 worth of parts, the low-profile, low-budget Ozma system had only one channel with a spectral resolution of 100 hertz and a sensitivity of one one-hundred septillionth (10^{-22}) of a watt per square meter: with current receiver technology, the same search would be thousands of times more sensitive. In the end, no signals were found after 150 hours of observation. Despite its failure, however, Project Ozma fired the imagination of the public.

In the Days before SETI

The first initiatives to communicate with extraterrestrial beings on the moon or on Mars began more than 150 years ago. German mathematician Carl F. Gauss (1777–1855) suggested that there be erected in Siberia a giant figure of the diagram used in Euclid's demonstration of the Pythagorean theorem. The hypothetical Selenites (moon dwellers), on seeing this figure through their telescopes, would recognize it as having been made by intelligent terrestrial beings and would respond accordingly. In 1869 French intellectual prodigy Charles Cros (1846–1888) suggested that rays from electric lights could be focused by parabolic mirrors so as to be visible to hypothetical inhabitants of Mars or Venus. He also presented a code using periodic flashes.

During the 1920s, an extensive debate about how to communicate with the hypothetical Martians began in the pages of *Scientific American*. In those days, radio pioneers Nikola Tesla (1856–1943), Guglielmo Marconi (1874–1937) and David Todd (1855–1939) began their speculations about the use of radio waves for interplanetary communication. On January 27, 1920, the *New York Times* reported that Marconi occasionally detected with his radio equipment "very queer sounds and indications, which might come from somewhere outside the Earth." No less a scientific authority than Albert Einstein was quoted as believing that Mars and other planets might be inhabited but that Marconi's strange signals stemmed either from atmospheric disturbances or experiments with other wireless systems.

In a 1920 *Scientific American* article, H. W. Nieman and C. Wells Nieman proposed a system to encode messages to other planets, arguing that the key to communication was the timing—in the duration of the signal to produce dots and dashes and in the lack of a signal to produce pauses. Their proposal was the basis for the encoding system used in 1974 by Frank D. Drake and his colleagues in the first interstellar message sent from the Arecibo Observatory in Puerto Rico toward the Great Cluster in the constellation Hercules. *—G.A.L.*


SCIENTIFIC AMERICAN

ENCODED MESSAGES can yield images for interstellar communications, as proposed in the March 20, 1920, Scientific American.

MAIN SETI PROJECTS NOW UNDER WAY

	BETA	META II	SERENDIP IV	SOUTHERN SERENDIP	ITALIAN SERENDIP	PROJECT PHOENIX		
Observatory	Oak Ridge	IAR	Arecibo	Parkes	Medicina	Parkes	NRAO	Arecibo
Starting observation date	1995	1990	1997	1998	1998	1995	1996–1998	1998
Site	Harvard, Mass.	Buenos Aires, Argentina	Puerto Rico	NSW, Australia	Bologna, Italy	NSW, Australia	Green Bank, W. Va.	Puerto Rico
Antenna diameter (meters)	26	30	305	64	32	22 and 64	30 and 43	305
Range of telescope motion (declination, in degrees)	–30 to +60	–90 to –10	–2 to +38	–90 to +26	–30 to +90	–90 to +26	–35 to +80	–2 to +38
Channels (in millions)	250 x 8	8.4	168	4.2 x 2	4.2 x 2		28.7 x 2	
Spectral resolution (hertz)	0.5	0.05	Down to 0.6	0.6	1.2		Down to 1	
Operation frequency (gigahertz)	1.4–1.7	1.4, 1.6, 3.3	1.4	1.4	0.4, 1.4, 1.6		1–3	
Instantaneous bandwidth (megahertz)	40	0.4–2	100	2.4	5		20	
Total bandwidth coverage (megahertz)	320	1.2–6	180	2.4	5		2,000	
Sensitivity (watts per square meter)	3×10^{-24}	8×10^{-24}	$\sim 10^{-24}$	2×10^{-25}	$\sim 10^{-25}$		$\sim 10^{-25}$	
Approximate sky coverage (percent)	70	50	30	75	75		Not applicable (targeted survey)	
Types of signals	C, Slow CH	C, CH	C, CH, P	C, CH, P	C, CH, P		C, CH, P	
Funding sources	Planetary Society, Bosack-Kruger and Shulsky Foundations	Planetary Society, CONICET	Planetary Society, Friends of SERENDIP, SETI Institute	University of New South Wales	Italian Research Council		SETI Institute	

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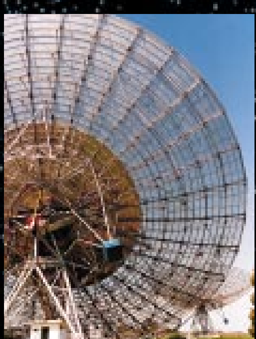

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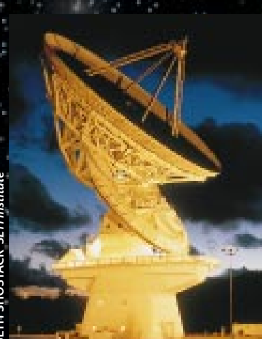

SETH SHOSTACK *SETI Institute*

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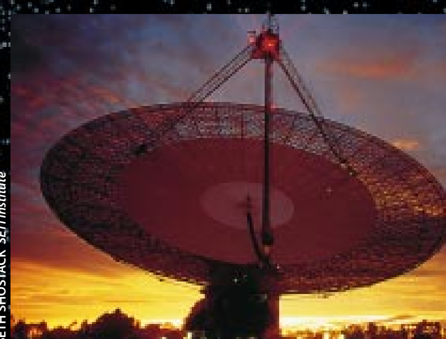

In the early 1970s the National Aeronautics and Space Administration began to show interest in SETI. The late Bernard Oliver, vice president for development at Hewlett-Packard, and John Billingham, a NASA scientist, headed Project Cyclops, a summer school convened to design an array of 1,000 100-meter-wide antennae to eavesdrop on the television, radar and other "domestic" transmissions of hypothetical galactic neighbors 1,000 light-years away. Project Cyclops, however, was too ambitious for NASA funding and was never built. Instead, during the 1970s and 1980s, NASA funding for SETI was limited to workshops and conferences. In 1992 NASA launched a 10-year, $100-million SETI project, but Congress canceled the program after a year.

Still, SETI researchers have managed without NASA funding. From 1973 to 1997 the Ohio State University Radio Observatory, led by John D. Kraus and

BETA, META and the three SERENDIPs make full-sky surveys for ultra-narrowband signals, limited only by the range of motion of each radio telescope (defined by its declination range). Project Phoenix searches for signals around nearby stars, using the Arecibo antenna and the 76-meter-wide antenna at Jodrell Bank in England as a means to confirm Arecibo signals. The number of channels, spectral resolution and instantaneous and total bandwidth are characteristics of each spectral analyzer. The sensitivity, which varies with frequency, is proportional to each antenna diameter and to the technical characteristics of the receivers and spectrometer. Carrier signals (C) are continuous, modulated waves (radio and television signals ride on carrier waves). Pulses (P) are brief, intermittent signals; chirps (CH) are pulses whose frequency changes.

OAK RIDGE

PLANETARY SOCIETY

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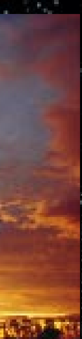


SETH SHOSTACK *SETI Institute*

STELIO MONTEBUGNOLI

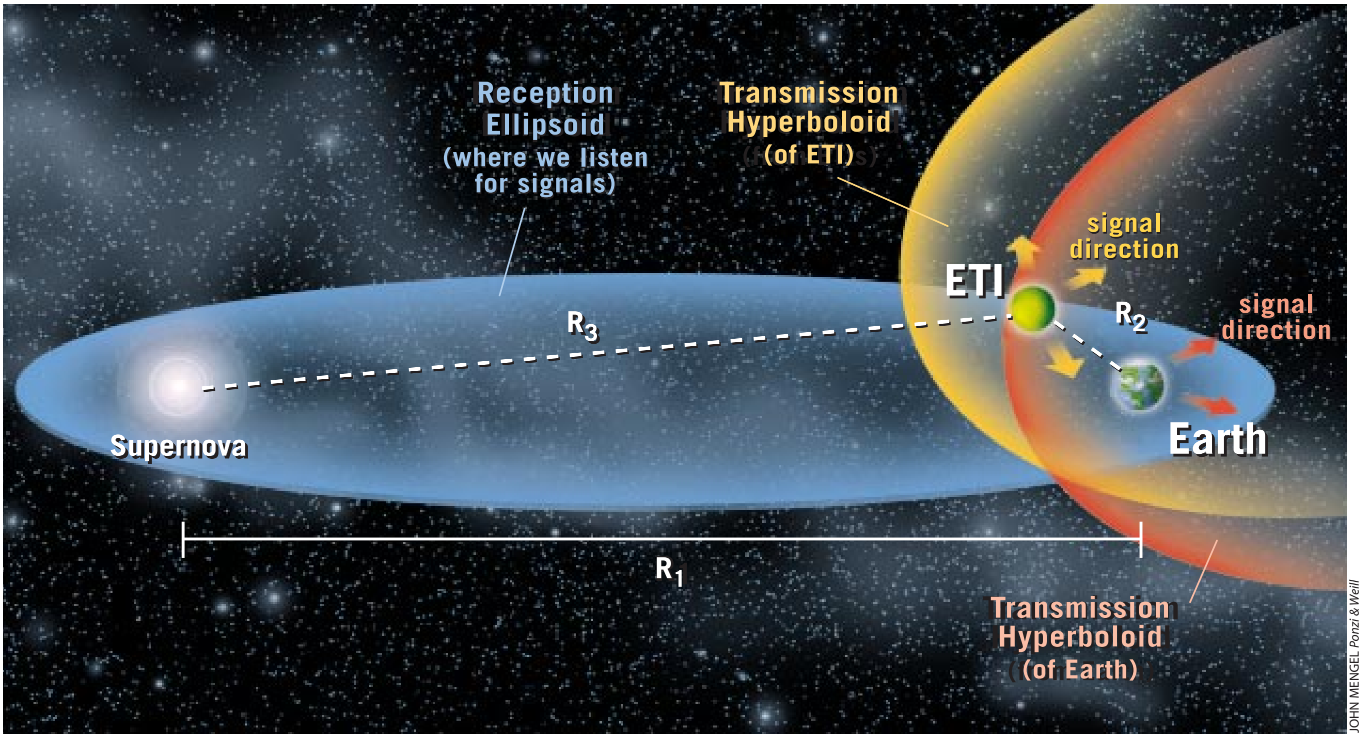
Robert Dixon, conducted the longest full-time, dedicated SETI search, entirely on a volunteer basis. In 1985 the Planetary Society, an organization based in Pasadena, Calif., with more than 100,000 members around the world, built an 8.4-million-channel analyzer known as META (Mega-channel Extraterrestrial Assay). The society installed the device, designed by Paul Horowitz of Harvard University, at the 26-meter antenna of Harvard's Oak Ridge Observatory. Five years later the society installed a similar spectral analyzer, META II, in one of the two 30-meter antennae of the Argentine Institute of Radio Astronomy near Buenos Aires. They were the first privately funded, dedicated, full-sky SETI surveys.

During the past 40 years, more than 90 different professional SETI projects have been carried out at observatories in Australia, Argentina, Canada, France, Germany, Italy, Russia, the Netherlands and the U.S. Together they have accumulated more than 320,000 observing hours, mostly in the so-called magic frequencies where we believe ETIs would broadcast. Unfortunately, none provided any conclusive evidence of the detection of an intelligent extraterrestrial signal.

Today private financial support for SETI comes from individual donations to nonprofit organizations, such as the SETI Institute, the Planetary Society and Friends of SERENDIP. Logistical support comes from institutions such as Harvard, the University of California at Berkeley, the National Astronomy and Ionospheric Center at Arecibo in Puerto Rico, NRAO, the University of New South Wales in Australia and the National Research Council of Argentina (CONICET). Thanks to the generosity of Hewlett-Packard's Oliver, the SETI Institute has a $20-million endowment that allows it to develop more ambitious projects. In particular, Project Phoenix is a mobile program that uses a 56-million-channel system; Berkeley's Project SERENDIP IV has 168 million channels; and the Planetary Society–Harvard's BETA has 250 million. These systems range in cost from several hundred thousand to several million dollars. The 64-meter antenna in Parkes, Australia, and the 43-meter antenna of the NRAO have already finished two observation campaigns and are now planning to extend their work using the observatories at Arecibo and Jodrell Bank in England.

Over the past few years, Paul Shuch of the SETI League, a nonprofit organization with members in more than 40 countries, has been trying to coordinate 5,000 small antenna dishes—built, maintained and operated by private individuals—in such a way that they will not miss any likely sky positions. Prototype stations went into operation in 1996, and many hundred enthusiasts worldwide are taking part in this project.

Another initiative, called SETI@home, is trying to use the Internet to organize 50,000 to 100,000 volunteers to perform massive parallel computation on desktop computers. Participants could download a screen-saver program that will not only provide the usual graphics but also perform sophisticated analyses of



STRATEGY TO USE SUPERNOVA AS A BEACON can narrow the search for an extraterrestial intelligence (ETI), which is assumed to rely on the exploding star as a source of attention. Earth radio telescopes would look for signals among stars that fall within an ellipsoidal region of space defined by Earth's distance to the supernova (R_1) and to the possible ETI planet (R_2), and by the distance from the supernova to the ETI (R_3). (The relation is $R_2 + R_3 - R_1$ = a constant for each specific time after the supernova explosion. The ellipsoid enlarges over time, and R_1 and R_3 can be several hundred thousand light-years.) Moreover, we could transmit greetings to stars that fall within a particular region, which is a "hyperboloid of transmission"—a shape defined by time and the supernova's position in the sky. It basically corresponds to a zone that provides the best view of the supernova and Earth, so that an ETI studying the supernova would also see our signal coming to it from the same direction. Likewise, Earth would fall in the transmission hyperboloid of the ETI, if the ETI chose an identical strategy.

SETI data using the host computer. The data would be tapped from Project SERENDIP IV's receiver at Arecibo.

SETI Search Methods

The practical requirements of SETI make the notion of "searching for a needle in a haystack" pale in comparison, because an electromagnetic transmission channel always has several variables that must be set. These include a four-dimensional aspect: the location of the extraterrestrial civilization (three dimensions in space) and a temporal dimension that coordinates transmission and reception (you can be looking to the correct place but at a moment when nobody is transmitting, or vice versa). Other factors include the frequency, the signal intensity and the cryptographic variables, such as polarization, modulation, information rate, code and semantics (which all must be overcome to decode any message). All these variables make up our "cosmic haystack."

Leaving aside certain complicating factors, there are roughly 3×10^{29} places, or "cells," in the sky to explore. Each cell's dimensions are 0.1 hertz wide, multiplied by the number of beams that a 300-meter Arecibo-type radio telescope (the world's largest) would need to conduct a full-sky survey. The calculation assumes a receiver sensitivity of 10^{-20} to 10^{-30} watt per square meter—less than the energy we would receive from a 100-watt lightbulb shining on Pluto.

Assuming Sagan's estimate of one million technological civilizations, this search is comparable to looking for an actual five-centimeter-long sewing needle in a haystack 35 times the size of Earth. So far only a small fraction of the whole haystack has been explored, a mere 10^{-16} to 10^{-15} of the total possible number of cells.

The success of the search depends not only on the number of civilizations in our galaxy but also on their transmission strategies. Historically, researchers assumed that some "supercivilizations" can make omnidirectional transmissions strong enough to be detected by full-sky surveys. Yet even if many civilizations are communicating with one another across the galaxy, only a vanishingly small probability exists that we on Earth, randomly observing different directions in the sky, would be able to eavesdrop on narrow-beam ETI signals. Full-sky surveys made by the Harvard, Arecibo, Ohio and Buenos Aires SETI projects did not find any evidence of omnidirectional supercivilization transmissions at a distance of 22 megaparsecs (70 million light-years).

What kind of intentional signal might we expect? It will most likely be narrowband, approximately one hertz or less in width and ideally a single wavelength (and thus obviously artificially generated), because the senders would want their signal to stand out as artificial against similar natural signals and because such a signal travels farthest for a given transmitting power. Most SETI projects can distinguish only the presence of such a signal among the broad band of cosmic noises but cannot ascertain the content of a message that might be coded in some unknown form.

Current SETI detection devices simultaneously analyze several million or billion spectral channels, whereas computers check for any strong narrowband signals among the cacophony of cosmic noise. Other instrumentation eliminates all human-made terrestrial and space radio interference. After years of observation and the analyses of hundreds of billions of signals, fewer than 100 signals have looked like potential extraterrestrial signals. Unfortunately, none of them could be detected in follow-up observations.

To cull the false alarms, James M. Cordes, Joseph W. Lazio and Sagan of Cornell University derived tests to analyze the unexplained signals detected by the META and META II projects between 1986 and 1995. Their analyses found signals that originated near the galactic plane that could not be ruled out as alien.

To check the origin of these and other unexplained signals, SETI researchers instituted new observation strategies. Horowitz's Project BETA now uses a billion-channel analyzer and three different antenna beams in order to exclude any possible terrestrial interference. Project Phoenix uses what its members call a FUDD (Follow-Up Detection Device): a second antenna hundreds of kilometers away that simultaneously analyzes signals and can screen out false ones (as shown in the recent movie *Contact*). Using these improvements, SETI researchers identified the META and META II candidate signals and other unexplained blips as different kinds of terrestrial interference.

Is it possible that we have already received an intelligent contact signal and that we missed it? I believe we probably have. But our detectors were not sensitive enough to distinguish it from the cosmic noise. Or it could be that our antenna was not pointed to the correct place at the right moment, or that we are searching in the wrong frequency or using the wrong observation strategy. Perhaps the signal faded because it passed through charged plasma clouds that pervade interstellar space.

I believe that the first evidence of an intelligent signal will probably come accidentally, when a traditional astronomer, unable to explain some anomalous observation, will realize that his or her data can be explained only as a consequence of some technological extraterrestrial activity. He or she will be able to draw this conclusion by using what we have learned through SETI.

This prediction reflects the distinctly unglamorous character of the day-to-day work of SETI. There are very few full-time SETI researchers: much time is spent designing and testing computer programs, and computers automatically do most of the work related to observation. The typical SETI researcher is also involved with learning and designing new hardware and software, developing new observational strategies and, most important, interpreting observational data to discern in them any possible intelligent signal patterns among the waterfall of cosmic noise.

Supernova Beacons

The greatest difficulty in making the first contact stems from the requirement that the incoming signal must arrive at the same time that the target civilization has its receiver pointed toward the unknown transmitter. The need for this synchronization is one of the weakest parts of our search strategy. But an extraterrestrial civilization using this kind of "active" search method (broadcasting signals to be discovered, in contrast to "passive" listening only) might overcome this problem by using a natural astronomical phenomenon—probably a supernova—as a "beacon" that would attract the attention of other civilizations. The sending civilization would transmit its own message in the diametrically opposite, or antipodal, direction of the supernova as seen from the transmitting planet.

In 1976 and 1977 Tong B. Tang of the Cavendish Laboratory of the University of Cambridge and P. V. Makovetskii of the Leningrad Institute of Aeronautical Instrument Manufacture independently argued that we might improve the probability of contact if we assumed that ETIs transmitting signals might use supernova beacons. They calculated that we should observe only those stars within an ellipsoidal volume, with Earth at one of the foci of the ellipse and a supernova at the other [*see illustration on opposite page*].

In fact, my colleagues and I have suggested that SETI researchers use exactly this strategy to attempt to contact ETI civilizations, using as the beacon the supernova detected in the Large Magellanic Cloud on February 23, 1987. Given that there are on average only one to four supernova explosions in our galaxy every 100 years and that the supernova, dubbed SN1987A, was the brightest one in 383 years, we can assume that most of the possible galactic civilizations would be paying close attention to it.

We would transmit our message in the direction antipodal to the supernova, in a field defined by a hyperboloid (roughly speaking, it corresponds to an area around Earth that provides the best view of the supernova within the ellipsoid). There are only 33 nearby objects inside this hyperboloid, which would focus the effort even further: of these 33 objects, 16 are solar-type stars that could have planets with other civilizations.

Are We Lunch?

The idea of using this kind of active search strategy concerns people in many quarters of the SETI community about whether to send such signals at all. The heat surrounding this issue can be traced to the first—and to date the only—attempt to send such a signal. On November 16, 1974, the Arecibo Observatory transmitted an interstellar message describing some characteristics of life on Earth toward the Great Cluster in Hercules, M13, a group of about 300,000 stars 25,000 light-years distant.

The action provoked some major protests. Former U.S. diplomat Michael A. G. Michaud considered the attempt a political act. He suggested a public discussion of the potential benefits and risks of ETI contact and urged that a decision be made openly, "with the involvement of public authorities." Martin Ryle, a Nobel laureate and Astronomer Royal of England, wrote to leading astronomers saying that he felt it was very hazardous to reveal our existence and location to the galaxy. For all we know, he said, "any creatures out there are malevolent or hungry," and once they knew of us "they might come to attack or eat us." He strongly recommended that no such messages be sent again.

Frank Drake replied to Ryle in a letter stating: "It's too late to worry about giving ourselves away. The deed is done, and repeated daily with every television transmission, every military radar signal, every spacecraft command...." According to Drake, Ryle seemed satisfied with the rejoinder.

Ben R. Finney, an anthropologist at the University of Hawaii at Manoa, has described human responses to contact with ETIs as "paranoid" (assuming that extraterrestrials are malevolent) or "pronoid" (assuming that interaction with ETIs would be extremely beneficial to humanity). Ever since H. G. Wells introduced in 1898 the idea of the invasion of Earth by murderous aliens in *The War of the Worlds,* the paranoid idea has dominated not only science fiction but also the thinking of some scientists. For example, in the early 1960s the Brookings Institution in Washington, D.C., prepared a report for NASA that concluded that "the discovery of life on other worlds could cause the Earth's civilization to collapse."

Medical anthropologist Melvin Konner of Emory University has said, "Evolution predicts the existence of selfishness, arrogance and violence on other planets even more surely than it predicts intelligence. If they could get to Earth, extraterrestrials would do to us what we have done to lesser animals for centuries."

"Any creature we contact will be every bit as nasty as we are," echoes Michael Archer, a biologist at the University of New South Wales. He thinks the gold-coated copper phonograph records affixed to each Voyager spacecraft—which contain, among other indications of intelligent life, 118 photographs of our planet, ourselves and our civilizations—are giant dinner invitations to the cosmos.

The pronoid school of thought is reflected in the writings of William J. Newman and Sagan, who have suggested that there may be universal impediments against cosmic imperialism. They have gone so far as to suggest that a *Codex Galactica,* produced by more mature civilizations, might exist to educate younger societies on cosmic etiquette. They have further argued that advanced civilizations with long histories must have learned how to be benign and how to treat an adolescent society like ours "delicately."

"As our own species is in the process of proving, one cannot have superior science and inferior morals. The combination is unstable and self-destroying," the science-fiction writer Arthur C. Clarke has said. This position was shared by the late Isaac Asimov and by other SETI proponents, including myself. If other civilizations agree, we might expect advanced societies to make only limited information available to emerging societies. This view is opposite to the contact scenario usually advocated by SETI pioneers, such as Sagan, who expect vast amounts of information or some kind of *Encyclopedia Galactica*.

Going beyond Adolescence

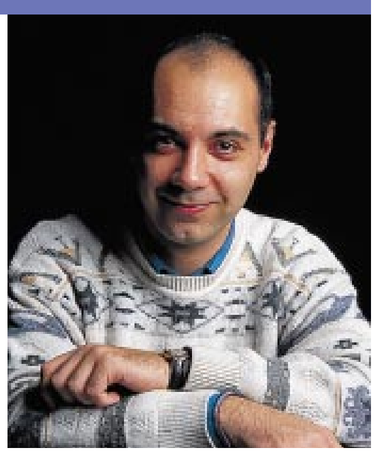
One final argument may be made in favor of active search strategies, which may imply strongly that they are essential if we are to have any hope at all of contacting extraterrestrial intelligence.

Communication is a two-way process. If all beings in the universe are trying to detect signals from other beings without sending out any of their own, then no one will receive a signal. This possibility conjures up the disturbing image of a galaxy filled with technological civilizations eager to make contact with one another but with all of them only listening and thus forever consigned to isolation.

Of course, such a "listeners-only" universe is unlikely, even if no intentional signals are being sent. As Drake noted, humanity has already made known its existence and location to a large part of our galaxy. Perhaps this announcement is typical for emerging adolescent civilizations, which may be no more cautious and quiet than adolescent humans.

Indeed, our position relative to the outcome of SETI is very much like that of an adolescent setting out on life's journey: the possibilities are infinite, the future is wide open, and we have grand plans, but much of the shape of that future hangs not only on what we do but also on luck—whether or not certain critical "ifs" actually come to pass. SETI may yield the greatest discovery in the history of humankind *if* life is ubiquitous across the cosmos; *if* life inevitably gives rise to intelligence and technology; *if* technological civilizations routinely survive long enough to broadcast and receive interstellar signals; *if* such civilizations want to be found; *if* we are using the correct search strategies and are tuned to the right frequencies; and *if* we recognize the signal when it arrives. Until then, we must do what most adolescents do very poorly: we must wait. SA

About the Author


COURTESY OF GUILLERMO A. LEMARCHAND

GUILLERMO A. LEMARCHAND was five years old when Neil Armstrong first set foot on the moon. "So I have always been interested in space," he says. "And I've always wondered whether life could have started on another planet in another place in the universe." But Lemarchand did more than wonder. As an undergraduate student in physics at the University of Buenos Aires, Lemarchand organized an international meeting on intelligent life in the universe. Some 500 students attended the meeting and listened to presentations by eminent biologists, astronomers and radio astronomers. A few months later Lemarchand made the first SETI observations at the Argentine Institute of Radio Astronomy—a project that he helped to establish and now coordinates.

When he's not scanning the sky for signs of intelligent life, Lemarchand works with mathematical models trying to understand long-term dynamics of social and economic systems and devotes his energies to promoting scientists' sense of social responsibility. He established the Argentine branch of Pugwash and organized an international symposium on scientists, peace and disarmament, where he proposed a Hippocratic oath for scientists, which is now used in graduation ceremonies at the University of Buenos Aires. Lemarchand's activism brought him to the attention of Carl Sagan of Cornell University, where he subsequently spent a year as a visiting fellow before returning to the University of Buenos Aires.

Further Reading

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