IAA-97-IAA.7.1.02

SETI TECHNOLOGY: POSSIBLE SCENARIOS FOR THE DETECTABILITY OF EXTRATERRESTRIAL INTELLIGENCE EVIDENCES

Guillermo A. Lemarchand

Instituto Argentino de Radioastronomía (CONICET) &
Centro de Estudios Avanzados (Universidad de Buenos Aires)
C.C. 8 - Sucursal 25, (1425) Buenos Aires, ARGENTINA
E-Mail: lemar@seti.edu.ar

Abstract: Using the hypothesis that the laws of physics, that govern the Universe, are the same everywhere, we can use our knowledge of these laws to set the strategies for the search of extraterrestrial intelligence. The main constraint of the SETI researcher -as well as any astronomer- is their entirely dependence on the characteristics of the available information carriers to do his or her observations. However, the information carriers are not infinite in variety. All the information we currently know about the Universe beyond our Solar System has been transmitted to us by means of electromagnetic radiation (radio, infrared, optical, ultraviolet, X-Rays, and γ-rays), and more recently by neutrinos. Several proposals and searches have been made in the past 40-years to find any extraterrestrial electromagnetic artificial signals or evidences of extraterrestrial technological activities from distant stars. There have also been several proposals to send interstellar automatic probes that could be sent for the detection of any kind of extraterrestrial artifacts in our Solar System, left here by alien intelligences in the remote past. The distance to the extraterrestrial intelligence location, is an important constraint that will also determined the expected flux of information exchange and possible impact of their discovery (e.g. the detection of a signal from a nearby star or the detection of a signal from a super-civilization in a nearby galaxy). In this presentation we make a description of the possible detection scenarios and a series of hypothesis of the kind of information that each particular scenario will provide us. Finally, we discuss the possible social impact of the announcement -for each particular scenario- for the discovery of any evidence of extraterrestrial technological activity.

Introduction

In recent years, there have been and interesting discussion, among social and physical scientists, about how to procedure if a signal from an extraterrestrial civilization (ETC) is detected [1,2]. Unfortunately, in most of these discussions, the implicit assumption was that the first evidence of an ETC will be a radio signal containing a message that will be easily decoded. Many scholars consider, that we should be prepared to make a prompt reply. A great debate was open to decide "Who will speak in name of Earth?", "What should we say?", "What kind of international legal tools is needed to control 'independent' transmissions?", etc. It is the intention of this paper to show that the characteristics of the on-going SETI projects, introduce several limitations for the type of signal that we are able to received in order to decode a possible message, in a fast way. This would take a much longer period of time.

It can also be that we detect an extraterrestrial signal (e.g. and extraordinary ultra-narrowband peak, unable to be originated by any of the natural physical mechanisms known by our science) but there is no message or any other kind of information content inside it. In this case, we will have good arguments to suppose that has an intelligent origin, but we will have very little information about the ETC. Only, with accurate VLBI measurements, we will know their position in space, and perhaps we will have a good estimation of their transmitting capacity. We will need longer astronomical studies to determine the possible characteristics of the transmitting planet. In this case: what kind of response we should send? Due to the huge interstellar distances: how many human generations will be required to establish a cosmic dialog?

As we will show, there is a large set of possible scenarios where we could discover -in a serendipity way- some evidence of an extraterrestrial technological activity, even while we are doing traditional astronomical work. For the majority of these scenarios the "Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence" and the "Declaration of Principles Concerning the

Sending of Communications to Extraterrestrial Intelligence" have several limitations because they were designed for the case of the most traditional scenario: a radio message from a distant star.

In the following sections we will examine our basic hypothesis about the technical possibilities of extraterrestrials. To do so we will discuss the traditional classification of the ETC considering their hypothetical level of energy consumption and accumulated knowledge. Then we will explore the limitations imposed by the laws of nature to the discovery technological ETC. We will see, how we deduce the best searching strategy according to our present understanding of those physical laws.

We will show the characteristics of the main SETI searches and we will discuss about the kind of signals they should detect. This will give us some idea about the timing process in decoding a hypothetical message -if any- after the discovery of an extraterrestrial artificial signal. Finally, we will present a series of extravagant, -but possible- scenarios for the detection of evidences of ETC technological activities, that were not taken into account in both projects of "Declaration of Principles".

Classification of Extraterrestrial Civilizations:

Kardashev[3] established a general criteria regarding the types of activities of extraterrestrial civilizations which can be detected at the present level of development. The most general parameters of these activities are apparently ultra-powerful energy sources, harnessing of enormous solid masses, and transmission of large quantities of information of different kinds through space. According to Kardashev, the first two parameters are a prerequisite for any activity of a *supercivilization*. In this way he suggested the following classification of energetically extravagant civilizations:

TYPE I: a level "near" the contemporary terrestrial civilization with an energy capability equivalent to the solar insulation on Earth (between 10^{16}-10^{17} Watts).

TYPE II: a civilization capable of utilizing and channeling the entire radiation output of its star. The energy utilization would then be comparable to the luminosity of our Sun, about $4x10^{26}$ Watts.

TYPE III: a civilization with access to the power comparable to the luminosity of the entire Milky Way Galaxy, $4x10^{37}$ Watts.

Dyson proposed the search for huge artificial biospheres created around a star by an intelligent species as part of its technological growth and expansion within a planetary system[4, 5]. This giant structure would most likely be formed by a swarm of artificial habitats and mini-planets capable of intercepting essentially all the radiant energy from the parent star. This would be one of the typical limits to a Kardashev's Type II Civilization.

According to Dyson, the mass of a planet like Jupiter could be used to construct an immense shell which could surround the central star, and have a radius of one astronomical unit. This kind of object known as *Dyson Sphere** would be a very powerful source of infrared radiation. Dyson predicted the peak of the radiation at 10 μm. It seems that all these exotic scenarios are still in the domain of science fiction. It is very hard to propose an accurate scenario of terrestrial contact with this kind hypothetical civilizations.

Kardashev also examined the possibilities in cosmic communication which attend the investment of most of the available power into communication. A Type II civilization could transmit the contents of one hundred thousands average-sized books across the Galaxy in a total transmitting time of one hundred seconds. The transmission of the same information intended for a target ten million light years distant, a typical intergalactic distance, would take a transmission time of a few weeks. A Type III civilization could transmit the same information over distance of ten billion light years, approximately the radius of the observing universe, with a transmission time of three seconds.

Sagan[6] considered that Kardashev's classification should be completed using decimal numbers to indicate a difference of one order of magnitude in energy consumption. For example, a civilization Type 1.7 expends 10^{23} watts, while a civilization Type 2.3 expends 10^{29} Watts. Sagan also suggested that, in order to be more accurate, a letter could indicate the societal information level (degree of their accumulated knowledge). According to Sagan, a Class A civilization will have 10^6 bits of information, a Class B, 10^7 bits, a Class C, 10^8 bits, and so on. Under this classification our terrestrial civilization is Type 0.7H. The level of the first extraterrestrial civilization that can make contact with us, would be between 1.5J and 1.8K. A galactic supercivilization would be Type IIIQ, while a civilization with the capacity to control a federation of galaxies would be Type IV Z. Table II shows the main characteristics of the proposed civilizations.

Serious consideration of supercivilizations takes us out to cosmological distances with correspondingly large redshifts. Recent all sky surveys for ultranarrowband microwave signals at a preferred frequency would be detectable out to 36 megaparsecs, within which there are something like 10^{14} stars. Unfortunately, no supercivilization was detected by any of the META sky-surveys in Harvard and Buenos Aires[7,8].

*The concept of this extraterrestrial constructions was first described in the science fiction novel "Star Maker" by Olaf Stapledon in 1937.

Kardashev's implicit assumption of exponential energy consumption growth, during large periods of time, is probably wrong. If we analyze the energy consumption per capita over the whole human history we will find a logistic curve with a saturation niche. Kapitza[8] has shown recently that the human population over 4 million years of history follows a power law, with different behavior at the beginning of the curve -appearance of the first intelligent hominids- and at the end of the curve -the so-call demographic transition near the year 2040. Near that time the human population must be stabilized in order to not saturate the carrying capacity of Planet Earth. In way or another there are several physical constraints for a given technology of exploitation of the environmental resources.

Table I: Characteristics of possible extraterrestrial civilizations according to N. S. Kardashev.

Level	TYPE I	TYPE II	TYPE III
Characteristics	-Planetary Society -*Developed Technology* *understanding the laws of physics * space technology *nuclear technology *electromagnetic communications -Initiation of spaceflight, -interplanetary travel, -settlement of space. -Early attempts at interstellar communication -Starting to push planetary resource limits	-Stellar system society -Construction of space habitats -"Dyson Sphere" as ultimate limit Search for intelligent life in space -Long societal lifetimes (10^3 to 10^5 years) -Initiation of interstellar travel/ colonization -Ultimately all radiant energy output of native star is utilized	-Galactic civilization -Interstellar communication/ travel -Very long societal life-times (10^8 to 10^9 years) -Effectively "the immortals", for planning purposes -Energy resources of the entire galaxy (10^{11} to 10^{12} stars) are commanded
Information Level	Information Level: I	Information Level: L	Information Level: Q Encyclopedia Galactica
Energy Consumption	10^{16} to 10^{17} W	10^{26} to 10^{27} W	10^{37} to 10^{38} W
Manifestations	Intentional or unintentional electromagnetic emissions, especially radio waves	*Electromagnetic* -radio waves -optical lasers -X-Rays -γ-Rays *Mass Transfer* -probes -panspermia -stellar ark	Feast of astroengineering Exotic communication -neutrinos -tachyons? -warmholes? -Waves "I"?

<u>The Rational Strategies Behind the Search for Technological Extraterrestrial Civilizations</u>

If we want to find evidence for the existence of extraterrestrial intelligence, we must work out an observational strategy for detecting this evidence in order to establish the various physical quantities in which it involves[10, 11]. This information must be carefully analyzed so that it is neither over-interpreted nor overlooked and can be checked by independent researchers.

Our basic assumption is that the physical laws that govern the Universe are the same everywhere, so we can use "our knowledge of these laws" to search for evidence that would finally lead us to an ETC[12]. For several scholars, this hypothesis of our correct interpretation of the physical laws to use them for interstellar communication, could be false. Nicholas Rescher, professor of Philosophy at the University of Pittsburgh, argues that extraterrestrials are extremely unlikely to have any type of science that would be recognizable to us[13]. The main reasons are the following: (1) they will certainly be different organisms, with different needs, senses, and behaviors; (2) they will inhabit environments strikingly different from our own, environments in which neither science nor technology may needed for survival; (3) since several species on Earth have survive longer than man, intelligence is not necessary adaptation, and should not be expected to develop elsewhere. For Rescher the science of a different civilization would presumably be closely geared to the particular pattern of their interaction with nature, as funneled through the particular course of their evolutionary adjustment to their specific environment. In this way alien civilizations might scan nature very differently. And so it will be impossible for us to distinguish any of "their" possible intelligent manifestations or understang the "contents" of a hypothetical message.

Contrary to Rescher, MIT's artificial intelligence pioneer Marvin Minsky[14] argues that intelligent extraterrestrials "will think like us, in spite of different origins". These arguments are based on the idea that all intelligent problem-solvers are subject to the same ultimate constraints --limitations on space, time and resources. In order for life to evolve powerful ways to deal with such constraints, they must be able to represent the situations they face, and they must have processes for manipulating those representations. He proposes two basic principles for every intelligence:

> ECONOMICS: every intelligence must develop symbol-systems for representing objects, causes and goals, and for formulating and remembering the procedures it develops for achieving those goals.
>
> SPARSENESS: every evolving intelligence will eventually encounter certain very special ideas -e.g. about arithmetic, casual reasoning and economics- because these particular ideas are very much simpler than other ideas with similar uses.

In this way, according to Minsky, aliens will have evolved thought processes and languages that will match our own to a degree that will enable us to comprehend them. SETI proponents have the implicit assumption that there is some sort of "convergence" in all the different interpretations of the physical laws, among the galactic civilizations.

Assuming the universality of the nature physical behavior (with reserves about our correct interpretation), for the SETI experiment, as well as in conventional astronomy, the mean distances are so huge that the researcher can only observe what is received. He or she is entirely dependent on the carriers of information that transmit to him or her all he or she may learn about the Universe.

However, according to our understanding of the physical laws, information carriers, are not infinite in variety. All information we currently have about the Universe beyond our solar system has been transmitted to us by means of electromagnetic radiation (radio, infrared, optical, ultraviolet, X-Rays, and γ-Rays), cosmic ray particles (electrons and atomic nuclei), and more recently by neutrinos.

There have also been speculations about interstellar automatic probes that could be sent for the detection of extrasolar life forms around the nearby stars in the far future or the possible detection of such probes sent by extraterrestrial neighbors to our solar system[15-17]. Another set of possibilities could be the detection of extraterrestrial artifacts in our solar system, left here by alien intelligences that want to reveal their ancient visits to us[18-22].

Table II summarizes the *possible information carriers* that may let us find the evidence of an extraterrestrial civilization, according to our knowledge and interpretation of the laws of physics. The classification of techniques in Table II is not intended to be complete in all respects. Thus, only a few fundamental particles have been listed. No attempt has been made to include any antiparticles. This classification, like any such scheme, is also quite arbitrary. Groupings could be made into different *astronomies*.

The methods of collecting this information as it arrives at the planet Earth make it immediately obvious that it is impossible to gather all of it and measure all its components. Each observation technique acts as an information filter. Only a fraction (usually small) of the complete information can be gathered. The diversity of these filters is considerable. They strongly depend on the available technology at the time.

Using our criteria of *sparseness* and of *economics* we should select those information carriers that should require a minimum amount of energy to exceed the natural background, to travel at --or close to-- the speed of light; not to be deflected by galactic or stellar fields; be easy to generate, detect and beam and not to be absorbed by the interstellar medium or by planetary atmospheres and ionospheres. Only photons survive all these requirements, and so electromagnetic waves of some frequency are the only known suitable signal.

Electromagnetic radiation carries virtually all the information on which modern astrophysics is built. The production of electromagnetic radiation is directly related to the physical conditions prevailing in the emitter. The propagation of the information carried by electromagnetic waves (photons) is affected by the conditions along its path. The trajectories it follows depend on the local curvature of the Universe, and thus on the local distribution of matter (gravitational lenses), extinction affecting different wavelengths unequally, neutral hydrogen absorbing all radiation below the Ly man limit (912 Angstroms), and absorption and scattering by interstellar dust, which is more severe at short wavelengths.

Interstellar plasma absorbs radio wavelengths of kilometers and above, while the scintillations caused by them become a very important effect for the case of ETC radio transmissions, because of the large temporal variability in the signal amplitude[23]. The inverse Compton effect lifts low-energy photons to high energies in collisions with relativistic electrons, while gamma and X-Ray photons lose energy by the direct Compton effect. The radiation reaching the observer thus bears the imprint of both the source and the accidents of its passage though space.

The Universe observable with electromagnetic radiation can be characterized as a multi-dimensional phase space. The space of configuration for the transmission and reception of interstellar electromagnetic signals includes a four dimensional coordinates subspace (spatial coordinates and transmission's epoch of the hypothetical partner) and a seven dimensional information subspace (modulation type, transmitting frequency, information rate, frequency width of the transmitting signal, polarization, code and semantics).

In 1961, SETI pioneer Sebastian von Hoerner classified the possible nature of the ETC signals into three general possibilities: local communication on the other planet, interstellar communication with certain distinct partners, and a desire to attract the attention of unknown future partners. Thus he named them as **local broadcast, long -distance calls, and contacting signals** (beacons)[24]. In most of the past sixty SETI radio projects, the strategy was planned with the main hypothesis that there are several civilizations transmitting omnidirectional beacon signals or that we are capable to eavesdrop the local broadcast activities of hypothetical nearby stars intelligent beings.

The success of a radio search for extraterrestrial intelligence depends not only on the unknown abundance of civilizations in our galaxy, but also on their assumed transmission strategies. How can the extraterrestrials announce their presence to his galactic neighbors? The best transmission strategy should set all the variables of the space of configuration following the so-called Principle of Anti-Cryptography[25]. In this way we are supposing that the signal will be designed and operated in such a way as to maximize its probability of discovery, both by intentional searches and by accidental observations probably made by all the possible "galactic interlocutors". The parameters should be selected according to the knowledge and interpretation of the astrophysical constraints, choosing those which minimize the number of unknown dimensions to be searched by the recipient.

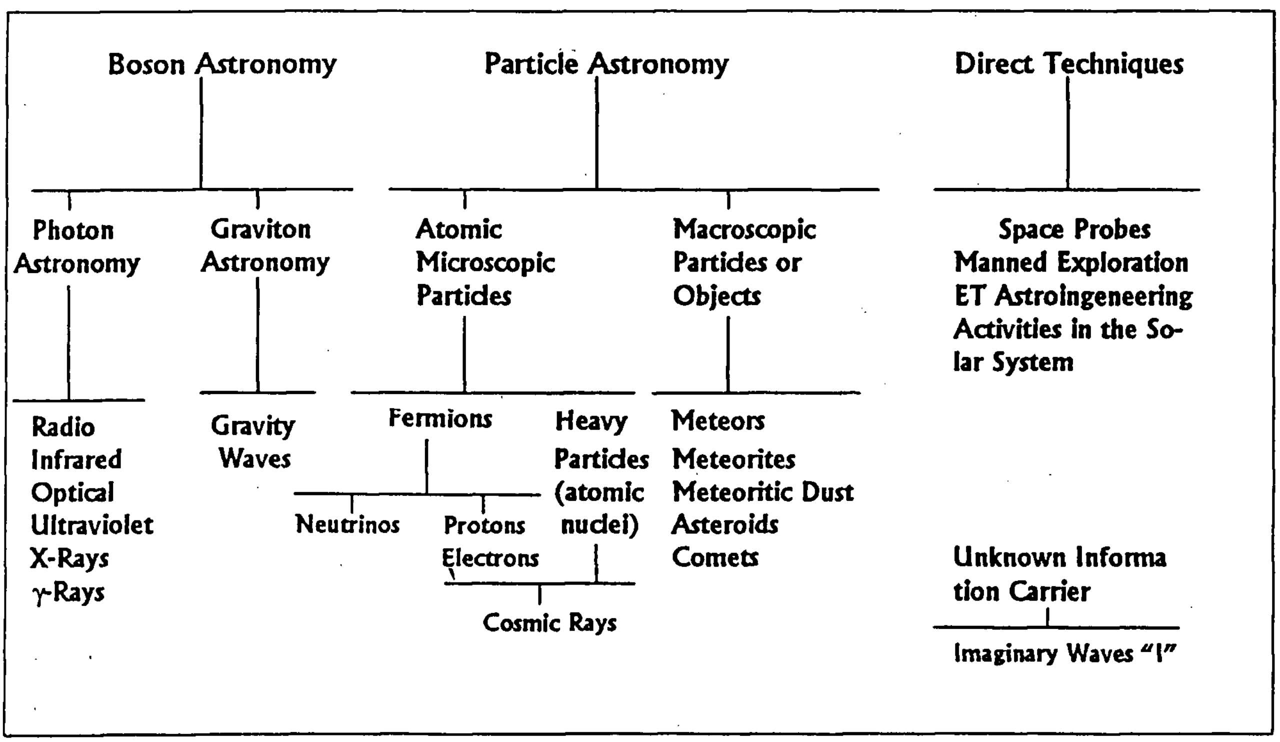

Table II: potential information carriers, according to our present understanding of the laws of physics, that could be used to find evidences of extraterrestrial intelligence in the Universe.

Even if there are large number of mutually communicative civilizations, the probability that the Earth would be able to eavesdrop on narrow beam ETI signals following a random addressing times strategy for transmission and reception, is vanishingly small. Very advanced civilizations might be able to broadcast omnidirectionally over great distances and during large periods of time, but such civilizations are likely to develop other interests than contacting emerging societies[26].

The real difficulty in making the first contact stems from the requirement that the transmission should be made in such a way that the target civilization should be pointed their receiver towards the "unknown transmitter" when signals are arriving at their home planet. Probably this is the most difficult element (synchronization in time) of our search strategy. It is possible to select and search rationally all the other elements (e.g. frequency, bandwidth, polarization, space directions, etc.) but without any doubt you should be extremely lucky to catch any extraterrestrial signal, aiming your radio telescope to a place in the sky just at the precisely moment that the message in passing through the Earth.

What kind of signal might one expect from a distant civilization? If it is send intentionally it will most likely be narrow-band (~ 1 Hz or less), ideally a single wavelength, something high monochromatic. This is so for two main reasons: (1) to distinguish between natural and artificial signals (e.g. the most monochromatic natural sources are the cosmic masers with bandwidths ~ 500 Hz) and (2) such a signal travels furthest for a given transmitting power. Most of the existing SETI projects are set to distinguish the presence of a monochromatic signal (continuous wave or pulsed) among a broad band cosmic noises, but not the possible content of the hypothetical message coded in some unknown modulation form. This kind of strategy limits our search to the detection of "long distant calls" and "contact signals" because "local broadcast" such as voice signals require a wider band of wavelengths and TV still wider (a standard satellite TV bandwidth transmission is 27 MHz or 27 million times more power that a sinusoidal 1 Hz beacon for the same detection).

In the last thirty five years, most of the SETI projects have been developed in the microwave region of the electromagnetic spectrum searching for interstellar monochromatic beacons. The main operating SETI programs are: BETA, META, PROJECT PHOENIX and SERENDIP IV. Recently, the Ohio State University has decided to abandon its radio-telescope and the SETI program that has been in operation since 1974, and allow it to be torn down by land developers. There are projects to expand the SERENDIP hardware and observing strategy, to radioobservatories in Australia and Italy. Some, intermittent SETI observations were made at Nancay (France) and a global amateur effort of the non-profit *SETI League* seeks to achieve continuous microwave monitoring of all 4 π steradians of space, in real time. The Table III shows the main characteristics, strategies and possible signal discoveries of the most sensitive programs. Unfortunately, no one has been able to show any conclusive positive evidence of success yet.

Following the same basic assumptions of extraterrestrial "beacon" signals, Townes and others have been exploring the possibility of interstellar communication in the infrared and optical wavelengths using continuous and pulsed lasers[27-31]. A high sensitive nanosecond pulsed search was made in Russia using a 6-m optical telescope[32] and an amateur search is under operation by Stuart Kingsley in Ohio[33].

Townes reviewed in careful detail the calculations of the detection capabilities of instruments in various parts of the electromagnetic spectrum, particularly the radio, optical and infrared. He demonstrated that there is no remarkably strong argument in favor of searches in any of these wavelength regions[34]. The main advantage of the optical regime in a sub-nanosecond pulsed code mode, is that a large amount of information could be included in each transmission. This is probable the most rational extraterrestrial strategy for "local broadcast" and "long-distance calls" signal categories, probably used by two galactic partners that already know each other.

SETI Detection Scenarios

A careful examination of Table III will show that the main SETI projects are designed to detect the following types of signals:

- *Continuous wave* (C) or a carrier, an essentially single frequency electromagnetic wave. This could be an extraordinary ultra- narrowband signal several times stronger than the statistical cosmic and system noise.
- *Slow Chirp* (SC) an ultra-narrowband signal that is changing its frequency in a slow way.
- *Chirp* (CH) a monochromatic signal that is changing its frequency as a function of time.
- *Pulse* (P) a signal that is on and off as a function of time.

Assuming a specific transmitting power for a hypothetical ETC, the maximum range R at which we are able to detect any signal with the available programs is the following:

$$R = (EIRP/(4\pi\, \phi_{min}))^{0.5}$$

where EIRP is the equivalent isotropic radiated power (watts) of a transmitting antenna system, product of the antenna directional gain and the real transmitted power; ϕ_{min} is the sensitivity of the search system in $W.m^{-2}$. A simple calculation will show that we are still not having the necessary technology to eavesdrop the "local calls" of our nearby stars. This is so, if we assume that our hypothetical neighbors have the same transmitting patterns of the present Earth civilization[35-37].

If we were to detect another technological civilization with our present technology, we are assuming that:

Table III: Technical characteristics of the main on-going microwave SETI projects:

PROJECT Site	**BETA** Oak Ridge	**META II** Buenos Aires	**PROJECT PHOENIX** NRAO -Green Bank	**SERENDIP IV** Arecibo-Puerto Rico
No. of channels (millions)	250 x 8	8.4	2 x 28.7	168
Antenna diameter (meters)	26	30	43	305
Spectral Resolution (Hz)	0.5	0.05	1, 2, 4, 8...	0.6, 1.2, 2.4,...600
Instantaneous Bandwidth (MHz)	40	0.4	2 x 10	100
Total Bandwidth Coverage (MHz)	320	1.2	2000	180
Sensitivity ($W.m^{-2}$)	$3x10^{-24}$	$8x10^{-24}$	$\sim10^{-25}$	$\sim10^{-24}$
Sky Coverage (% of 4 π)	70	50	few percent (targets)	30
Types of Signals	C, SC	C	C, CH, P	C, CH, P

(a) they might well have much more powerful transmitters for the "microwave region" for their local communications (very unlikely in we consider that for local communications the laser beams seems to be much more efficient) or

(b) they want to contact our emerging civilization sending us a "beacon".

Eavesdropping Nearby Stars:

For the assumption (a) no special attention should be paid to any "magic frequency" because the ETC will make their "local broadcast" or "long distance calls" taking into account only the transmitting characteristics according to their needs and use. Even, if these signals could be rich in information content, it will probably be impossible for us to break their code or their semantics. Because they were designed for their own use, these kind of signals are not suppose to be based in the so call *"Principle of Anti-cryptography"* (ACP). Due to observational constrains in the movements of our antennas, the change of getting a complete message content -originally designed for their own or third party use- is very low. To decode the message content of the signal detected, will probably require several years.

Project Phoenix, is the most sensitive SETI program and it is designed to detect signals from nearby solar-type stars. Taking into account the implicit hypothesis of case (a), the probability of a contact scenario with these characteristics is very low[37].

But we can still imagine that a nearby ETC is using planetary radars (similar to Arecibo) to make a survey of dangerous nearby comets and asteroids, and imagine that one of their shots were sent in the direction of our Sun. If they are using any frequency between 1.4 to 3 GHz, this signal will probably be detected. For this hypothetical scenario we will have to be lucky enough in being aiming our antenna at the correct star in the same moment that their transmission is passing through the Earth.

Supposing that all these restrictions are satisfied, probably that kind of signal will not be "on the air" for a long period of time. In this case, our protocol[1] to confirm its origin will be useless, even though we are really detecting the first evidence of an ETC. Assuming that we -in fact- realized about their extraterrestrial origin, this signal will be of very poor information content, similar to some of the "active search" proposals[26].

For this case: is there any need to arrange any kind of reply? The most important information will be that "we are not alone in this Universe". But our knowledge about them will be very scarce. We will know that they have certain electromagnetic transmitting capacity, that they are living in a specific nearby star. Probably we will be likely to find several orbital parameters of their home planet. A cosmic dialog will demand several dozens or hundreds years.

For a reciprocal detecting scenario, Peter Boyce and Lawrence Wasserman[38] examined the list of nearby stars that were swept by our planetary radars high power beams while we were studying different solar system objects from Arecibo and Goldstone. A strategy to search for replies to our terrestrial signals could be set-up for the near future. The first planetary radar terrestrial signals were sent in the early seventies. A possible reply from a nearby star will arrive us in 20 or 30 years.

The Detection of Beacon Signals

For the assumption (b) we can explore different contact scenarios:

- A nearby civilization whose detection technology (for radio transmissions and for obtaining images of extra-solar terrestrial-type planets) is several orders of magnitude better than ours. Taking into account the principle of causality, (e.g. the detection of our first strongest radio signal), these civilizations would be closer than 25-30 light years from our Sun. We are capable to receive the first replies to the terrestrial signals sent more than 50 years ago, from stars located at those distances. This scenario is also valid for those Optical SETI searches for nanosecond and sub-nanosecond pulsed laser signals. It is very likely to assume the use of an ACP for the message design. Probably the encoded message will be rich in information. But, the SETI programs of Table III will be capable only for the detection of the "beacon signal" not the message content in a first stage. A generational interstellar dialog could possible be established. Both "Declarations of Principles" sounds adequate for this kind of contact scenario.

- Any of the SETI-sky surveys programs detects a beacon signal. This could come from a nearby star that is inside the beam width while they are scanning the sky or from a distant source, probably generated by a supercivilization. If we detect a "beacon" intended for us it should be designed using the ACP. In this case a further VLBI study will be needed to identify the source (a nearby or distant star). If it is a nearby star this case is similar as the preceding one.

- But, if it is from a distant star (several hundreds or thousands light years far from us), it has other kind of problems. Supposing that the Milky Way has one million technical civilizations distributed homogeneously in the Galaxy, the nearby civilization will be 300 to 400 light years far from us. The uncertainty in the determination of galactic distances longer than 400 light years in general is big, only a few percent means several light years. Here it is very clear that a prompt reply is far from being necessary because an uncertainty of 10 light-years means an uncertainty in 10 years for the arrival of the reply. If it cames from a longer distance the scintillations effects became important[23]. Due to this effects the signal will appear most of times attenuated by the interstellar plasmas and a few times will appear amplified. A confirmation of their extraterrestrial origin will require a different re-observation strategy[39]. Again several years will probably be needed to confirm and decode the hypothetical message. In a first approach a rich information content will be expected.

There are good theoretical[40] and empirical[7-8] results that shows the non-existence of any Type II supercivilization in our Galaxy or any Type III within the current observable cosmic horizon. These arguments also stimulates us for other kind of questions: Which kind of civilization in the galaxy will give great amounts of information and knowledge to unknown emergent civilizations? Our terrestrial history shows how high technology and low morals constitutes a very unstable situation for the continuity of the civilization. Will a supercivilization put for their disposal an incredible amount of knowledge in a message content, knowing that the adolescent civilizations will destroy themselves using technologies that they are not prepare to manage with? I consider that this kind of thoughts are useful to be prepare for simple message contents. It is very unlikely that an extraterrestrial civilization that knows nothing about us will send a recipes on how to avoid self destruction. If they are a self confident society they will probably only say "here we are" and no much more.

In the following section we will present a set of possible detection scenarios based in the detectability of extraterrestrial technological activities, where no special message reception is made.

Extravagant Contact Scenarios

Over the years there have been a large amount of extravagant proposals for the search of extraterrestrial technological activities. In a previous paper we made a careful review of those possibilities[10-11]. In the search for extraterrestrial intelligence the only restrictions that we have are the limitations imposed by the laws of nature (see Table II). We must therefore be aware and open to numerous ways in which advanced civilizations across the Milky Way and beyond may make themselves known to others, both directly and as the extraneous results of their technological activities.

In Table IV we make a brief summary of the main exotica proposals published in the scientific literature in order to detect a signal of extraterrestrial technological activities. In all these cases we can find some unexpected evidences that could be interpreted as a consequence of an extraterrestrial technological activity. In all these cases both "Declarations of Principles" seems to be useless, mainly because the discovery of such an indirect evidence of ETC could be made by a scientist that works in the traditional branches of astronomy and physics and that are "outsiders" from the SETI community. We have to take into account that there are more than 12,000 professional astronomers and astrophysicists all over the world, only a small fraction are members of the International Astronomical Union Bioastronomy Commission (~600) and a smaller fraction are active SETI researchers (less than 100). SETI researchers are making most of their observations inside a small region of the whole electromagnetic spectrum and with a specific observing strategy. The great majority of the scientists are exploring the rest of all the possible information carriers, with a great variety of sensibilities, strategies and "filters". There is a small possibility that the first real evidence of extraterrestrial intelligence will come as a serendipity discovery (eg the first real evidence for an extra-solar planetary system appeared in a place and in a way that nobody in the past would have supposed: around a neutron star...).

It is quite conceivable that there are types of communication between the stars for which we are completely unaware of. Extraterrestrial beings could be signaling us -still using the fundamental forms of radiation we have summarized here- with encoding and symbols which can neither understand nor respond to. We could be witnessing activities and messages which we do not recognize as artificial due to our limited experience and knowledge.

Our ignorance of what dwells in the universe should compel human race to make even more extensive celestial explorations with many techniques at our disposal as possible. If there are civilizations among the stars of the Milky way, then it may be only a matter of time before we find them, if we have the patience and skill to search. As the Louis Pasteur said: "Unexpected discoveries are favored by prepared minds".

Table IV: Extravagant Methods of Finding Evidences of Extraterrestrial Technological Activities

Information Carrier	Observational Effect	Proposer - Reference
Infrared Radiation	Dyson Sphere	Dyson (4-5)
Optical Radiation	Discovery of technetium or other short-lived isotope not ordinary found in the typical stellar spectra.	Drake & Shklovskii (12)
	Discovery of Technetium, plutonium, praseodymium or neo-dymium as a consequence of artificial generated nucleo-synthesis to changed the stellar spectra. This would be the case if the central star is used as a repository of radioactive fissile waste material.	Whitmire & Wright (41)
X-Ray	The use of an equivalent of the total terrestrial nuclear power for nuclear power for a single space explosion. This could generate a detectable omnidirectional X-Ray pulse easily detected over 200 l-y.	Elliot (42)
	X-Ray flashes generated by dropping material onto neutron stars.	Fabian (43)
γ-Rays	Anomalous γ-rays flashes generated by the artificial annihilation of matter-antimatter processes (eg for interstellar propulsion systems	Viewing et al.(44) Harris (45-47)
Neutrinos	Detection of artificial neutrino beams from an ETC	Saenz et al (48) Subotowicz (49) Pasachoff (50) Uberall et al (51) Learned et al (52)
Matter exchange	A possible channel for interstellar communication based in a DNA biological coded message capable of self-replication in suitable environments	Yokoo & Oshima (53) Nakamura (54)
Direct techniques	Small Space Probes (long-delay echoes)	Bracewell (15-16)
	Search for Artificial Objects in the Solar System	Freitas -Valdes (18-20)
	von Neumann machines	Tipler (55)
	ET objects in the Asteroid's Belt	Papagiannis (21-22)
Exotica	Warmholes, tachyons, the use of undiscovered physical laws	Science Fiction

References

1. **Tarter, J.C. and M.A. Michaud** (Eds.), SETI Post-Detection Protocol, a special issue of *Acta Astronautica*, vol.21, No.2, 1990.

2. *A Decision Process for Examining the Possibility of Sending Communications to Extraterrestrial Civilizations: A Proposal;* Position Paper prepared by Billingham, J. et al., formally approved by the Board of Trustees of the International Academy of Astronautics (IAA) and by the Board of Directors of the International Institute of Space Law (IISL).

3. **Kardashev, N.S.**, Transmission of Information by Extraterrestrial Civilizations, *Soviet Astronomy*, vol.8, No.2, pp.217-220, 1964.

4. **Dyson, F.J.**, Search for Artificial Stellar Sources of Infra-

red Radiation, *Science*, vol.131, pp.1667-1668, 1959.

5. **Dyson, F.J.**, The Search for Extraterrestrial Technology, in *Perspectives in Modern Physics* (Essays in Honor of Hans Bethe), R.E. Marshak (editor), John Wiley & Sons, New York, 1966.

6. **Sagan, C.**, *The Cosmic Connection: An Extraterrestrial Perspective*, Doubleday, New York, 1973.

7. **Horowitz, P and Sagan, C.**, Five Years of Project META: An All-Sky Survey Narrow-Band Radio Search for Extraterrestrial Signals, *Astrophysical Journal*, 415: 218-235, 1993.

8. **Lemarchand, G. A., Colomb, F.R., Hurrell, E. And Olalde, J.C.**, Southern Hemisphere SETI Survey: Five Years of Project META II, in C. B. Cosmovici, S. Bowyer and D. Werthimer (Eds.), *Astronomical and Biochemical Origins and the Search for Life in the Universe*, Proceed. of the IAU Colloquium 161, Editrice Compositori, Bòlogna (Italy), 1997.

9. **Kapitza, S.P.**, Phenomenological Theory of World Population, *Uspekhi Phys. Nauk*, vol.166 (1), pp.63-79, 1996.

10. **Lemarchand, G.A.**, *El Llamado de las Estrellas*, Lugar Científico, Buenos Aires, 1992.

11. **Lemarchand, G.A.**, Detectability of Extraterrestrial Tech-nological Activities, *SETIQuest*, vol.1, No.1, pp.3-13, 1994.

12. **Sagan, C. and Shklovskii, I.S.**, *Intelligent Life in the Universe*, Holden-Day, Inc.; San Francisco, 1966.

13. **Rescher, N.**, Extraterrestrial Science, in E. Regis (ed), *Extraterrestrials, Science and Alien Intelligence*, Cambridge University Press, pp.83-116, 1985

14. **Minsky, M.**, Why Intelligent Aliens will be Intelligible?, in E. Regis (ed), *Extraterrestrials, Science and Alien Intelligence*, Cambridge University Press, pp.116-127, 1985

15. **Bracewell, R.N.**, Communications from Superior Galactic Communities, *Nature*, vol.186, pp.670-671, 1960.

16. **Bracewell, R.N.**, *The Galactic Club: Intelligent Life in Outer Space*, H. Freeman & Co., San Francisco, 1975.

17. **Freitas, R.A.**; Interstellar Probes a New Approach for SETI, *J. of the British Interplanetary Soc.*, vol. 33, pp.95-100, 1980.

18. **Freitas, R.A. and Valdes, F.**; A Search for Natural or Artificial Objects Located at the Earth-Moon Libration Points, *Icarus*, vol.42, pp.442-447, 1980.

19. **Freitas, R.A. and Valdes, F.**, A Search for Objects Near the Earth-Moon Lagrangian Points, *Icarus*, vol.53, pp.453-457, 1983.

20. **Freitas, R.A. and Valdes, F.**,The Search for Extraterrestrial Artifacts (SETA), *Acta Astronautica*, vol.12, No.12, pp.1027-1034, 1985.

21. **Papagiannis, M.D.**, Are we Alone or Could They be in the Asteroid Belt?, *Q.J.R.Astr. Soc.*, vol.19, pp.277, 1978.

22. **Papagiannis, M.D.**, An Infrared Search in Our Solar System as Part of a More Flexible Search Strategy, in *The Search for Extraterrestrial Life: Recent Developments*, M.D. Papagiannis (ed.), Reidel Pub. Co., Boston, 1985.

23. **Cordes, J. M. and Lazio, T. J.**, Interstellar Scattering Effects on the Detection of Narrow-Band Signals, *Astrophysical Journal*, vol.376, pp.123-134, 1991.

24. **von Hoerner, S.**; The search for Signal from Other Civilizations, *Science*, vol.134, pp.1839-1843, 1961.

25. **Dixon, R.**, A Search Strategy for Finding Extraterrestrial Radio Beacons, *Icarus*, vol.20, pp.187-199, 1973.

26. **Lemarchand, G.A.**, Passive and Active SETI Strategies Using the Synchronization of SN1987A, *Astrophysics and Space Science*, vol.214, pp.209-222, 1994

27. **Schwartz, R.N. and Townes, C.H.**, Interstellar and Interplanetary Communication by Optical Masers, *Nature*, vol.190, pp.205-208, 1961.

28. **Townes, C.H.**; At What Wavelengths Should we Search for Signals from Extraterrestrial Intelligence?, *Proc. Natl. Acad. Sci. USA*, vol.80, pp.1147-1151, 1983.

29. **Betz, A.**; A Direct Search for Extraterrestrial Laser Signals, *Acta Astronautica*, vol.13, No.10, pp.623-629, 1986.

30. **Kingsley, S.A. (ed.)**, The Search for Extraterrestrial INtelligence (SETI) in the Optical Soectrum, *SPIE Proceeding Series*, vol.1867, 1993.

31. **Kingsley, S.A. and Lemarchand, G.A. (Eds.)**, The Search for Extraterrestrial Intelligence (SETI) in the Optical Spectrum II, *SPIE Proceeding Series*, vol. 2704, 1996.

32. **Beskin, G.M.; N. Borisov; V. Komarova; S. Mitronova, S. Neizvestny, V. Plokhotnichenko and Marina Popova;** The Search for Extraterrestrial Civilizations in the Optical Range, Methods, Objects and Results, in C. B. Cosmovici, S. Bowyer and D. Werthimer (Eds.), *Astronomical and Biochemical Origins and the Search for Life in the Universe*, Proceed. of the IAU Colloquium 161, Editrice Compositori, Bologna (Italy), pp.595-600, 1997.

33. **Kingsley, S.A.**, A Prototype Optical SETI Observatory, in Kingsley, S.A. and Lemarchand, G.A. (Eds.), The Search for Extraterrestrial Intelligence (SETI) in the Optical Spectrum II, *SPIE Proceeding Series*, vol. 2704, pp. 102-116, 1996.

34. **Townes, C.H.**, Optical and Infrared SETI, in C. B. Cosmovici, S. Bowyer and D. Werthimer (Eds.), *Astronomical and Biochemical Origins and the Search for Life in the Universe*, Proceed. of the IAU Colloquium 161, Editrice Compositori, Bologna (Italy), pp. 585-594, 1997.

35. **Sullivan III, W.T., Brown, S. and Wetherill, C.**, Eavesdropping:The Radio Signature of the Earth, *Science*, vol.199, pp.377-388, 1978.

36. **Sullivan III, W.T.**, Eavesdropping Mode and Radio Leakage from Earth, in *Life in the Universe*, p.377-390, MIT Press, Cambridge, MA., 1981.

37. **Billingham, J. and Tarter, J.C.**, Detection of the Earth with the SETI Microwave Observing System Assumed to be Operating out of the Galaxy, *Acta Astronautica*, vol.26, No.3-4, pp.185-188, 1992.

38. **Boyce., P. B. and Wasserman, L.H.**, A SETI Technique: Monitor Stars to Which we Have Sent Signals, inJ. Heidmann and M.J. Klein (eds.), *Bioastronomy: The Search for*

Extraterrestrial Life - The Exploration Broadens, pp.240-243, Springer-Verlag, Berlin, 1991.

39. **Cordes, J.M., Lazio, T. J. and Sagan, C.**, Scintillation Induce Intermittency in SETI,, *Ap.J.* in press 1997.

40. **Gott III, J.R.**, Implications of the Copernican Principle for Our Future Prospects, *Nature*, vol.363, pp.315-319, 1993.

41. **Whitmire, D.P and Wright, D.P.**, Nuclear Waste Spectrum as Evidence of Technological Extraterrestrial Civilizations, *Icarus*, vol.42, pp.149-156, 1980.

42. **Elliot, J.L.**, X-Ray Pulses for Interstellar Communication, in *Communication with Extra Terrestrial Intelligence*, C. Sagan (Ed.), pp.398-402, MIT press, 1973.

43. **Fabian, A.C.**, Signalling Over Stellar Distances with X-Rays, *J. of the British Interplanetary Soc.*, vol 30, pp.112-113, 1977.

44. **Viewing, D.R., Horswell, C.J. and Palmer, E.W.**, Detection of Starships, *J.of the British Interplanetary Soc.*, vol.30, pp.99-104, 1977.

45. **Harris, M.J.**, On the Detectability of Antimatter Propulsion Spacecraft, *Astrophysics and Space Science*, vol.123, pp.297-303, 1986.

46. **Harris, M.J.**, A Search for Linear Alignments of Gamma Ray Burst Sources, *J. of the British Interplanetary Soc.*, vol.43, pp.551-555, 1991a.

47. **Harris, M.J.**, SETI Through the Gamma Window: A Search for Interstellar Spacecraft, in *Bioastronomy: the Search for Extraterrestrial Life,* J. Heidemann and M.J. Klein (eds.), Lectures Notes in Physics 390, Springer-Verlag, Berlin, 1991b.

48. **Sáenz, A.W., Überall, H., Kelly, F.J., Padgett, D.W. and Seeman, N.**, Telecommunications with Neutrino Beams, *Science*, vol.198, pp.295-297, 1977.

49. **Subotowicz, M.**, Interstellar Communication by Neutrino Beams, *Acta Astronautica*, vol.6, pp.213-220, 1979.

50. **Pasachoff, J.M., and Kutner, M.L.**, Neutrinos for Interstellar Communication, *Cosmic Search*, vol.1, No.3, pp.2-8, 1979.

51. **Überall, H., Kelly, F.J. and Sáenz, A.W.**, Neutrino Beams: a New Concept in Telecommunications, *J. Wash. Acad. Sci.*, vol.69, No.2, pp.48-54, 1979.

52. **Learned, J.G., Pakvasa, S., Simmons, W.A., and Tata, X.**, Timing Data Communication with Neutrinos: A New Approach to SETI, *Q.J.R. astr. Soc.*, vol.35, pp.321-329, 1994.

53. **Yokoo, H. and Oshima, T.**, Is Bacteriophage ϕX 174 DNA a Message from an ETI?, *Icarus*, vol.38, pp.148-153, 1979.

54. **Nakamura, H.**, SV40 DNA: A Message from Epsilon Eridani?, *Acta Astronautica*, Vol.13, No.9, pp.573-578, 1986.

55. **Tipler, F.J.**; Extraterrestrial Intelligent Beings do not Exist, *Q.J.R. Astr. Soc.*, vol.21, p.267, 1980.