Rocznik Filozoficzny Ignatianum • The Ignatianum Philosophical Yearbook
https://czasopisma.ignatianum.edu.pl/index.php/rfi XXIII / 2 (2017), s. 7–28
• Artykuły recenzowane • Peer-reviewed articles •
PL ISSN 2300–1402

Marek Szydłowski*, Paweł Tambor°
*Wydział Fizyki, Astronomii i Informatyki Stosowanej UJ
°Wydział Teologii KUL

Risky anthropic reasoning in cosmology. For or against an evolutional nature of the Universe?

Summary

In contemporary cosmology, from the creation of the General Theory of Relativity to the second half of the twentieth century, the main task of cosmologists was to construct and test cosmological models of the Universe. Nowadays you will notice that besides these objectives there is a new type of justifying the fact that the observable Universe's properties are such as they are, and no other. Ways of reasoning called the anthropic explanation are formed, attempting to answer the question: *why does the Universe have a nature (properties) necessary for the biological life to come into existence in it?* Their objectives are: firstly, an attempt at solving the difficulties of the Standard Cosmological Model, secondly, seeking an explanation of the coincidence of large numbers and the so-called physical constants. The supporters of this kind of explanation are themselves aware of its fundamental weakness: it is neither a causal, nor a nomological explanation; it fails to have the structure of a generalizing explanation, it is alleged to be a tautology. The anthropic principle in cosmology was initially regarded as an observational constrain for cosmological parameters of the standard model of the Universe. However, it can be shown that some consequences of anthropic reasoning are testable, as well as that its explanatory nature is more evident in the specific forms of the theory of explanation.

Key words: cosmology — anthropic reasoning — multiverse

Introduction

Aristotelian Cosmology had a dualistic ontology: the earthly sphere consisted of four elements: earth, water, air and fire. The natural movement of those earthly compounds was based on their natural tendency to take up places according to their weight. In turn, the beyond-lunar sphere was built of another, fifth element, characterized by an infinite circular motion around the center of the Universe. Christianity took over this image, which corresponds to the conviction that the humanity takes up a privileged position within the Universe. The works of Copernicus moved the center of the Universe towards the Sun (1543). The 18th century along with the results of William Hershel's studies dispose us to think that the center of the Universe is situated in the center of the galaxy. The discovery of Walter Baade in mid-20th century, that our galaxy is one of many spiral type galaxies, and the earlier works of Harlow Shapley (1922) bring about a new change of paradigm, seemingly irrevocably removing humankind from the center of the physical and philosophical frame of reference. Thus, on the one hand we have the methodological awareness, connected with the use of the so-called cosmological principle, that our presence in the Universe from the global point of view, has no special location; on the other hand, however, the objects surrounding us locally, form quite a unique system, especially conductive to the emergence and evolution of biological life.

The origins of anthropic thinking may be found already in the 19th century, in the works of Ludwig Boltzman, who aimed at deducing the properties of the thermodynamic arrow of time from mechanics, which lead him to the conviction that either our universe is currently in a highly improbable state, or the region in which we are located is only a small part of the Universe, which generally remains in the state of thermodynamic balance. Boltzman is thought of as the forerunner of the weak anthropic principle[1].

This paper presents, first of all, the past and current ways of anthropic thinking and ways to formulating the so-called anthropic principle. We shall show that in a strictly defined sense one can treat anthropic reasoning as, despite all the controversy, rooted in the research practice of modern cosmology, which guides itself with some main methodological principles. Science should be considered as seeking the unchanging aspects of physical reality expressed in the form of fundamental laws or principles. Every law uses constants, the values of which it does not explain. The values of some of these constants can be interpreted as particularly suited, as a kind of condition necessary for the emergence of intelligent life. This necessary condition is considered a selection tool, not an explanation that narrows the collection of possible Universes.

The criticism of anthropic reasoning from a physical, philosophical, and — above all — methodological point of view depends on which version of the anthropic principle we address. To begin with, let us therefore clarify the difference between the weak and the strong anthropic principle. The weak anthropic principle states that we must observe such a location in the world, which is friendly to life. The powerful version replaces the term “location” with “Universe”, and asserts in an ontologically powerful way that the world without intelligent observers is impossible. We argue that there is physical importance only to the weak anthropic principle. It is not a principle or law of the same significance as the physical laws are, but it could be reasonably argued in favor of the explanatory nature of anthropic reasoning in its weak version, and even in favor of the possibility to test its predictions of the scope of cosmological parameters allowing for an evolution of the Universe as well as the evolution of biological life.

[1] Cfr. Kanitscheider, The anthropic principle, p. 365.

The strong version of the anthropic principle has a definite metaphysical tinge, as it contains a speculation the character of a teleological necessity: "the Universe needs to be the way it is".

As a methodological tool performing a testing role in relation to questions of cosmology, anthropic reasoning is one way of dealing with problems generated by modern cosmology, especially in the 1960s[2]. What is more, we shall present a strong connection between anthropic reasoning and thinking of the Universe in multiverse terms, which form the context of anthropic thinking. Each of the mentioned concepts will be provided with empirical-methodological reservations.

Different forms of anthropic argumentation

The introduction mentioned Boltzman as the forerunner of anthropic thinking. It appears that in search for anthropic intuitions, which are basically close (analogous) to its modern formulations, one could reach further into history, that is to the breach of the age in which modern physics was born. One of the most interesting attempts was made one year before the appearance of Newton's Principia by a French philosopher, Bernard Le Bouyier de Fontenelle (1657-1757), who wondered why the orbits of comets within the solar system do not fit within the ecliptic, and why they are so different from the planets' orbits within the solar system. The answer to this question is quite similar to anthropic reasoning and may even be treated as a predecessor of such reasoning in the context of the solar system. Of course, Le Bouyier de Fontenelle did not know the results of Newton's and Halley's work. In 1686 he wrote:

> the reason why the planes of cometary motion are beyond the plane of the ecliptic and the plane of motion of any planet is exceptionally obvious; If that were the case, it would be impossible for the Earth not to find itself on a comet tail path. The

[2] Cfr. Leciejewski, *Rola zasad antropicznych*, p. 15–83.

> possibility of encounters and collisions would be too frequent, and, given the velocity of comets, such a collision would be destructive to both bodies[3].

Of course, such reasoning may not be called an explanation of the comets' movement in the nomological or causal sense, however it does express the basic intuitions of selectively understood anthropic reasoning. We thus have, according to Milan Ćirković, three kinds of explanations, which may be extrapolated to the problems of cosmological fine tuning: an explanation resorting to a form of intelligent design (in the form of theism, panentheism, normative necessity with a source somehow outside the physical world); a causal or nomologically-deductive explanation, which we speculatively predict in the form of a Fundamental Theory that would be a form of a great unification — a theory of everything; and finally the anthropic explanation, understood in the spirit of multiverse thinking. It follows the following scheme:

1) There exist all possible combinations of initial conditions,

2) there exists a subset of this set of all possibilities, which makes it possible for intelligent observers to exist.

Returning to the analogy of a planetary system and Le Bouyier de Fontenelle's intuition, we could say that:

1) Assuming that within the whole galaxy there exist all forms of planetary systems that are possible and admitted by Kepler's laws.

2) Our Solar System is contained within this set.

3) Our existence deems this system as allowing for such conditions in which biological life may emerge and evolve.

[3] Ćirković, On the first anthropic argument, p. 245.

In our opinion, Le Bouyier de Fontenelle definitely formulated a reasoning which could be called anthropic in the weak version, although referring to the Solar System, not the Universe[4].

The twentieth century context that possibly elicited the ideas of anthropic solutions, was brought about by speculation on numerical relationships between the values of physical and cosmological parameters. These relationships were discussed repeatedly in the literature of the subject in a collective and critical manner[5] , so here they shall only be mentioned briefly. In 1923 Arthur Eddington calculated the number of protons and electrons in the Universe (10^{79}) noted that it is connected (as a root) with the relation of the values of electromagnetism and gravity forces (10^{39})[6] similar conclusion was reached by Paul Dirac, who stated that the values of cosmological parameters must be related to the age of the universe by means of an unknown fundamental law[7]. Both forces, related to electrical and gravitational interactions, take the form of a reverse relationship to the squared difference between the charges or masses, which is why their ratio in the case of an electron or a proton, for example, is a fundamental number. While considering the scenario of a dynamic universe, speculation was made about the possibility of changing the value of physics constants (such as the gravitational constant) in the course of a cosmological evolution (such opinions were uttered by e.g. Edward A. Milne in his kinematic theory of gravity based on a priori accepted rules, as well as by Dirac). In the quoted paper from 1961, Robert H. Dicke substituted the speculation on the variable nature of physical bodies with anthropic reasoning, which is not treated as a cosmological principle, but a result of selection related to the possible values of these constants, assuming that carbon-based life is a fact

[4] Cfr. Ćirković, On the first anthropic argument, p. 250.

[5] Cfr. Griffiths, Book Reviews: Cosmology; Leciejewski, *Rola zasad antropicznych*; Mosterín, Anthropic explanations in cosmology.

[6] Cfr. Dicke, Dirac's cosmology and Mach's principle.

[7] Cfr. Dirac, The cosmological constants.

empirically dependent on the physical parameters of the microworld and the paste of cosmological evolution[8].

Christopher B. Collins and Steven Hawking continued thinking within the framework of anthropic observation selection, not only of the values of physical constants, but also such properties of the universe as isotropy or flatness. If biological life depends on the existence and level of evolution of stars and galaxies, a universe with an excessively great gravitational energy in its early phases of existence will collapse before galaxies are able to form. If, in turn, this energy is too low, condensed matter, which enables the emergence of stars and galaxies, will not form[9]. Bernard Carr and Martin Rees in the late 1970's proved that the emergence of biological life based on carbon is incredibly sensitive to the fine-tuning of physical constants[10]. Brandon Carter's article "Large Number Coincidences and the Anthropic Principle in Cosmology"[11] and a vast, 700 page book by John Barrow and Frank Tipler *The anthropic cosmological principle*[12] are considered to be the program works containing the formulation of each version of the so-called anthropic principles.

Let us now enumerate the basic expressions of anthropic principles in their weak and strong forms. Konrad Rudnicki points out, that in the weak version one claim that the physical properties of the observable part of the Universe are a logical consequence of the fact, that the Universe is observed by human beings[13]. Probabilistically speaking: a conditional probability of our universe, which belongs to the set of the possible universes (where carbon-based life is permitted), is different and greater than the absolute probability of the universe without the existence of intelligent observers. As the weak version, we can interpret in terms of physical principle of selection, the strong

[8] Cfr. Vidal, Computational and biological analogies.
[9] Cfr. C. B. Collins & Hawking, Why is the Universe isotropic?
[10] Cfr. Carr & Rees, The anthropic principle.
[11] Carter, Large number coincidences.
[12] Barrow & Tipler, *The anthropic cosmological principle*; Anderson, Review: The anthropic cosmological principle.
[13] Cfr. Rudnicki, *Zasady kosmologiczne*.

one is in fact metaphysical assumption. The strong Anthropic principle goes further. It states that an environment suitable for biological life must exist. As expressed by Brandon Carter "the Universe (and hence the fundamental parameters on which it depends) must be such as to admit the creation of observers within it at some stage"[14]. Barrow and Tipler write in a similar way: "The Universe must have those properties which allow life to develop within it at some stage in its history"[15].

Let us now briefly characterize the basic multiverse concepts. The notion of multiverse is often used in the context of the anthropic question as an attempt at its solution. The basic intuition binding the multiverse with anthropic thinking is that the conditions in our universe, where life emerged and evolved are discussed using the notion of probability. Of course, this probability may be understood differently: for example, in a Bayes way, if we point out the epistemological element of wonder at the fine tuning of physical parameters observable in our universe[16]. We may also try to estimate the probability density in a classical way, by theoretically building a certain sample space of universes with different physical constants and parameters. The variety of multiverse concepts is connected to the property of a certain set, in which we try to establish the probability function. Overall, the intended effect of those attempts is such, that although our universe still remains interpreted as fine-tuned, the issue of its uniqueness ceases to exist. It is just one of many realizations of a physical system that emerged in a certain configuration.

Let us begin with the concepts that are loosely, or not at all, connected with anthropic problems. One of them is David Lewis' proposal called modal realism. This idea, of a rather formal nature, consists of many universes which are logically possible. The main objection posed against this concept is its non-physicality, as the universes are treated as mathematically allowed objects. Another proposal, far

[14] Carter, Large number coincidences, p. 294.
[15] Anderson, Review: The anthropic cosmological principle, p. 85.
[16] Cfr. Garrett, A Bayesian looks at the anthropic principle.

from anthropic thinking is the famous Everett's multiverse, which indeed consists in asserting the real existence of states described by a wave function. Everett's worlds in quantum mechanics refer to quantum states in superposition to one another.

The proposal by Alexander Vilenkin and Andre Linde is a multiverse concept based on quantum physics. It uses the mechanism of eternal inflation in early cosmology of the Universe. Fluctuations in quantum vacuum lead to the development of a separate (causally and spatiotemporally) multitude of worlds. Each of those worlds, as a result of the eternal inflation, produces further worlds, which take up space-time within the primary structure. Our universe takes up part of such space (a bubble universe). Although this concept is often charged with unfalsifiability and untestability due to a lack of a causal relation between the worlds, the concept is a kind of a physical structure, in which a certain mechanism of creation is given, which is causal and as such may be empirically tested, from within our universe, of course.

Another proposal worth considering in the context of this discussion is Wheeler's cyclic or oscillatory multiverse. It is a structure of inflating and deflating universes, each of which inherits different initial conditions and realizes another detailed scenario along the lines of a similar scheme: big bang, expansion, contraction, big crunch and a big bang again. Wheeler's proposal met with basically two main allegations: firstly, if the evolution dynamics is every time potentially different, in case of a sufficiently long expansion phase (if the universe becomes flat or open), infinite expansion is possible, which means breaking the cycle. Secondly, the succeeding universes lose the "memory" of their predecessors, which means that the whole process does not guarantee, even in an infinite number of cycles, an emergence of a universe such as ours. Ian Hacking interpreted this possibility in terms of the gambler's fallacy, known from statistics.

The last of these proposals is a multiverse by George F.R. Ellis and Geoff Brundrit, who, based on an open, infinite universe by Friedman-

Robertson-Walker, proposed a structure consisting of many separate domains separated by an event horizon. The Ellis multiverse is infinite and chaotic: it contains an infinite number of different states of expansion and has, to a different extent, the property of homogeneity and isotropy. It is realized within the conceptual network of the GTR. What draws criticism towards such concept is the fact that an infinite set of certain values does not exhaust all possibilities[17]. For example, an infinite set of all even natural numbers does not contain e.g. the number 15 although it is infinite. A section of the real number axis contains incalculably infinitely many real numbers, but still infinitely many natural numbers remain outside this section. Therefore, the parameter space constructed by Ellis does not exhaust all possibilities and does not mean that our universe will be contained within the set.

Among the modern scientific speculations based on anthropic reasoning as a selective factor we can cite Alexander Vilenkin[18]. As it was suggested, anthropic arguments are sometimes judged as an unpredictive speculations lore of no scientific value. Vilenkin showed that this is not true if we treat anthropic reasoning as a selective procedure for the cosmological constant problems. There are two types of the cosmological problem. The cosmological constant is associated with the vacuum energy density, ρ_V. It seems to be natural to set its value in according with Planck scale energy: $\rho_V \sim \left(10^{18}\right)^4$GeV. This value is 120 orders of magnitude greater than the observational bound $\rho_V \sim \left(10^{-3}\right)^4$eV. This is Cosmic Coincidence Problem (CCP1).

Before the discovery and an empirical confirmation of the expansion of the Universe, it was believed that something so small could only be zero. In an accelerating universe, cosmological constant value is observed to be $\rho_V \sim \rho_{M_0} \sim \left(10^{-3}\right)^4$eV. Where ρ_{M_0} is the present density of matter. Vilenkin writes:

[17] Cfr. Earman, The sap also rises, p. 315.
[18] Cfr. Vilenkin, Anthropic approach.

> This brings yet another puzzle. The matter density ρ_M and the vacuum energy density ρ_V scale very differently with the expansion of the universe, and there is only one epoch in the history of the Universe when $\rho_V \sim \rho_M$. It is difficult to understand why we happen to live in this special epoch. Another, perhaps less anthropocentric statement of the problem is why the epoch when the vacuum energy starts dominating the universe ($z_V \sim 1$) nearly coincides with the epoch of galaxy formation ($z_G \sim 1$–3), when the giant galaxies were assembled and the bulk of star formation has occurred[19].

This is the second Cosmic Coincidence Problem (CCP2).

An attempt at assessing the epistemic value of anthropic principles

Let us notice here the fundamental objection: it seems to be a tautology. Let q be the premise: "all physical constants have values, as we observe them"; and p = "there are existing observers". The q is a necessary condition of p only if "$p \rightarrow q$". So, we have a *modus ponens* as follows: $[(p \rightarrow q) \wedge p] \rightarrow q$. The weak anthropic principle is formally (logically) correct but does not explain anything. The anthropic principle is not a principle in the sense of physical principles or cosmological principles[20]. It suffers the paradoxes well known from the Hempel's deductive-nomological framework. There are questions as to the physical aspects of anthropic reasoning[21]. And it is *post hoc*: it is hard to find any predictions based on anthropic thinking that lead to uncovering a previously unknown property of the Universe. The problem of the anthropocentric role of the observer. The anthropic principle helps select the values of physical constants and big numbers only with respect to their order of magnitude (not the exact values).

19 *Ibid.*, p. 1194.
20 Cfr. McMullin, Indifference principle.
21 Cfr. Carr & Rees, The anthropic principle.

As we stated, while the weak version can be interpreted in terms of a physical principle of selection, the strong anthropic principle is in fact a metaphysical assumption. The physical properties of the (entire) Universe are a logical consequence of the fact that there are observers in some region of the Universe. Our existence has an impact on the properties of the Universe.

What type of explanation does anthropic reasoning offer? Let us relate to a certain property of the Universe. The anthropic answer to the question: Why does the Universe fulfill the cosmological principle (it is homogeneous and isotropic on a large scale) is: because we are in this universe. Of course, the properties of homogeneity and isotropy are not a consequence of our existence in the Universe (neither in the causal nor teleological sense). The consequence of our existence is not the isotropic nature of the Universe, but the fact that we are able to observe the Universe as such. The mere fact of observation is a consequence! It corresponds with a remark made by Carter himself, who expressed his regret that instead of "the anthropic principle" he did not use the term "cognizability principle".

Let us reconstruct in a more detailed way the structure of the anthropic argument:

1. The values of cosmological parameters are not a logical consequence of a more fundamental physical law.
2. Hence, we may say that their values are random or incidental.
3. If the values are incidental, the could have been different.
4. The emergence of biological life depends on many coexisting parameters and physical constants (both on the physical and chemical level).
5. The anthropic argument states that such co-occurrence of so many parameters could not have happened incidentally.

The first issue of a logical and physical nature that this form of the anthropic argument ensues is that the above depicted reasoning leads to an assertion that a universe with other physical parameters does not allow for the emergence of biological life. On the other hand, it may be stated that scientific speculation concerning the possibility of life emerging in a universe with a different structure of cosmological parameters is nonsensical, because it is inevitably based on the laws and principles that rule our universe. This is why calculating a degree of probability of life's existence in a multiverse set is doomed to failure. The anthropic reasoning seems to depend on the claim that we can know it is very improbable that other universes, with different laws or constants, could support life. We speculate about the hypothetical universes on the basis on the knowledge elaborated in our Universe. We make those calculations only by using the scientific laws of this universe. But the premises of anthropic principles say the universes could be (or is in principle) other than they are. As a result of that we cannot be sure, that the conditions of our Universe are so improbable and that there is no life in different universes. Moreover, we assume the premise, incorporated in anthropic abductive thinking is true, that the knowledge of the laws of biology, chemistry and physics is not only the truth, but it always has (during past evolution of the Universe). The progress of exhaustive scientific explanation for the fact of life; its origins and prospects of future evolution is still in the state of search for final theory. In other words, we can say, that the fact that (b) there is a life in the Universe based on carbon biology (*explanans*) implies both: (a) that the Universe embodies the global properties observed as cosmological coincidences and (c) the global properties of the Universe form the conditions for the existence of the life in the Universe based on carbon biology. It is however not equivalent to the reasoning that (a) and (c) imply (c).

So, the whole anthropic argumentation may be undermined by a simple statement arguing that we cannot be certain that a universe with different parameters does not allow for the existence of an intelligent observer.

> For example, [...] if the mass of the neutrino had been ten times greater, "the gravitating power of the primeval background would have caused a drastic alteration in the expansion of the

> universe...” But how do we calculate what would happen in hypothetical universes having greater neutrino mass? Obviously, we can make those calculations only by using the scientific laws of this universe — the laws which the APDA says could be other than they are. [...] But “the equations of physics” can only mean the equations we have learned from observation of the existing universe[22].

An important argument that the multiverse concept does not solve the problem of fine-tuning: it does not mean that the probability of our universe emerging within this set of universes increases. It only means that the initial physical conditions of the multiverse are generic, random. The emergence of our universe in this case is not obvious.

> [...] even if the hypothesis of there being many universes increases the probability that some universe will be life-permitting, it does not increase the probability that our universe is life-permitting. The hypothesis is that the initial conditions and constants of each universe are chosen randomly and independently of the other universe. The choices are like independent rolls of a die[23].

Differences and similarities between anthropic and evolutionary explanations can be found. Firstly, the direction of the explanation is different: in the anthropic explanation, the conditions in the Universe are the *explanandum*, while the fact that life exists is the *explanans*.

The reasoning based on the weak version of the anthropic principle is as follows: we are able to observe the world; therefore, the world allows for the existence of intelligent observers. The properties of the universe, which are such and no other, are related to the velocity of the expansion of the universe, which is close to critical and which leads to the fact that the universe is approximately isotropic.

[22] Fulmer, A fatal logical flaw, p. 105.

[23] Jesús Mosterín paper on www: http://philsci-archive.pitt.edu/1658/1/Anthropic_Explanations_in_Cosmology_.pdf, p. 28. This article appeared in: Mosterín, Anthropic explanations in cosmology.

This results in the Universe having such and no other properties, because we exist. The character of this reasoning is teleological. An anthropic explanation is a bottom-up type of explanation, but it is not inductive reasoning, because the fact of life's existence in itself is something individually special. The explanation is also two-staged. First, reductive reasoning, i.e. looking for a reason to the obvious fact of existence of biological life, and then deductive reasoning, where we want to deduce life as a logical consequence of some established, certain physical, chemical and biological principles. A weakness of the whole reasoning may be found in its enthymematic character, because we have to inevitably accept the knowledge concerning the mechanisms of life's emergence and evolution as true. A very important consequence of anthropic reasoning for philosophy and science, however, is that it states that life may not emerge in any random universe. Definitely, we need to be aware that there is often a mixture of levels in establishing the relationship between the *explanans* and the *explanandum.* Coincidences are scientific facts, while the anthropic principle is a philosophical thesis. Kanitschneider also points out to a certain anthropic paradox: from the cosmological point of view, our location within the Universe is not special, however we located in an especially fine-tuned "ecosystem"[24]. Should we therefore say that we exist despite the Universe being homogenous and isotropic, or rather because it is so?

In the previous paragraph, we have not pointed out to some hopes of testing, in a physical sense, the concept of a multiverse formed as a result of an inflation process, because the idea of inflation itself is a well theoretically defined proposal, and models reconstructing an inflatory universe are being tested in cosmology today. For us, in the context of the discussion taken up by this paper, it is especially important to present the relations between certain multiverse concepts and the problems addressed by anthropic reasoning.

We may in a way say that the Universe has no center, or that the center of the Universe is wherever the observer is. Any observer re-

[24] Cfr. Kanitschneider, The anthropic principle.

mains in the center of the universe they observe. Due to this location and the fact that the position and duration of objects are described using the notion of space-time, which constitutes a certain absolute element in the General Relativity Theorem, one could point out to two kinds of objects: world lines in a space-time diagram denote objects that last in time, while points mark objects of only temporary existence. As a result, we distinguish two kinds of horizons determining our cognitive access to objects within the Universe: a particle horizon and an event horizon. A particle horizon may be imagined as a surface in space, where the observer is in the center. An event horizon separates events that we are ever able to see from those that we will never observe.

In static or dynamic homogenous and isotropic universes, the event horizon broadens in relation to the observer at the speed of light. In the case of a static universe, an event horizon does not exist — if the universe is eternal, each event will eventually find itself within the observer's light cone. If the universe has an end, however, there are events that remain outside the light cone.

The eternal world scenario, which leads to an inflation[25] , the pre-inflatory universe expands from the parameters ($t = 10^{-44}$s, $density = 10^{94}\text{g}/\text{cm}^2$, $T = 10^{32}$K) in the Planck scale, to the universe of the grand unification epoch ($t = 10^{-36}$s, $denstiy = 10^{78}\text{g}/\text{cm}^2$, $T = 10^{28}$K). During this process, the pressure is positive and the universe decelerates. A delay in the phase of transition to quarks and leptons, leads to a negative pressure, which in turn drives the exponentially expanding universe in the phase from 10^{-36} to 10^{-34}s. The accumulated energy translates into mass, which retains the pressure on a constant level.

The inflation solves a number of problems emerging in relation to the evolution of the Universe: the problem of magnetic monopoles, the problem of flatness of the Universe, the problem of the horizon. The flatness problem contains itself in the question: why is the early

[25] Cfr. Guth, Inflationary universe.

Universe characterized by such flatness — why is its curvature so small? If the curvature was positive, the post-expansion universe would begin to shrink until collapse. In the case of a negative curvature, the standard cosmological model predicts an eternal expansion of the universe. Anthropic reasoning is an attempt at answering the close to zero curvature problem, as it states that only in a nearly flat universe, the evolution of life is possible. The inflation theory gives an explanatory better answer, because it offers a causal mechanism: the flat Universe is a result of a rapid and quick expansion that took place in the inflation phase[26].

The third problem that the inflation theory attempts to answer is the horizon problem. Intuitively we could say that the particle horizon is connected with a maximum distance between the observer and the observed object that possibly can causally influence the observer. The particle horizon recedes from us at the speed of light. In an expanding universe, the distance that the light needs to cover is constantly increasing, as space expands. The horizon problem is connected to: how past events may be searched for the reasons of the Universe's present state, since they were outside the horizon in the past. The phenomenon of inflation solves this problem, by making the regions of the early universe remaining in a causal interaction, have retained the effect of homogeneity connected to the earlier causal interaction as a result of the rapid expansion.

Conclusion

The problem of the so-called fine-tuning has been traditionally met with three types of answers: a theistic answer (intelligent design), a multiverse answer, and finally accepting this state of affairs as a fact that does not require an explanation or justification[27]. Let us note, however, that such types of answers to the questions concerning the role of the observer and the existence of an outside world have

[26] Cfr. Koonin, The cosmological model of eternal inflation.

[27] Cfr. R. Collins, Modern cosmology.

their analogous equivalents in the discussion on realism, idealism and antirealism in philosophy and science. The traditional discussion of idealism calls the problem of existence and access to the outside world a "scandal in philosophy". Immanuel Kant in his *Critique of pure reason* found it scandalous that we need to believe in the existence of the outside world and that the proof of its existence has not been formulated so far. Martin Heidegger found it scandalous that we expect such proofs at all and that we try to create them.

The multiverse category meets an attempt to explain the uniqueness and fine-tuning of our universe with our existence, using the observer-selection principle. Of course, stating that our universe has such values of physical constants and cosmological parameters that allow and condition our existence is a tautology. But placing this statement in the multiverse conceptual context makes us interpret the data that we have access to differently. Therefore, if our universe is a part of a greater and more complex whole, the issue of fine-tuning maybe does not disappear, but the epistemic "wonder" at it does. In other words, we are able to say: it is not so, that the Universe is fine-tuned for intelligent observers to appear, but the Universe is fine-tuned — that is its physical parameters are such — that in a certain period of its evolution it allows for the existence of beings that observe it and are aware of this fact.

From the physical point of view, those versions of the conceptual category of multiverse are especially interesting in that they demand a physical mechanism of its emergence and evolution. One may therefore say that the problem of fine-tuning does not in fact disappear, but it is moved to a different level — the level of laws governing the emergence of the superstructure of the multiverse. The situation bears an analogy to the issue of the origin of life on Earth. There have been ideas postulating an extraterrestrial origin of life on Earth (panspermia). The problem of the origin of life still remains, as we try to explain its development on our planet. Robin Collins points out to an extraordinarily adequate analogy of the cosmological multiverse in the form of a thermodynamic observer, sometimes dubbed the "Boltzmann Brain". Well, as an observer in a physical system described in thermodynamic terms we may recognize such part of this system, which is characterized by a state of low entropy, which is very improbable, but possible.

Another proposal connected with the attempts at explaining the specificity of our Universe is based on the consideration of theist metaphysics, or more widely, a position named by John Leslie — axiarchism[28]. It means adopting a certain order in the observed reality, which points to the real existence of certain values apart from physics, such as moral or ethical values. Therefore, axiarchism means the acceptance of the existence of a certain purposeful arrangement in the world of physical phenomena, which has the properties of metaphysical necessity. We could name many representatives of this way of perceiving the question of the validity of fundamental laws. Newton, for example, discerned in nature a certain normative mechanism regulating the behavior of physical systems.

A certain analogy to the concept of multiverse on the methodological level is the problem, known in the methodology of science, of indefiniteness of theory by empirical data. It applies to the situation where a scientific theory confronted with empirical data allows for the formulation of many hypotheses (construction of many models), which comparably well explain the data, at the same time allowing different specific predictions concerning the behavior of the same physical system in the future.

Streszczenie

W kosmologii współczesnej głównym zadaniem kosmologów jest konstruowanie i testowanie modeli kosmologicznych. Poza tymi standardowymi procedurami pojawiają się szczególne typy uzasadnień dla tego, że obserwowany Wszechświat posiada takie, a nie inne własności. Na pytanie: *dlaczego Wszechświat posiada własności, które są konieczne dla zaistnienia w nim*

[28] Cfr. Leslie, Design and the anthropic principle.

biologicznego życia?, proponowane są rozumowania nazywane antropicznymi, które fakt istnienia organizmów żywych opartych na chemii związków węgla traktują jako element wyjaśniający dla parametrów fizycznych. Artykuł przedstawia krytykę wyjaśniającej funkcji tzw. zasad antropicznych i sprowadza ich rolę (w szczególności zasady antropicznej w wersji słabej) do czynnika selekcji dla wartości parametrów kosmologicznych.

Słowa kluczowe: kosmologia — zasady antropiczne — wieloświat

Literature

Anderson, J. L., *Review: The anthropic cosmological principle, John D. Barrow and Frank J. Tipler, 706 pp. Oxford U.P., New York, 1986.* Physics Today 40/9 (1987), pp. 84–86, DOI: 10.1063/1.2820190.

Barrow, J. D. & F. J. Tipler, *The anthropic cosmological principle*, New York: Oxford University Press, 1986.

Carr, B. J. & M. J. Rees, *The anthropic principle and the structure of the physical world.* Nature 278/5705 (1979), pp. 605–612, DOI: 10.1038/278605a0.

Carter, B., Large number coincidences and the anthropic principle in cosmology, [In:] *Confrontation of cosmological theories with observational data. Proceedings of the IAU Symposium 63*, [Ed.] M. S. Longair, Dordrecht: D. Reidel Publishing Co., 1974, pp. 291–298.

Collins, C. B. & S. W. Hawking, *Why is the Universe isotropic?*, Astrophysical Journal 180 (1973), pp. 317–334, DOI: 10.1086/151965.

Collins, R., Modern cosmology and anthropic fine-tuning: Three approaches, [In:] *Georges Lemaître: Life, science and legacy*, [Ed.] R. Holder & S. Mitton, (Astrophysics and Space Science Library, vol. 395), Berlin, Heidelberg: Springer, 2012, pp. 173–191, DOI: 10.1007/978-3-642-32254-9_13.

Ćirković, M. M., *On the first anthropic argument in astrobiology*. Earth, Moon and Planets 91/4 (2002), pp. 243–254, DOI: 10.1023/A:1026266630823.

Dicke, R. H., *Dirac's cosmology and Mach's principle*. Nature 192 (1961), pp. 440–441, DOI: 10.1038/192440a0.

Dirac, P. A. M., *The cosmological constants*. Nature 139/3512 (1937), p. 323, DOI: 10.1038/139323a0.

Earman, J., *The sap also rises: A critical examination of the anthropic principle*. American Philosophical Quarterly 24/4 (1987), pp. 307–317, DOI: 10.1023/A:1017599008013, URL: http://www.jstor.org/stable/20014208 (visited on 10/03/2014).

Fulmer, G., *A fatal logical flaw in anthropic principle design arguments*. Journal for Philosophy of Religion 49/2 (2001), pp. 101–110, DOI: 10.1023/A:1017599008013.

Garrett, A., A Bayesian looks at the anthropic principle, [In:] *Maximum entropy and Bayesian methods*, [Ed.] C. R. Smith, G. J. Erickson & P. O. Neudorfer, (Fundamental Theories of Physics, vol. 50), Dordrecht: Kluwer Academic Publishers, 1992, pp. 153–164.

Griffiths, D. J., *Book Reviews: Cosmology: The Science of the Universe, 2nd ed., Edward Harrison, Cambridge U.P., New York, 1981 (Laurence A. Marschall, Reviewer)*. American Journal of Physics 69/4 (2001), p. 523, DOI: 10.1119/1.1349545.

Guth, A. H., *Inflationary universe: A possible solution to the horizon and flatness problems*. Physical Review D 23/2 (1981), pp. 347–356, DOI: 10.1103/PhysRevD.23.347.

Kanitscheider, B., The anthropic principle and its epistemological status in modern physical cosmology, [In:] *Philosophy and the origin and evolution of the Universe*, [Ed.] E. Agazzi & A. Cordero, (Synthese Library, vol. 217: Studies in Epistemology, Logic, Methodology, and Philosophy of Science), Dordrecht, Boston: Kluwer Academic Publishers, 1991, pp. 361–397.

Koonin, E. V., *The cosmological model of eternal inflation and the transition from chance to biological evolution in the history of life*.

Biology Direct 2/15 (2007), pp. 1–21, DOI: 10.1186/1745-6150-2-15.
Leciejewski, S., *Rola zasad antropicznych w rozwoju współczesnej kosmologii. Studium metodologiczne*, (Pisma Filozoficzne, t. 106), Poznań: Wydawnictwo Naukowe Instytutu Filozofii UAM, 2007.
Leslie, J., *Design and the anthropic principle*. Biology and Philosophy 7/3 (1992), pp. 349–354, DOI: 10.1007/BF00129975.
McMullin, E., *Indifference principle and anthropic principle in cosmology*. Studies in History and Philosophy of Science 24/3 (1993), pp. 359–389, DOI: 10.1016/0039-3681(93)90034-H.
Mosterín, J., Anthropic explanations in cosmology, [In:] *Logic, methodology and philosophy of science. Proceedings of the Twelfth International Congress*, [Ed.] P. Hájek, L. Valdés-Villanueva & D. Westerståhl, London: King's College Publications, 2005, pp. 441–471, URL: http://philsci-archive.pitt.edu/1658/1/Anthropic_Explanations_in_Cosmology_.pdf (visited on 03/12/2004).
Rudnicki, K., *Zasady kosmologiczne*, Bydgoszcz: Wyższa Szkoła Ochrony Środowiska, 2002.
Vidal, C., *Computational and biological analogies for understanding fine-tuned parameters in physics*. Foundations of Science 15/4 (2010), pp. 375–393, DOI: 10.1007/s10699-010-9183-x.
Vilenkin, A., *Anthropic approach to the cosmological constant problems*. International Journal of Theoretical Physics 42/6 (2003), pp. 1193–1209, DOI: 10.1023/A:1025750314289.