

TOWARDS MULTI-DISCIPLINARY SETI RESEARCH

Garry Nolan (+), Jacques Vallée (§) and Federico Faggin (*)

The modern approach to the scientific exploration of intelligent life in the universe was pioneered in the early 1960s by Frank Drake and Carl Sagan in the US (1) and by Schklovskii and others in the USSR (2). It was based on a recapitulation of the physical parameters of astrophysics (primarily, planetary astrophysics based on our own solar system) and on extrapolations from our understanding of the biological structures (brains) that support consciousness. This resulted in the famous "Drake Equation" (3). It broadly assumed that the extant of civilizations where conscious, intelligent, life could be found would be proportional to the number of stellar systems, to the number of planets actually supporting "life" where such consciousness evolved, to the percentage of conscious entities on such worlds reaching a stage of intelligence recognizable as such (to us), to the percentage having developed means of interstellar communication (or generation of detectable electronic or other signals), and to the expected duration of such races' existence in a form that transmitted a recognizable signal.

With the passage of time the initial technology used in the search, namely individual radio telescopes and (later) large arrays of antennas, has been broadened somewhat with optical tools (4) but the main thrust has remained – based largely on attempts to detect faint, patterned, electromagnetic signals suggestive of intelligent communication as we know it on this planet.

In this paper, we draw lessons from the non-detection of such recognizable electromagnetic signals despite more than a half-century of sustained effort. We propose to broaden the scope of the Drake equation parameters by leveraging recently-discovered facts about forms of life, consciousness, and potential communication modes that the founders of SETI didn't have at their disposal in the initial decades. We also support the concept of an expanded EM search in less noisy environments.

We consider these opportunities in three areas: *First*, extensions of the terms of Drake's equation; *second*, a widening of focus taking into account current concepts of modern biology, and AI, that have a bearing on consciousness, hence on intelligence and available modes of communication, and *third*, broadening the concept of signaling by considering modalities to include quantum information, direct interaction with consciousness, and examining how reliable observations of anomalous phenomena in the earth's atmosphere and nearby environs might be currently suggestive of potential communication by non-human intelligences.

1. A revised Drake Equation and the expectations of extraterrestrial intelligence

It was logical and appropriate for SETI to start from "life as we know it" as it has developed on Earth, and to assume that similar conditions elsewhere in the universe would produce outcomes that resulted in autonomous beings capable of intelligent communication through technology.

Two questions arise immediately, based on the experience of the last 60 years: Aside from searching for the conditions of life as we know it, and of intelligence directly derived from such life, couldn't we pose the problem in the form of a search for *consciousness*? If we assume that consciousness may not always be attached to a body in the material, biological sense as we currently understand it, how could the parameters in Drake's equation be revised? Similarly, we could realize that each advance in humanity's long-range communication systems has had a short half-life (lighted fires, telegraph, telephone, radio waves, fiber optics, and terahertz waves to name a few). The common mode amongst these is electromagnetic waves. While it is the primary medium of current human communications, it is "slow" at interplanetary distances and perhaps moot at a cosmic scale -- wherein a civilization might transcend understanding or disappear in the time frames between "Hello" and "Yes, who's calling?"

What we today consider to be advanced communication is certainly an artifact of our burgeoning, but still limited, knowledge of physics, biology, and what in fact constitutes a receptive consciousness that works with technologies similar to our current standard. In addition, much of SETI assumes a civilization that is actively looking to be

found, or unconcerned about detection (They never got the memo from Stephen Hawking). To the extent that distance dilutes the strength of a communication signal, can certain terms of the Drake Equation be refined using a determined radius near our stellar neighborhood that is most likely to contain civilized intelligences, and which are aware that nearby intelligences might detect them? One of us proposed a stochastic approach to this as early as 1965 (5) and it was further quantified by Maccone in 2009, with a calculated optimum distance of 2000 light years (6). Is this metric still valid today or are new assumptions needed?

Given this, the question of the appropriate detection technologies naturally arises. Radio signaling in today's computer networks (or fiber optics) would not have been detectable with the best electronic equipment in the 1960s (7), so what does that say of a truly advanced civilization that might be 10s of thousands or millions of years older than our own? Are there novel forms of "signal" we could monitor by studying other physical properties by which the universe is currently known to operate (8)? Is electromagnetics the only form of communication? Have we considered quantum signaling approaches amongst our signaling modalities? Even remaining with electromagnetics, as a first step we strongly support the idea of relocating the search to an array of small, automated antennas sited on the far side of the Moon, where human-originated EM noise will not be a factor.

2. Modern biology and advanced AI suggest needed extensions of the model

At the time when the SETI model was initiated the common scientific definition of life was a narrow one. Some forms of life on Earth had not yet been discovered, such as archaea (9), the extremophiles known to survive in harsh conditions close to underwater volcanoes (10), or algae that thrive on ice. These examples alone would suggest that creatures could evolve in conditions very different from those anticipated by Drake et al. If we also consider the progress of AI (11) and of the interface between biology and electronics (12), the model could even include civilizations that have transferred their consciousness and their ability to communicate to physical substrates such as plasmas or solid state systems capable of operating at temperatures, pressures, and other environmental conditions far above and below the ranges permissible for carbon-based life. In such form they might have migrated far from their "birth" star and a classical search would fail to find them. We focus on stars—but are the vast reaches of intergalactic space or inter-supercluster volumes being ignored?

Because it is hard to imagine all possible life forms, and given the short time that life and consciousness have been scientifically studied (less than one century), it would be prudent not to rule out possibilities that may appear unfashionable. Life may thrive underground and in space, near and far from planets and stars, and under conditions we may now consider prohibitive (13). With the newly essential understandings of quantum physics and quantum information, are "biological brains" the only place consciousness could have evolved?

To this point, new models for the evolution of consciousness and matter are under study (14) that suggest novel possibilities to interpret the nature of reality and which are at odds with a materialistic worldview. This includes the possibility of other forms of communication or contact with alien intelligences that are considered "science fiction" by mainstream science, yet have an extraordinary history of anecdotal evidence. We are speaking of everything from telepathy, empathy, remote viewing, and out of body experiences that may be pointing towards channels of communications beyond what electromagnetic waves can reveal.

Before dismissing such ideas, we need keep in mind that all sensory apparatus our consciousness employs to interpret our immediate universe relies upon electromagnetic waves which propagate as quantum fields. Our sensory apparatus operates in that quantum reality. We perceive quantum information and construct our internal "animal" view of reality—but are we perceiving all information fields enfolding us? Are we *consciously aware* of everything we are perceiving? Animals, and now humans, are recently understood to perceive magnetic fields. The proteins in our brain that form our neurons sit in a quantum mix where information is transferred in still unfathomable manners. Are those proteins and biologicals completely blind to all forms of information passing through them?

3. Anomalous signals provide an opportunity to test novel hypotheses

Throughout its history, SETI has considered a signal to be a patterned light pulse or electromagnetic wave that displays intelligent formation or information content. Animals, and humans, signal to each other through emotions, body language, sound, intent, and numerous social cues. Presumably, a non-human civilization would have evolved complex modes of standard interaction. A civilization experienced at inter-species communication would either have to tailor communication to each new species it expects to contact, or might have a common mode for such interaction. So, what really constitutes a signal?

Over the last 60 years progress has been made in the study of anomalous objects reported in the atmosphere and beyond by competent observers, both civilian and military, in all countries. Although the subject has been controversial, several serious groups have been formed to screen and analyze observations from the public (15) and the special files of aviation reports (16). These observations may not be directly relevant to "detection" of a non-human intelligence, but they provide a ready-made test bed for the improvement of the methodology and its extension to forms of consciousness that might have already traveled to our solar system. Many intriguing, yet reliable astronomical observations from the 18th and 19th century tend to confirm this possibility (17). If we remove a potentially strong signal from the table of consideration, i.e. something that is somehow "directly" signaling to our consciousness today, are we blinding ourselves to the "wow" signal for which we've been searching? Have we defined the solution so narrowly that when it knocks on our door we refuse to see it for what it is?

Is the appearance of a clearly non-terrestrial anomaly in the sky a signal? Religions have long used signs in the sky to indicate that "God" or the supernatural is signaling intent. Does the Drake equation, for SETI, implicitly assume the signal is intended, or is simply a "leaked" signal that we pick up as bystanders? If the signal is intended, might it come via other modes of visualization or physical manifestations deployed via technologies we have yet to understand (18, 19)?

Further, mainstream physicists currently and reasonably argue quantum realities, multiverse concepts, "warp" drives, the universe as a simulation... yet the Drake equation (and SETI) takes these considerations off the table. If there is more than one universe, each with different timelines and potentially different rules of physics, might they be able to signal us at a subconscious level, while ~~we~~ we have not yet learned how to understand what we are receiving? Given the theoretical framework for faster than light travel, it is not inconceivable to consider the "signal" to be what people have claimed to see for millennia. In other words, do aliens being "here" have to involve landing on the White House lawn? Is our concept of what is an alien structured too much by Hollywood?

It was not long ago that airplanes, travel to the moon, and even nuclear power were considered ridiculous. Do reasonable scientists take evidence off the table if it cannot be explained, or when it doesn't fit a preconceived model? It's fine to have models and Occam's razor. But they are not universal truths, and history proves that discovery happens when anomalies are not ignored.

Conclusion:

A multidisciplinary Virtual Institute for SETI would be presented with a rich and varied range of research opportunities. Drake's equation and the SETI program in general have often been criticized by mainstream science for the conjectural nature of the values ascribed to the various parameters. The response to such criticism lies in part in reframed definitions of the object of the search itself, taking into account the most recent discoveries in relevant, expanded disciplines of science and consciousness. We therefore propose (1) an extension of SETI research in the direction of better technology away from human-generated noise, (2) a more liberal assessment of what an intelligent alien "signal" could be and (3) targeting areas of the cosmos that were not previously thought to harbor life.

AUTHORS

(+) Rachford and Carlota A. Harris Professor in the Department of Microbiology and Immunology at Stanford University School of Medicine. First recipient of the Teal Innovator Award (2012) from the DoD and first recipient of an FDA grant for a "Bio-agent protection" contract and for a "Cross-Species Immune System Reference." Co-founder of several high-technology startups.

(§) President, Documatica Financial. Former P.I. on ARPA's "Forum" network collaboration project. Co-founder and General partner of five international venture funds (including NASA's Red Planet Capital) that spearheaded investment in over 60 startups in computer science, nanotechnology and healthcare. Recipient of the Jules Verne Prize. Co-author of the first computer-based map of Mars.

(*) Founder, Federico and Elvia Faggin Foundation for the study of consciousness. Inventor of the first commercial microprocessor (the Intel 4004) and of the self-aligned MOS silicon gate. Co-founder and CEO of Zilog, co-founder and CEO of Cygnet Technologies and of Synaptics. Recipient of the Marconi International Fellowship Award and of the 2009 National Medal of Technology and Innovation.

REFERENCES

1. Frank Drake first proposed his formula on November 1st 1961 at a conference in Green Bank, W.Va, estimating the number of civilizations in the Milky Way *whose electromagnetic emissions are detectable*. The seven parameters are: The rate of formation of stars suitable for such development; the fraction of those stars with planetary systems; the number of planets, per solar system, with an environment suitable for life; the fraction of suitable planets on which life actually appears; the fraction of life bearing planets on which intelligent life emerges; the fraction of civilizations that develop a technology that releases detectable signs of their existence into space; and the length of time such civilizations release detectable signals.
2. Shklovskii, I.S. and Sagan, C.: *Intelligent Life in the Universe*. (San Francisco: Holden-Day, 1966).
3. Dr. Drake's own solution to the Drake Equation reportedly estimates 10,000 communicative civilizations in the Milky Way. Many authors have proposed extensions of the formula, in particular D.S. Jones (2001), Zaitsev (2005), Hetesi & Regaly (2006), T. Dean (2009) and Govert Schilling (2011) or even declared its obsolescence (Dworsky 2007).
4. In 2006, The Planetary Society unveiled the first All-Sky Optical SETI (OSETI) telescope, operated by a Harvard University team and completely dedicated to capturing that one pulse of light that might be a communication. Over the years, the members have processed enormous amounts of data. With its 72-inch primary mirror, the OSETI Telescope is the only large telescope in North America devoted to SETI.
5. Vallée, Jacques: "Note on the probability of contact with superior galactic communities" in *Anatomy of a Phenomenon* (Chicago: Regnery, 1965).
6. Maccone, Claudio: "The statistical Drake equation" in *Proceedings of the 59th International Astronautics Congress*. Glasgow, September 2008.
7. The earliest experiments in ARPANET radio packet switching by Paul Baran in the 1960s used the frequency range of the control tower at San Francisco International Airport and were not detectable by commercial or aviation equipment at the time. Thus our own radio technology had already obsoleted itself in just a few decades through use of spread spectrum.
8. A major prediction of Albert Einstein's 1915 general theory of relativity was verified on September 14, 2015 by both of the twin Laser Interferometer Gravitational-wave Observatory (LIGO) detectors, located in Livingston, Louisiana, and Hanford, Washington, USA. Gravitational waves carry information about their origins and about the nature of gravity that cannot otherwise be obtained.
9. Archaea have been found in a broad range of habitats, including soils, oceans, marshlands and the human colon, oral cavity, and skin. Archaea are particularly numerous in the oceans, and the archaea in plankton may be one of the most abundant groups of organisms on the planet. Woese argued that this group of prokaryotes is a fundamentally different sort of life. To emphasize this difference, Woese later proposed a new natural system of organisms with three separate Domains: the Eukarya, the Bacteria and the Archaea, in what is now known as "The Woesian Revolution".
10. In the 1980s and 1990s, biologists found that microbial life has an amazing flexibility for surviving in extreme environments—niches that are extraordinarily hot, or acidic, for example—that would be completely inhospitable to complex organisms. Some scientists even concluded that life may have begun on Earth in hydrothermal vents far under the ocean's surface. According to astrophysicist Steinn Sigurdsson, "There are viable bacterial spores that have been found that are 40 million years old on Earth—and we know they're very hardened to radiation." On 6 February 2013, scientists reported that bacteria were found living in the cold and dark in a lake buried a half-mile deep under the ice in Antarctica. On 17

March 2013, researchers reported data that suggested microbial life forms thrive in the Mariana Trench, the deepest spot on the Earth. Other researchers reported in related studies that microbes thrive inside rocks up to 1900 feet below the sea floor under 8500 feet of ocean off the coast of the northwestern United States.

11. On April 12, 2016 Stephen Hawking, several other scientists and investor Yuri Milner announced *Breakthrough Starshot*, a \$100 million initiative to develop technology enabling dispersion of flotillas of miniprobes equipped with the ability to search for alien life. Accelerated to 20% of the speed of light, they would study the environment of nearby star systems.
12. Modern bioelectronics deals with the coupling of the worlds of electronics and biology, and this coupling can go both ways. The natural ability for “recognition” in the biological world, such as between two complementary DNA strands, can be combined with the power of microelectronics to process signals to build powerful new biosensors. At the same time, electronic devices can help “guide” biological events, for example cell growth, thereby creating new tools for biomedical research. This cross-fertilization between the two disciplines improves our understanding of life processes and forms the basis for advanced disease detection and treatment. Tools generated in this arena, such as medical diagnostics and brain implants, will dominate the future of healthcare. Alien forms of life could be using such abilities to enhance survival in extreme conditions.
13. Hoyle, Fred: *The Black Cloud* (William Heinemann Ltd, 1957).
14. Faggin, Federico: “The Nature of Physical Reality,” *Atti e Memorie dell'Accademia Galileiana di Scienze, Lettere ed Arti*, Volume CXXXVII (2014-2015), Padova, Italy.
15. An international meeting on UAPs was held at CNES Headquarters in Paris on July 8-9, 2014 with over 100 representatives of several French government agencies, invited speakers from seven nations, and private researchers. Since 1975 CNES has maintained a team of scientists (variously called Gepan, Sepra and Geipan) relying on formal agreements in place with French Airforce and other government agencies to monitor and screen reports of unidentified aerial phenomena.
16. Weinstein, Dominique: Computer database of UAP sightings by pilots, (Paris, 2016) private communication.
17. Corliss, William R.: *A Handbook of Astronomical anomalies*. (Glen Arm: The Sourcebook Project, March 1979). Also Vallée, J. and Aubeck, C: *Wonders in the Sky* (New York and London: Tarcher-Penguin, 2010).
18. Radin, Dean: *Entangled Minds: Extrasensory Experiences in a Quantum reality* (Paraview: Pocket Books, 2006).
19. May, Ed: *Anomalous Cognition: Remote Viewing Research and Theory*. (McFarland and Company, Inc., 2014).
