

Creation: a Multifaceted and Thematic Concept in the Construction of Modern Cosmology – from Friedmann’s Creation of the Universe to the Steady-State’s Continuous Creation

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This article focuses on the multifaceted and thematic nature expressed by the concept of creation in 20th-century cosmology, namely in the construction of the big bang cosmology and its rival, the steady-state cosmology.

Regarding the approaches of three of the main founders of big bang cosmology (Friedmann, Lemaitre, and Gamow), we can find, in an explicit or implicit way, two different forms of creation – creation from nothing or creation from shapeless matter. On the opposite side, suggested by the proponents of steady-state cosmology (Hoyle, Bondi, and Gold), we can find another form of creation – the continuous creation of matter.

*It is proposed that the multifaceted concept of creation, due to the wide interest it aroused and the intensity of cosmological debates it provoked, as well as its historical longevity and its disciplinary and cultural transversality, may be recognized as a *thema*.*

*Keywords: creation, creation from nothing, creation from shapeless matter, continuous creation of matter, big bang cosmology, steady-state cosmology, *thema**

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Introduction: *creation*, a problematic issue in modern cosmology

As observed by Helge Kragh (2007: 240), after the Big Bang cosmology had defeated its rival steady-state cosmology in the 1960s, cosmologists avoided for some time the concept of *creation* for being “a concept which might seem to be foreign to science and better suited to philosophical and theological discourses.”

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This “somewhat timid attitude” has given a place in recent decades to several different attitudes (Kragh, 2007: 240-241), which again brought creation to the cosmological discussion. This does not mean, however, that creation does not continue to be a very problematic and controversial issue. Indeed, such attitudes of cosmologists have a strong personal component “depending in part on their favoured models and in part on their spontaneous philosophical preferences” (Kragh, 2007: 240). Besides that, creation continues to be generally avoided, at least in the sense of being an issue to which relatively little scientific attention is paid, with cosmology continuing to be clearly more occupied with questions such as the evolution and structure of the Universe.

Regardless of the attitude of each cosmologist towards creation, it is undeniable that this concept is an unavoidable concept in modern cosmology, especially since it is a cosmology based on the idea of a finite-age universe, and it is worth to see when and how the concept was introduced, as well as on what forms it manifested in the construction of the big bang cosmology and in the dispute between the big bang cosmology and the steady-state cosmology.

Creation in the construction of the big bang cosmology

Many scientists have contributed to construct the big bang cosmology. However, there are three founders who played a special role and whose texts, covering three decades of important developments, from 1922 to 1952, contain the essential lines of the big bang cosmology. They are Alexandre Friedmann, who first proposed, in the “seminal article” of the big bang cosmology (Kragh, 2013: 1), published in 1922, the two essential ideas of big bang cosmology – the idea of the origin of whole the Universe at one certain moment in the past and the idea of its expansion (Friedmann, 1922); Georges Lemaître, who, in 1927, associated for the first time the idea of expanding Universe with experimental observations, namely the spectral redshift of galaxies; and George Gamow, who proposed with Ralph Alpher and Robert Herman the idea of a hot, dense primordial state of the Universe that would become the standard model of the big bang cosmology.

Friedmann and the creation of the Universe

It was Alexandre Friedmann who, in 1922, used the expression “creation of the universe” for the first time in a scientific article. In fact, in the article “Über die Krümmung des Raumes” [“On Space Curvature”], Friedmann admitted the possibility of an expanding universe from a zero-initial radius, introducing the expression “creation of the universe”:

We will call the time that R [radius of the Universe] takes to grow from 0 to R_0 by time after the creation of the Universe (Friedmann & Lemaître, 1997: 275).

The idea of creation of the Universe appeared again in a Friedmann’s book, *Mir kak prostranstvo i vremya* [The Universe as Space and Time], published in 1923, and this time in the form of religious references, especially biblical ones. The first chapter of the book begins with an epigraph which refers to a passage of the Bible (Book of Wisdom, 11:20): “He created everything according to measure and number” (Friedmann & Lemaître, 1997: 108).

However, perhaps the most significant religious reference is in the following passage, regarding three variable universe models (a monotonous universe in expansion from a zero-initial radius, a monotonous universe in expansion from non-zero initial radius, or an oscillating universe with cycles of expansion and contraction):

This reminds certain mythological conceptions of the Hindus regarding “cycles of existence”; we could also speak of *a creation of the Universe from nothing*. But all of this should only be taken as a curiosity (Friedmann & Lemaître, 1997: 275; original italics).

It should be noted that Friedmann, being the first scientist to treat the idea of the creation of the Universe in purely scientific terms, namely in physical-mathematical terms, introduces, in his 1922 article, the expression *creation of the Universe* in an entirely natural meaning and never as recognition of some kind of action carried out by some supernatural entity, namely God. Indeed, as some authors have noted, one of the strengths of this work is precisely the idea that the creation of the Universe arises naturally as a solution of the relativistic field equations (Luminet 1997: 34).

However, by admitting a beginning of the Universe, spatially from a zero-initial radius, Friedmann’s cosmology easily evokes the idea of creation from nothing through the intervention of a supernatural entity, the creation *ex nihilo* of Judeo-Christian cosmogony. In this regard, wrote Merleau-Ponty:

(...) for all of the minds formed in the reverence or the derision of the Judeo-Christian dogmas – that is, for almost all the members of the scientific city of the twentieth century – the idea of an origin of the Universe evokes necessarily the concept of creation *ex nihilo* of the world that ancient and medieval thought ended up emerging from the confrontation between the speculations of Greek philosophy and biblical mythology (Merleau-Ponty, 1965: 343).

Therefore, although Friedmann assumed that it is just “as a curiosity,” like the evocation of the Hindu cycles of existence, the evocation of the Judeo-Christian concept of creation from nothing cannot be ignored. And the simple verbalization of this “curiosity” in a cosmological text contributes, albeit unintentionally, to keep religion in the field of cosmology, and even making possible a certain suggestion that modern cosmological science corroborates ancient religious cosmogonic beliefs.

Friedmann, who was an orthodox Christian, ends his book by quoting some verses addressed to God:

To measure the depth of the oceans,
 To count the grains of sand and the radius of the planets
 All this the human spirit can do.
 But he cannot find the measure of You! (Friedmann & Lemaître, 1997: 213)

As noted by Jean-Pierre Luminet (Friedmann & Lemaître, 1997: 213), these verses of the Russian poet Gavriil Romanovitch belong to a book entitled *God*, and Friedmann ends his book with a religious reference similar to the epigraph at the beginning of the book, which may reinforce any eventual interpretation that associates Friedmann’s cosmology with Judeo-Christian theology.

Regardless of any religious association, Friedmann’s cosmology has recovered an old concept that until then was usually removed from the scientific study of the Universe, the concept of *creation* (Merleau-Ponty, 1965: 107). And the emergence of this concept in the cosmology of the 20th century is a remarkable moment. So remarkable that, as Jean-Pierre Luminet observes:

This term “creation of the universe,” once launched in the field of relativistic cosmology, would cause many whirls and misunderstandings and psychologically block most physicists (Luminet, 1997: 40).

For Friedmann, an assumed orthodox Christian, the adoption of the word *creation* in his cosmological texts may have been spontaneous and unconscious as a simple result of his intellectual culture. It may also have been conscious, but without any concern about a lexical alternative, for not giving importance to the issue. Or it may have been as purposeful as conscious. We will never know, because there is no evidence in Friedmann’s published texts that could lead us to this question, and his book suggestively titled “Creation” was never published, its manuscript having been lost.

Lemaître and the effort to avoid the word creation

Unlike Friedmann, who seems to have no problems with the word *creation*, Lemaître always avoided this word in his scientific texts, preferring to speak in *origin*, *commencement*, or *conditions initials* (when published in French), and *beginning* (when publishing in English).

Especially illustrative of this concern is the text “The Beginning of the World from the Point of View of Quantum Theory” (Lemaître, 1931). In this very short note, Lemaître speaks briefly about the origin of the Universe as a quantum *beginning* and ends with this sentence: “The totality of matter in the universe must have been present from the beginning, but the story it tells us can be written step by step.” However, it was later discovered that the manuscript of this note contains this final paragraph, which Lemaître decided not to include in the published version of his text:

I think that everyone who believes in a supreme being supporting every being and every acting, believes also that God is essentially hidden and may be glad to see how present physics provides a veil hiding the creation (cited by Godart & Heller, 1985: 73).

As far as is known, it was the only time that Lemaître used the word *creation* in a scientific text and, as we see, by deciding not to publish the last paragraph of the manuscript, he prevented the word from appearing in a published article.

In fact, and according to Lemaître (1972: 9), the “philosophical background” of his *primeval atom hypothesis* does not integrate the idea of *creation*, which he conceived as something completely outside the reach of any scientific theory. His theory is only about a completely natural beginning, the primeval atom. And what is the origin of the primeval atom? As a cosmologist, Lemaître does not answer, leaving the question of the origin of this initial unity, that is, the origin of everything, entirely open from the scientific point of view. Lemaître’s cosmology is not explicitly a cosmology of the creation of the Universe, namely a creation from nothing, but rather a cosmology of the beginning of cosmic evolution from an initial unity, the primeval atom, into multiplicity. Therefore, if Lemaître’s cosmology is a cosmogony, in the sense that it deals with the origin of the Universe that we know, it is not a complete cosmogony, in the sense that it leaves out the question of the origin of the initial unity. In such a conceptual framework, there is no place for the theological concept of creation.

Lemaître is very satisfied with this naturalness of the initial state of the Universe, as we can see in this passage where he again uses the word just to convince that the idea of creation does not belong to his cosmology:

Personally, I believe that such a theory is entirely outside any metaphysical or religious issue. It leaves the materialist free to deny any transcendent being and to be able to take, in relation to the foundation of space-time, the same attitude of spirit that he could adopt for events that occurred in non-singular places in space-time. For the believer, [the theory] excludes any attempt of familiarity with God (...). Which is in accordance with the word of Isaiah of the “Hidden God,” hidden even at the beginning of creation (Lemaître, 1972: 9-10).

Lemaître was perfectly aware of the possible religious uses of his theory, either by a materialist or by a believer. He draws attention to the fact that his theory was entirely outside of any of these uses. Besides that, Lemaître was aware of the risk that his scientific ideas could be easily associated with his own religious beliefs, because he was also a Catholic priest. It is widely recognized that, throughout his scientific career, Lemaître has always tried to separate cosmology from theology (Robredo, 2011: 87-94; Lambert, 1999: 97-98). He even wrote that the Christian scientist must “abstract himself from his faith in his research” (Lemaître, 1936: 70), and his persistent care in avoiding the word *creation* in his published scientific literature may certainly be understood as part of this attitude.

However, this Lemaître’s concern was not enough to completely avoid associations between the idea of a beginning of the Universe and the old theological concept of creation *ex nihilo*. Indeed, although the word *creation* does not appear in Lemaître’s scientific texts, there was a context of strong historical heritage already referred to regarding Friedmann’s theory (Merleau-Ponty, 1965: 343).

In such a context, it seems that the idea of creation is implicitly inscribed in these new cosmological conceptions and thus inevitably ends being evoked. The idea is like a kind of ghost that is invisible but whose presence is felt. The mentioned episode of the last paragraph of the manuscript is really enlightening regarding this issue. In a certain sense, not publishing that paragraph (without, however, destroying the manuscript, which would become posthumously known and commented) is hiding the word and the idea of *creation*, and precisely when talking about creation as something which is hidden by the “veil” of the primeval atom hypothesis. This presence of the word *creation* in the unpublished manuscript is a kind of metaphor for something that cannot be observed but that happened. Also enlightening is the mentioned passage in which Lemaître refers to the “Hidden God, hidden even at the beginning of creation.”

For all of this, and as the *creation of the Universe* of Friedmann’s models, Lemaître’s *primeval atom* is, in an implicit way, very suggestive of the idea of creation *ex nihilo* as considered in Judeo-Christian cosmogony. And it is even more suggestive because it is proposed by a scientist who is also a Catholic priest. A Catholic priest who wore clerical clothes even when teaching science and when he met with other scientists, and who signs his scientific articles with the religious title “Abbé G. Lemaître” – Abbot/Father G. Lemaître. Even in scientific texts, other cosmologists referred to Lemaître as “Abbé Lemaître” (Eddington, 1930: 668). From a scientific point of view, we can say that all of this is just a small set of irrelevant details, but Lemaître’s research focused on a cosmological issue which easily and really evoked a concept with a strong religious connotation.

It would be difficult not to notice that a scientist priest (or a priest-scientist) was proposing a cosmological theory that suggests a beginning of the Universe in a remote past. And, despite all Lemaître’s concern, his cosmological ideas were easily considered as a creationist (with religious connotations), a criticism that has endured over time. For example, physicist

José Croca and philosopher of science Rui Moreira, referring to the “Lemaître’s creationist theory,” state that “the Catholic astronomer, Abbot Lemaître, managed to reconcile his religious beliefs with the facts, with “the experimental evidence” and, “as strange as it may seem to a rational, open and prejudice-free spirit, the prerogative of any scientist who seeks the truth, the cosmology accepted by the majority of the scientific community is the creationist cosmology of the Big Bang” (Croca & Moreira, 2003: 38-40).

Gamow and the creation of the Universe from shapeless matter

George Gamow saw the history of the Universe as a long “creative process” (Gamow, 1952: 134), and his most famous book is *The Creation of the Universe*, which exposes the word *creation* on the title.

Gamow did not use the word *creation* in the Christian sense of *creation ex nihilo* but in the Greek sense of creation from shapeless matter (Merleau-Ponty, 1965: 344). Indeed, Gamow’s cosmogony begins, not with anything from which the Universe would be formed, but with a state of primordial matter from which the entire Universe would have evolved. According to Gamow (1952: 59), the first material state in the Universe would be a “hot nuclear gas” made up of neutrons that would have decayed very quickly and created protons and electrons. Once formed, the protons and electrons would have started to originate neutrons through the reverse process, creating a primordial homogeneous mixture (of neutrons, protons, and electrons) that Gamow, like Ralph Alpher (1948: 1581), called *Ylem*, in the sense of “the first substance from which the elements were supposed to be formed” (Gamow, 1952: 60). *Ylem* is, therefore, a raw material, an elementary (or practically elementary) material from which atoms would have been built, and it is a shapeless raw material because it is a mixture without any constructed structures. A fundamental matter was waiting to take the form of nuclei and atoms and, later, the form of molecules and all the microscopic and macroscopic material structures of the Universe. Avoiding a beginning from nothing and being something without form from which something can be done with the form, we can say, like Merleau-Ponty, that *Ylem* suggests the imagination of an ancient Greek. Indeed, Gamow does not seem to have realized that the name *Ylem* is an English derivation of the ancient Greek word *hylé* (ὕλη), precisely used by Aristotle to name the fundamental substance from which all matter would have come.

After the first edition of his famous book, and realizing some confusion concerning the religious connotations of the word *creation*, so exposed in the title, Gamow felt a need to clarify the meaning in which he used the word, and, from the second printing of the book, he complemented the preface with this note:

In view of the objections raised by some reviewers concerning the use of the word “creation,” it should be explained that the author understands this term, not in the sense of “making something out of nothing,” but rather as “making something shapely out of shapelessness,” as, for example, in the phrase “the latest creation of Parisian fashion” (Gamow, 1952: vi).

However, despite this note and despite the concept of *creation* in his theory of the hot, dense primordial state of the Universe, it must be recognized that Gamow let his ideas become involved, at some extent and albeit unintentionally, in possible religious connotations.

The issue was not only in the title of the book. In fact, the dedication page of the book (v) presents an excerpt of the musical score of *The Creation*, a Haydn’s masterpiece about the

Genesis myth. A few pages ahead (xii-xiii), in the introduction, Gamow explicitly assumes that he is in favor of “the hypothesis of a ‘beginning’” for the Universe, in line with the “imaginative Belgian scientist, Abbé Georges Edouard Lemaître,” which are some simple but meaningful words that can arouse the religious associations concerning Lemaître’s theory. Additionally, in chapter II, regarding a hypothesis to explain the origin of the primordial material of the Universe, in which the hot, dense state is called by Gamow as “the Big Squeeze” (36), we can read:

(...) nothing can be said about the pre-squeeze era of the Universe, the era which may properly be called “St. Augustine’s era,” since it was St. Augustine of Hippo who first raised the question as to “what God was doing before He made heaven and earth” (Gamow, 1952: 37).

In addition to these religious references in Gamow’s book, some episodes may have reinforced some religious associations with Gamow’s cosmogony. Indeed, according to Kragh:

In 1951 he sent a copy of a popular article to the pope, Pius XII, which was received through the apostolic delegate, the archbishop of Laodicea. According to the archbishop, the paper “was presented to the Holy Father who read it with satisfaction and who looks forward to the publication of your book ‘The Creation of the Universe.’” A few months later, the secretary of state of the Vatican City informed Gamow that the pope had received the book from its author and was eager to read it (Kragh, 1996: 117).

As if this was not enough, Gamow started the short article “The role of turbulence in the evolution of the universe,” published in 1952 in the prestigious scientific journal *Physical Review*, with a quote from Pope Pius XII regarding his theory about the early state of the Universe (Gamow, 1952: 251).

More informally, Gamow would even call “divine creation curves” to the graphic representation of the initial history of the Universe (graph with the variation in temperature and the concentrations of neutrons, protons, and deuterons in the first minutes), which appeared in articles such as “The Evolution of the Universe” (Gamow, 1948: 681). In fact, there is no known publication in which Gamow used the expression “divine creation curves” to designate that graphic representation, but, according to Alpher and Herman, his close collaborators, Gamow even used that expression informally (Alpher & Herman, 1988: 31).

It is as if cosmogony always slips, consciously or unconsciously, deliberately, or involuntarily, into a religious sense of creation. An orientation which many scientists seem to be unable to escape, even those who, like Lemaître, tried to “separate the waters” or those, like Gamow, suggested an idea of creation of the Universe different from the idea of creation from nothing.

The creation, according to the steady-state cosmology

The idea of the creation of the Universe, especially the creation from nothing with theological connotations, provoked a strong reaction, which even reached an assumed repulsion of some cosmologists. The steady-state theory became the main reaction of opposition, proposing a stationary universe without any temporal or spatial beginning and replacing the once-creation of the entire Universe by a continuous creation of matter, which

would be scattered across the Universe and would be able to keep the observed homogeneity on a cosmic space in expansion.

Regarding this issue, Merleau-Ponty writes:

To the eyes of the new cosmologists – at least, of some of them – the materialist version of the Universe was irremediably condemned and, as a result, traditional Theology was reestablished in its claims about nature (Merleau-Ponty, 1965: 115).

This reaction to alleged theological claims about a cosmological territory was especially intense in Fred Hoyle, one of the three proponents of the steady-state cosmology (the others were Bondi and Gold), who was openly anti-Christian and most violently objected to the big bang idea. According to Kragh, the three steady-state pioneers worked on a religious background:

There can be little doubt that the discussions among Hoyle, Gold, and Bondi, which led to a tentative formulation of the steady-state theory in 1947, were colored negatively by the views expounded by Whittaker, Milne, and other religious scientists. The three steady-state pioneers were atheists and either hostile or indifferent to organized religion; the same was the case with Sciama, the most important of the young theoreticians. Although the motives behind the steady-state model were not religious (or, rather, antireligious), it must surely have added to their satisfaction that it was possible to design a universe in which there allegedly was no room for a Creator (Kragh, 1996: 252-253).

Considering such a reaction, a question may arise regarding the use of the word “creation” by the supporters of the steady-state. Suppose they associated the idea of an origin of the Universe to a demiurgical act of creation. Why, in their alternative theory, did they not prefer to speak, for example, on the continuous *formation* of matter instead of the continuous *creation* of matter? Why did they also use a word with such a strong theological charge, the same word used by those they criticized so much? Unfortunately, we do not know any text by the steady-state defenders that clarifies this question. Still, it is very plausible that it was just a natural and spontaneous use: the word *creation* is perfectly logical because the continuous creation of matter would be a true creation of something.

Anyway, the result is a kind of conceptual substitution, a recovering of a territory supposedly lost in favor of theology by using the same basic concept – creation – in a new and profoundly different way, without any theological connotations, like a claim that there is only one kind of cosmic creation – the continuous creation of matter. One creation comes out (theologically connoted, unique, *ex nihilo* or from the shapeless matter), another creation comes in (without any theological connotations, multiple, continuous).

With the alleged continuous creation of matter, the steady-state cosmology proposed a modification of the law of conservation of mass. The quantity of mass is preserved, but only inside the observable Universe, insofar as the continuous exit of matter beyond the observable Universe (due to the expansion of space) is compensated in the exact proportion by the continuous creation of matter inside these limits.

The idea of continuous creation of matter caused a lot of discomforts and was no less fracturing than the idea of creation of the Universe in the past, largely because of its strong implications to the law of conservation of mass, which is perhaps one of the most powerful,

consensual, and unquestioned laws of the history of science. The reformulation of this so well-established law was theoretically unconvincing for many physicists and cosmologists, and it did not have any experimental support – the creation of matter was a phenomenon never observed and would be difficult to observe.

As much as the authors and followers of the steady-state theory have endeavored to defend that we are only facing a reformulation of the law of conservation of mass, in the eyes of many physicists, cosmologists, and philosophers of science, the continuous creation of matter constitutes even a clear violation of this law.

The discussion about the idea of creation, and especially about the idea of continuous creation of matter, was quite intense, pitting scientists and philosophers against the supporters of the steady-state in such a way that some of the opponents even referred to the continuous creation of matter as “the creation fantasy” and “pure magic” (Kragh, 1996: 232). In fact, this kind of creation has never been observed, not even afterward.

Conclusion: *creation*, an old *thema*

As we saw, the concept of *creation* has expressed itself in a multifaceted way in 20th-century cosmology, revealing a plurality of meanings since, in 1922, Friedmann used the expression “creation of the universe” in a scientific context. Moreover, this plurality was such that it served the purposes of two rival perspectives: the big bang cosmology and the steady-state cosmology.

More or less explicit, and more or less assumed, the concept of *creation* assumed an unavoidable role – a simultaneously unifying and controversial role, in a process in which different forms of creation have contributed for a true bipolarization of cosmology: on the one hand, creation as a unique and original event of the entire Universe; on the opposite side, creation as an event continually happening in an infinite and ageless universe.

This multifaceted character and this simultaneously agglutinating and controversial role, capable of polarizing cosmological debates, justify looking at the concept of *creation* as a concept which we can recognize the statute of *thema*, in line with the *thematic* analysis proposed by the physicist and historian of science Gerald Holton.

Gerald Holton (1975: 47-68) recognizes in the scientific activity a dimension that, even unconscious or not assumed, is nevertheless very important in the work of scientists, in implicit articulation with the experimental and the theoretical dimensions of science. This is the *thematic* dimension, constituted by *themata* – concepts, methodologies, and hypotheses with a metaphysical, aesthetic, logical, or epistemological nature, associated both to the cultural context and the individual psychology of scientists. *Themata* guide and polarize the research of a scientist or a scientific community in a given context, conditioning the production of knowledge, causing adhesions or rejections in relation to the knowledge produced by other scientists, provoking and polarizing intense scientific debates.

According to Holton (1975: 62), the big bang cosmology is mainly based on the *thema* of *the life cycle*, and the steady-state cosmology is based on the opposite *thema* of *continuous existence*. The passionate controversy that these cosmological views carried out is part of an old cosmological opposition: the *thematic* opposition between an evolutionary view of the world (associated to Heraclitus) and a stationary view (associated to Parmenides). Personal preferences seem to have been important in this controversy, often based on philosophical reasons and beliefs (Merleau-Ponty, 1965: 106-107), which corresponds to personal adhesion to a certain *thema* or set of *themata*.

Creation was not explicitly identified by Holton as a *thema*, namely in physical sciences

and, particularly, in cosmology. We can only implicitly recognize *creation* in two of the *themata* identified by Holton: in the *thema* of *once-created, real Universe* (Holton, 1975: 33) and in the *thema* of the *life cycle*, which is a sequence constituted by beginning, evolution, and end (Holton, 1975: 62), whose beginning can be associated with *creation*. However, there are some important reasons that justify the explicit recognition of the concept of *creation* as a *thema*.

Indeed, according to Holton (1975: 47-68, 91-114, 115-161), we can identify some fundamental properties in any *thema*, namely: polarizing effect in the discussion and research (whether by adherence to the *thema* or by opposition and controversy), historical longevity, and disciplinary and cultural transversality. It is possible to find these *thematic* properties in the concept of *creation*.

Indeed, as a polarizing concept of debate, *creation* exerted a great and unquestionable strength in cosmology, fascinating or provoking repulsion like any important *thema*. Either in its form of creation *ex nihilo* (even if just implicit in Friedmann or Lemaître theories) or in its form of creation from shapelessness material (as in Gamow’s Ylem), or even, on the opposite side, in its form of continuous creation of matter (as in the steady-state of Bondi, Gold, and Hoyle), the concept of *creation* played an undeniable polarizing role in cosmological discussion and research, at least until the 1960s, when the big bang won its dispute with the steady-state. As observed by Holton (1975: 64), “the wide interest and the intensity” of scientific debates, “among both scientists or enraged and intrigued laymen,” is a great indication of the presence and the strength of a *thema*.

As we saw about Friedmann’s texts, the arrival of the concept of *creation* to the physical sciences, in particular the modern cosmology, is relatively recent. But *creation* is a very old concept. Throughout history, we can see its presence and central importance in religion, art, philosophy, and other areas of culture. After being already present in others, the introduction of a new *thema* in a certain discipline is rare but can happen (Holton, 1975: 62, 115-161). What happened in 1922 with the article by Friedmann was precisely the arrival of an old *thema* to the nascent relativistic cosmology – the *creation*.

This arrival of *creation* to modern cosmology revealed a very interesting aspect of the concept as a *thema*, which is that *creation* takes several specific forms in the same subject area. In fact, *creation* manifested itself in cosmology under three derived forms: *creation from nothing*, although it is only implicit; *creation from shapeless material*; and *continuous creation*. Applied to the big bang cosmology and the steady-state cosmology, these three forms of the fundamental *thema* of *creation* are specific *themata* of cosmology that have equivalent specific *themata* in other areas. For example, we can see the *creation from nothing* in theology (where is usually named as *creation ex nihilo*); the *creation from Ylem*, in the Gamow hypothesis, has equivalents in areas such as art (for example, the creation of a sculpture from shapeless materials); the *continuous creation of matter*, specific of the steady-state cosmology, has in spontaneous generation of life, an outdated idea of spontaneous appearance of life from non-living matter, its equivalent in biology (Kragh, 1996: 255). In other words: the fundamental *thema* of *creation* has disciplinary and cultural transversality, which is a characteristic of any *thema*, that is also expressed through its derived *themata*, each of them assuming a specific form in a certain area.

In practice, some facts showed this disciplinary and cultural transversality of the concept of *creation*, either by acceptance or rejection. Indeed, some attentive institutions to developments in cosmology were not indifferent to the presence of *creation* in new cosmological theories, and that for very different or opposite reasons. This is what happened

to the Catholic Church, with Pope Pius XII welcoming in a speech to the Pontifical Academy of Sciences the new scientific developments about the origin of the Universe (Pius XII, 1951). On the opposite side, the materialist Soviet regime considered Friedmann (who was Russian) as a creationist (in the religious sense) and, according to some authors, there are indications that he could have been pursued for that if he had not died prematurely in 1925, after having published his cosmological texts (Luminet, 1997: 30, 40-41). Curiously, even the atheist Hoyle did not escape the dislike of the Soviet regime: in 1958, in Moscow, he discovered, with astonishment, that his ideas would have been more acceptable in Russia if he had used other words to talk about the continuous creation of matter. His Russian colleagues told him that “the words “origin” or “matter-forming” would be O.K., but creation in the Soviet Union was definitely out” (Hoyle, 1989: 101).

The intensity of the debates observed inside cosmology and illustrative examples like these clearly reveal that the concept of *creation* is really a *thema* with a strong and wide presence in culture, establishing relationships between areas as distinct as science, religion, and politics. In particular, and since 1922, *creation* is a problematic and controversial *thema* of modern cosmology, with various specific forms like the ones we have seen.

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