

Emil Betak - Franc Cvelbar*

DISCOVERIES AND OTHER INFORMATION IN PHYSICS AND ASTRONOMY OF THE LAST DECADE, WHICH HAVE A POTENTIAL TO INFLUENCE OUR VIEW ON THE UNIVERSE

In the last decade, natural sciences (sometimes called exact sciences) have nearly every week brought some discoveries or important news, which have consequences on our understanding of the world and the whole Universe, its past and future, and which may stimulate possible new philosophical look at the world and human beings in it.

We have selected several such cases and will try to present them to colleagues working outside the natural sciences to serve as motives for their work: i) Water, the basic liquid for our life, seems to be much more abundant (though not in clear form without ingredients) on and inside the Earth and in the Universe than was assumed still a decade ago. What does it mean and which are the consequences for us? ii) Is our Earth the only place of intelligent life in the Universe or not? What do both these possibilities mean for us, for philosophy, ethics and theology? iii) Nature is full of various surprises, which may come as a disaster in a global scale. Are we prepared to cope with them?

Keywords: Water in the universe, life beyond Earth, habitable zone, threats from universe to our Earth.

1. Introduction

There has been, is, and will be a long discussion about the origin, present state and about further destiny of our Earth and the Universe. Some of the results of the so-called exact sciences - especially in the 19th and in the first half of the 20th century - seem to contradict the Bible and were used as arguments against religious (Christian) approaches to the world. Discovery of the expansion of our Universe, and consequently the idea of the Big Bang indicated that there was a beginning of both space and time. Since that, a lot of progress has been achieved both in exact sciences and in theological approach to and understanding of the question. Currently, the Big Bang is taken as a fact, which occurred some 13.8 billion years ¹ ago. Other discoveries and ideas (to name only some of physics and astronomy) with deep impacts on our understanding of the world, were the emergence of quantum physics, discovery of the expansion of the Universe and the possibility of its huge inflation which at the extremely early times increased enormously the size of the Universe, ideas of dark matter and dark energy, which left only less than five per cent of the total mass for the matter as we usually understand it, the discovery of the Higgs boson (so-called the God's particle), detection of gravitational waves, etc.

We leave aside different possible explanations of the Exodus of Jews from Egypt across the Red Sea [1 and 2], the Higgs boson (rather often referred to as "the God's particle") and also gravitational waves, because these topics were subjects of many papers in the last years. We restrict ourselves to three wider topics which will be discussed below, namely *i)* the existence of (yet undiscovered) water on our Earth and elsewhere in the Universe; *ii)* is there an (intelligent) life in the Universe outside of our Earth?; and *iii)* possible (and/or probable?) threats to the life on our Earth.

2. Water in the Universe and "at home"

Water as the important chemical compound, which is necessary for the very existence of life (at least of the kind of life we know), was in the focus of investigations of bodies outside of our Earth. Some water was found in comets, which (even though they are able to extend their tail sometimes up to more than 100 000 000 km), however, are of negligible mass. Practically all mass of a comet is in its nucleus, which is usually less than 50 km in diameter. NASA already reported liquid water on Mars (see e.g. [3]), but the winners of this undeclared competitions are probably the moons of big planets, Jupiter and Saturn. Saturn's moon

* ¹Emil Betak, ²Franc Cvelbar

¹Institute of Physics, Slovak Acad. of Sci., Bratislava, Slovakia

²J. Stefan Institute, Ljubljana, Slovenia

E-mail: emil.betak@savba.sk

Enceladus, which has been a suspect already for a decade (Cassini orbiter found hydrothermal vents of salty vapor from the interior near Enceladus south pole in 2005, and the subsequent flybys confirmed ocean of about 10 km depth below 30 or more km of ice), hosts deep beneath its ice real oceans of water. If we consider only the confirmed Enceladus oceans, a rough estimate of their contents of water is about 50 times the amount of water in all oceans on the Earth together [3 and 4]. As Enceladus is relatively small (about 500 km in diameter), the assumed reason for keeping its interior hot is gravitational interaction between Saturn and its moon. The Enceladus conditions (salty warm water) lead some scientists to consider the possibility of life there [5]. Enceladus' "bigger brother", Jupiter's moon Ganymede (diameter about 5300 km), also signals presence of ocean(s) of salty water deep below the surface [6]. In addition, it has also a magnetic field (the only one confirmed at moons of planets till now), so one can observe polar light there [6].

However, one should not forget about our Earth. A great surprise came at the end of 2013 with a small scratched, clapped-out diamond from the Juina mine (Brazil). It contains a tiny piece of ringwoodite (olivine mineral). The diamond did not come from the outer space, therefore, it should be of Earth's origin. The ringwoodite (named according to A.E. Ringwood, Professor of geology at ANU) was confirmed by X-ray diffraction and by Raman and infrared spectroscopic data [7 and 8]. But in order to be created, this mineral needs a presence of high temperatures and high pressure and also of *liquid water (!)*. It is easy to answer where the high temperature and pressure can be found: beneath the surface of our Earth, in its mantle (in depths of about 400 to 700 km). But the only possible explanation of water is to conclude that the mantle contains a big amount of water, which is several ten times (or even a hundred times) more than all oceans, lakes and rivers on the Earth (!). Months later, similar piece of ringwoodite was found also close to US-Canadian border...

Not without interest is the direct observation of water snow-line at V883 Ori [9]. If a (proto)star has still a protoplanetary disc, its parts close to the central star are hot and there is no chance to keep compounds like water (di-hydrogen oxide) or carbon oxides in their liquid state – they are soon melted and evaporated (or sublimated). In the very remote regions, these oxides are sufficiently below the surface. In the mean region, one can observe a bright ring (illuminated by the central star), which moves its forefront with occasional thermal instabilities (outbursts) of the protostar. It was observed with carbon oxides at TW Hya and HD-163296 (see the references quoted in [9]) and only very recently even with water [9].

3. Life / intelligent life in the Universe

A very surprising fact about our Universe is that the basic physical constants (constants valid for the Universe as a whole,

not just describing local property at some place) are in very special relation, which is/was necessary for the creation of stars, galaxies, etc. If any of the values of these constants were changed by one part in a billion of its value, the present Universe would not be created or would already finish (see, e.g., [10]). In other words: "the basic physical constants must have exactly such values as they have - otherwise we would not exist here". This is what we call "a (weak) anthropic principle". There is also "a strong anthropic principle" saying that the Universe was created for us to live in it.

There has been a question for many centuries, whether we are alone in the Universe or do we have "brothers and sisters" somewhere? It is a trivial task to write the equation yielding number of planets with life (or even intelligent life) in our Galaxy or in the Universe as a whole. Such equations exist in many forms, and all of them have some common features; the most familiar of them is the Drake equation. While some of the terms in the equations are more-or-less known, like the average number of stars in a galaxy, percentage of stars with planetary systems, percentage of planets which orbit their sun within a habitable zone, etc. - at least with a precision of a factor one thousand up or down, there are two factors we cannot estimate at all, namely the probability that life really developed there; because keeping just the physical conditions, like temperature, gravity, presence of water, ... is just a set of *necessary* conditions, but not a *guarantee* that the life really is there (see also [11 and 12]). Another such factor in the Drake equation is the probability that the life there reached the intelligent level and that it is still within.

There are many approaches to getting answers about alien life (and especially its intelligent phase) beyond the Earth, from the point of view of (astro)biology, searching for the chemicals as markers of life, through geology, astrophysics etc. [11 - 16]. Being physicists, we'll write some notes on the estimates by Behroozi and Peebles [13]. They start considerations from estimating the number of Earth-like and giant planets (about 10^9 and 10^{10} , respectively), their time-dependence and elemental abundance. The process of planet formation continues with different speed for the Earth-like and the giant planets; giant planets are rare in low-mass galaxies. Median of giant planets ages (about 2.5 Gyr) is shorter than for Earth-like ones. The solar system formed after about 80 per cent of existing Earth-like planets. If we assume that gas cooling and star formation continues, the Earth was formed earlier than 92 percent of similar planets of the Universe. This implies 8 per cent chance that we are the only civilization the Universe will ever have (!). Well, 8 per cent is a small number, but many billion times larger than it would correspond to pure statistical formation of stars and their planets and, consequently, to the origin and development of (intelligent) life. Is this just a chance of statistics?

A lot of rumor has been very recently devoted to the finding of planet of Proxima Centauri (Proxima b), which is estimated to be by 30 per cent bigger (more massive) than our Earth and which is in a habitable zone [17]. Immediately after the discovery,

E. Tasker (one of leaders of the team which found a planet in the habitable zone of Proxima Centauri) cooled down the initial emphasis with several caveats [18]: *i)* Determination of both the mass and size is very unsure; the reported value of 1.3 Earth's masses is only the lower limit, whereas 70 Earth's masses is the upper one. Similarly, we know nothing about its size, and consequently about density - the planet can be (even though it is not much probable) also a gas giant planet. *ii)* Stating that Proxima b is in a habitable zone does not imply that it is habitable. It only says that its orbit is in such distance from the central star of the system that temperature on the planet surface (estimated by the amount of heat the planet receives) is reasonable. *iii)* The central star, Proxima Centauri, is a red dwarf. And red dwarfs are less stable stars than e.g. our Sun. *iv)* It is surprising, but (the planet) Proxima b *may not exist at all* (and all irregularities in brightness of (the central star) Proxima Centauri, interpreted as a presence of planet gravitation, could be caused by the irregularities and instabilities of the central star itself). *v)* Already several planets have been discovered with masses closer to that of Earth than it is in the case of Proxima b. Proxima b is not the first planet found within the habitable zone of some star. But ... *vi)* Even though Proxima b is a planet of our nearest star, using of present-day spacecraft would need some tens of thousands of years to reach it. Future possible spacecraft (currently only in a stage of ideas) would shorten this time to a few decades. This already sounds more reasonable. Further on, the remark of Taylor Redd [19] that planets have also their own source of heat, and the estimated distance from the central star of the system may be already in regions where life is not possible².

There is still one topic which could also be placed here. It is the star KIC 8462852 in the western wing of Cygnus (Swan) (star is nick-named "Tabby's star" according to Tabatha Boyajian, who discovered very special variations in its brightness) [20]. Variable stars are nothing special in astronomy, but usually the reason for periodic changes of their light is known: they can be binaries (system of two stars, when one eclipses the other while being on the line between it and the Earth), some kind of pulsations, or permanent irregular variations of brightness due to instable processes within the star. Here it is something rather different: Tabby's star has generally stable light flux, but completely irregularly it becomes for some hours (or even a day or two) fainter (never brighter than its standard). The difference in brightness is irregular as well: its brightness decreases by few per cent in local minima, but sometimes up to even 20 per cent. There is no acceptable explanation to such behavior, and possibly the most widely used is the assumption of *gigantic artificial constructions* (this means - say - from 300 000 km up to a million km or even more (!!)). One is afraid to accept that, but no alternative has been suggested yet.

4. Threats to the life on the Earth

Let us skip considering the possibility of a great war with inclusion of all possible weapons. Obviously, one cannot ignore such possibility, but the decisions of politicians and still more those of different criminal or terroristic groups and organizations are outside the frame of the present contribution.

Let us look back in history. In September 1859, a strong flash of brightness erupted on the Sun with the energy equivalent to 10 billion Hiroshima bombs. Massive coronal mass ejection released about trillion kg of charged particles, which at speeds close to 3000 km/s were flying over the space. In the Earth's magnetosphere they triggered the largest ever "solar superstorm" on record. This event was named the Carrington Event (R. Carrington spotted it as the first one). People could see intense polar light, but that was practically all. Some damage was done also on telegraph lines - at that time the only electrical infrastructure. But according to NASA's director of planetary science division J. Green, the Earth is in the path of similar event every about 150 years. What would do such flash today? The answer is simple: *i)* damage large portion of high-voltage lines (especially those going over long distances) and the transformers; *ii)* put the mobile phone networks, TV and radio broadcasting out of order; *iii)* disable various electronic automatic machines and instruments (including ATMs and cashiers in shops and petrol stations and electronic control at power plants, trains, airplanes, ...); *iv)* put out of order practically all computers, phones, tablets etc. which were on. Without electricity there will be no supply of water to houses (the pumps to higher floors use electric power), no possibility to fill your car with gasoline or diesel, banks will not be functioning. According to the considered scenario, this should last for a month or so, and the return to previous situation about one year [21]. Enough?

A more detailed study of possible threats from different sources has been presented by Rosen [22]. She puts the solar storm as the threat number one.

Threat number two is the danger of cosmic collision. Probably we are able to do something with small asteroids, if we know about them sufficiently in advance. But there is much smaller chance with objects above 1 km - and it is not so easy to observe a "newcomer" of that size. One threat from this group is the asteroid 101955 Bennu (originally 1999 RQ36), a diameter of about 500 m. It was already pretty close to the Earth couple of years ago, and the next close approach will be very close again, so that Earth's gravity could change its trajectory in the way that at the end of the 22nd century a direct contact with the Earth is not excluded. To minimize possible effects on our Earth, OSIRIS-REx spacecraft is to be launched on 8th September 2016, to study the asteroid for two years, take a sample and return it (in 2023) to Earth for further investigation [23 and 24]. The knowledge of Bennu would help us to find the most effective way to reduce the effect of possible future collision or avoid it at all.

Number three is possible explosion of a supervolcano. Obviously, it is not a danger from space, but from “our home”. Supervolcano is the one which ejects more than 450 cubic kilometers of magma. It follows from the study of erupted material that such super eruptions tend to be repeated. Some of the known supervolcanos: Yellowstone, Long Valley Caldera (California) and Valles in USA, Cerro Galan in the Andes, Taupo Volcanic Zone (New Zealand) and Toba (Indonesia).

Number four is the fact that people are not prepared. They do not have enough reserves of water and food, and they think that they can behave under extraordinary conditions in the same way as they are used to.

5. Conclusions

Each new knowledge brings new questions. For the three groups of exposed facts, the questions may be the following ones:

First, water, which is an essential compound for the (intelligent) life as we understand it, and which was assumed rare in the Universe, appears to be abundant in our Solar system and it is found also in systems of distant stars. Does it imply the possibility of expansion of mankind to other worlds irrespective of immense obstacles?

Second, the civilization on our Earth is subject to permanent natural threats of cosmic and/or Earth origin (cosmic impact, supereruption of our Sun, explosion of supervolcanos and/or global earthquakes), but also those coming from the mankind itself (e.g. wars). Are we able to be sufficiently prepared to withstand all of it?

Third, the question possibly touching far future: are we alone in the Universe or are there other civilizations as well? If yes, how would the contact with them look like? Would it be a friendly one or a conflict of enemies? Are we able to prepare ourselves to survive it, when (and if) it comes?

There is much more interesting news from natural sciences, which could influence not only our view on the world, but also our life on the Earth. The choice we have made is a personal one, and has not passed any wide-scale evaluation of what really is the most important topic.

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ⁱ We use here the American convention (not the old British one!) for large numbers: billion = thousand times million = 10^9 (referred to as milliard in the British form), trillion = million times million = 10^{12} (= billion in the British style), etc.

ⁱⁱ Extrasolar planets are so far from us that one cannot measure their temperature directly. It is derived by calculating the flux from the central star and how it can warm the body of planet. For instance, our Earth receives only about 60 per cent of heat from the Sun; the rest 40 per cent originate from continuous nuclear reactions in its interior.