On the Origin of Space
Introduction:
A Centuries-old Line of Thoughts in Physics

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Abstract
This is an historical review of scientific thoughts introducing a multi-parts work to be published as a series of articles as listed below in their logical sequence. The numbers in brackets will be used in the text. Part numbers follow the sequence of publication envisioned at this point.

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In search of the true makeup of reality

As Einstein advanced by saying “Imagination is more important than knowledge: Knowledge is limited while imagination encircles the world,” (Viereck, 1929), and as Bronowski (1958) also pointed out, knowledge is not enough to reach the true make-up of reality; imagination must be brought in to tackle such a task. Through that tool, I want to orient the search toward preparing the ground for replacing the two essentially separate sets of formal (mathematical) principles established in this century, namely Relativity and Quantum Mechanics, with one future constructive theory that would cover them both, a theory I will base on the new concept of Monadic Spaces.

As expected from their intrinsic novelty, the nature of these elements appears to be foreign to the existing framework of Mathematical Analysis. Since I need to go past the conceptual level to detailed features in order to obtain experimentally verifiable consequences supporting the hypotheses, I will have no choice but to forget using a formalism to guide the search and follow instead a purely physical approach remaining close to experimental data, something I will call “conscious experience” as art. [1] describes.

I first look in this introduction at some of the past and present themes of the scientific imagination, taking stock of where others went or have been going in the line of thoughts dealing with the origin of space, a subject which has never been really addressed directly in the past, but which begs to be addressed now after the implicit inroads of the 20th century on the subject. Essentially, I will have to try to distinguish the concepts that were missed earlier on that matter.

Then, through arts. [2, 3, 4], I will examine several hunches expressed by various scientific personalities from the past as well as from the present. I succeed there in identifying a common thread by filling up the incomplete thoughts and entering the latest facts obtained from Nature that the original thinkers did not know about, and end up that way with hypothetical elements that would underlie the present formal theories, i.e. monadic spaces.

The analysis of past experiments corroborating the approach will initially involve Quantum Physics [5, 6, 7] and subsequently extend to Particle Physics [8] and Astrophysics [9, 10, 11, 12]. I will examine consequences there to sharpen the picture obtained earlier, ending up questioning key hypotheses underlying the
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Theory of Relativity. I will also find that the universal spatial expansion, thought to have been observed for now two generations, is instead a physical effect originated locally through the make-up of space, itself a product of the elements of space hypothesized earlier.

A conclusion of that magnitude will give me no choice but to contemplate widening the experimental base of the approach to make it more sound. This attempt will be through a review of the Life Sciences via arts. [13] through [19], since a key hypothetical feature of space identified in an earlier article looks to have its most immediate evidences in that field.

A long historical search for answers

The first known of long-lasting “best efforts” in the search for answers about the makeup of reality was a system of ideas, the ancient Greeks’ view of the world, a world imagined to be made out of four “elements,” earth, water, wind and fire. Why 4, and not 5, 6 or 3? Because it seemed obvious at the time. A first lesson to draw here: Watch out for the obvious as handed out by Nature and conventional wisdom! These elements were seen as molded and directed by gods to follow not only their moods and passions, but also the eternal concepts of numbers and geometric figures. The goal was no less than to read the mind of the gods, so ways to understand and thus be able to control fate could be found. The result was Euclid’s “Elements” (Euclid, 1956) among several other mathematical starters that happened to remain unequaled for almost two thousand years - see Eves (1989). Here then I have an example where the vision was containing some truth, and only time proved that fact. On the other hand, such a lapse of time without further progress demonstrated that reality needed more than imagination and mathematics in order to be understood.

With the Renaissance in Europe imagination was at last combined with experimentation by Galileo - see Drake (1978 and 1990). Why? Because as a bright young man he was revolted by the manifest fantasies he was being taught at school such as weights not falling at the same rate, which for him was an obvious falsehood that he proceeded to test. In other words, Galileo gave us the “Principle of Equivalence,” that was subsequently ignored by Newton and rediscovered 300 years later by Einstein (who acknowledged this in p. 287 of Einstein, 1982), the perfect example of a basic concept taking centuries to be understood! A check on such fantasies was overdue, and the time allowed freedom of thought, or so Galileo believed. In the meantime, Cavalieri’s seat-of-the-pants “indivisibles” modeled on the old Archimedes geometric dreams were a preparation for the “calculus” of Newton and Leibniz, just in time for the astronomical data processing by the astrologer Kepler to provide fodder for the first wild guess at “fields,” gravitation - Dugas (1988). Yet Newton’s output was all still conceived very much as a fantasy: how can cosmic bodies act on each other in-
stantaneously at enormous distances? “Hypothesis non fingo,” I will not form a hypothesis, mumbled Newton, and on that word left Science for managing England’s Mint.

From the mathematical consequences of the mechanics surrounding the discovery about gravitation, Maupertuis, Euler, Leibniz and others later on such as Lagrange and Hamilton mathematically distilled the “Principle of Least Action,” a principle that allowed the world to imagine a parsimonious god guiding the evolution of our reality for the best of everyone, at least as far as the mathematics could tell – Dugas (1988). In a sense it was the “Theory of Everything” for three centuries. Imagination looked at this deduction from mathematics and prepared an immediate revenge. Voltaire derided the whole thing with the phrase “we are in the best of all possible worlds” put in the mouth of a friend of his famous Candide. It was the “fields” born in the imagination of the experimenter Faraday followed by the “aether fluid” of Maxwell that led us to the electromagnetic field, not mathematics. The ground was prepared just in time for Einstein, through his imagined travels at the speed of light, to realize that this second field did not jazz with the first one by Newton, forcing him to at last tamper with the absolute space and time of the Greeks that Newton took for granted, thus putting himself in the position to imagine a curved “spacetime” to explain the origin of gravitation - Pais (1982). He only had to call on his friend, the mathematician Grossman, to make his vision “reasonable.” This approach seemed at first glance to replace the action-at-a-distance intellectual void from Newton with a physical connection between cosmic bodies through the “curvature” of this new spacetime. At least the world thought so.

A few clouds on the horizon

But with the turn of the 20th century, the epoch arrived, unlike Voltaire’s time, to “seriously” question imagination in the name of scientific “purity.” Science was a serious thing after all! A first philosopher, Ernst Mach, derided the 18th century Principle of Least Action as only a tool without any metaphysical or teleological meaning, with no deeper origin than the theories it explained, themselves based on experimentation. Mach’s logical positivist philosophy can be better understood through others’ perceptions, such as Einstein, Schroedinger and Feynman’s. His original work is in Mach (1883). Mach was much more effective than Voltaire at influencing scientists, being a scientist himself after all. Manifestly Einstein could not be taken seriously with his curved spacetime since the theory failed to explain what space is made of, as not only it can curve and flatten but shrink and expand too. An expansion or contraction can only happen to “something” physical after all. It looked like “hypothesis non fingo” all over again, but this time unstated.
For Mach’s followers (as Mach died in 1916), a vocal group supporting his philosophy in the 1920s and 30s (see Miller, 1996), this state of affairs vindicated his philosophy, Relativity being only a set of principles with no intent to provide a constructive description of the true elements of space and time, only a formalism to describe gravitation. Of course this was never Einstein’s intent, only the intent of mathematicians, such as Hilbert and Weyl, who took over his physical theory. Science would not reach its goal if such elements were unknowable as Mach implied, being understood then as the work of a deity, thus unreachable by Science. Further, the concept of curved spacetime may have been all right if Relativity’s “spacelike slices” had a constant total volume. As a matter of fact a static closed universe was Einstein’s original idea. He even introduced a “cosmological constant” to make it so in his equation before Hubble told him he was seeing an expansion of the cosmos through his telescope. Then the constant became the “worst mistake of his life.” I think more likely that Einstein lost track of his original inspiration at that very moment. Not that the constant was right, but that his theory was missing something after all, and maybe not a constant, and he tried to find the missing elements for the rest of his life. I shall see in arts. [9] through [12] what can be made of this in light of recent astronomical data. This problem will be the “first cloud of 20th century Science.”

As a result of the discovery of the quantum between 1900 and 1930 (the history of quantum mechanics can be gleaned from biographies such as Moore, 1989 and review books such as Miller, 1994), a second philosopher scientist, Niels Bohr, spread out the injunction against imagining further beyond experimental confirmations and predictions in physical theories, this to the profound dismay of Einstein and Schroedinger, who knew where their physical theories came from! Metaphysics was not to influence the mind of physicists any more - see Crease and Mann (1996) and Wheeler (1994) for Bohr’s background. “Imagination” a la Maupertuis and “visualization” a la Maxwell were no longer to be tools of discovery, only theories following closely results of experiments were to be taken seriously. Theories made of principles were to be conceived, not constructive descriptions of the true elements involved as they were supposedly unreachable by the Human mind. As an example the “liquid drop” model of the atomic nucleus served well in bringing the nuclear bomb to the world, but no-one, including its inventor Bohr, would take it as having any meaning for the constitution of matter, only as a tool to do calculations. An obtuse set of principles called Quantum Physics was born in that manner from the efforts of Planck, Einstein, DeBroglie, Bohr, Pauli, Heisenberg, Born, Schroedinger, Dirac, Fock, Landau, von Neumann and many others to mathematically explain by means of principles the results of experiments at the atomic level. – see Cohen-Tannoudji et al. (1977), Dirac (1958) and Sakurai (1994) for examples of textbooks on that subject. These experiments seemed to leave us no choice but to conclude that both matter and
radiation have a split personality, both wave-like and particle-like, the origin of which we could not know. Nothing was to be presupposed further according to Bohr. His “Principle of Complementarity” (Bohr, 1928) was thereby elevated to a “Natural” principle, implying a “least action” role for imagination.

But imagination refused to shut down. A late 1950s paper (Everett, 1957) right after the death of Einstein by an imaginative graduate student showed that this split personality of matter and radiation may be in fact hiding a multiple-reality quality for the universe. I shall look at this fundamental hypothesis in arts. [2] and [6], as it appears to be one of the key concepts dreamed by Humanity, ranking with the Atomic Hypothesis, maybe even more important. This work was kept in the university files carefully away from the limelight until the 1970s when it was dug up in a desperate attempt to reconcile Quantum Physics with the physics of Einstein (DeWitt and Graham, 1973) as these two did not connect at all with each other. This last effort, even with the use of Everett's vision by Hawking and others (for a popular introduction, see Hawking, 1994), has been in vain in spite of 50 years of arduous efforts by a plethora of scientists. Would this, maybe, come from the still remaining theoretical void on the ultimate nature of space and time in Einstein’s theory as I discussed above? Or is it because the many-realities idea as the route to a constructive theory of the quantum is itself incomplete? Maybe both, as I have already outlined for Einstein’s theory and shall see for Everett's view in art. [6].

I shall call the absence of a really physical “quantum gravity” theory and the related debate on the meaning of the quantum (the Many-Realities Interpretation vs. Bohr's Complementarity Principle) the “second cloud of 20th century Science.” Unlike the previous cloud, this one was not born from experiments not matching theory, but from formal theories not connecting to each other. Roger Penrose stated (Penrose, 1994) that a new revolution in Science will be necessary to clear up this cloud. I think that we must get unstuck from the mathematical quagmire of present theories and attempt to go beyond them by identifying new constructive hypotheses, even if a formalism is not available or even possible to deal with them. Such a route was followed in the late part of the 19th century by Boltzmann and others when the Atomic Hypothesis of the Greeks was brought back into the forefront of Physics to explain the phenomena that mathematical Thermodynamics was unable to describe. As to the lack of formalism, Faraday earlier handled such a situation by sticking to experimental verification to prevent going into some sidetrack. Empirical and heuristic rules can lead the way. The essential is to find physical effects corresponding to the envisioned constructive hypotheses from which we can develop further our understanding.

The gathering storm

In the meantime, still in the 1950s, and in the spirit of Mach and Bohr,
Yourgrau and Mandelstam (1955) attempted to deliver the final blow at the metaphysics behind the Principle of Least Action. Bad luck, as Feynman was right then demonstrating that Nature after all had a good reason for following such a principle because of the newly discovered quantum aspect of reality, and in particular the quantum “stationary phase trajectories” as they were mathematically required by Schroedinger's nonrelativistic equation for the electron. Feynman enthused by his discovery thanked Dirac (Mehra, 1994) for the original hint. But Dirac didn’t want to be associated with his wild and imaginative guess, he wanted to remain an “austere” (i.e. mathematician-) physicist. Subsequently, and without publication, Feynman tried to find a stationary phases origin for Dirac's own relativistic equation of electron motion by postulating that everything at the fundamental level in this world goes at the speed of light (Schweber, 1994). Needless to say that such a bizarre (but fundamental) idea also merits to be explored further, and I shall do so in art. [3].

But Feynman’s unpublished hypothesis was not very consistent with someone who was intent on getting rid of metaphysics in Science as he wanted to portray himself, and so maybe, deep down an ambivalence crept through him, as he was undoubtedly influenced by Bohr and Mach. thanks to his formal education. For example, in the 1960s he attempted to show that Einstein's geometric origin of gravitation was only one way to put a meaning into gravitation theory (Feynman et al., 1995), a thought right in line with Mach’s teachings. He, among others, introduced by 1963 the idea of “gravitons” as an alternative for describing the existence of gravitational forces. Gravitation would be then a field with its own “particles” as electromagnetism had with photons. However, this track did not please his former thesis advisor. By 1973 John Wheeler reaffirmed with his “geometrodynamics” that there is no other way for gravitation to exist but through the geometry of space as Einstein described it, gravitons being incapable of describing all the physical aspects of Einstein’s theory and require an unphysical “flat space” as a starting point for their theory. See Misner et al. (1973) - §7.1 and Box 18.1, where “spin-2,” i.e. gravitons, derivation of Einstein’s equations is shown as being an “unphysical and incomplete mathematical artifice.” While there is, as we have seen, and most likely, a fundamental addition to make in Einstein’s theory, the fact remains that only one coherent way exists to think about the meaning of gravitation, the geometry of space. Nevertheless, to this day the idea of gravitons is still being considered by Quantum Field Theory. See Weinberg (1993), p. 300 note for p. 141 “there is no serious doubt of the existence of gravitons.” Weinberg heavily criticized logical positivism in that reference, apparently not identifying his own attitude as closely following that philosophy, especially in its pan-mathematical aspect. 20 years earlier (Weinberg, 1972) he presented his mathematical “alternative” to Einstein’s physi-
cal approach in the line Feynman adopted in the 1960s, and in sharp contrast with Wheeler's position.

It is thus extremely difficult to get rid of unphysical concepts purely via mathematical principles, an approach far removed from experimentation, and regrettably one of the ways Science, by following Mach, has been attempting to discover fundamental things in the 20th century. For a scathing diatribe on this matter see Lerner (1992). There is also a large number of books on the “understanding” behind our present mathematical theories, such as Teller (1995) and Auyang (1995). I cannot find any real understanding in them. In fact they tell me that there is no understanding. In fact, the logic of a mathematical theory may have an unchecked thrust of its own when no longer guided by imagination. As an example, Superstring Theory was invented in the 1980s out of purely mathematical considerations in order to explain the unphysical gravitons (Kaku, 1994, 1995). Maybe the pendulum has swung too far away from imagination in fear of falling into a sidetrack, or being plain wrong, when a formalism is not available. Conversely, it seems that “sound” imagination can also protect us from mathematical sidetracks when they are reached via perceived mathematical necessities through mathematical analogies. Gravitons came from such analogies because we don’t know what a field really is, we know only its mathematical shape. The Yukawa exchange forces across nucleons came also from an analogy, and, even though Yukawa’s theory was quickly rewarded with a Nobel prize, it was later on found not to match reality! (Aitchison and Hey, 1989) The so-called “Grand Unified Theories” (Kaku, 1994, 1995) were all based on mathematical analogies, not physical insights like Einstein had. We don’t know the physical reasons behind these analogies, as they do not provide a physical meaning. No new physical features are imagined. Some work, some don’t. As Aitchison and Hey wondered, they just replace one question by another: What is behind these analogies? Just an erroneous sense of correctness. Such theories are examples of non-constructive mathematical thinking in the line of Mach’s philosophy, a line which can of course provide material for theses, being based on checkable math, but also can easily lead to physical sidetracks and waste of time (and money) impossible to recognize as such rationally. As recent History will show below, we must above all guard ourselves against imagination designed to buttress a formal mathematical theory that is wished to be correct for its own sake.

The eye of the storm

As the 1950s seemed to nail down the coffin of metaphysical (imaginative) physicists, the biggest metaphysical idea yet to be dreamed of in Science appeared in the 1960s, thanks to Gamov, following an earlier guess by a priest, Lemaitre, under the name of the “Big Bang” (Hoyle’s coinage per Gribbin, 1986).
Science rediscovered Genesis! This grand dream came from a consequence of Einstein's closed universe hypothesis which was one of the bases of his theory. After all the progress made about understanding our reality along the thousands of years following the appearance of our civilization, this reality is now seen through the biblical Genesis concept, to the point that the Pope in the early 1990s at last forgave Galileo, 350 years after his condemnation, so that once again Jesuits are at the top of mountains watching the stars to read the mind of God. See Reston (1994) - Bellarmine, who judged Galileo and Bruno, was a Jesuit. Quantum field theorists, now objective allies of the Pope against Giordano Bruno (Mc Intyre, 1903), must promote the Big Bang because it is needed for supporting their “effective field theory,” an incomplete formal (mathematical) theory which includes the phenomenology of a “weak” field that would be there to connect the various elementary particles “flavors.” (Weinberg, 1977, 1993, 1995, 1996)

Indeed, we still don’t know the origin of all the masses found in Particle Physics and what “particles” and “fields,” i.e. matter and radiation, really are, except items in meaningless mathematical expressions. Here the fight of Feynman vs. the superstring theorists needs to be read in Mehra (1994). The artificial mathematical basis of the Higgs field hypothesis will be discussed in art. [8]. “Hypothesis non fingo” is an everyday motto in this fundamental area of Physics because mathematicians and their unphysical analogies have indeed taken over physics. Also, a concept that envisions a beginning to all cannot explain this beginning itself except through some additional mathematical artifice, and thus can only give an incomplete understanding. It looks to be then a dead-end for the scientific approach, while leading to the end to all, the Big Crunch and Christianity Augustine’s vision of doom on a non-scientific level. David Deutsch (1997) tried to get away from this doom via Tippler’s “Omega-Point” theory but this attempt looks very artificial.

Here we have more than a cloud, we have a “storm over 20th century Science.” No less than the foundations of Science were put in question over a century ago by Mach limiting the scope of Science’s search to formal methods, and Mach seems to have at last succeeded. Arts. [2, 3, 4] will address this storm through the question of the elements making up our reality, trying to find hints out of hunches expressed long ago in the history of Science by Bruno and Leibniz. These hunches have been forgotten by Science since they were only the product of the imagination, even though more recently Einstein belatedly remembered them, right before his death. But this he did only via popularization articles, not “hard” publishing, as it seems he did not know what to do with such ideas, not having the crucial physical facts that were to be found after his time.
Conclusion - The road toward a new understanding?

I can see from this storm that there are in fact two fundamental barriers that still have not been crossed in our understanding of reality, (1) the true nature and foundation of this reality, and, correspondingly, (2) the true nature of our intimate perception of it.

Early this century we have learned, and only now begun to understand with the help of Everett’s imagination, that reality is built out of a world constantly searching many transitory realities, what is called the “quantum world.” With the help of Feynman’s hypothesis, and the Bruno/Leibniz/Einstein view that space is constantly built out of its contents, this search may be conceptualized, as I shall initially describe in art. [3], as an “uncountably infinite parallel computation,” with further discussions in art. [4] under the term of “extended computation,” a computation that would be “uncomputable” by the Turing definition of computation (Turing, 1936). Even though this notion of computation was extended by Deutsch to quantum Turing Machines in the 1980s using the present Quantum Theory formalism, it appears to need another look as Nature may have an approach quite different from the ones humans have thought about so far.

First I shall investigate Everett’s view through its consequences for Mathematics, by reviewing the physical meaning of the continuum (art. [2]). There I shall find that Mathematics is still essentially missing the new concepts discovered by Quantum Physics, as apparently mathematical inspiration still comes after so many years from concepts immediately obtainable from our perceived reality, i.e. the concepts of Classical Physics. Einstein was lucky (together with the world) to have had mathematicians before him who thought about curved spaces because he himself was not a mathematician as he advanced many times.

Since now, unlike earlier times, the formalism seems not to be there (and this in a fundamental way) to buttress the advanced hypotheses, this work has no choice but to mainly use an informal approach. Of course, the corresponding formalism can only come in the future if the understanding is sufficiently communicable for mathematicians to acquire it. Their role will then be to make it more precise to allow physicists to subsequently establish a formal theory allowing additional conclusions that would hopefully be experimentally verifiable. A process of establishing an understanding outside a formalism if the formalism is not there to support it in the first place is a sensible route for the scientific discovery process, as it has been used successfully many times before (the experience of Faraday is an example). In the end, reality may be comprehensible, but the understanding acquired through imagination and checked through experiments may not be fully formalizable (for example, can we formalize creativity?). Then the key will be to find methods that can capture the essential features of the understanding. If this cannot be done then we will have to go via empirical rules or heuristic methods to fill up the gaps of the formalism.
Then, through art. [3] covering Feynman’s unpublished idea, leading to the concept of a universe built out of a computation, I shall investigate in art. [4] whether a meaningful image can be obtained for the true elements of our reality. Space will indeed “materialize” through my mind’s eye, instead of being an undefined ghost within Einstein’s and Bohr’s principles. Within such a picture, matter, radiation and space have a fundamental relative scale defined through their relations. Each is then a set of 3-dimensional spaces, constantly being generated through one another in the spirit of Bruno’s and Leibniz’s “monads,” and producing a 3 times 3-dimension scaled relational reality instead of the immediate (classical) 3-D space with no inherent scale. Newton’s space had no predefined scale. Many have thought previously that maybe our spacetime is of a fractal nature, with no end at the bottom or top, but this view can’t include the quantum and its key function to differentiate things at a certain scale in an infinite superposition. Arts. [4] through [8] will elaborate. This old idea of monads will acquire hopefully meaningful details this time around. The hypothesis obtained in art. [2] that space is generated by its contents will be then found in art. [8] to be experimentally verifiable through the physical absence of a formal entity postulated by Quantum Field Theory called the Higgs field. This would be a clear example of a finding requiring no formalism, only understanding. A similar (much simpler) example late last century was the Michelson-Morley experiment proving the absence of “ether.”

Between the 1950s and the 1970s, Particle Physics discovered the confining character of the “strong” field within atomic nuclei, the third field besides gravitation and electromagnetism (Gottfried and Weisskopf, 1984; Crease and Mann, 1996). But so far the meaning of such confinement and freedom qualities for the nature of the quantum, as well as for space and time, has not been addressed. Such a meaning will be essential to the understanding of arts. [4], [5] and [8], with art. [4] including a first glimpse at what “space” physically is.

Everett’s vision portends a fundamental departure not only from the old Greek view of the world but also from all the physics and mathematics that has been conceived up till now, as everything in Science assumed a “flat” monovalued reality. This fact, being so new and different, has not been factored into today’s Science, including Mathematics, even though experiments pretty well tell the story when the many-realities point-of-view is used, as art. [7] will describe. Everett’s vision includes composite quantum systems as described in art. [6] (itself introduced by art. [5]), but that understanding was never clearly identified, and the practical use of such systems was consequently missed.

The above world view will be applied to the present problems of Astrophysics in arts. [9] through [12]. There astronomical data will appear to confirm that space is continuously generated and eliminated, with its own sources and sinks. Such a concept could not have been considered in Einstein’s lifetime since the
“confined” and “free” qualities of matter/radiation were then unknown.

An independent confirmation of the physical world view will be obtained by applying Everett's approach to the Life Sciences. There, a new kind of force will be identified through arts. [13] through [20], thereby launching a whole new science beyond the ones Galileo identified. This will lead me at last to considering the true nature of our intimate perception of reality.

A potential application for Computer Science is brushed upon in art. [21], showing an application of the understanding acquired at that point. The difficulties of Mathematics about dealing with the real world are brushed upon in arts. [22] and [23], and the conclusion gives a philosophical reminder about what real Science is about.

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