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# Cosmology, *Cosmologia*, and Reality: How the Cosmological Model Challenges the Intelligibility of Reality

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**Abstract:** More than four centuries after the Copernican Revolution and the consequent dismissal of Aristotelian Cosmology, the modern model of the cosmos has reached a similar if not superior level of a satisfactory understanding of physical reality. This extraordinary feat was achieved by using the Galilean scientific method of investigation, which was demonstrated to be extremely powerful in modeling cosmic physical phenomena. Unexpectedly, the main global characteristic of the cosmos was found to be its evolution in time; the universe's history passes through very different phases, all linked together by a subtle *fil rouge.* This very fact, by now incontrovertible, is challenging our interpretation of reality by the sole use of the scientific method. The time may have come to reconnect, in a collaborative and constructive way, science, philosophy, and theology, which for too long have proceeded along independent, parallel, or even divergent paths. Only in this way may we hope to reach a more satisfactory understanding of global reality.

**Keywords:** cosmology; scientific method; philosophy of nature

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## 1. Introduction

The Copernican Revolution and the adoption of the Galilean scientific method represent an epochal turn in the definition and intelligibility of nature. For almost two millennia, the understanding of physical reality was based on the principles of Aristotelian cosmology, whose main characteristic, in view of what will be discussed later, was the sharp distinction between the sub-lunar world and the empyrean. This separation of reality into two substantially different worlds—the ever-changing and corruptible terrestrial world and the eternal quintessential empyrean world—influenced the approach to their interpretation. In the absence of the modern concept of Galilean experimentation, events were understood and deduced from the nature of their substance and associated with a priori behavior; in particular, in terms of their motion in space and time, rather than by repeated and controlled observations.

The revolution in the understanding of reality that occurred across the 16th and 17th centuries, in spite of its consolidated "Copernican" attribution, has its roots in two fundamental experimental achievements: the observations of celestial bodies by Galileo with his *cannocchiale* and, as clearly proposed by Thomas Kuhn in "*The Copernican revolution*" (Kuhn [1957] 1992), by the new concept of motion.

The crystalline spheres of Aristotelian cosmology were shattered by the observations, in December 1609, of the mountains and valley of the lunar surface, brilliantly illustrated by Galileo in his *Sidereus Nuncius*. The observations demonstrated that there was no substantial difference between the Moon and Earth, and hence between the sub-lunar and the empyrean reality. At the same time, Galileo was studying the motion of falling bodies, and this fortunate coincidence almost certainly influenced his reasoning about the emerging scientific method. In a letter that the Pisan scientist wrote in December 1612 to his friend Mark Welser, we can find a synthetic definition of it:

"Because, either we pretend, philosophizing, to penetrate the true and intrinsic essence of the natural substances; or we content ourselves with learning some of their mutual relationships. I believe that sounding the essence is an impossible feat—and a useless wearing one—both for the nearby substances and for the celestial faraway ones.

But, if we limit ourselves to discover some relationships, I don't think we should give up hope to find and understand them in the most remote bodies in the universe as well in those surrounding us"[1].

We can consider this limpid text as the manifest of the modern scientific method; no other prophecy has come true exactly as foreseen, even exceeding any expectations. Indeed, several years later, Isaac Newton, completing the work initiated by Galileo, would establish the foundations of classical mechanics by proposing his universal gravitation theory and by changing drastically—possibly in a more covert way—the previous concept of space and, consequently, time.

Later, in 1618, in his treatise "*Il Saggiatore*", Galileo elaborated further on his method of investigating the universe. The treatise is written in the form of a debate about the nature of the comets, and although his interpretation of the phenomenon—a visual effect produced by the reflection of the sun's rays in the atmosphere—is wrong, his defense of the modern scientific method is exemplary. Two passages are worth mentioning here in the context of the present paper: the first concerns the decisive value of the experimental results and the second attributes mathematics as a fundamental role in the intelligibility of reality.

In order to demonstrate the superior role of the experiment with respect to the authority of old written texts, he affirms that he was ready to believe that the ancient Babylonians were able to cook eggs by revolving them as fast as possible in a slingshot, as was reported in a famous Byzantine encyclopedia of the time. However, he writes:

"If an effect does not happen to us that was successful by others in previous times, it is necessary that in our experiment we lack what was the cause of the success of that effect [ . . . ]: now, we do not lack eggs or slingshots, nor robust men who turn them, and yet the eggs do not cook [ . . . ]; and since we lack nothing but being from Babylon, therefore being Babylonian is the cause of the hardening of the eggs, and not the friction of the air"[2].

Beyond the irony of the example, Galileo defines the essential elements of the modern scientific experiment: the accurate and complete description of its boundary conditions and its repeatability. Lacking these two elements, an experiment, as interesting as it may be, does not have, strictly speaking, scientific meaning. We will turn to this essential point when discussing the modern cosmological model.

In Chapter 6 of "*Il Saggiatore*", Galileo opens another window into the intelligibility of reality. He writes:

"Natural philosophy is written in this huge book that is constantly open before our eyes, I mean the universe; but it cannot be understood unless one first learns its language and knows the characters in which it is written. It is written in mathematical language, and the characters are triangles, circles and other geometric figures, without which it is humanly impossible to understand a word of it; without these it is a vain wandering through a dark labyrinth". (Ibidem, chp. 6)

This famous quote has been historically interpreted as evidence of Galileo's belief in the intrinsic nature of mathematics as a part of reality. Today, the nature of mathematics and its role in the description of phenomena is highly debated: does mathematics and its "objects" ever exist independently of our consciousness, which can then gradually discover them together with their properties, or is mathematics invented or "evoked" by our rational capacity?[3] Certainly, mathematics plays a fundamental role in the interpretation of physical phenomena, not only providing a descriptive tool of their underlying regularities (the "physical laws"), which allows the scientist to predict the result of an experiment before it is performed, but in some cases, it can itself unveil phenomena previously unknown. Possibly the best example of this latter power of mathematics is the discovery of electromagnetic waves, and hence of the nature of light, by James Clerk Maxwell. By simply manipulating his four differential equations that describe, separately, electric and magnetic phenomena, he obtained a new equation that described the propagation of a generic wave. Without detracting from the merits of the Scottish scientist, one could say that the intrinsic properties of differential equations were instrumental in discovering the true nature of light.

Returning to Galileo's belief in mathematics, it should be noted that he applied it only to the description of the relationships occurring in an experiment, and not to the essence of reality, which he considers, explicitly and with honest humility, unfathomable.

The immediate and long-term consequences of the adoption of the Galilean scientific method were diverse and far-reaching.

## 2. The Scientific Method and the Lost Cosmology

The introduction of the scientific method, after the initial studies of motion by Galileo, had its greatest success in the development of the universal gravitational theory and celestial mechanics by Isaac Newton. The motion of planets following elliptical orbits and Kepler's empirical laws were mathematically deducted from a single principle, and their calculated position was confirmed by observations at all levels of accuracy. The new celestial mechanics were, in fact, powerful enough to be able to predict the existence of new planets on the basis of discrepancies between the calculated position of the known planets and their observed location.

The huge success of this new science had many profound consequences, some of which are particularly relevant in a discourse on the intelligibility of nature.

First of all, the branch of philosophy that was, until then, involved in the study of nature—the Philosophy of Nature—came to an end based on the belief that the only truthful method of investigating physical reality was the Galilean one. This hasty and erroneous decision is at the origin of the growing divergence between science and philosophy that only in recent times has begun to be recognized and corrected.

Similarly, but possibly more serious, was the crisis between the Catholic religion and the new science, which had its monumental beginnings in the notorious trial of Galileo. The literature on the latter is enormous and discussing it is well beyond the purpose of this paper. I limit myself to highlighting two elements that, in my opinion, might be useful to understand the origin of the violent contrast between science and religion that has afflicted Western culture for about four centuries and has only recently begun to settle. One evident reason is that the Biblical exegesis of the time was at its lowest levels. The vehement defense by Saint Augustine of Hippo[4] of the priority of natural observations over the naïve interpretation of the Bible was ignored, and the evidence of celestial motions as observed through Galileo's *cannocchiale* was negated as heresy. We had to wait for the II° Vatican Council and for the revision of Galileo's trial[5] to begin healing the wounds. A second, less evident reason is related to the mentioned decay of Aristotelian cosmology which, following Galileo's observations, could no longer be sustained.

While Galileo's telescope opened a new window into the cosmos and initiated a new era of astronomical research, the limited capability of the early instrumentation did not allow scientists to collect enough data and interpret them physically so as to build an alternative cosmological model that could replace the previous one (it suffices to recall that the nature of light, the essential cosmic messenger, was only discovered in 1865). Scholastic theology was heavily dependent on an understandable cosmology, and the Aristotelian anthropocentric cosmology offered a privileged background to the theologian studies, particularly when considering the special role that could be attributed to the empyrean. In the absence of a satisfactory understanding of the new cosmic reality that was gradually unveiled, the distance between theology and science continued to grow.

The path toward a new satisfactory cosmology took almost four centuries to take shape. The reason for such a long delay was both scientific and technological; the successors of

Galileo's *cannocchiale* revealed a universe populated by a large number of stars that were too faint to be seen by the naked eye. That number steadily increased with the larger light-collecting power of the new telescopes; however, it was only in 1838 that astronomers began to realize the huge distance at which the stars were located[6]. Moreover, physical science was in its infancy, and the very nature of the stars and their apparently everlasting luminosity was still a mystery. As in ancient times, humanity returned to feelings of awe and anguish when faced with an incommensurable cosmos hosting distant beautiful stars that seemed to have no obvious relation with its existence. This feeling was vividly expressed by poets, such as John Milton. In his poem "*Paradise Lost*", he wrote:

> *How Nature, wise and frugal, could commit*
> *Such disproportions, with superfluous hand*
> *So many nobler bodies to create?* (Milton 2020, Book VIII, 25–27)

Similarly, Giacomo Leopardi, in his "*Canto notturno di un pastore errante dell'Asia* (*Night song of a wandering shepherd in Asia*)" (Leopardi [1831] 2018, Canto XXIII. 84–98), wrote:

> *E quando miro in cielo arder le stelle;*
> *Dico fra me pensando:*
> *A che tante facelle?*
> ...
> *Uso alcuno, alcun frutto*
> *Indovinar non so.*
> *(When I see the stars bright in the sky,*
> *I question myself:*
> *What's the use of all those beacons?*
> ...
> *I cannot imagine*
> *Their use, their yield.)*

Hence, for a long period of time, the technological advancements of observational instruments—telescopes—unveiled a vaster and richer universe which, however, was becoming more and more mysterious and apparently completely detached from human phenomena and consciousness. Any effort to achieve cosmic intelligibility was inevitably frustrated.

## 3. The Advent of the New Cosmology

The situation changed in a revolutionary way in the second half of the 19th century, starting with the previously mentioned discovery of the nature of light and electromagnetic phenomena. In a rapid and dramatic sequence, scientists discovered the quantization of energy and matter, the relativity of space–time, the atomic structure of matter and associated phenomena, quantum physics, and finally, the gravitational curvature of space–time.

The consequences for the intelligibility of cosmic phenomena were exciting. The possibility of analyzing the spectral distribution of the light emitted by celestial objects, in particular the stars, combined with emerging knowledge about the atomic structure and the associated light-emitting processes, allowed astronomers to obtain basic physical parameters, such as the temperature and pressure of the stellar atmosphere, as well as indications on its chemical composition. In 1957, the pivotal paper *Synthesis of the Elements in Stars* (Burbidge et al. 1957) created a flourishing new branch of astrophysics: stellar structure and stellar evolution. In the following decades, the entire life of stars of various masses, from their formation by the collapse of gaseous nebulae through their maturity to their final slow or explosive decay, was theoretically modeled and observationally tested.

In parallel, cosmologists were investigating the large-scale structure and composition of the universe. In 1922, the American astronomer Edwin Hubble was able to determine that the nebulous image in the Andromeda constellation was actually a galaxy, an ensemble of several hundred billion stars, similar to our own galaxy and located at a distance of 2.5 million light years from us. The universe suddenly became much larger and its building blocks were no longer stars, but galaxies: hundreds of billions of galaxies of different shapes and distances. While new, more powerful telescopes were exploring the uncharted distant regions of the cosmos, cosmologists were confronted with the revolutionary concepts of space and time of Einstein's theory of General Relativity. According to this new theory, space and time can no longer be considered separate and absolute entities. Rather, they are a continuum whose characteristics are influenced by the presence of mass and energy; clocks run slower in the presence of large masses and these, in turn, shape space geometry. These effects are practically unmeasurable in a terrestrial laboratory but become evident on the cosmic scale. The first scientist who applied Einstein's theory to the entire universe and tested the result with observational data was the Belgian priest George Lemaître. In his seminal paper "*Un univers homogène de masse constante et de rayon croissant, rendant compte de la vitesse radiale des nébuleuses extra-galactiques*."[7], published in 1927, he created modern cosmology by unveiling the most fundamental and unexpected characteristics of the universe: its expansion.

This fact, predicted by General Relativity and confirmed by observations, was so revolutionary that it took decades before it would be universally accepted. However, with the advancement of astronomical instruments and, in particular, with the advent of the space era, which opened the entire electromagnetic spectrum to cosmic observation, cosmologists were able to confirm that the universe is essentially evolutive. Its history saw phases that were quite different from each other but were all intimately interconnected by a unitary process that produced and is producing entities and phenomena of increasing complexity.

Today, we are able to follow the cosmic history along a period of about 13.8 billion years, moving from a rather undifferentiated mixture of elementary particles and electromagnetic energy to a first, primordial nucleosynthesis that produced a sizeable quantity of helium and traces of light elements, followed by the formation of stars of various masses, in the interior of which, as already mentioned, the chemical elements were formed. Later, at the explosive end of life of the most massive stars, the elements were distributed in the cosmic medium which, therefore, became chemically enriched. We know today that when a new star is born from the gravitational collapse of a gaseous nebula, a planetary system is also formed; every star we see in the sky has several planets orbiting it. One of these planets, an insignificant speck of dust in the vastness of the cosmos, hosted the emergence of biological life which, patiently evolving, brought out that consciousness that today observes and explores the universe that generated it.

## 4. How the New Cosmology Changes Our Concept of Reality and Its Intelligibility

The new concept of reality that emerges from the new cosmology is indeed revolutionary, and its far-reaching consequences in philosophy, anthropology, and theology have not yet been completely grasped. To begin with, Heidegger's fundamental question: "Why are there beings at all instead of nothing?" should be paired with an equally fundamental one: "Why beings are in evolution?". The essential evolutionary nature of reality as a whole means that our existence, including our consciousness, is inextricably linked to cosmic evolution; if stars of different masses were not formed as part of cosmic history, the largest ones to produce the chemical elements we are made of and the smaller ones, such as our Sun, to create a stable planetary environment for billions of years to allow life to emerge, we would not be here reasoning about the universe and its origin. Milton's and Leopardi's enigma about the relationship between us and the twinkling stars is now clearly explained. Each and every iron atom of the hemoglobin that circulates with the blood in our veins was formed in the interior of some remote star!

The intimate interconnection of the entirety of reality and its unitary history has profound consequences. The clear-cut distinction between matter and spirit, between the environment we live in and our consciousness, begins to fade away in favor of the continuity of the global cosmic evolutionary path. In this new vision, it becomes harder and harder to believe that the emergence of consciousness on planet Earth that we experienced is a unique event in the entire universe. If our existence and our consciousness are part of cosmic evolution, then it is reasonable to believe that the emergence of life and consciousness is a general feature that might have occurred or will eventually occur elsewhere in the universe, wherever or not the favorable stable environment we have enjoyed on Earth exists. Because of the enormous cosmic distances and the finite speed by which we can exchange information, we will never be able to prove the above hypothesis, which, however, could become more credible if future explorations on Mars and other bodies of our planetary system reveal traces of biological life. In any case, the mere possibility of extraterrestrial cosmic consciousness, as a sort of next-level Copernican Revolution, has to be taken into account when reasoning about our role in the universe.

At this point, a related question emerges about the intelligibility of reality and the means we may use to approach it. During the past five centuries, investigations into global physical reality, i.e., the cosmos, and that of the spirit and its phenomena have proceeded along separate paths. The separation stemmed from the substantial difference in the methods of investigation. Physical theories have the possibility of being verified (or falsified, using Popper's famous criterium) by objective experimental data, something that cannot be applied by the sciences of the spirit, in particular by religion and theology. Ian Barbour, in his analysis of methodological parallels between science and religion, wrote: "The positivists had portrayed science as *objective*, meaning that its theories are validated by clear-cut criteria and are tested by agreement with indisputable, theory-free data. Both the criteria and the data of science were held to be independent of the individual subject and unaffected by cultural influences. By contrast, religion seemed *subjective*." (Barbour 2013). This sharp methodological separation was held to be true and undisputed until the middle of the last century, when the emergence of quantum physics and General Relativity suggested that experimental data and their interpretation were not completely theory-free, but rather theory-laden. The classical book by Thomas Kuhn (2012), "*The structure of Scientific Revolutions*", paved the road for the philosophy of science to critically discuss the *objectivity* of the scientific method.

The history of the construction of the modern cosmological model, starting from the cited 1927 paper by George Lemaître to the discovery of the so-called CMB radiation by A. Penzias and R. Wilson in 1964[8], represents a vivid example of how physical theories, in particular cosmological models, can be influenced by the cultural heritage and personal tenets of scientists.

As already mentioned, before the work of George Lemaître, nobody believed that the universe was expanding. The data about the apparent outgoing velocity of galaxies was still scarce and none of the existing physical theories, prior to General Relativity, suggested the expansion of the universe as a whole. The belief in a static universe was so deeply rooted that, when Einstein himself applied his General Relativity equations to the whole cosmos and found that the solution was unstable, indicating that the cosmos should be expanding or contracting, he decided to modify his equation by introducing an ad hoc constant (the cosmological constant) in such a way that the new solution would describe a static universe, i.e., the universe he had in mind due to cultural tradition. The great merit of George Lemaître, who with good reason should be considered the father of modern cosmology, was to believe in the original solution of Einstein's equations and to verify it using the few experimental data that were available at the time. When Lemaître discussed his findings with Einstein during the 5th Solvay Congress of Physics in Brussels in 1927, the comments of the father of General Relativity were very crude[9]: "Your calculations are correct, but your grasp of physics is abominable.". Even a genius such as Einstein could be influenced by cultural prejudices! One year later, in July 1928, both Georges Lemaître and the American astronomer Edwin Hubble attended the 3rd General Assembly of the International Astronomical Union in Leiden and exchanged views about the relevance of the observational data of the galaxies to the emerging evolutionary model of the universe. Stimulated by the discussion with Lemaître, Hubble immediately began observations with the new 100-inch Telescope at Mount Wilson (the largest telescope in the world until 1949), and in 1929 he published a paper that confirmed the expansion of the universe, as predicted by Lemaître[10]. Confronted with the evidence of the new data, Einstein eventually recognized that the universe was indeed expanding, as his original equations had told him. He is reported to have later said that the artificial introduction of the cosmological constant was "the biggest blunder of my life"[11].

Cultural prejudices regarding the emerging new cosmic scenario were not limited to Einstein's case. The British astrophysicist Fred Hoyle (Burbidge et al. 1957), although he could not avoid acknowledging the observational evidence of the recession of the galaxies, was not at all convinced by the emerging cosmological model that implied a "beginning" of the universe (ironically, it was Hoyle that nicknamed the new model as the "Big-bang cosmology", in a derogative comment during an interview by the BBC). In order to reconcile the observational data with his personal conviction of a cosmos with no beginning, he proposed the alternative "Steady State" model, in which, in order to compensate for the expansion, matter would have to be continuously created out of nothing (a concept not to be confused with St. Thomas' *Creatio continua*). In his model, the universe would be always the same. In spite of the ever-growing evidence of the adequacy of an expanding and evolving model, Hoyle sustained his vision until his death in 2001, even after the discovery in 1964 of relic radiation and the above-cited CMB, which was predicted in 1948 by the astrophysicist G. Gamow as an inevitable consequence of an expanding cosmos.

These two historical detours show how personal beliefs may influence the formulation of physical theories. However, it should also be noted how, in the end, any cultural prejudice has to surrender in the face of the observational data. Indeed, the repeatability of experimental verification is one of the pillars of the Galilean scientific method and it can both dispel inadequate theories and confirm bold hypotheses. A beautiful example of the latter case is represented by the formulation of General Relativity by Einstein. When he proposed the principle of equivalence, which is at the root of his new theory of gravitation, there were no known experimental facts that would have induced scientists to look for a modification of Newton's theory[12]. Einstein, as he reported, was inspired to develop his revolutionary theory by a sort of enlightenment. "Suddenly a thought struck me," he recalled. "If a man falls freely, he would not feel his weight ... This simple thought experiment ... led me to the theory of gravity." The consequences of General Relativity, in particular the curvature of space–time, were dramatic and hard to believe, and only the *experimentum crucis* of the 1919 Solar Eclipse (the bending of the starlight grazing the eclipsed Sun) could convince the world that Einstein's intuition was right.

We may conclude that a crucial methodological separation, represented by data verification, persists between the scientific method and the sciences of the spirit.

However, is this epistemological distinction still valid today when we attempt to model the entire evolutionary cosmos using the Galilean scientific method? The question might appear paradoxical. It is thanks to modern scientific theories, in particular quantum physics and General Relativity, that we have been able to successfully describe a wealth of cosmic phenomena that occurred in the various phases of cosmic evolution. Some of these phenomena, such as black holes and gravitational waves, are so intrinsically complex and their physical conditions are so far away from what we can hope to study in our terrestrial laboratories, that we can only look back in wonder about the effectiveness of the scientific method in modeling reality. In particular, it is thanks to the scientific method that we were able to unveil the main characteristics of the cosmos, i.e., its evolution. Why should we then raise doubts about its applicability to the entire cosmos?

The reason is very simple: the cosmos, seen as a global and unitary phenomenon, is unique, and we cannot rewind cosmic history and start it again by modifying its initial conditions. This is what physicists ordinarily do when they perform experiments; they repeat them by changing the initial conditions in such a way that some regular patterns would emerge to later be called physical laws. The repeatability of the experiment is an essential feature of the scientific method because it allows physicists to separate the effect of the initial conditions from the underlying physical laws. Obviously, this classical procedure cannot be applied to the cosmos as a global unitary experiment; not only we cannot modify the initial conditions of the emerging universe, but we cannot even determine what they were.

One may object that the same situation applies to the study of all celestial phenomena, such as the Sun, a planet, or even a black hole. However, the inability to modify the initial conditions is amply compensated by the possibility of observing a large number of objects belonging to a specific class, such as the stars. By observing millions of stars with different masses, dimensions, temperatures, chemical compositions, etc., astrophysicists were able to learn a great deal about the structure of the stars, including their formation and evolution.

Unfortunately, it is impossible to investigate the properties of a cosmos other than the one we live in (I will talk about the multiverse hypothesis in a moment). Consequently, we cannot effectively distinguish between the initial conditions and the physical laws that guided the initial phases of cosmic evolution. This epistemic crisis is exacerbated by the difficulties encountered by theoretical physicists in combining, in a single compatible theory, the two main pillars of our rational understanding of reality: quantum physics and General Relativity.

While we must admire any attempt to dig deeper and deeper into our ability to understand reality, we have to admit that there is an elephant in the room. Given the above considerations about the unicity of the cosmos, should not we recognize, with Galilean humbleness, that the scientific method alone is inadequate to investigate the origin and evolution of the universe as a whole? Or, in this fundamental quest, should not the scientific method deliver its findings to philosophy and theology to complete the task? In other words, should cosmologists not become, or return to being, as in the old times, philosophers of nature?

This appeal is the core message contained in the letter[13] that the Holy Father Saint John Paul II wrote in 1988 to the Director of the Vatican Observatory, Father George Coyne SJ. The letter not only sanctioned in a definitive and unappealable manner the impossibility, on a rational ground, of a real contrast between science and Christian faith, but also indicated the necessity of the effective collaboration between theology and science. "Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes" wrote the Holy Pontiff, hoping that theology and science would not be satisfied with a respectful dialogue at a distance, but that the former would analyze with courage and determination which of the scientific results required review, and eventually a reformulation of dogma, and science would draw inspiration from religion to question itself on the intrinsic limits of the scientific method, thus avoiding unconsciously transforming itself into idolatry.

Did this prophetic sentence have any effect on contemporary theology and cosmology? On the theological side, there have been several authors that have explored the theological implications of an evolving universe, especially on the concept of Creation and the intimate relation of the human phenomenon with it. Particularly relevant are the contributions of Karl Rahner, Jürgen Moltmann, John Polkinghorne (1998), Ian Barbour (2013), John Haught (2007, 2021, 2022), and more recently José Arregi, Leonardo Boff, José Maria Vigil (Fanti et al. 2018), Francesco Brancato (Brancato and Benvenuti 2013; Brancato and Galleni 2014; Brancato 2017), Costantino Rubini (2013; Rocchetta and Rubini 2020), and others[14]. While these authors have addressed some of the most relevant issues with which the evolutionary cosmos challenges theological traditions, such as the concept of Creation, the possible elimination of a sharp separation between matter and spirit, and the concept of eternity and its eschatological implications, we have to recognize that we have not yet reached in theology that change in paradigm that, according to Thomas Kuhn, characterizes a revolution. The innovative thoughts of the cited authors still encounter difficulties in entering the formal study programs of the Pontifical Theological Universities, and the study of cosmology is essentially absent. A sign of change seemed to be the Apostolic Constitution *Veritatis Gaudium*[15] by Pope Francis; however, after the enthusiasm created by the strong appeal to the interdisciplinarity of its Foreword, the subsequent formal body of the document, somehow in a contradictory way, cut off any hope for a real paradigmatic change. The dramatic consequences of the status quo are that theological innovations remain confined within academic circles, and they never reach the catechists or the church's pulpits. In this way, while children know today about the big bang and the evolving universe, they are still taught about Creation as an event that happened long ago in space and time and about Original Sin as "the original fault freely committed by our first parents . . . at the beginning of the history of man"[16]. There is still a long way to go before the Pope's words are fully realized.

The situation is no better in cosmology. Cosmologists have reacted to the crisis opened by the cited inapplicability of the Galilean scientific method in the analysis of the unique phenomenon of the evolving universe by proposing models that circumvent the issue of the initial conditions, as well as of the beginning. In the multiverse hypothesis, our universe could be just one of the many or infinite possible universes, each of them with diverse initial conditions and possibly physical laws and evolutionary histories. Alternatively, our universe could have a cyclical history, therefore avoiding a beginning. These are fascinating hypotheses that, in fact, gained high popularity among experts as well as laymen. They are indeed very interesting and scientifically plausible, but they all lack intrinsically the possibility of being verified by observational data. Parallel universes cannot send messages across their respective boundaries, and a cyclic universe cannot send us news about its previous existence.

These hypotheses, which could be considered attempts to exit from the current cosmic impasse, are not scientifically verifiable, or, more technically, falsifiable. It would be excessive to qualify them as "idolatry", but certainly they belong to the wider category of philosophical or theological proposals. As such, they require a free and personal act of faith to be accepted.

An interesting proposal, which may be a promising path forward, was introduced by the cosmologist and theologian George F. R. Ellis, who makes a distinction between cosmology, intended as the investigation of the various phases of the evolution of the universe that can be described by the scientific method, and *Cosmologia*, intended as the attempt to understand the evolution of reality as a whole, including matter and energy, as well as human consciousness (Ellis 2017).

Considering the incontrovertible discovery that the cosmos has a history and that its evolution is responsible for the emergence of the existence of entities and phenomena of ever-increasing complexity, most of them unpredictable a priori, and that the most complex and intriguing reality that emerged at the tip of a 13.8 billion-year journey is human consciousness, is it not logical and convenient to move from pure scientific cosmology (or, perhaps, evolutionary astrophysics) and embrace the concept of a global cosmology, or *Cosmologia*, that, as in previous times, includes human consciousness and its cosmic destiny in its considerations?

In fact, the discourse about the intelligibility of reality becomes much more interesting if we take into consideration the various possible global cosmological models. These *Cosmologiae* will all have, as a common, solid, and necessary pedestal, the findings of the (verifiable and falsifiable) scientific models of cosmic evolution. However, they will differ in the choice of the solution to the stumbling blocks that, as we have seen, the scientific method encounters. These can be represented by the multiverse hypothesis, the cyclical universe, or other philosophical or theological hypotheses, such as the Christian concept of Creation; in this sense, all these cosmological models share the same scientific credibility (because of the initial common assumption), and they have all the same trustworthy dignity; however, the motivation to choose one of them cannot be the result of a demonstration, as we do with a geometrical theorem; rather, it requires a free personal act of faith.

I may, for example, believe that the cosmos and its evolution, including the emergence of life and consciousness, is simply due to chance; I am living by chance in the singular universe, among the infinite possible ones that are compatible with life. By taking this choice, cosmic evolution and its products of ever-growing complexity, culminating with the human phenomenon, do not seem to have a purpose. In this essentially atheistic universe, the personal human experience terminates with material death, and one may wonder why the very intelligibility of reality should be of any concern.

Alternatively, and—I wish to emphasize—with equal dignity, I may choose a model in which the entire cosmos and its progressive evolution toward consciousness is the result of a free act of love that keeps in existence the entirety of reality[17], matter, and spirit, and is waiting patiently for emergent consciousness with an equal free act to recognize it and reciprocate the unconditional love toward all humanity and the entire cosmos, becoming in this way a partner in cosmic existence[18]. This profound cosmic relationship, which I dare to call Trinitarian, lives forever in the Kayrós and will resist the insults of Krònos. By making this choice, science and theology are again reunited in providing a vision of reality as a whole, Heaven and Earth, that, in its intrinsic humility, is perfectly intelligible.

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## Notes

1 Galileo Galilei, Letter to Mark Walser, 1 December 1612, translation by the author.

2 *Il Saggiatore*, in *Le Opere*, Edizione nazionale, vol. VI, Firenze, G. Barbera, 1896, p. 340.

3 For an extensive review of the various interpretations of the role of mathematics in physics, see (Unger and Smolin 2014).

4 S. Augustine, *De Genesi ad Litteram, 1, 19, 39*. The same passage is cited by Galileo in his *Letter to the Grand Duchess Christina of Lorraine.*

5 For an interesting report about the work of the Pontifical Commission on the Galileo's case see: (Artigas and de Toca 2009).

6 The first reliable star distance was measured by Friedrik W. Bessel using the parallax method. The star called 61 Cygni was found to be 10.3 light years away.

7 Annals of the Scientific Society of Brussels, 1927. See (Lemaître 1927).

8 The CMB, accidentally discovered by A. Penzias and R. Wilson in 1964, is the radiation emitted by the whole cosmos at a very early stage of its evolution, when it was just a mixture of ionized gas and electromagnetic radiation. The original radiation was emitted in visible light, but, because of the expansion of the universe, it is today received in the microwave wavelength band. The CMB is considered one of the pillars of the modern cosmological model. See https://www.space.com/25945-cosmic-microwave-background-discovery-50th-anniversary.html (accessed on 27 April 2023).

9 D. Lambert, https://inters.org/einstein-lemaitre (accessed on 27 April 2023).

10 Soon after the publication of his papers, the cosmic expansion became universally known as the "Hubble law"; The International Astronomical Union, in its 30th General Assembly in Vienna in 2018, approved at large majority a resolution, proposed by the author of this article, that modified the name of the name "Hubble Law" into "Hubble-Lemaître Law", acknowledging the primacy of the Belgian priest in giving birth to the modern cosmology. https://www.iau.org/news/pressreleases/detail/iau1812/ (accessed on 27 April 2023).

11 Cormac O'Raifeartaigh, "Investigating the legend of Einstein's "biggest blunder"" https://physicstoday.scitation.org/do/10.1063/pt.6.3.20181030a/full/ (accessed on 27 April 2023).

12 In reality, Newton's theory had failed in explaining the anomalous precession of Mercury's apogee while it was later correctly predicted by Einstein's General Relativity. However, this particular observational data was proved only after the new theory was developed and it had no influence in its formulation.

13 Letter of His Holiness John Paul II to Reverend George V. Coyne, S. J. Director of the Vatican Observatory, https://www.vatican.va/content/john-paul-ii/en/letters/1988/documents/hf_jp-ii_let_19880601_padre-coyne.html (accessed on 27 April 2023).

14 Almost all these authors were influenced by the seminal thought of Pierre Teilhard de Chardin, although with some critical distinctions.

15 https://www.vatican.va/content/francesco/en/apost_constitutions/documents/papa-francesco_costituzione-ap_20171208_veritatis-gaudium.html (accessed on 27 April 2023).

16 Catechism of the Catholic Church, 390.

17 "*Non enim est creatio mutatio, sed ipsa dependentia esse creati ad principium a quo statuitur*", Thomas Aquinas, Contra Gentiles, II, 18.

18 John's Gospel, I, 12.

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