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Fine-Tuning The Origin Of The Universe

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Abstract.-This article explores the origin of the observable universe, emphasizing the near-unanimous conclusion that the universe had a beginning. It contrasts two main paths to this conclusion: the classical route through general relativity equations, supported by empirical evidence like the universe's expansion and cosmic microwave background radiation, and a formal approach derived from the Principle of Directional Evolution. The latter suggests that the universe's cause is external and unknowable through science limited to this universe. The paper also discusses the fine-tuning of the fundamental physical constants from a probabilistic perspective, considering the number of constants and the number of their invariant decimal figures, demonstrating that fine-tuning supports the universe's origination by a cause external to the universe itself.

1. Introduction

The article begins by recalling the dual path that leads to the almost unanimously accepted conclusion that the observable universe is not eternal and necessarily had an origin. The first of these paths is the classical route, starting from the equations of general relativity and later empirically confirmed by both the expansion of the universe and the cosmic microwave background radiation. The other path is the formal approach proposed by the author, which starts from the Principle of Directional Evolution of the observable universe and formally demonstrates that this universe had an origin and that the cause of this origin could only be external to the universe itself and is, therefore, unknowable to science derived exclusively from this universe. The alternatives that try to avoid the origin (creation) of the universe are very briefly discussed under the prism of the inconsistency of the actual infinite and the logical impossibility that nothing is the same as something (First Law of Logic).

In this context of a universe originated by an unknowable and external cause, the fine-tuning of fundamental physical constants is discussed from a new probabilistic perspective: the calculation of probabilities of different sets of fundamental physical constants based on both the number of constants in the considered sets and the number of decimal figures that must remain invariant in each constant. It is then demonstrated that, even in the least demanding cases (the cases of maximum probability), the random origin of any of these sets of fundamental constants is practically impossible: their maximum probability is on the order of 10^{-15} in the most favorable case of 5 constants with 3 decimals each. And as just indicated, the alternatives involving the infinite or the violation of the First Law of Logic are also inconsistent.

Therefore, the fundamental physical constants, those that are part of the equations that control the directional evolution of the observable universe, had to be intentionally calculated so that this observable universe evolved in the manner we observe: in the direction of the irreversible increase of its global entropy (isotropy). The Theorem 1 of the Calculated Universe is then demonstrated, whose statement establishes that the observable universe not only had to be created but also had to be previously designed and calculated. In the next section, the few aspects that can be considered about the cause that originated the universe are very briefly considered (from now on, the word universe will always refer to the observable universe, whether or not the adjective observable is included), considerations that for the moment can only be more metaphysical than physical.

The article concludes by proposing a new source of information about that possible reality from which the universe might have emerged. Despite being unknowable to science, that other possible reality that designed, calculated, and created the universe so that it would evolve directionally as we observe, there could be a source of information about that unknowable reality, a source of information beyond the objects and processes of the observable universe, information that has not yet been considered by science. This would be information based on the accounts of certain experiences of some human beings that medical sciences and neurosciences are beginning to consider in scientific terms: the accounts of near-death experiences in which their protagonists describe certain aspects of that other possible reality, aspects that should interest physics once that source of information is accepted as valid. In fact, this interest is beginning to awaken, although still very timidly, among some contemporary physicists.

2. A summary of the classic Big-Bang

In the 1920s, the first papers by A. Friedmann and G. Lemaître on the origin of the universe were published [10, 11, 22, 23, 24, 25, 26], both works derived from Einstein's general theory of relativity [8]. The new theory proposed a universe of finite age and consequently a universe with an origin in time, an idea opposed to the eternally static universe firmly accepted at that time (recall the cosmological constant included by Einstein in his equations to nullify the expansion deduced from those same equations). The initial rejection of the theory, grotesquely renamed as the Big Bang, was almost total, including political persecutions in Hitler's Germany and Lenin-Stalin's Russia, where some were even condemned to death for defending this cosmological theory because it implicitly pointed to a creative act, which is unacceptable to certain political ideologies and certain scientists.

The theoretical works of A. Friedmann and G. Lemaître were soon followed by several publications of a more empirical nature, which are actually evidence of the expansion of the universe, and consequently of its impossible eternity. Indeed, in 1929, E. Hubble [17] discovered the redshift (Doppler effect) of light coming from stars, suggesting a recession of galaxies, as has been confirmed later. In 1964, A. Penzias and R. Wilson discovered the cosmic microwave background radiation (CMB), the electromagnetic residue of the initial explosion (Big Bang) that permeates all space [33], and whose spectral energy distribution corresponds almost exactly to that of a black body, with a current temperature of 2.725 K. A radiation that Lemaître called "l'éclat disparu de la formation du mondes" (cited in [31, p. 67]) and whose existence was also announced in 1946 by G. Gamow [13] and in 1948 by R. Alpher and . Herman [1].

One of the most notable characteristics of the CMB is its isotropy, with variations less than one part in 100,000. The very small deviations observed are of great importance to explain the subsequent formation of structures, such as galaxies, in the universe. The first of these small anisotropies were observed in the seventies. The BOOMERANG balloon (1997) and the satellites COBE (1989), WMAP (2001), and Planck (2009) have examined them with increasing precision due to their importance in determining the basic geometry and evolution of the universe. The well-known images provided by these satellites correspond to the universe 380,000 years after the Big Bang and the small colored lumps represent small temperature variations, red being the highest and blue the coldest. There is, of course, abundant literature on the Big Bang, e.g. [16, 36, 21, 15, 3, 19, 9, 20, 35, 34] etc.

The Big Bang put an end to the idea of an immobile and eternal universe. But at the same time that scientific materialism accepted its almost inevitable reality, the Big Bang was completed with other theoretical speculations with the sole objective of making this original act of creation of the universe unnecessary. Thus, infinite cycles of Big Bangs and Big Crunches appeared, infinite in number, universes arising from fluctuations of nothingness, etc. However, as will be seen in this article, it is possible to formally demonstrate that the universe necessarily had to be originated by a first cause external to the universe itself, a first cause that cannot be established from knowledge constructed from within the universe itself. An external and unknowable first cause whose necessity is deduced exclusively from the two fundamental laws of logic and an inductive principle of the highest empirical evidence, a principle that establishes the directional evolution of the universe (in the direction of the increase of its global entropy).

3. The origin of the universe: a new formal approach.

As announced at the end of the previous section, it is possible to formally demonstrate, based on an inductive principle of the highest empirical evidence, that the observable universe could only have originated from a first cause external to the observable universe itself. Therefore, this first cause is unknowable to humans since we can only extract knowledge from within the observable universe. Naturally, this unknowable first cause of the origin of the universe and the Big Bang theory mutually confirm each other, which is why it was briefly recalled in the previous section. Now it is time to recall the Principle of Directional Evolution of the Universe [29]:

> The observable universe always evolves independently of its observers and in the same direction of increasing its global entropy.

Where entropy can be replaced by isotropy [27]. According to its statement, the Principle of Directional Evolution is a generalization of the Second Law of Thermodynamics that explicitly states the independence of the directional evolution of the universe concerning its possible observers. We have overwhelming empirical evidence for the Principle of Directional Evolution of the universe: everything we know about the universe confirms it, including other local directional evolutions that seem to go in the opposite direction: the generation and evolution of open systems that exchange matter and energy with their surroundings. In these systems, there is a significant increase in their complexity and anisotropy and a significant decrease in their entropy, but in return, there is an even more significant increase in the entropy of their surroundings, so the final balance is the directional evolution of the universe in the direction established by the Principle of Directional Evolution.

The main results formally deduced from the principle just stated are recalled below, results that use the following prior definitions:

Definition 1 *Physical magnitude: A physical property of certain components of the universe, or the entire universe, that is necessary or convenient to describe the directional evolution of the universe itself.*

Definition 2 *Physical law: A unique mathematical relationship between two or more variable physical magnitudes in which one or more numerical constants with or without dimensions may intervene.*

From the Principle of Directional Evolution, the following two results are formally deduced, whose proofs can be seen in [29]:

Theorem of the Consistent Universe: The universe evolves under the control of a unique consistent set of invariable physical laws.

Theorem of Formal Dependence: No concept defines itself; no statement proves itself; no physical object is the cause of itself; and no cause is the cause of itself.

Additionally, considering the definition of an infinite set and the Axiom of Infinity [30], other very significant results for the origin of the universe can be demonstrated, particularly the last four listed below (all proofs are very brief and can be seen in [29] and [30]):

1: **Theorem of Infinite Sets**: All infinite sets are inconsistent [30].

2: **Corollary of the Axiom of Infinity**: The Axiom of Infinity is inconsistent [30].

3: **Corollary of Infinite Divisibility**: The infinite divisibility of any formal or physical object is inconsistent [30].

4: **Theorem of the Inconsistent Continuum**: The spacetime continuum is inconsistent [30].

5: **Theorem of Discrete Space**: No physical or abstract space of non-zero extension can be constituted by points of zero extension but by units of non-zero extension [30].

6: **Theorem of Consistent Reality**: A consistent reality cannot consist of an infinite number of universes; nor can a consistent universe be infinite in extent, duration, number of components, or cycles of creation and destruction [30].

7: **Theorem of Finite Entropy**: The entropy of the observable universe is finite [29].

8: **Theorem of the Non-Eternal Universe**: The observable universe cannot be eternal [29].

To the list of previous theorems and corollaries, the following is now added:

Theorem 1 (of the First Cause) *The observable universe had an origin whose cause is external to the universe itself and scientifically unknowable.*

Proof.- Since it is not eternal (Theorem 8 of the Non-Eternal Universe), the universe must have had an origin. And the cause of that origin must have been external to the universe itself; otherwise, the universe would be an object that causes itself, which is impossible (Theorem ?, of Formal Dependence). If instead of a single cause for the origin of the universe there was a succession of causes, that succession could not be infinite and consistent (Theorem 1 of infinite sets), nor could that succession originate itself (Theorem ?, of Formal Dependence). Finally, the universe could not have originated from a fluctuation of nothingness, because then, contrary to the First Law of logic, nothingness would not be nothingness but something with the capacity to fluctuate and create universes, and that something could not originate itself either (Theorem ?, of Formal Dependence). In all cases, we would have a cause external to the object whose origin we are trying to explain, and being an external cause to that object, that external cause cannot be explained in terms of scientific knowledge extracted from within that same object. Therefore, the cause of the origin of the universe is scientifically unknowable. □

4. Two paths to the same conclusion

From the equations of general relativity, it is possible to deduce, as A. Friedmann and G. Lemaître did, a cosmological model in which the universe expands and, consequently, the universe might not be eternal and could have an origin. Depending on the cosmological constant, the formalism of general relativity leads to either a non-expanding universe (as Einstein initially left it [8]) or an expanding universe. Thus, the relativistic formalism suggests that the universe could either be eternal or have an origin. It has been the subsequent empirical evidence of the universe's expansion and the discovery and measurements of the cosmic microwave background that have confirmed the latter alternative, which, as is well known, was rejected and even ridiculed for several decades until empirical observations prevailed.

In the previous section, we saw an independent formal approach from the relativistic path that demonstrates, along with other significant results, that the universe cannot be eternal and must have had its origin in a cause external to the universe itself, a cause unknowable to human science. This new approach does not demonstrate a possibility but a formal necessity. It does so based on very simple foundations: an inductive principle (the Principle of Directional Evolution) and an inconsistency (that of the hypothesis of the actual infinite, which is demonstrated in just over half an A4 sheet [30], and in up to 40 different ways in [28]). Obviously, the relativistic conclusion about the origin of the universe and that based on its directional evolution mutually support each other. Moreover, the formal independence of both arguments provides additional support for their common conclusion about the origin of the universe. A conclusion supported by all empirical observations of modern cosmology.

The persistent rejection by some scientists of the idea that the universe could have had an origin (that it could have been created) is likely due to their anti-deistic prejudices. To avoid the origin of the universe, these scientists have proposed alternatives that include infinite numbers of universes or universes with infinite cycles of creation/destruction, or universes arising from nothing. These theories can be divided into two groups: those that make use of infinity (such as the aforementioned infinite number of universes, or infinite cycles of creation/destruction) and those that defend their origin from nothing or the void. The first group of theories faces the inconsistency of the infinity. In the second group, it would have to be admitted that nothing (or the void) is something with the capacity to create universes, and the origin of that something with that capacity would need to be explained. Or else, the First Law of Logic would be violated: nothing is the same as something, and consequently, a thing is what it is not, and is not what it is.

5. Fine-tuning the fundamental physical constants

The first consequence of the Principle of Directional Evolution is the Theorem of the Consistent Universe, which establishes the control of this evolution through a unique set of invariant and consistent physical laws. These laws involve variable magnitudes and constant numbers, both dimensionless and with dimensions. These are the physical constants. Some of them could be called particular because they only intervene in specific processes that are little or not at all relevant to the overall evolution of the universe; others could be called, as is usually the case, universal or fundamental constants because they have significant consequences on the directional evolution of the universe. There is no general agreement on the total number of fundamental physical constants, although there is a committee that continuously studies and reviews them: CODATA (Committee on Data for Science and Technology). The recommended values of the fundamental constants of physics and chemistry published by CODATA in 2021 increase the number of such constants to 234 [37, p. 46-51].

The problems posed by the fundamental constants of physics and chemistry (hereafter referred to as fundamental constants of physics) are usually more metaphysical than physical (as is the case in this section), which is why their study is not usually part of the main core of scientific education for physicists, none of whom, incidentally, has managed to explain the value of a single one of these constants [2, pos. 98]. However, in a discrete universe, and according to J. Garrigues-Baixauli, at least some of these constants could be calculated simply by assuming that space is made up of 4D spheres with a diameter equal to the Planck length. In any case, there is some literature specifically dedicated to the matter of fundamental constants of nature [32, 2, 12, 18, 14], etc.

Some fundamental constants are interesting in themselves, for example, the first non-zero decimal of the cosmological constant (involved in the expansion of space) appears after the decimal point and 51 zeros. Or a variation in the 13th decimal of the fine-structure constant (which should be called the Sommerfeld constant) would make the formation of matter impossible. In the words of M. Born [5, p. 180]:

> The fine-structure constant touches one of the outstanding unsolved problems of theoretical physics.

A problem that, as I write this (summer of 2024), remains an unsolved problem of theoretical physics. The precise values of the fundamental constants pose the problem of their fine-tuning: small variations in one of these values would make the universe as we know it unviable. Naturally, this physical problem raises the metaphysical problem of the origin of this fine-tuning, which is one of the objectives of this section.

Many renowned physicists, including atheists and agnostics, recognize the extraordinary importance of the fine-tuning of the values of the fundamental constants of physics for the observable universe to be genuinely observed. The list would be endless: M. Planck, A. Einstein, M. Born, P. Dirac, F. Hoyle, R. Feynman, R. Penrose, S. Weinberg, S. Hawking, G. Smoot, R. Laughlin, etc. [4]. There were also classical authors like A. S. Eddington who defended the idea that the fundamental physical constants could be calculated in mathematical terms [7, 38]; or like P. Dirac who proposed their variation over time since the Big Bang [6]. Naturally, there are also authors who defend alternatives to the single universe finely tuned in its fundamental physical constants, although in this case, the list is much more limited, for example, L. Smolin, M. Tegmark, A. Linde, P. Steinhardt, J. N. Gardner, and others.

Although, indeed, changing the value of one of these constants could be catastrophic for the evolution of the universe, one could consider the possibility of simultaneously changing the values of all the fundamental constants, i.e., one could consider the possibility of different sets of fundamental constants finely tuned to each other and compatible with the observed evolution of the observable universe, thus increasing the chances of randomness in the origin of the universe. But as will be seen below, this random alternative is practically impossible. The discussion is very basic, simply setting upper probability bounds for several sets of fundamental constants, each set defined by a certain number of constants, and each constant by a certain number of invariant decimal places. For each fundamental constant under consideration, the total number (n) of all possible constants with the same number of decimal places as the constant under consideration will be calculated, of which only one will be the fundamental constant under consideration. Therefore, the probability of that considered fundamental constant will be $1/n$.

Indeed, let us consider a set of n fundamental constants, each with d decimal places, all of which must remain invariant. The set of these n fundamental constants, each with d invariant decimal places, will be equivalent to a single string with $n \times d$ invariant decimal places. Considering that each of these $n \times d$ decimal places can take 10 different values (the ten digits from 0 to 9), it is straightforward to calculate the total number $T_{n\times d}$ of all different strings with $n \times d$ decimal places:

$$T_{n\times d} = 10^{n\times d} \tag{1}$$

of which only one string will correspond to the considered set of n fundamental constants. Therefore, it is obvious that the probability $P^1_{n\times d}$ of that single string (i.e., the probability $P^1_{n\times d}$ of that single set of fundamental constants) will be:

$$P^1_{n\times d} = \frac{1}{10^{n\times d}} \tag{2}$$

$$= 10^{-n\times d} \tag{3}$$

which demonstrates the following

Theorem 2 (of the Constants) *The random probability of a particular set of n numerical constants each with d decimal places is exactly $10^{-n\times d}$.*

Let us consider some concrete cases, with a few constants and a few decimal places each, to establish some probabilistic references on the maximum probabilities that a set of fundamental constants could arise randomly. For the case $d = 3$, that is, for the case that all fundamental constants have their 3 decimal places invariant, we would have the following probabilities for sets of 5, 10, 15, and 20 such fundamental constants with 3 decimal places each:

$$\text{Set of 5 fundamental constants: } P^1_{5\times 3} = 10^{-15} \tag{4}$$

$$\text{Set of 10 fundamental constants: } P^1_{10\times 3} = 10^{-30} \tag{5}$$

$$\text{Set of 15 fundamental constants: } P^1_{15\times 3} = 10^{-45} \quad (6)$$
$$\text{Set of 20 fundamental constants: } P^1_{20\times 3} = 10^{-60} \quad (7)$$

If instead of fundamental constants with only 3 decimal places ($d = 3$) we consider fundamental constants with 6 decimal places ($d = 6$), that is, fundamental constants that have their 6 decimal places invariant, we would have the following probabilities for sets of 5, 10, 15, and 20 such fundamental constants with 6 decimal places each:

$$\text{Set of 5 fundamental constants: } P^1_{5\times 6} = 10^{-30} \quad (8)$$
$$\text{Set of 10 fundamental constants: } P^1_{10\times 6} = 10^{-60} \quad (9)$$
$$\text{Set of 15 fundamental constants: } P^1_{15\times 6} = 10^{-90} \quad (10)$$
$$\text{Set of 20 fundamental constants: } P^1_{20\times 6} = 10^{-120} \quad (11)$$

As can be seen, even the maximum probability $P^1_{5\times 3} = 10^{-15} = 0.000000000000001$, which corresponds to the case of a set of only 5 fundamental constants each with only 3 decimal places, is extremely low. In the more realistic case of a set of 20 fundamental constants each with 6 decimal places, the probability is practically zero: $P^1_{20\times 6} = 10^{-120}$. Considering that the number of fundamental physical constants necessary for the directional description of the observable universe is almost certainly greater than 5, and each of these constants has at least 3 invariant decimal places, we must conclude that the origin of the fundamental constants for a directionally evolving universe like ours could not have been random. Consequently, these fundamental constants must have been intentionally calculated and defined. Ultimately, the following can be demonstrated:

subTheorem 1 (of the Calculated Universe) *The observable universe must have been intentionally calculated and created so that it would evolve as established by the Principle of Directional Evolution.*

Proof.- The observable universe had an unknowable origin for humanity (Theorem of the First Cause, page 3). It is a universe whose directional evolution is directed by a unique invariant set of consistent laws (Theorem of the Consistent Universe, page 3), which implies that each of the constants necessary for these laws must be invariant. If the number of such constants is equal to or greater than 5 and the number of their respective invariant decimal places is equal to or greater than 3, then the probability of the random origin of that set of constants is practically nil. Therefore, the observable universe must have been intentionally calculated and created to evolve as we observe it: according to certain physical laws involving certain fundamental constants. □

Note that a sub-theorem, like the previous one, is not an entirely formal conclusion based on the laws of logic and modes of logical inference, but also makes use of statistical results of great conclusive value.

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