

Search for Extraterrestrial Intelligence

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Are we alone in the cosmos?

The question is the research subject of the American astrophysicist Frank Drake for over 50 years. On October 19, 2017, I attended to a lecture given by him, promoted by the Department of Astronomy of Cornell University, in Ithaca, NY. This lecture was part of the celebration of the 40 years of the Voyager 1 and 2 missions for the exploration of Jupiter and Saturn (see <https://www.nasa.gov/centers/jpl/missions/voyager.html>).

Frank Drake, 87 at the time, is a researcher at the SETI (*Search for Extraterrestrial Intelligence*) Institute and is known, amongst other things, by the “**Drake equation**”, which is a probabilistic formulation for the estimation of the number of intelligent and technological civilizations in the Milky Way galaxy, our galaxy, also called the Galaxy. Frank Drake considers an advanced civilization as one capable of having radio astronomy. It is a limited definition, but it makes it possible to estimate its number \mathbf{N} , which will be the result of the product of the factors of the equation:

$$\mathbf{N} = \mathbf{N}_* \times \mathbf{f}_p \times \mathbf{n}_e \times \mathbf{f}_l \times \mathbf{f}_i \times \mathbf{f}_c \times \mathbf{f}_L.$$

The estimations of the factors on the right-hand side of the Drake equation are shown below and were put forward by Carl Sagan (1934-1996) in chapter XII of his book **COSMOS**, where a more thorough discussion of the equation

and of the reasons for the choice of each factor can be seen. The factors are then:

\mathbf{N}_* = number of stars in the Galaxy ($4 \times 10^{11} \equiv 400$ billion)

\mathbf{n}_p = fraction of stars with planetary system (1/3; 100% is the modern value, see below)

\mathbf{n}_e = number of planets, in a given system, ecologically suitable for life (2; in the solar system, for example, one has Earth, possibly Mars, Jupiter and Titan, a satellite of Saturn, being, therefore, 2 a prudent number)

\mathbf{f}_l = fraction of suitable planets in which life really blossomed (1/3)

\mathbf{f}_i = fraction of inhabited planets in which intelligent life evolved

\mathbf{f}_c = fraction of planets inhabited by intelligent beings in which a communicative technological civilization developed ($\mathbf{f}_i \times \mathbf{f}_c = 1/100 \equiv$ one percent)

\mathbf{f}_L = fraction of the duration of planetary life favored by a technological civilization ($1/10^8 \equiv$ one per 100 million; fraction characteristic of Earth, that has life with some billion years and a technological civilization characterized by radio astronomy of only some decades)

With the relatively arbitrary factors adopted above (with the exception of \mathbf{N}_*), we obtain $\mathbf{N} = 10$ planets with advanced intelligence in the Galaxy. We are sure that \mathbf{N} must be at least equal to 1 (the Earth!) but, if we have erred in some of the factors above, \mathbf{N} could be much larger than 10. Only the technological development will enable us to a more precise estimation of the factors of Drake's equation and consequently of \mathbf{N} .

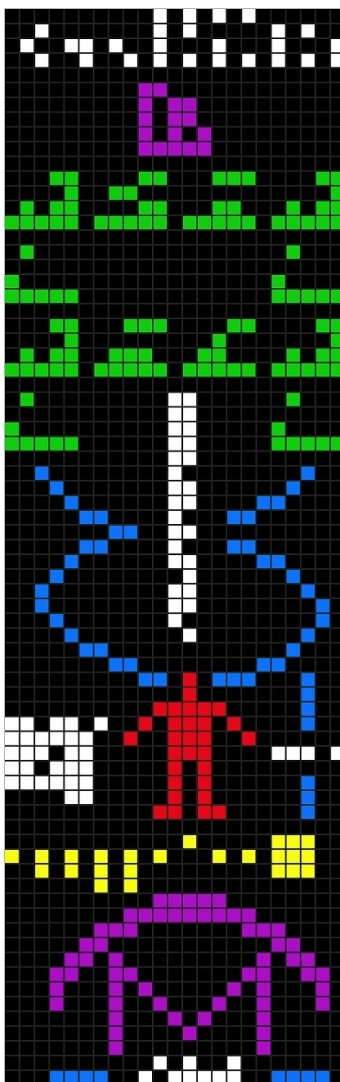
Let's go back now to Frank Drake's lecture. Next, I enumerate some points I found interesting, not exactly in the order they were presented but according to my recollections.

- 1) The scientific interest for the search of extraterrestrial intelligence dates back to XIX century with the German physicist, mathematician and astronomer Carl Gauss (1777-1855) and the Italian physicist and inventor Guglielmo Marconi (1874-1937). Marconi tried to send radio signals to space, but he would not succeed due to the fact that the frequency he used does not go out (nor comes in) the Earth, because it is blocked by the atmosphere.

- 2) Nowadays, the SETI research uses radio telescopes all over the world, such as, Parkes, 65-m aperture, in Australia, Green Bank, 100 m, United States, Arecibo, 305 m, Puerto Rico (United States; it was damaged by the 2017 Hurricane Maria, but it will soon return to full operation), FAST (*Five-hundred-metre Aperture Spherical Radio Telescope*), 500 m (400-m effective), China, the largest radio telescope in the world.
- 3) SETI is beginning to adopt visible light in its searches, an old idea, but only now starts to be used. Laser beams are directed to all regions of our galaxy and detectors try to observe pulsating lasers eventually transmitted by extraterrestrial civilizations.
- 4) Pano-SETI or *Panoramic SETI* is a new SETI project that aims at observing all the sky continuously. There exists on average 1 star per 24 cubic light-years in the Milky Way and according to the results of the Kepler probe all stars have planetary systems and 1 in 5 stars has planets in the so-called “habitable zone” (region around a star that offer similar conditions to those prevailing on Earth to the development of life).
- 5) In 1974 there was a great investment for the reform of the Arecibo radio telescope that had been inaugurated in 1963. It is located on the island of Puerto Rico, an United States territory in the Caribbean sea. To commemorate the reinauguration of the telescope, Drake and colleagues had the idea of using the telescope to send a message to our likely neighbors of the Milky Way. The message could not be long in order not to bother the authorities — it was a monotonous radio signal coded in such a way to correspond to an audible sound signal. The radiofrequency used was 2380 MHz, which corresponds to the wavelength of 12.6 cm. The message should contain images and information in the form of a sequence of binary numbers (0 and 1), so as to be understood by a civilization that has the logical characteristics of a intelligent mind — that was the idea of Drake and colleagues. And so, they did. With the technology of the time, the message was sent at a rate of 10 bit/s for 3 minutes, that is, $10 \times 3 \times 60 = 1800$ bits = $1800/8 =$ simple 225 bytes (1 byte = 8 bits).

Exercise: look at the image of the Arecibo message below and count

the approximately 1800 little squares, 1 bit for each one; anyone wanting to check his counting with the exact number of bits in the image may email me (dsoares@fisica.ufmg.br).



The **Arecibo message** was sent on November 16, 1974 by the Arecibo radio telescope. The colors are just for illustration.

6) The great difficulty of SETI is the profusion of spurious local radio

signals and especially signals from artificial terrestrial satellites. There are about 200 satellites in Earth orbit emitting signals (communication, meteorological, military, etc.). All those signals must be identified and excluded from the data base.

- 7) SETI counts primordially with private funding for its researches, because governmental agencies have difficulties in accepting research projects that have no perspective of an ending. The success, or failure, of the search for extraterrestrial intelligence cannot be predicted. Drake cited the example of a Russian immigrant and investor that has made a commitment to ensure to the SETI Institute a non-repayable grant of 100 million dollars in 10 years. His name is Yuri Milner.

As we see, the Search goes on and with the trends of increasing sophistication, keeping up with the scientific and technological development of humanity.