Which of the Two Competing Cosmological Models is the Most Probable: an Eternal Steady-State Model or a Big Bang Model Emerging From an "*Exploding*" Single Particle?

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Abstract

In 1949, as the term "*Big Bang*" was coined for the first time in cosmology, an enduring controversy began between the proponents of a stationary, expanding eternal universe and the proponents of a universe that arose from a hot "*primordial atom*" from which space, time and all chemical elements should have arisen. The putative trigger for the Hot Big Bang theory was the physicist Gamow's belief that his findings about nucleosynthesis should fit perfectly with the "*primeval atom*"-theory of the cosmologist and mathematician Lemaître. The cosmic microwave background radiation predicted at the same time and discovered by chance in 1964 was then celebrated as a triumphant confirmation of the Big Bang hypothesis. However, many questions that are by no means ingenuous remained unanswered. Is there such a thing as a center of the universe, where everything began? As it continues to expand, where does it expand? There must be some space at the edge of the universe into which it is expanding. What happened before the Big Bang? How can our entire universe have arisen from an "*empty vacuum*"? The aim of the author of this article is in no way to deal with the ongoing work carried out by very well specialized cosmologists, but rather to express the legitimate doubts of a scientist fairly inexperienced in cosmology, as to whether the claim of the Big Bang theory to be considered as definitive is justified. Anyway, according to the latest findings, and since the energy of the "*empty vacuum*" (*dark energy*) identified as the cosmological constant Λ can be used to describe the recently discovered accelerated expansion of the universe, it is tempting to hypothesize that the opposing forces of gravitation and dark energy may combine, leading to an oscillating eternal universe.

Key words: Big Bang model, steady state model, universe expansion, gravitation, cosmological constant, earth expansion, cosmic microwave background radiation, oscillating eternal universe.

Introduction

Abbreviations: BB: Big Bang, CMB: cosmic microwave background radiation, GTR: general theory of relativity, G: gravitational constant, Λ: cosmological constant.

A.Friedmann (*1888-1925*) who realized in 1922 that the General Theory of Relativity (*GTR*) combines three essential requisites for humans: namely gravitation, time and space, quickly understood that this theory allowed the study of the structure of the universe as a whole and that the underlying mathematical equations might lead to the description of an expanding universe (1). The einsteinian GTR is a geometric theory of gravity that contains a differential equation that links the geometry of any container (*spacetime)* to its contents (*matter-energy*). Friedmann described consequently three types of evolution of the universe over time, one notably involving an initial singularity (2, 3). For a long time Einstein refused to accept such a non-static universe. The cosmological constant Λ introduced by him in his GTR for that very reason was reflecting the then common view of a static universe (4).

Indeed, when it was shown that the universe was expanding, this constant Λ, which was deemed unnecessary, was removed by Einstein from the equations. Unfortunately, it also needs to be mentioned that the story, repeated over and over again, about Einstein's deep regret to have removed his cosmological constant, is not absolutely guaranteed and may be most probably only a legend. This often retold anecdote that Einstein called the withdrawal of the cosmological constant as the "*biggest blunder of his life*" might have been "*faked*" later, for unclear reasons, by Friedmann's former student Gamow.

Nevertheless, it cannot be denied that the GTR, even freed from Λ, introduced an extremely revolutionary concept for the time, namely the inferable cosmological principle stating that our planet does not occupy a privileged position in the universe, a finding that allowed Einstein to describe the structure of the universe as homogeneous and isotropic, that is to say similar to itself whatever the place and the direction in which we look. This position was daring at the time, because there were no conclusive observations confirming the existence of objects outside the Milky Way. However, as will be explained below, the removal of the cosmological constant might have been too premature, as recent research has shown that Einstein was probably partly right after all. The cosmological constant Λ can namely, in fact, be used to describe the recently discovered accelerated expansion of the universe (5).

In any case, A.Friedmann can be considered as one of the three "*initiators*" of the Hot "Big Bang" theory, along with Georges Lemaître and George Gamow, who was one of Friedmann's students. A crucial, and not yet answered, question is, however, whether the BB theory should be considered as definitively correct or not. In other words, is this theory the unique and most probable model or do alternative models exist as possible candidate models that do not implicate an initial starting singularity?

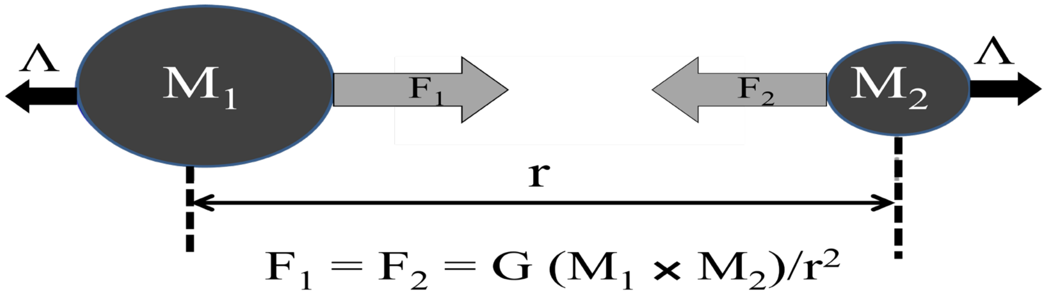

Fig.1. **The equivalent attractive forces of two masses M1 and M2.** G is the gravitational constant: 6.6743×10^{-11} $N.m^2.kg^{-2}$ (*which according to Dirac's gravitation hypothesis may vary in time*), M_1 and M_2 are respectively the masses of objects 1 and 2, r is the distance between objects 1 and 2, and Λ is the Einsteinian cosmological constant.

In the following, by scrutinizing the three essential phenomena closely associated with our daily life, namely gravitation, time and space (6), I will try to show that the greatest challenge the human mind had encountered in the course of its evolution was not understanding gravity and time; rather, it was to develop a concept that would have allowed humans to structurally grasp the true nature of the surrounding space, a challenge that, contrary to all intuition and despite all discoveries made in the mathematical sciences, has remained, until now, unsolved.

1. Modelling an expanding universe requires a deep and precise understanding of the nature of real cosmological space ("*What is Space*?").

Before the seminal discoveries made by I. Newton in the 17th century, gravity was a poorly understood phenomenon experienced as a force attracting animals or objects to the ground, all being attracted by the same force. Newton's main work: "*Philosophiæ naturalis principia mathematica*" published in 1687 not only marks the beginning of the mathematization of physics, but also rationalizes the phenomenon of gravity. Indeed, in his works, Newton also exposed the principle of inertia, the proportionality of forces and accelerations, the equality of action and reaction, and the laws of shock. He also studied the movement of fluids, tides, etc. and, above all, exposed his theory of universal attraction. Recognizing that objects, therefore, fall at the same velocity, unless the air provides them with enough resistance to slow them down, afterwards became common knowledge. He realized, furthermore, that bodies attract each other with a force proportional to the product of their mass and inversely proportional to the square of the distance separating them **(Fig.1)**. However, what is less known, when Newton formulated his law of gravitation in his monumental work, he was keenly aware of how unsatisfactory the notion of "*action at a distance*", implied by his equations, was. In 1692, in a letter to Richard Bentley (*1662-1742*), he wrote: "*…that one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one another, is to me so great an absurdity that, I believe, no man who has in philosophic matters a competent faculty of thinking could ever fall into it."* (7).

This inconsistency, well grasped by Newton, about the mediation of an action at distance which appeared in the expression of the universal gravitational force, was circumvented many years later through the introduction of a gravitational field structured in analogy to Michael Faraday's electric field and allowing, thus, the emergence of a field distributed in space that emanates from a mass and can have an influence on any other bodies that are nearby or even far away. The gravitational field, G(r), created at any point by a point body derives from a Newtonian scalar potential noted Φ(r) in 1/r, analogous to the electrostatic potential. The gravitational field is a vector field that describes the gravitational force that would be applied on an object in any given point in space, per unit mass. It is actually equal to the gravitational acceleration at that point. In fact, there is a formal analogy between the electrostatic field and the gravitational field, and their respective scalar potentials. The GTR interprets the gravitational field as a modification of the metric of spacetime, in other words, gravitation is a manifestation of curved spacetime instead of being due to a force propagated between bodies. Energy and momentum distort spacetime in their vicinity, and other particles move in trajectories determined by the geometry of spacetime.Today every educated person knows why a cup he accidentally drops falls to the floor and breaks.

Time, the second natural phenomenon that has always remained a mystery to the human intelligence, is also notoriously difficult to define. Perhaps its most striking feature is the fact that there always seems to be a moment, which we call the present, and which seems to move inexorably from the past towards the future. Everyone remembers Augustine's aphorism, "*What then is time? Provided that no one asks me, I know. If I want to explain it to an inquirer, I do not know*" (8). If a person living in the 21st century is confronted with an analogous question, but related to the nature of space, one can be sure that this person would give an answer similar to Ausgustine's. This may be surprising, because for modern people, space seems to be easier to conceptualize than time. Let's imagine that this person is watching a film in a cinema, the story captivating him so much (*something like how one would experience one's nightly dreams*) that he has the impression to be present in the sequences of the film. This tech-savvy person would know perfectly well that the time during which the action takes place, is nothing more but a series of images at frequencies of 24 or 48 Hz, frequencies that correspond to the way we see the world. This person is also aware that the irreversible sequences of images, after reaching the neuronal networks of his own brain, will lead to the construction of an absolutely subjective personal time. In an even more scientific formulation one would say: time is created as space expands.

In which way is space perceived during staring at the film sequences? Something amazing seems to happen at this point: the initially one-dimensional images are surprisingly transformed and perceived in three dimensions. People, things and landscapes seem to be recognized as a unit, integrated in a spatial 3D-dimension. If all those things are disappearing from the screen, the viewer sees a blank surface, but no space any more. How can one mentally imagine the geometry of space without matter? In spatial geometry, a sphere is a surface made up of all points located at the same distance from a point called the "center". The value of this distance from the center is the radius of the sphere. In a metric space, a sphere is the set of points located at the same distance from a center **(Fig. 2)**. Their shape can then be very different from the usual round shape. A "*full*" sphere is a ball, the points of which have a distance from the center less than or equal to the radius. Even if a global view does not take into account the external shape of space objects (*whether spherical like the planets, or spiral like the galaxies*), the important question still arises as to whether it makes sense to assume an expanding universe and to consider the matter contained therein as separate.

Basically, it is important to recognize that the expansion of the universe, interpreted as an increasing infinite and limitless "*void*" space, is solely followed by all the celestial material objects contained therein (*galaxies, stars, planets, etc*.) (9). The Greek philosopher Aristotle, speculating about nature's fear of emptiness (*horror vacui*) 300 years B. C., argued that a vacuum could not exist because the surrounding matter would immediately fill it, was wrong. Unlike, for example, an object being immersed in a liquid, the volume of the space itself is not displaced by the immersion of matter. The volume of space is not reduced by the presence of matter; in other words, there is no interface between the celestial bodies and space-time **(Fig.2)**.

If these basic ideas are accepted, it becomes clear that the generally accepted assumption that galaxies are moving apart from each other is fundamentally wrong. Not every star in the universe is moving away from us but rather our nearest neighbors seem to be wandering aimlessly, some coming closer, others receding. Space is not only expanding between groups of galaxies, celestial bodies are also expanding at the same pace, as is our planet and the sun (10, 11). In popular science people are often asked to imagine as a paradigm for an expanding universe a well-kneaded dough rising in a warm place and covered with a cotton cloth, until it has almost doubled in volume. However, the analogy ends here for the following reason: there is an essential difference between a rising dough and an expanding universe: when the universe (*i.e. an empty vacuum*) is expanding, the presence of matter does not influence this expansion; one would have rather to assume that matter is created through the expansion of space (9).

Absolutely erroneous information in popular science publications is, for example, when one is asked to imagine galaxies as dots on a balloon that you inflate. Each galaxy would then be a point on the balloon's surface. You draw a few such dots on it with a felt-tip pen and inflate the balloon. The spots, i.e. the galaxies, are moving away from each other. The authors of such abstruse ideas do not seem to realize that in the case of the balloon used in this thought experiment, pressure is supposed to be blown in from outside (*with the help of an air pump*), while the inflation observed in the universe is most likely caused by something originating from space itself resulting in negative pressure.

In order to get a correct conceptual representation of the expansion of space, it is helpful to remember the following definition given by the great French mathematician and philosopher Blaise Pascal: *"It is an infinite sphere, the centre of which is everywhere, the circumference nowhere"* (10). Translated into a language that is understandable today, it would be read as follows: *"The empty (entirely free of matter) space is an infinite ball, the centre of which is everywhere, the surface nowhere"*. In the model universes constructed by today's cosmologists, no edge or beginning can be identified - just as there is no point on a spherical surface from which the surface begins. For an observer living in such a universe, it is quite impossible to detect a postulated expansion of the universe. The only classical way is the red spectral shift, although this shift can be explained in several ways. There are two possibilities to shed light on this expansion: in the case where the material object is spherical, the surface of these spheres should exhibit a structure (*such as the continents of our planet*); consequently an analysis of the changes in the structure of the surface could allow to get an idea of the expansion of the universe, this is what P. Jordan tried to do (11, 12), without meeting much approval (*as discussed below*). In the case of a complex exterior surface (*i.e. galaxies with different shapes*) only mathematical solutions seem to be possible.

Based on the daily experience of space by humans, which, as we know, have always been subject to major changes depending on cultures and times, classical physics has over the course of its history developed idealized concepts of space, considered as a "*natural*" framework for phenomena, although, in reality, they were only artificial mathematical constructions.

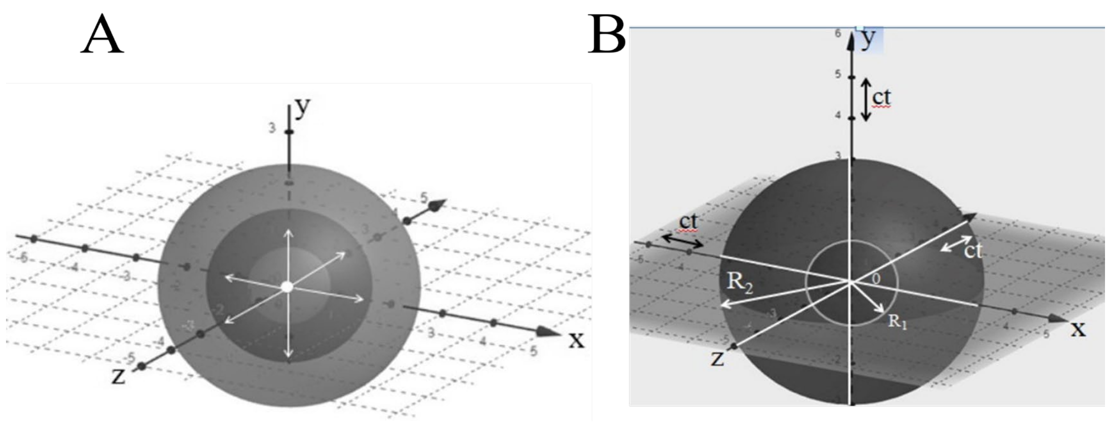

Fig.2 Schematic representation illustrating an expanding universe at an allegoric level. The small balls symbolize all cosmic objects in space (*planets, stars, galaxies, clusters of galaxies, etc*.). The large outer sphere symbolizes empty space (*or dark energy, Λ*?). **A:** The volume of the empty space (*container*) expands and all the matter (*contents*) follows the increasing volume. Even if all matter were removed from space, space would expand unchanged. The point (*at the center of the inner sphere*) projects in all directions onto the surface of differentially increasing concentric spheres; the amount of curvature is the same for all concentric spheres. **B:** R_1 is the radius of the symbolic representation of all matter in the universe; R_2 is the radius of the symbolic representation of the vacuum space (*of the "dark energy", Λ* ?). The length unit in the three cartesian coordinates may be expressed as the product c.t , c being the velocity of light and t the time variable increasing from 0 to ∞. For details see text.

2. The intricate story about the construction of the standard hot-Bing-Bang theory.

The hypothesis of an expanding universe has a long history and many fathers. It has been already mentioned that Friedmann expressed in 1922 the idea of an expanding universe that contained moving matter. In his book published in 1923 Friedmann described not only three types of evolution of the Universe over time, but also one notably involving an initial singularity. He described such a model as follows: "*the universe contracts into a point (into nothing) and then increases its radius from the point up to a certain value, then again diminishes its radius of curvature, transforms itself into a point*" (3).

Five years later G. Lemaître, a Belgian catholic priest and astronomer, independently published in a Belgian Journal under the title "*A Homogeneous Universe of Constant Mass and Growing Radius Accounting for the Radial Velocity of Extragalactic Nebulae*") a paper that at that time had little impact because the journal in which it was published was not widely read outside francophone countries (13). In this communication, he presented the hypothesis which he derived from GTR that the universe is expanding. Three years later on the occasion of a scientific meeting in London he developed further this idea in a report published in Nature (14). Lemaître scrutinized what consequences an expanding universe might have and came to the conclusion that it must have emerged at a finite point in time. If the universe is expanding, it was smaller in the past, and extrapolation back in time should lead to an epoch when all the matter in the universe was packed together in an extremely dense state. Relying on the new quantum theory of matter, Lemaître argued that the physical universe was initially a single particle: a "*primeval atom*" which disintegrated in an "*explosion*", giving rise to space and time and the expansion of the universe that continues to this day. Later on, Lemaître's hypothesis became better known as the "*Big Bang theory*", a term coined during a 1949 BBC radio broadcast by the astronomer Fred Hoyle, who was rather a proponent of the steady state universe, a point of view that he maintained until his death in 2001. In the BBC interview of March 28th 1949 Hoyle explained the reason why he rejected such a bizarre theory: "*These theories were based on the hypothesis that all the matter in the universe was created in one big bang at a particular time in the remote past*". However, the term used by him to characterize Lemaître's "*primeval* *atom*" was in his opinion absolutely not derogatory and should have not be given too much importance, but was only intended to express his rejection of a theory because it would be too reminiscent of a dynamite explosion or of any unverifiable proof of the existence of a divine creator. With the benefit of hindsight we can today recognize in Lemaître's "*primeval atom*" hypothesis the germ of the later hot Big Bang theory, but in the 1930s it was scarcely taken seriously (15, 16). Most astronomers either ignored it or dismissed it as imaginative mind games. Shortly before his death, Lemaître learned that Arno Penzias and Robert Wilson had discovered the cosmic microwave background radiation, according to the majority of researchers, the first and still most important observational evidence in support of the Big Bang (17). It is tempting to assume that Lemaître's deeply-held religious beliefs might have led him perhaps unconsciously to the notion of a beginning of time. One should keep in mind that the Judeo-Christian tradition had propagated a similar idea for millennia.

It is well known that the expansion of the universe, originally proposed by Georges Lemaître in 1927, was clearly confirmed in 1929, almost at the same time, by Edwin Hubble. Hubble found that the farther away a galaxy is from us, the faster it moves: twice as far, twice as fast. Recently it has even been found that some extremely distant galaxies are disappearing at a rate nearly two-thirds the speed of light. However, it is little known that Hubble was very sceptical about the Bing-Bang theory. Einstein once visited Hubble and tried to convince him that the universe was expanding, indeed unsuccessfully. In December 1941, Hubble reported to the American Association for the Advancement of Science that results from a six-year survey with the Mt. Wilson telescope did not support the expanding universe theory. According to a Los Angeles Times article reporting on Hubble's remarks: "*….the nebulae could not be uniformly distributed, as the telescope shows they are, and still fit the explosion idea. Explanations which try to get around what the great telescope sees, he said, fail to stand up. The explosion, for example, would have had to start long after the earth was created, and possibly even after the first life appeared here*" (18).

Exactly four years after the end of the Second World War, something amazing happened in the cosmological research: the well-known British astronomer F. Hoyle, who was a fierce opponent of the "*primeval atom*", published an article in the journal Nature with the expanding universe as subject (19). A few months earlier, G. Gamow and colleagues had published an article in which they presented their investigations on the origin of chemical elements (20). However, the most striking thing about this commonly known as the αβγ-paper (*replacing the authors' initials with Greek letters was a bizarre idea by Gamow, who added the name of his friend H. Bethe, though not involved in this publication*), was that two items that actually had nothing to do with each other, were merged into a more sophisticated theory: namely the Lemaître "*primeval atom*" and the so-called "*primordial nucleosynthesis*". These authors postulated the initial state (*a unique cosmic singularity*) to consist of a very hot, compressed mixture of nucleons and photons, an event (*i.e. synthesis of atomic nuclei*) which, according to the "*Hot Big Bang theory*", took place throughout the Universe during the first tens of minutes of its history (*in a time interval between 10 s and 20 min*).

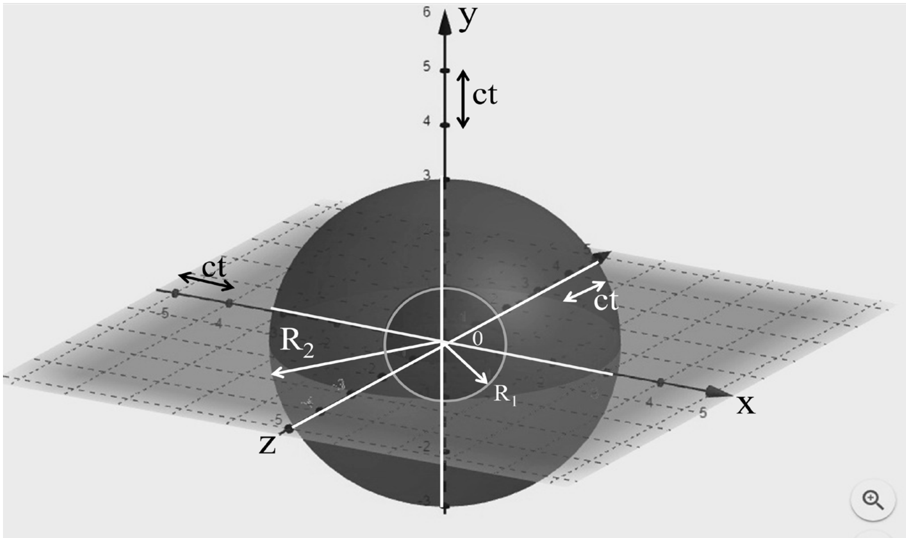

Fig.3. **The planet earth is expanding together with the Universe.** *Inner Sphere*: R_1: radius of the earth. Annual increase of R_1: at least 0.3mm. *Outer Sphere*: R_2: Dimension and structure of the cosmological space is unknown. R_2 increases at a rate which is just of the magnitude of the velocity of light? The dark energy might fill the space evenly and causes the expansion of the universe to accelerate. It was introduced as a generalization of the cosmological constant to explain the observed accelerated expansion of the universe.

Although several models of the expanding universe worked out by various groups have appeared in the literature over the years, some of which are well-founded (21), in this article I would only like to compare the two most important models, namely the one still dominant standard hot Big Bang model as representative of a model beginning with an "*explosion*" and the rival, but less preferred model, characterized as stationary and eternal.

3. In the past, influential cosmologists have made crucially flawed assumptions while constructing models for eternal stationary universes.

The most uncompromising opponent to the Big Bang theory was Fred Hoyle. Although agreeing with the idea of an expanding universe, Hoyle believed that this expansion should be interpreted differently, being of the opinion that, despite increasing expansion, the universe was stationary, in other words, that on average, both structure and general properties remained unchanging over time. This assumption presupposed that as the universe expanded, the density of matter would be expected to diminish, triggering the production of new hydrogen atoms that formed clouds of gas that condensed into new stars and galaxies (15, 22, 23). The weak point of this idea was that the number of new hydrogen atoms that should be produced each year to compensate, and most likely incorrectly calculated by the authors at the time, was so small that it could not be measured directly. Recent findings show that the decrease in mass density due to expansion is compensated for by the continuous creation of new matter in intergalactic space (24).

What made matters worse was the fact that continuous creation of new mass would have to violate a central rule known as the law of the conservation of mass. This law says that the total amount of mass does not change. Mass is not created from nothing or destroyed. Hoyle's theoretical conclusions ultimately reached a dead end on the simple grounds that the expansion of cosmic "*void space*", the main phenomenon with which he should have been concerned, represents a process that has nothing directly to do with the production of new matter in the universe.

Around 1938, the physicist Paul Dirac, one of the most famous founders of quantum mechanics and quantum electrodynamics, dealt with the interrelationship of the very large dimensionless combinations of nature constants. One such number is

$$\frac{e^2}{G.m.M} \cong 10^{39} \tag{1}$$

where e is the elementary charge, *G* is the gravitational constant, *m* and *M* the mass of the electron and the proton, respectively. Another pure number of the order of 10^{39} is the age of the universe expressed in "*atomic time units*" $e^2 = m.c^3$, where c is the speed of light in a vacuum. Because the hugeness of the number 10^{39}, which also represents the ratio of electric to gravitational attraction in the hydrogen atom**,** this ratio could be interpreted by hypothesizing that the gravitational constant G was decreasing inversely proportional to the age of the universe (25). In any case, Dirac's theoretical considerations did not unveil any direct relationship between the expansion of the universe and contingent variations of the gravitational constant.

Unexpectedly however, Dirac's original ideas prompted Pascual Jordan, a well-known German physicist who made significant contributions to quantum mechanics and quantum field theory (26), to adopt Dirac's hypothesis that the gravitational constant G was not actually a constant but rather a function of the age of the cosmos. This was done by modifying the hypothesis within the framework of a scalar-tensor theory, which Jordan developed in the 1940s and which he presented in his 1952 book Gravity and the Universe (27). In this work Jordan speculated that the planet Earth might have doubled in radius in the last hundred million years, expanding to its current size, from an initial ball of a diameter of only about 7,000 kilometres. He explained the continental drift as a result of the expanding terrestrial globe. A similar theory was later presented by Carl H. Brans and Robert Dicke, focussing on an implementation of Mach's principle (28, 29).

Although Jordan may have been right in his speculation concerning the increase in the Earth's radius as a function of Earth's age, he nevertheless made a fatal mistake: he did not state clearly that the expansion of the universe was the actual cause of the increase in the Earth's radius, but rather described this assumed Earth expansion as if driven directly from the Earth. This increase can namely only be understood if one considers the center of the earth's sphere as an integral part of the expanding universe. Only in this case does the Earth expand over time in infinite concentric and ever-increasing spheres, all of which show the same degree of curvature **(Fig. 2 A)**. In his article (30) one can read following revealing sentence: "…*in the sense of adapting to the* ***decreasing*** *curvature of the earth's surface…*" (*page 494, left column, 9th line from the bottom*). So Jordan believed that as the Earth expands, the curvature of the Earth's surface should be decreasing, which shouldn't necessarily be the case.

In the, until now, undecided dispute between the supporters of the Big Bang theory, which, as well known, begins with a unique singularity, and the supporters of an eternally existing stationary universe, one cannot help but wonder whether the paper, published in Nature in 1949, four years after the end of the war, from the pen of a former member of the Nazi party (*see below for further details*) was not detrimental for Hoyle and his like-minded cosmologists; it definitely and immensely benefited the initiators of the Hot Big Bang theory, resulting in the final triumph of their theory.

4. The "*tug-of-war*" between the cosmological constant and the gravitational constant.

According to today's generally accepted opinion, the Big Bang began as follows: immediately after the Big Bang there was a so-called inflation phase in which the entire universe expanded exponentially. And only then could the formation of the elements, galaxies, stars and planets take place.

However, it is worth noting that some formerly proponents of an inflationary standard Big Bang model and now reluctant about the idea of an initial singularity, believe that this theory does not deal with the origin of the universe, but rather about its evolution in time; consequently it would not necessarily follow in their opinion that the universe was ever point-shaped. The modified cyclical Big Bang model describes a universe eternally oscillating between bangs and bounces (31, 32). Ultimately, however, one has to admit that for many proponents of a cyclic steady state universe, without beginning and without end, the existence of a Big Bang singularity (*Lemaître's "primeval atom*) remains incomprehensible.

When it comes to the anecdote of Newton and the falling apple, many believe that it happened the way it is always told. But the truth is somewhat different: in 1665, Newton left the university in pest-threatened Cambridge and moved to his birthplace of Woolsthorpe-by-Colsterworth in Lincolnshire. More than half a century later, on Monday April 15, 1726, the elder Newton (*83 years old*) sits with his young friend W. Stukeley (*39 years old*) in the garden with a cup of tea "*under the shade of some apple trees*".

In his "*Remembrance of Things Past*", Newton told his "*apple story*" to Stukeley, who relayed it as such: "*After dinner, the weather being warm, we went into the garden and drank thea, under the shade of some apple trees…he told me, he was just in the same situation, as when formerly, the notion of gravitation came into his mind. It was occasion'd by the fall of an apple, as he sat in contemplative mood. Why should that apple always descend perpendicularly to the ground, thought he to himself*: *why should it not go sideways, or upwards? But constantly to the earth's center? Assuredly, the reason is, that the earth draws it. There must be a drawing power in matter*" (33).

Forty years earlier, in 1686, Newton first presented his three laws of motion in the "*Principia Mathematica Philosophiae Naturalis*". The third law states that for every action (*force*) in nature there is an equal and opposite reaction. Was the aging Newton no longer aware of his third law while drinking tea with his young friend? If Newton was so clear about Earth's gravity (*G = actio*), why didn't he think about the nature of the opposite force ("*reactio*")? Is it conceivable that the cosmological constant, Λ, introduced inadvertently by Einstein in the 19th century, should be nothing other than the counterforce ("*reactio*") overlooked by Newton many years before? Today Λ is no longer interpreted as a parameter of GTR, but as the time-constant energy density ρ_{vac} of the vacuum:

$$\Lambda = \frac{8.\pi.G}{c^2} \times \rho_{vac} \tag{2}$$

where G is the gravitational constant and c is the speed of light.

However, for practical reasons the dimensionless density parameter Ω_Λ is usually used instead of Λ:

$$\Omega_\Lambda = \rho_{vac} / \rho_c \tag{3}$$

with the critical mass density:

$$\rho_c \approx \frac{3H^2}{8.\pi.G} \tag{4}$$

where H is the Hubble constant. The assumption that the vacuum energy density ρ_{vac} remains constant even as the universe expands leads to the equation of state:

$$\rho_{vac} = -\frac{p}{c^2} \tag{5}$$

From this equation it can be deduced that a positive vacuum energy density leads to negative pressure, which drives the accelerated expansion of the universe, a phenomenon that could be observed by measuring the brightness or redshift of distant Type Ia supernovae (5).

According to some estimations from different observations the value of Ω_Λ is approximately 0.7, expressed differently it represents around 70% of the energy density in the universe and most probably in the form of the not yet well explored "*dark energy*" (34, 35).

All information given above represents today's well-documented knowledge. However, that almost a century ago G. Lemaître had expressed and published the same insight with almost the same wording, and that this fundamental discovery was completely ignored until today, one can't help but be amazed.

In a talk given on 20 November 1933 to the National Academy of Sciences in Washington D.C. Lemaître expressed the opinion that "*we must associate a pressure $p = -\rho c^2$ to the density of energy ρc^2 of vacuum. This is essentially the meaning of the cosmical constant λ*," (17). According to Lemaître (32), the energy-mass density of vacuum is given by:

$$\rho_{vac} = \Lambda c^2/4\pi G \cong 10^{-27} \text{ g cm}^{-3} \tag{6}$$

Lemaître thus offered a physical interpretation of the cosmological constant as a vacuum energy density; admittedly, he did not associate his interpretation with the zero-point energy of space or otherwise relate it to quantum physics. Nor did other physicists at the time, who not only ignored Lemaître's paper of 1934 but also failed to take the quantum vacuum seriously.
As we know today, all objects in the observable universe (*gas, dust, particles, nebulae, stars, etc*.) would only constitute about 5% of its total energy density. The rest of the energy density is made up of a quarter of "*dark matter*", and the rest of "*dark energy*", the exact nature of which is not currently known (34, 35).

If one were to assume that dark matter (85%) should consist of countless invisible planets (*dark exoplanets*), wouldn't it be possible that it could be "*detected*" with larger, more sophisticated space telescopes? The recognition that the "*dark energy*" (*or its Avatar Λ*) might counteract the phenomenon of gravitation eliciting the expansion of the universe brings inevitably to mind an analogy with the "*Yin-and-Yang*" symbol **(Fig. 4),** a concept that describes how opposite forces might be complementary, interconnected, and interdependent in our world, and how they may give rise to each other as they interrelate to one another.

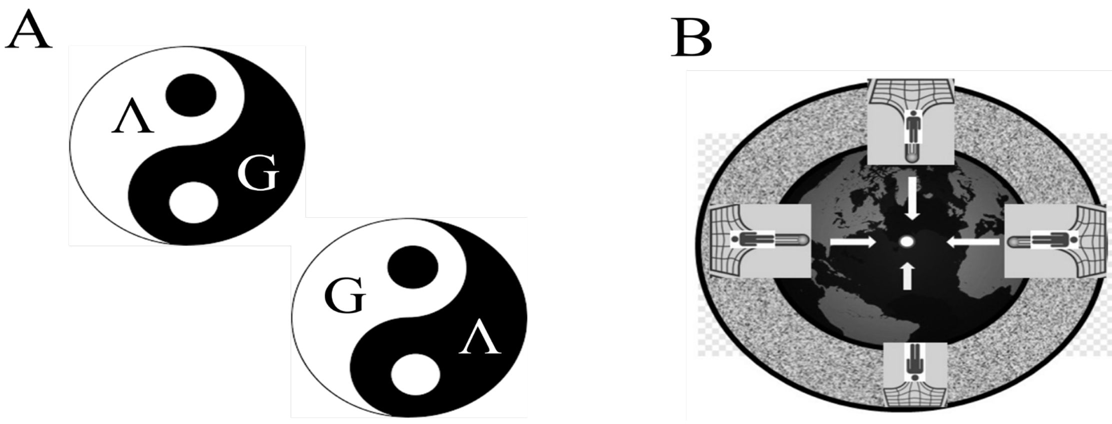

Fig.4 The constant factors that govern the evolution of the universe. A. "*Yin-and-yang*" symbol representing the non-static balance between Λ (*Cosmological constant*) and G (*Gravitation*). The symbol above indicates that the equilibrium is shifted in favor of Λ, while the symbol below shows the opposite situation. The symbol should be imagined as a Möbius strip-like structure. In this symbol both elements look as though they are flowing into and out of each other. There's never a point where Λ and G stop moving, the same way the amount of light and dark is always changing as the sun rises and sets each day. Their opposite interaction is thought to maintain the harmony of the universe and to influence everything within it. **B.** Schema showing the gravity fields surrounding the earth from a macroscopic perspective. For details see text.

5. The steady state model resulting from periodic entropy changes in the universe.

In accordance with the second law of thermodynamics, an expanding universe always moves toward ever greater entropy; consequently, it would have to be assumed that during a reversal of the expansion, the entropy should fall to zero until a singularity is reached (36). It should be assumed that during increasing entropy, gravity plays an important role in the increase because gravity causes dispersed matter to accumulate into stars, which collapse eventually into black holes (37).

On the other hand, if one assumes that there is enough matter and the dark energy, viewed as Λ, is decreasing, then the effect of gravity would become stronger than that of dark energy. From this point, the expansion of the universe would stop and turn into an accelerating contraction. Minutes before the Big Crunch, radiation would lead to an explosion of atomic nuclei before they end up in giant black holes. A few seconds before the Big Crunch, supermassive black holes would merge with each other. In the end, only a single "*black megahole*" exists, which contains all matter and, in the final moment of the Big Crunch, swallows the universe, including itself.

How does the universe behave during the contracting part of the oscillation? During the contraction all physical processes are reversed in time. In particular, entropy decreases with time. The result is that at the end of the contraction the state of the universe is the same as it was at the beginning of the expansion, so that the cycle can then be repeated (38).

Discussion

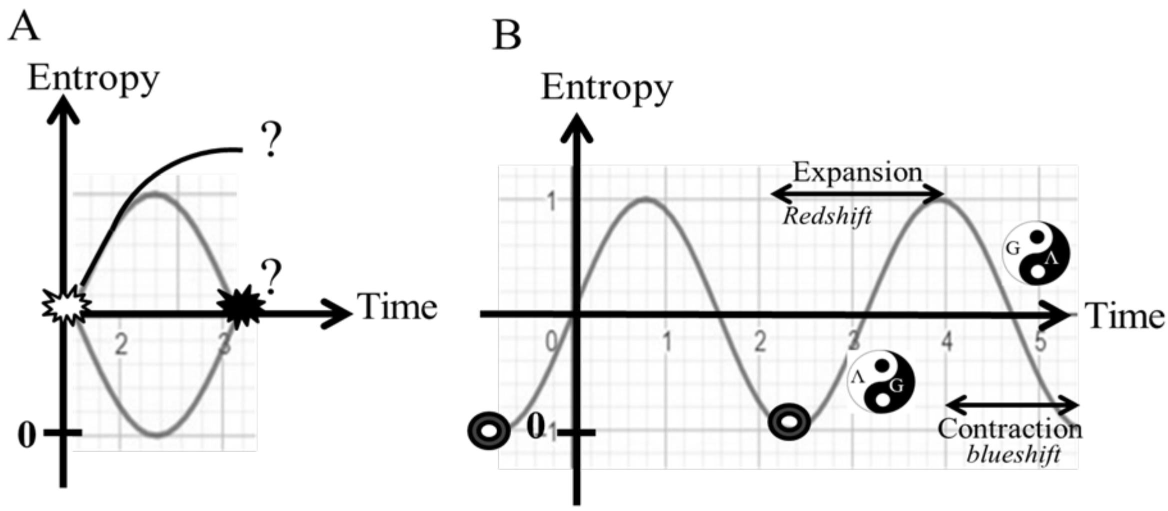

Fig.5 Comparison of the Big Bang Model with an indefinite, self-sustaining cyclic universe. A. Entropy changes as consequences of the expansion of the universe is plotted over time; the big-bang model cannot be cyclic. : Big Bang **B.** proposed model for a thermodynamically controlled indefinite, self-sustaining cyclic universe. The time-dependence of the entropy of a eternal steady-state model. : "*mega black hole*" as a singularity; In the ascending part of a cycle is Λ (*the cosmological constant*) the dominant force and responsible for the expansion; this manifests itself in a redshift. Living organisms are only possible in the ascending part of the period when entropy increases according to the second law of thermodynamics. The "*cosmological constant*" endows the space of the universe with an inherent repulsive force that precisely balances the mutual attraction of the masses present in that space. In the descending part of a cycle, gravitation is the dominant force; the contraction is perceived as a blue shift. For details see text.

Hubble's discovery of the expansion of the universe in 1929 convinced not only Einstein, but also the entire scientific community, that the universe could not be static. However, an expanding universe had obviously serious consequences.

If the validity of the law of conservation of energy is recognized, then this law of conservation according to Einstein's famous formula $E=mc^2$ can also apply to matter. The expansion of the universe would consequently lead to a general thinning of matter. From this statement it might be concluded that in the past the universe would have been denser, which may represent one of the necessary prerequisites for the development of a Big Bang theory. Conversely, in order to counterbalance the dilution of matter elicited by the expansion of the universe, one can also imagine that expansion is accompanied by the continuous creation of matter. In this case, such an expanding universe would then be stationary. As a matter of fact, even if one just sticks to these premises, it is still not easy to decide which of the two models is the most plausible. In the Big

Bang theory, a non-obvious extrapolation is necessary in order to trace back from an increasingly dense universe to a primordial atom (*a singularity*), while in the second theory a constant, not yet reliably proven, new formation of matter should be accepted. An important, admittedly rather historical, question is how the Big Bang theoreticians had managed to push an alternative, but equally well-founded theory, such as the steady-state theory, into the background.

The reasons could possibly lie in the political circumstances of the time when the two rival views confronted each other. Four years after the end of World War II, the British journal Nature published an article by Pascual Jordan, which was introduced by his former teacher Max Born (39). This article referred to another paper published by Fred Hoyle in the same journal a few months earlier (19). Before the war, Jordan was part of a trio of scientists responsible for publishing key discoveries in quantum mechanics: Max Born and Werner Heisenberg were the other two, but Jordan was known to be the main thinker in the elaboration of the foundations of quantum mechanics (40). In the thirties of the last century, the fates of the two researchers took very different paths. In 1933 Born, who was Jewish, after his immigration to the United Kingdom, remained in Edinburgh until 1952 and after his retirement returned to West Germany where he died in 1970.

The fate of his student Jordan took a completely different path. For unknown reasons, Jordan did not emigrate and although rather a conservative nationalist during the Weimar Republic, he joined the Nazi Party in May 1933, along with a host of other opportunists. Despite his ambiguous political activities, Jordan was, according to his associates, personally a shy and kind man (26). Only after denazification in 1947 did Jordan (40) receive a visiting professorship in Hamburg thanks to a recommendation from Wolfgang Pauli. In 1953 Jordan became a full professor until his retirement in 1971. In his paper published in 1949, Jordan who supported Paul Dirac's hypothesis that the gravitational constant G is decreasing like the reciprocal of the age of the universe, expressed his intention to develop this hypothesis into a general theory of the expanding universe, however not aware that Dirac had long since abandoned his hypothesis. For the Anglo-Saxon Cosmologic community, apparently the only one who still took Dirac's hypothesis seriously was a German and to make matters worse, a former member of the Nazi party. Even if it wasn't felt that way at the time, those circumstances certainly were very detrimental for Hoyle and his like-minded cosmologists; it definitely benefited the initiators of the Hot Big Bang theory, resulting in the final triumph of their theory. And now things get even worse: when Pius XII read the original version of the Big Bang hypothesis published by Lemaître in 1931, he was convinced that the Big Bang model would represent a confirmation of the biblical story of creation; he believed that only an all-powerful being would be able to ignite such a primal explosion. In retrospect, even if it turns out that the hot Big Bang theory should not be the ultimate truth, one would have to consider the papal statement to be quite legitimate, since, as H. Kragh emphasized, "*the history of* *science offers no support for the view that progress in cosmology has either supported or undermined the theological claim of a divinely created universe*" (41).

As a conclusion and to best answer the question posed in the title of this article, I would like to quote what a very eminent historian of science, Gerald Holton, wrote about the apparent final triumph of the Big Bang creation cosmogony over the rival view based on eternal existence; he predicted the following, "*this thema will come in again through the back door*" (42). Indeed, this is what has happened during the last decades.

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