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WHERE ARE THEY? - FERMI PARADOX OR GREAT SILENCE OF THE UNIVERSE AND ITS IMPLICATIONS

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Abstract

Fermi paradox and attempts to find a solution have been reviewed and discussed. Also, an overview of the attempts to search an extraterrestrial intelligence has been provided as well as of the planned cosmic missions which could contribute to the search for extraterrestrial life and its origin

Keywords: Fermi paradox, extraterrestrial life, Astrobiology, SETI project, universe

1.Introduction

When someone looks at the starry night sky, he sometimes wonders if we are alone. Are there other civilizations of a similar level of knowledge, who would like to establish a connection with us? Today, this is a question of astronomers, dreamers, poets and those who dream of looking at the stars, but four centuries ago Giordano Bruno was burned in the Piazza dei Fiori in Rome among other 'sins' and because he preached the existence of many inhabited worlds.

This question, are we alone, was present from ancient times. The existence of many worlds, possibly like Earth, assumed Anaximander (VI century BC), Xenophanes of Colophon (565–488. BC), Diogenes Apolloniates (510–400. BC), Anaxagoras (500–428. BC), Leucippus (V century BC), Democritus (460–370. BC), Epicurus (341–270. BC) and many others. We could find it in some form and in the *Hexameron* [1], the most important work of Basilius the Great Archbishop of Caesarea and Saint of the Eastern and Western Christian Church [2].

If we look the next passages of the first speech:

"Therefore in their opinion, that the universes are ungoverned and unruled travelling randomly, they were deceived by their atheism which they had inside them" [1]. And further:

"…so does also the Creator of this Universe, His creative power is *not confined within the measures of one world only, but it is infinitely greater*".

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With these passage, Saint Basilius (Figure 1.) try to answer, by intuition, a cosmological but also theoretical problem, tormenting and Giordano Bruno: Is our world unique in the context of natural creation? To consider this question it is not necessary to be a professional astronomer.

Figure 1. Saint Basil the Great [https://greenchurches.ca/wp-content/uploads/2018/08/basil.jpg]

Namely, astronomy differs from other sciences, since in addition to not so many professional astronomers, it also relies on an 'army' of amateur astronomers. Even without the study of astronomy, a person can enter the history of this science, while, say, amateur medicine is considered quack doctor. For example, William Herschel, the man who discovered the planet Uranus, the first that was not known to the ancient peoples, was by profession a musician - organist in a church in the English city of Bath. He discovered the new planet from his backyard, with a telescope he constructed himself. There are a lot of such cases. Amateur astronomers have discovered a number of new comets, and minor planets.

An interesting example of how someone entered in the history of this science just because of one question, is the Nobel laureate Enrico Fermi. On one occasion, in 1950, when during a lunch was a discussion how many technological civilizations there are in our Galaxy, assuming, given its age, that there are thousands and even millions of inhabited worlds, Enrico Fermi, listening how numerous they are, asked

'Where is everybody?'. This question was the reason why the non-existence of signs of the existence of at least one civilization outside the Earth is called the Fermi paradox. Some even called it the Great Silence [3], the Astrosociological Paradox [4], or simply: "Why is it too damn quiet in the universe around us?" [5]

The interest for this question could be seen from numerous literature as for example [6-12].

As early as in the nineteenth century, there were several proposals how to establish a connection with extraterrestrial civilizations. Thus, the famous mathematician Carl Friedrich Gauss, who was also interested in astronomy, proposed in 1830 that a huge triangle-shaped forest with three squares on its sides should be made in Siberia, so that the aliens could see that we know Pythagoras' theorem.

Karl Janski from Bell laboratories, discovered in 1931 radio waves from the Sun. This was the birth of radio astronomy. Giuseppe Cocconi and Philip Morrison published in 1959 in the journal *Nature* an article [13,14], in which they proposed radio astronomical methods for the search of extraterrestrial civilizations.

The most important events that follow are:

1960 - Frank Drake begins the OZMA project [15,16], the first search for extraterrestrial intelligence. Two solar-type stars, Tau Ceti (11.9 light-years from Earth) and Epsilon Eridani (10.7 light-years) were observed over two weeks from the National Radio Astronomical Observatory in West Virginia.

1961 - The first SETI Conference (acronym for Search for Extra Terrestrial Intelligence (see Drake [17-19]) was held in Green Bank, California. At this Conference Frank Drake presented his famous equation for estimating the number of civilizations in our Galaxy - Milky Way, that can communicate with other civilizations.

20-23 May 1964, a scientific conference on extraterrestrial civilizations was held in Byurakan, Armenia, with the participation of legends of Soviet astronomy Iosif Shklovsky, Dmitry Martynov and Nikolai Kardashev, who exposed there his division of alien civilizations into three types:

Those who use resources of their planet and move freely everywhere on it (type III). These are civilizations with a level of development similar to ours. Their need for energy is of the order of 10^{20} erg / s. Type II are civilizations that control the energy radiated by their star. The need for energy per second is equal to the energy radiated by the Sun ($4 \cdot 10^{33}$ erg / s). Traces can be seen up to ten million light-years away. Civilizations that use the energy of their galaxy and move around it are of the first type. Their energy needs are about 10^{44} erg / s, and traces can be observed up to ten billion light years [20, 21].

The aforementioned three celebrities of Soviet astronomy convened a press conference on April 12, 1965, at which they announced the discovery of traces of the activities of the civilization of the first type. After a few days, they gave a denial. The false alarm was caused by the quasar CTA 102, and the first idea was that it was a grandiose engineering work that should provide energy to the civilization that rules its galaxy.

Anthony Hewish and Jocelyn Bell, who discovered the first pulsar in 1967, were more careful. Although the precision and speed of the pulsations first led them to think that it was the message of an alien civilization, they did not rush in and announced the discovery when they investigated what it was about.

1971 - An international scientific conference on extraterrestrial civilizations is held at the Byurakan Astrophysical Observatory.

1972 – 'Pioneer' 10 and 11 are sent with plaques (Figure 2.) with the message to alien civilization who might find them. In front of the silhouette of the ship are a man and a woman. Above is the transition scheme of the hyperfine structure in the hydrogen atom in the ground state, in which the proton or nucleus of the atom changes the direction of rotation, ie spin. This transition originates the radio line of 21 cm. The message is that this line should be used for communication. To the left of the ship is the position of the Sun in relation to the 14 pulsars and the center of the Galaxy, and below are the Sun and the planets with information from which of them the ship started.

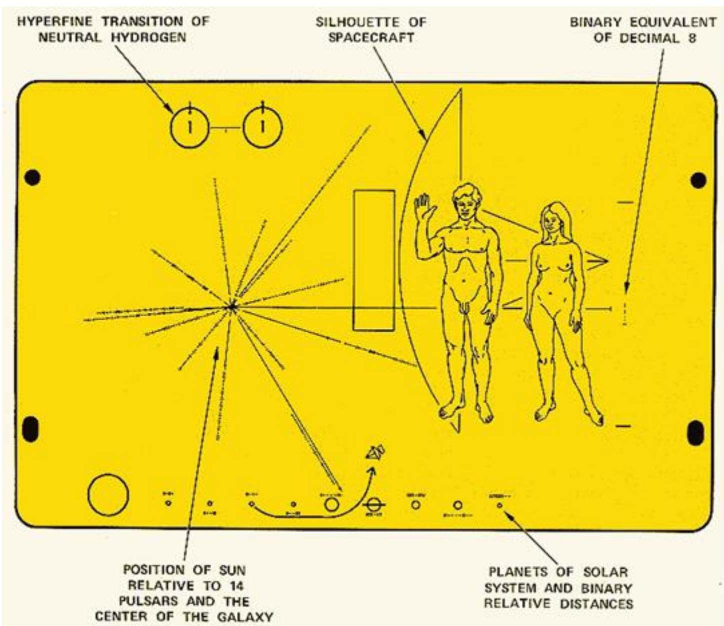

Figure 2. Plaque on the spaceships 'Pioneer' 10 and 11.

1974 - On November 16, 1974, Drake and Oliver send a radio message to the globular cluster M13 in the constellation Hercules from a 300-meter radio telescope in Arecibo, Puerto Rico (Figure 3.). It is 23,000 light-years away and contains almost 30,000 stars. The signal is set so that when it gets there, due to scattering, it will be so wide that it will irradiate all the stars in the cluster. Although this act was largely symbolic, as the eventual answer would arrive after 46,000 years, it aroused great attention.

1977 – 'Voyager' 1 and 2 are sent into space with disks that record sounds from planet Earth.

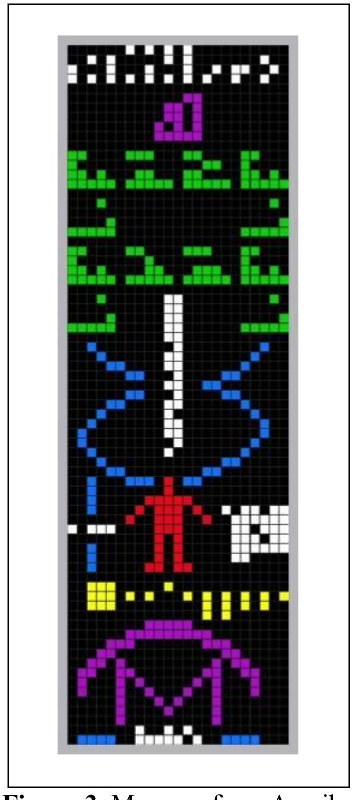

Figure 3. Message from Arecibo

1982 - At the General Assembly of the International Astronomical Union in Patras, its Commission 51 dedicated to the search for extraterrestrial life is established. The first president was Michael Papagiannis and the vice presidents were Frank Drake and Nikolai Kardashev.

1996 - US President Bill Clinton announces at a press conference that American scientists have discovered in meteorite ALH8001, originating from Mars, which was found in Antarctica, fossilized traces of life from this planet. These conclusions were controversial from the beginning, and finally had been rejected when all the unusual features in the meteorite had been explained without requiring life to be present

How many interacting civilizations are there in our Galaxy today? The answer to this question is very important for the strategy of the SETI program and one attempt to answer is the equation formulated by Frank Drake in 1961, which bears his name. It is especially interesting because it represents an analysis of factors that determine the number of such alien societies. Drake's equation is:

$$N = N^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot f_L ,$$

here N^* represents the number of stars in the Milky Way galaxy, and current estimates are around 100 billions. A part of these stars, that have planetary systems, is marked with f_p, and estimates are 20% to 50%. The number of planets per star with a planetary system that can support life is represented by a quantity n_e, whose value is from 1 to 5. With f_l is given a part of the planets that can support life, where it was actually evolved. This is one of the critical factors as current assumptions range from 100% (where life can evolve) to close to 0%. The next coefficient, f_i is the part of the planets on which there is life, where it has become intelligent. And for him, the proposals range from 100% (reason is such an advantage for survival that it will surely develop) to close to 0%. What percentage of intelligent societies have the ability and desire to communicate? The answer to this question is described by the quantity f_c and it is assumed that there are 10-20% of such civilizations. Among the critical factors is f_L, which describes the period of the planet's existence during which communicating civilizations survive. If we take the Earth as an example, the life expectancy of the Sun and our planet is roughly ten billion years. We have been communicating with radio waves for less than a hundred years. How long will our civilization last? Will we be destroyed in the near future or will we solve our problems and last for thousands of years? If we disappear tomorrow the answer is 1 / 100,000,000. If we survive 10,000 years the answer will be 1 / 1,000,000. When all these factors are multiplied, we get N, the number of communicating civilizations in our Galaxy.

Based on this equation, Drake and Sagan estimated the number of civilizations in our Galaxy able to communicate with us, at one million. Is this result realistic? Then Enrico Fermi justifiably asks, 'Where is everybody?'

Fermi's question imposes another ... Where and how should we look for them? Shklovsky concluded that it is best to examine stars of the late spectral type, i.e. the type of the Sun, with a low speed of rotation. Namely, stars of early spectral types usually have a mass larger than the Sun, and if the star is more massive, thermonuclear reactions in its interior are more intense and its lifespan is shorter, so there is not enough time for a communicating civilization to develop. Also, the low speed of rotation of the star indicates that it shared its moment of rotation with the planetary system around it.

Intense scientific controversy was also caused by the question of which wavelengths are most suitable for communication with a civilisation of a similar level of knowledge [13, 14, 21-24]. In 1959, Coconni and Morrison were the first to propose a radio line of neutral hydrogen at 21 cm, as a magic line for the SETI program. It is a transition between two levels of hyperfine structure in hydrogen in the state with the main quantum number 1. Hydrogen is the most abundant chemical element in space, so radiation at this wavelength comes from all sides, the line is in the radio range, which is important for the SETI program, which uses radio astronomical methods, and stands out among others, since it occurs when the nucleus of the hydrogen atom in the ground state, i.e. the proton, changes the direction of rotation, i.e. spin. Later, others suggested suitable wavelengths, which stand out with their noticeable uniqueness, high prevalence and optimal in space conditions. Thus, for example, Kardashev [21] proposed a wavelength of 1.5 mm, which is the maximum in the frequency distribution of background radiation. Special satellites intended for background radiation research, COBE and WMAP, investigated it in detail and very precisely, but no message was noticed.

In order to elaborate the search strategy for aliens, it should be established what we are looking for, ie what are signs of the existence of advanced civilizations. Frieman Dyson pointed out [25-32], that a civilization of the type II in Kardashev's division, could make a thin shell in the space, which would collect the radiation of their star, in order to use it as a source of needed energy. Since work done on an object generates heat, and that is actually infrared radiation, Dyson suggested to search the stars that have an inexplicable lack of radiation in the visible and mysterious surplus in the infrared part of the spectrum. Since all sources of energy are known to be fully ineffective in comparison with the annihilation of matter and antimatter, when the efficiency is one hundred percent, Harris is looking for traces and consequences of the use of antimaterial fuel [33, 34]. Annis pointed out [35] that if the third type civilization uses the starlight of its galaxy to meet energy needs, it will no longer be in accordance with the laws of proportion between surface shine, star distribution radius, and thermal speeds of stars. In graphics that show this proportionality, such a galaxy will be curled and could be easily perceived.

When in 1990, Hubble telescope (Figure 4.), with a mirror of 2.4 m, had been launched into orbit, astronomers obtained a new, extremely powerful instrument for searching for extraterrestrial civilizations. Although images of different, sometimes very strange cosmic objects were obtained by it (Figure 5.), no traces of activities of the second or third type civilizations were observed.

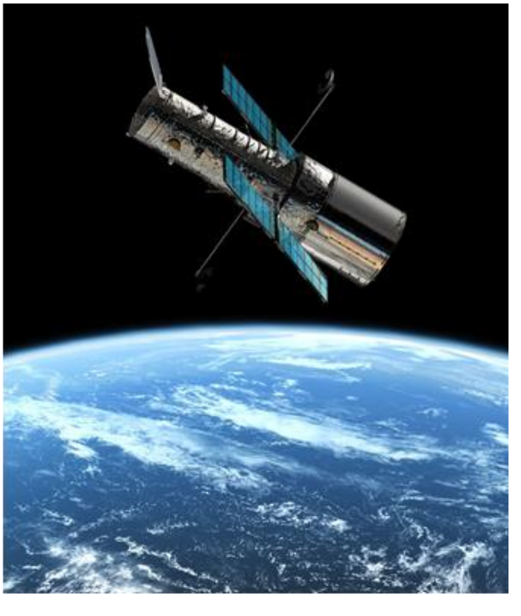

Figure 4. The Hubble Space Telescope [https://www.esa.int/ESA_Multimedia/Images/2010/04/The_joint_ESA_NASA_Hubble_Space_Telescope]

For example, Weinberger and Hart, from Innsbruck, together with their everyday astronomical activities, have studied different surveys of heaven, databases and star atlases, searching for the presence of aliens. They published [36] that they found no traces of existence of civilizations of the type II and III, 10000 - 20000 light years around us.

Figure 5. The Helix Nebula (also known as the 'Eye of God', NGC 7293 or Caldwell 63) is a planetary nebula (PN) located in the constellation Aquarius [https://wallpaperaccess.com/gods-eye-nebula]

Drake and Sagan were thinking about the large number of communicating civilizations in our galaxy. Frank Tipler went to another extreme and proposed his solution to Fermi's paradox [37-40]. Our civilization is unique in the galaxy! Let's consider what is probability that the advanced forms of life will develop. Our planet is about 4.6 billion years old and the fossil remains of microorganisms indicate that life existed around 3.77 billion years ago, and possibly is 4.28 billion years old [41]. Developed forms were created just much later, and we started trying to establish communication only in the last sixty five years (counting from the project OZMA in 1960).

It means that almost five billion years should have passed from the planet's occurrence that humanity would become a possible interlocutor with aliens. In addition, the latest research shows that the age of our universe is 13.8 billion of years, which is only three times higher than the age of our planet.

It should also be taken into account that in the early Cosmos, some technological civilization could not develop. Only hydrogen, helium and very few lithium atoms were created in the times of Big Bang (Figure 6.). All other elements in us, carbon, calcium, phosphorus ... are created in thermonuclear reactions in the interior of stars and dispersed in space during their explosions. The cosmos is slowly chemically enriched and it was long to pass to be chemically rich enough to enable the development of beings as we are. This greatly influences on the reduction of possible number of civilizations that existed or exist in our galaxy.

Tipler shows that it is high probably that, if developed, a civilization will relatively quickly explore the entire galaxy. It is enough to send to the stars, computers that will behave like Von Neumann self-replicating machines. For example, if an average distance between the stars, R, is five light years, and the cosmic ships travel at speed V = 0.1 c - speed of light, travel time t to adjacent star will be 50 years. If one sends two computers, each of which make two more and send them further, they will spread by geometric progression through the Galaxy with the speed of 5 ly for 50 years, or 1 ly for 10 years, and for 10 × 100 000 = 1 000 000 years they will pass through 100 000 ly, or the way equal to the proportions of our galaxy. Comparing to the age of the Earth of rounded 5 billion years, this is negligibly little. Based on that, Tipler concludes that a galaxy either flourish of life or the life is an extremely rare occurrence in it, and that we may be the only civilization in the Milky Way.

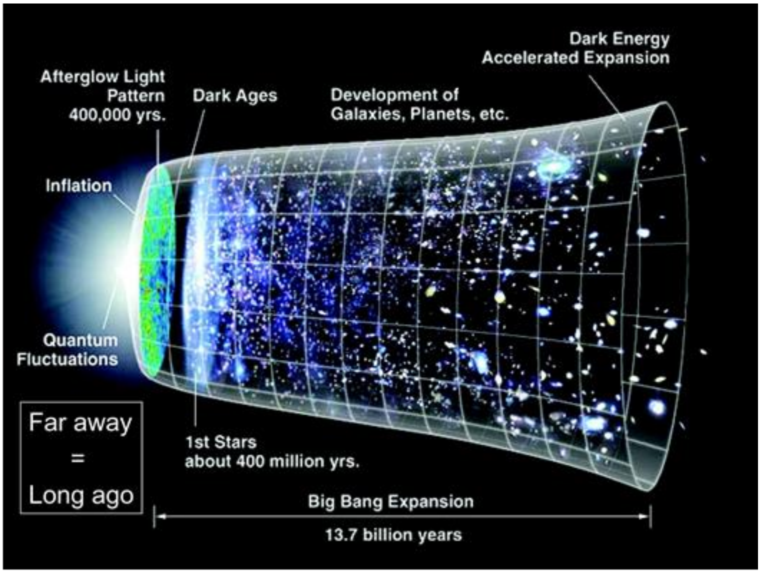

Figure 6. The history of evolution of cosmos [https://astronomy.com/news/2014/11/gravity-may-have-saved-the-universe-after-the-big-bang]

Michael Papagiannis [42-45] analyzed what colonization of the Galaxy would look like if large space stations capable of accommodating 100 to 1 000 people were sent instead of Tipler's computers (Figure 7.). They could be built in orbit around the Earth as today's space stations, and it is relatively easy for them to become interstellar travelers. If we take V = 0.02 c and R = 10 ly for the values of their speed and mean distance between stars, then the colonists will come to the next star for 500 y. If we assume that the colonists would need 500 y to send the next expedition, the wave of colonists would move through the Galaxy at a speed of one light year for hundred years and, relatively quickly in comparison to the age of the Earth, humanity would populate the entire Galaxy (see also [46, 47]).

Critics of the theories about a large number of civilizations in Milky Way, have underlined that if there are a million civilizations today, according to Drake and Sagan, if we take those that existed in the past, that number could reach a billion and it would be enough to study nearby stars to find their tracks.

Those who doubt in the rapid settlement of planets around other stars, mention the cost of such an endeavor, the energy needed to accomplish it, and especially the motivation.

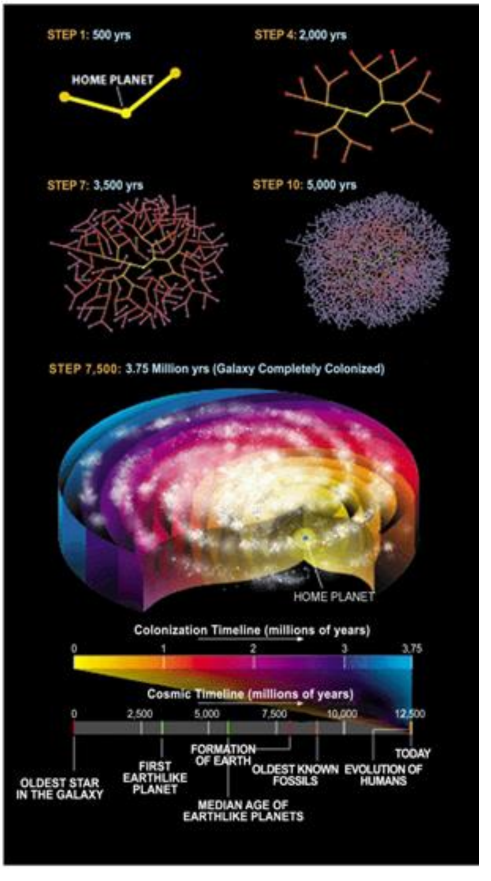

Figure 7. A model of colonization of Galaxy [https://waitbutwhy.com/2014/05/fermi-paradox.html]

The day before the colonists board the spaceship, the intellectual capital of the whole planet is available to them; for the specialization of necessary jobs and their distribution, they have the human potential of all mankind; there is infrastructure and goods that have been accumulated for hundreds and even more than a thousand years and collected knowledge of available natural resources.

On the first day on the new planet, interstellar travelers will have only their intellectual capital and the one who is 'trapped' in books. And how easy it is to make, say, an airplane where you only have the appropriate descriptions of the necessary procedures. Specialization and division of labor can be done only among the colonists, which of the goods and infrastructure possess only what was brought on the spaceship, and their knowledge of available natural resources is very superficial.

A possible solution of Fermi's paradox is that the drastically reduced standard of living and technological level of the new interstellar colony demotivate potential space travelers, whose children would have the life standard of America's first colonists.

Annis [48] assumed, that one of the possible solutions is the existence of some mechanism of global regulation, some dynamic process that prevents or prohibits the uniform occurrence or development of life throughout the Galaxy. These can be for example gamma bursts, which have a sterilizing effect on relatively large areas.

In any case, the presented facts indicate that galaxies probably have some kind of phase transition on a relatively short time scale from a mostly dead place to the one filled with life of great complexity.

The traditional view of the special creation for humanity, made by Lord or 'cosmic mind', has no problem with Fermi paradox. The discussion about this solution can be found in Refs. [49, 50] (see also [51, 52]).

Ćirković [6] considered a large number of possible solutions of Fermi paradox, dividing them mainly in hypotheses including extraterrestrials, 'rare earth' and catastrophic hypotheses.

In the first category are hypotheses like UFOs of extraterrestrial intelligent origin (e.g. [53]). It can also be assumed that there are many type II and III civilizations without any interest in communicating with us (Hypothesis of the ZOO park where we are in a cage, see Ball [54-56]) or that advanced cosmic civilizations forbid contact with us [57] due to ethical or other reasons [58]. In this group, Ćirković [6] includes and the hypothesis of Bostrom [59], that we maybe live in a computer simulation made by an advanced technological civilization from the 'real' universe.

The 'Rare Earth' hypothesis is based on the facts [6]:

- that a planet which is habitable should be in a habitable zone around its star which is narrow;

- that a large moon, stabilizing the planetary axis, which is crucial for the long-term stability of climate is a 'Rare Moon'.

- A giant planet ('Rare Jupiter') at right distance to partially protect the planet deflecting much of dangerous comets and asteroids and considerably decreasing possibility for impact catastrophes.

- 'Rare elements' (especially U and Th) sufficiently present in the interior of the planet in order to enable plate tectonics as well as to enable the good functionality of the carbon-silicate cycle.

- Ćirković [6] also underline the need for 'Rare Cambrian-explosion analogs', episodes of sudden diversification and expansion of life, needing very special physical, chemical and geological conditions.

We see that the realization of each of these conditions is very rare, so that realization of all together is extremely rare, maybe unique in our Galaxy.

Here enters in play the anthropic principle of fine-tuning including a number of other facts and constants which enable that we exist. For example, George Gamov concluded that if the speed of light is greater than ~300 000 km/s, stars would live shorter because they would faster spend their fuel, and it would be impossible to develop a civilization like ours needing more than four billion years for that. If the speed of light is smaller, the chemical elements needed for life would be captured in stellar rests, because the explosions of supernovas, needed for chemical evolution of cosmos, will be very rare.

One of non-Copernican hypotheses explaining the 'fine-tuning' is that this is made by Lord or a 'Cosmic Mind'.

Here may be mentioned and the hypothesis of Wesson [60] that, due to enumerated facts with very small probability, within our cosmological horizon only few civilizations are located.

In the group of catastrophic hypotheses enters and the above mentioned proposition of Annis [48], of the existence of dynamic process that prevents the development of life throughout the Galaxy. Besides the sterilizing gamma bursts, Ćirković [6] enumerates the risk of cometary/asteroidal bombardment [61-63], super volcanism [64], nearby supernovae [65, 66]. Some hypotheses based on selfdestruction of advanced civilizations are enumerated in [67]. One of attempts to explain Fermi paradox is, that majority of technologically advanced civilizations in our Galaxy finally end by selfdestruction or in one of enumerated catastrophic events.

Among the interesting propositions for solution of the 'Great silence of the Universe', is that advanced civilizations after exhausting natural resources in a part of the Galaxy, move further, leaving the wasteland. According to this hypothesis, there is no other civilizations around us because our Solar system and its surroundings are just in such 'post colonization wasteland' [68, 69].

Ćirković and Bradbury [70] proposed that the solution might be the fact that advanced technological civilizations would try to extremely optimize the use of available resources. Since such extreme optimization will be limited by the temperature of surrounding space, and since the temperature decreases with the increasing of the distance from central parts of the Milky Way, they assume that the logical conclusion is that majority of the advanced technological societies will migrate towards the outer edges of the Milky Way in order to avoid energetic astrophysical events and processes.

It should be mentioned that still Tsiolkovsky [71], under the influence of Russian cosmists, assumed that we cannot notice the manifestations of activities of older civilizations since they evolved in 'something else', in a 'super mind' with God-like powers and capabilities and with interests and objectives not conceivable by us. Consequently, we cannot recognize them as a civilization and cannot establish they presence and find manifestations of their activities with a SETI program.

The big impulse for the development of ways and strategies for the search for extraterrestrial life, was the discovery of the extraterrestrial planets. First detections of exoplanets around pulsars, in 1988 and 1992, have been confirmed later. The first exoplanet, orbiting around a star, 51 Pegasi, has been discovered in the fall of 1994 by Didier Queloz and Michel Mayor (Figure 8.). They published their discovery in 1995 and in 2019 received the Nobel prize for it. On 14th February of 2025, there are 5834 confirmed exoplanets. Besides the planets orbiting around other stars there are and rogue planets without a star.

On the basis of Kepler mission data, one can suppose that there are 100 billion stars in our Galaxy and a G-type (Solar type) star fraction of 0.041. Bryson et al. [72] estimated that there are at least 287 million rocky planets orbiting, in habitable zone of Solar type (G-type) stars in the Milky Way. Are all they lifeless or various forms of life are there?

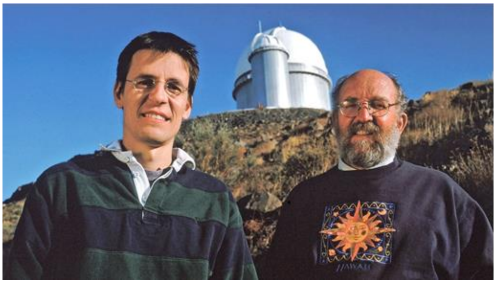

Figure 8. Didier Queloz and Michel Mayor, 2019 Nobel prize winners for discovery of the first exoplanet [https://astrobiology.nasa.gov/news/exoplanet-science-flying-high/]

The near future will give to astronomers new opportunities to search for life outside our planet, first of all on very numerous exoplanets. *The Large European Telescope* (LET) of 39.3 m should see the first light in 2028, for the wavelength range of 0.4 - 21 µm. The 39 m telescope will make it possible to obtain photographs of exoplanets in habitable zones (Figure 9.), study the characteristics of their atmospheres and search for signs of life.

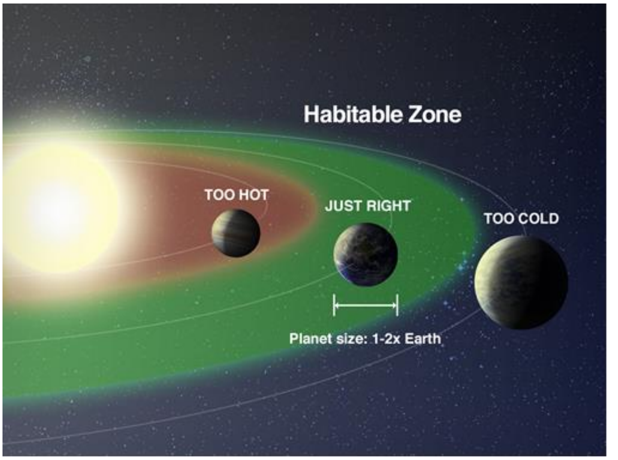

Figure 9. Habitable zone around a star [https://earthsky.org/space/small-rocky-exoplanets-can-still-be-habitable/]

On 25th December 2021, the 6.5 m *James Webb* space telescope, has been launched. It works at wavelengths of 0.6 - 27 µm, i.e. in the infrared area, suitable especially for examining exoplanets and the cold Universe. In addition to other problems for which it is intended to study, it should also study the formation of galaxies, stars, protoplanetary and planetary systems and the origin of life.

Astronomers are also planning a series of very interesting space missions. For example, The European Space Agency (ESA) mission the *JUpiter ICy moons*

Explorer (JUICE) has been launched on 14th April 2023. Its objective is to make multiple flybys of Jupiter's satellites Ganymede, Callisto, and Europa and then to go into orbit around Ganymede. The science goals focus on Jupiter and its three moons, where under surface ice maybe exist conditions favourable for life. Additionally, for 2028 is planned *Dragonfly* - NASA quadcopter drone mission to Titan, the biggest satellite of Saturn. *PLAnetary Transits and Oscillations of stars* (PLATO) mission is planned for launch in 2026. One of the most important mission goals is to search for earth-like planets in the habitable zone around sun-like stars where water can exist in liquid state. Particularly interesting is the mission named *Atmospheric Remote-sensing Infrared Exoplanet Large-survey* (ARIEL), a space telescope planned for launch in 2029. One of the main aims of this space mission is to observe one thousand planets orbiting around distant stars and also to make the large-scale survey of the chemistry of exoplanet atmospheres. With the help of a spectrometer on the board, the chemical fingerprints of gases in the planets' atmospheres will be determined and investigated.

Obviously, astronomers and astronomy enthusiasts will not be bored in the 21st century. All of the above indicates that Fermi's question: 'Where are everybody?', is still without a completely clear and satisfactory answer. Probably, among the countless galaxies in the Universe, some are full of intelligent life, but the distances to them are so great that, due to limitation by speed of lights, communication is possible only theoretically. The answer to our eventual message to the nearest galaxy, Andromeda, the humanity would wait around five million years.

As we saw, there are many possible solutions of Fermi paradox. There may be other civilizations around us, but they live and flourish relatively shortly. Most become type I and do not develop further. Maybe civilizations of type II and III, if exist, have no interest or will to show themselves and to communicate with us. Finally, it is possible that we are alone in our Galaxy. That we are the first here, and that our descendants, if we do not destroy ourselves beforehand, will move from star to star and become lords of the Galaxy. On their way, maybe would not encounter a rival.

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