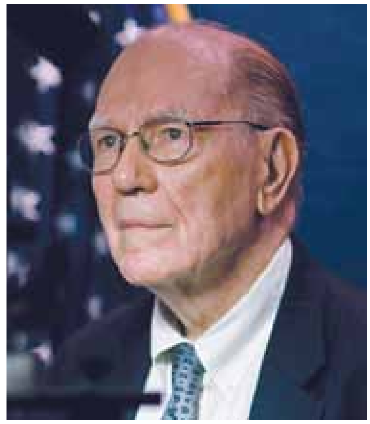
The 'Finite but Unbounded' Universe of Einstein, Planck, and LaRouche

by Judy Hodgkiss

NASA

Spiral Galaxy NGC 4414, as imaged by the Hubble Space Telescope.



Lyndon LaRouche

Feb. 3—Regular readers of *EIR* have seen Lyndon LaRouche's references to the complex notion developed by Albert Einstein, that we live in a universe which is "finite but unbounded." Such a universe, LaRouche has asserted, is ruled by universal physical principles which allow for efficient, least action pathways for the evolution of anti-entropic phenomena, as we see in biological systems, and in human creative mentation. Such an anti-entropic universal principle is inherent even within the abiotic, supposedly dead, physical universe at large.

But how would a universe defined as finite but unbounded, be significant for such potentials?

As the first step in investigating the origin of Einstein's concept, and understanding the concept's relationship to the theories of Max Planck and Lyndon LaRouche, we must, as background, look to the influence on modern science of the great historical figures, Gottfried Wilhelm Leibniz, of the 17th century, and Bernhard Riemann, of the 19th century.

Leibnizians, First and Always

Einstein, Planck, and LaRouche were steeped in Leibniz, and the Leibnizian method of hypothesis making, from an early age: Einstein and Planck, because they were schooled in the German philosophical-scientific tradition of their homeland; LaRouche, because, at age 12, his paternal grandmother had given him a collection of philosophical tracts that included Leibniz. LaRouche recalls, "This encounter with Leibniz was the most important intellectual experience of my childhood and youth."[1]

LaRouche first studied Leibniz's philosophical and scientific works; then, years later, upon discovering Leibniz's 1671 essay, "Society and Economy," LaRouche became devoted to elaborating and further developing a Leibnizian notion of physical economy. LaRouche says:

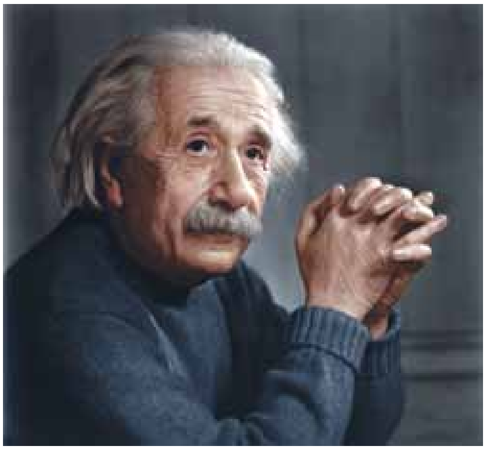
> The first economic scientist, in the strict modern

1. Lyndon H. LaRouche, Jr., *The Power of Reason: 1988, an Autobiography*. Executive Intelligence Review, Washington, D.C., 1987. On pages 16-17 LaRouche states:

"My attitude toward ideas was one fairly described as 'Socratic.' . . . This emerged clearly beginning my 12th year.

"I had begun poking into the writings of philosophers. After a few readings, I decided to begin all over again, this time in chronological order. I began with selections published in the Harvard Classics, a set given to me by my grandmother Ella LaRouche that year, and supplemented that with other texts. The list ran, Francis Bacon, Thomas Hobbes, René Descartes, John Locke, Gottfried Leibniz, David Hume, Berkeley, Jean-Jacques Rousseau, and Immanuel Kant.

"Bacon, Hobbes, Locke, Hume, Berkeley, and Rousseau I hated. Leibniz moved me with a sense like that of coming home after a long homesickness. I read the *Monadology*, *Theodicy*, and the Clarke-Leibniz correspondence again and again, going on to writers later in my series, and back to Leibniz again. By fourteen, I was an avowed student of Leibniz."



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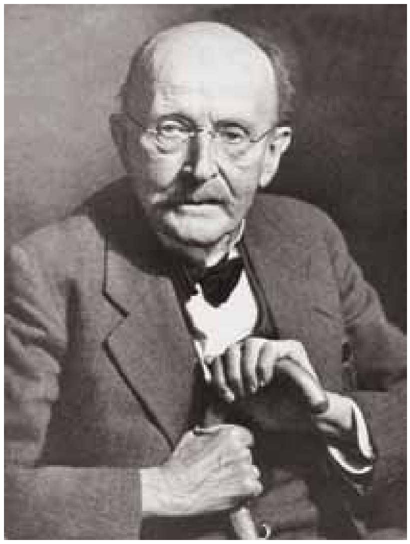
Albert Einstein



German Press & Info. Office

Max Planck

sense of science, was Gottfried Leibniz, who also was the first to produce a differential calculus, and also more branches of modern science than most university graduates could list from memory of their names. . . .[2]

Albert Einstein saw in Leibniz's works a prescient notion of relativity, particularly in Leibniz's arguments against Isaac Newton's notions of absolute space. Einstein wrote on the subject for an article in *Scientific American* in 1950:

> [My theory of relativity] overcomes a deficiency in the foundations of mechanics which had already been noticed by Newton and was criticized by Leibniz and, two centuries later, by Ernst Mach: Inertia resists acceleration, but acceleration relative to what? Within the frame of classical mechanics the only answer is: Inertia resists acceleration relative to space. This is a physical property of space—space acts on objects, but objects do not act on space. Such is probably the deeper meaning of Newton's assertion *spatium est absolutum* (space is absolute). But the idea disturbed some, in particular Leibniz, who did not ascribe an independent existence to space but considered it merely a property of "things" (contiguity of physical objects).[3]

In his theory of the quantum, Max Planck relied heavily upon Leibniz's notion of a principle of "least action." Most today refer to Planck's theory as involving the "quantum of energy," or the "quantum of light," but Planck himself said his theory was based on the idea of the "quantum of action." In a 1908 lecture titled, "The Principle of Least Action," Planck says:

> Among the more or less general laws, the discovery of which characterize the development of physical science during the last century, the principle of Least Action is at present certainly one which by its form and comprehensiveness, may be said to have approached most closely to the ideal aim of theoretical inquiry.[4]

Planck and Einstein were among the dying breed of scientists in the 20th century who dared to conjure Leibniz's name, and to defend him against his many detractors. In his lecture, Planck, contrary to the contemporary vogue of crediting the development of least action theory to the perverse Frenchman Pierre Moreau Maupertuis, instead reveals the way that Maupertuis bowdlerized Leibniz's ideas, and how his attempts to claim priority over Leibniz backfired on him (at least, at that time,—Maupertuis was later rehabilitated). Planck says:

> [Of those who helped to develop the idea of least action], the first was Leibniz; indeed, he was the chief, according to a letter dated 1707, the original of which has been lost. . . . Then came Maupertuis and [Leonhard] Euler. . . . Maupertuis repeatedly announced in different forms, his principle of *Mitwelt*, and zealously defended it against what were often authoritative criticisms. The zeal with which he did this rose at times to fanaticism, and was quite disproportionate to the

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2. Lyndon H. LaRouche, Jr., *So, You Wish to Learn All About Economics?: A Text on Elementary Mathematical Economics*, EIR News Service, Inc., Washington, D.C., 1995. The book is available online.

3. Albert Einstein, "On the Generalized Theory of Gravitation," *Scientific American*, Vol. 182, No. 4, April 1950. Pp. 13-17. The article is available online.

4. Max Planck, "The Principle of Least Action," in his *A Survey of Physical Theory* (formerly titled *A Survey of Physics*), R. Jones and D. H. Williams, transl. Dover Publications, New York, 1960. A reprint is available online.

scientific value of his enunciations.... This is especially shown in the passionate attempts he made to dispute Leibniz's letter when it was produced by Professor Samuel König in 1751—attempts which almost led him to abuse the high position he occupied [as president of the Berlin Academy of Sciences]. Human weakness and vanity have hardly ever been more severely punished than in this case....

Gottfried Wilhelm Leibniz

One of the most intriguing observations in Planck's lecture is his statement that Leibniz's least action theory reminds him of Leibniz's other theory, the one about the "best of all possible worlds." Planck says:

> In this connection mention may certainly be made of Leibniz's theorem, which sets forth fundamentally that of all worlds that may be created, the actual world is that which contains, besides the unavoidable evil, the maximum good. This theorem is none other than a variational principle, and is, indeed, of the same form as the later principle of least action.

Planck, himself, does not elaborate the deeper principles inherent in that "best of all worlds" theorem—in fact, he simplifies the idea quite a bit in order to fit his immediate example—but the very fact that Planck opened the door to such a multifaceted metaphor in the middle of his scientific treatise, set the empiricists howling.[5]

Leibniz's metaphysical theorems open the way for questions about free will, the goodness of God, the arbitrariness of natural disasters, etc.: All of which, in turn—as we will see—is connected to the question of an anti-entropic universe that is finite, but unbounded.

When Leibniz poses the idea of the best of all possible worlds, one is compelled to ask: Where is there room for human free will in a world that is destined to be the "best," anyway? What can be better than "best"? Is it possible that something "bad" in the world, can actually, through the intervention of human will, be turned into something that makes the world "better" than that which was "best" before?

These are questions similar to those that arise in Leibniz's theory of the possibility of "higher perfection." Leibniz argues that each species of being strives toward the perfection defined by its ideal form; but, in addition, it is possible that the principles that define the perfect form, are themselves not fixed, but develop towards a more perfect form.

Such is the realm of ideas that exercise the mind in a way that allows us to grasp analogous concepts within the realm of the physical sciences—concepts such as series of higher orders of infinity, or the appearance of

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5. See Wolfgang Yourgrau and Stanley Mandelstam's *Variational Principles in Dynamics and Quantum Theory*, Saunders, Philadelphia, 1968, a book which begins with a dedication to Planck and ends with an avalanche of attacks on him, including the following:

"Among the staunchest protagonists of a metaphysical content to the action principle was Planck, who, with great philosophic poise, sought first to clarify and then to extol its rank in science.... In striking contrast to his otherwise calm and balanced judgment, he dubbed the principle of least action the 'most comprehensive of all physical laws which governs equally mechanics and electrodynamics.'...

"Whilst, in his appreciation of the unique place which the principle of least action holds in physics, Planck's views are steadfast and consistent, his advocacy of a teleological interpretation of this law is characterized by a certain measure of contradiction ... Such a principle, he asserts, suggests to a person free from prejudice the presence of a rational, purposive will governing nature, for a physical system must choose that route which directs it most easily towards its objective....

"An outstanding example is the extraordinary manner in which Planck comprehends as a variational principle Leibniz's maxim that our world is the best of all possible worlds! ...

"Planck pursued this train of thought with more fervour than did any other physicist.... Planck, when dealing with the division of phase space, had intimated that the action was associated with whole multiples of *h*, which he designated the 'elementary quantum of action' ... Planck posed the question, 'Can it be that the astonishing simplicity of this relation rests once again upon chance? It is becoming more and more difficult to believe this. On the contrary, the impression forces itself upon us with elemental power that Leibniz's principle of least action can afford the key to a deeper understanding of the quantum of action.'

"Planck's arguments concerning this problem are steeped in considerable metaphysical hypothesis to which it is difficult for the critical scientific reader to give assent."


Least action pathways are not always straight lines. A brachistochrone and a pencil in water, illustrate the least action curve of a ball rolling down a track, and the least action refractive angle for light going from air to water.

infinites which are only infinities because we are measuring a higher order manifold with a ruler which belongs to a lower order manifold (to use Riemann's language). These are the kinds of concepts which we must comprehend in order to understand Einstein's description of his "finite but unbounded" universe.

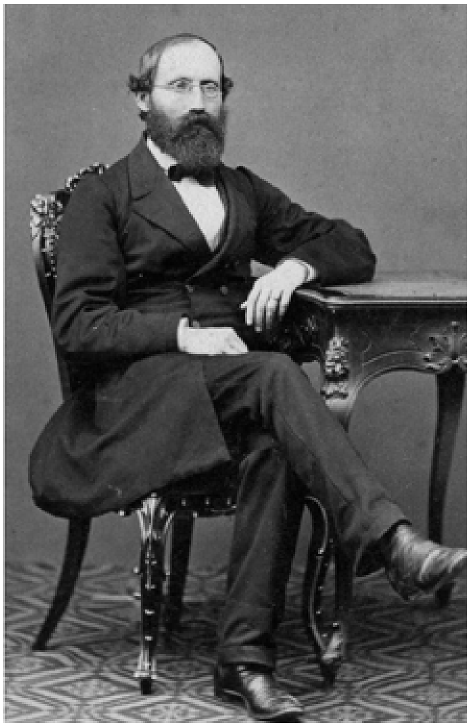
Riemann and Higher Order Manifolds

This leads us to a discussion of Riemannian geometry, which provided a form for the generalization of relativity theory.

The best introduction to Riemannian geometry, though, is through LaRouche's description of his first contact with Riemann's works and how he applied Riemann's geometry to what LaRouche calls the "King and Queen" of the sciences:[6] physical economy. In his autobiography, *The Power of Reason: 1988*, LaRouche gives a history of the development of the LaRouche-Riemann economic model:

> During the postwar period, U.S. national income accounting was reorganized under the so-called Gross National Product system. This system, which is intrinsically incompetent as a way of measuring economic performance, took over reporting functions of government, and shaped the practice of the economics profession. During the 1940s and 1950s, an absurd doctrine concocted by John Neumann, "linear systems analysis," became the basis for what was known as "econometrics." This concoction then became the basis for most applications of accounting and economics practice to computer systems. . . .
>
> [During that same period,] I had the good fortune to have made two discoveries which are, combined, a major contribution to economic science.
>
> Since Leibniz, we have known the general nature of the cause-effect relationship between the introduction of an advancement in technology and a resulting increase in the productive powers of labor. Improvements in technology enable us to reduce the amount of labor consumed in producing a good. It was not known, until my work of the early 1950s, how to show that this cause-effect connection itself could be measured. . . .
>
> We distinguish today, between those advances in technology which represent the introduction of a 'new scientific principle', and those which are merely a more advanced expression of a scientific principle already well established. It

6. LaRouche, *op. cit.*, calls physical economy the King and Queen of the sciences, because all of the other sciences are subsumed by the history and future development of economic systems—in the sense that, on the one hand, the present state of such systems depends on creative achievements in the various branches of science in the past, while, on the other hand, the future state of such systems depends on the conscious creation of conditions which foster creative achievement in those branches (and the creation of new branches), into the future. Physical economics seeks not to achieve any particular, individual revolutionary discovery, but to promote a succession of such discoveries.



Bernhard Riemann

is the introduction of a new scientific principle which represents, at once, both a discontinuity in scientific thinking, and which generates a generalized discontinuity in the course of technological-economic growth.

In this way I formulated the first part of my two-step discovery in economic science. On the one side, the characteristic features of creative mental activity are negentropic and therefore implicitly so measurable. Advances in technology, as mental conceptions, could be measured implicitly in this way. The introduction of these advances in mental conceptions, to production, causes economic growth, the which is also negentropic in form, and measurable. So, measurable negentropy in the first instance, causes measurable negentropy in the second instance. By reducing this causal connection to a single functional expression, the causal relationship between technological progress and economic growth is measurable, and this in a way which admits of predicting the benefits of adopting a specific form of technological progress.

This was the first part of my discovery.

The problem posed by the discovery, was the question: where to find the mathematics appropriate to such a function?

At first glance, I recognized that Georg Cantor's notion of transfinite ordering touched directly upon the kind of mathematics needed. I spent the greater part of every possible moment, over approximately a year, fighting my way through Cantor's work. I had stabbed at Riemann's work years earlier, by way of [Luther] Eisenhart's text. Working through Cantor, I saw Riemann in the right way for the first time. I read Riemann's famous 1854-published inaugural dissertation, "On the Hypotheses Which Underlie Geometry," with what can be described only as an empyreal quality of excitement. From that moment, everything I had sought began to fall into place.

Let us look at the beginning of the above-mentioned inaugural dissertation, given before the mathematics faculty at the University of Göttingen, where we find Riemann asserting—to the shock of the assembled professors (excepting Riemann's mentor, Carl Gauss, who was also present, but not at all shocked)—that the fundamental axioms underlying Euclid's geometry, accepted as given for the past millennium, are in fact open to question.

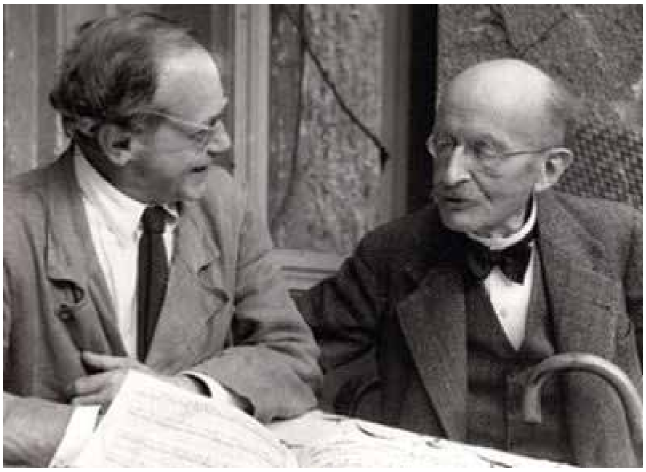
Riemann then proceeds to develop possible geometries which are *not* based on the Euclidean assumptions of a flat universe extending linearly into infinity. He investigates the possibilities of curved space, and the varieties of discrete and continuous manifolds which describe physical phenomena of either type within such a space; and, also, how an individual manifold might transform from one order of connectedness to a higher order.

At the end of the dissertation, Riemann again shocks his audience of mathematics professors by announcing that it was not presently possible to come to conclusions regarding his proposed geometry, because "this [discussion] leads us into the domain of another science, that of physics, into which the object of today's proceedings does not allow us to enter."

The domain of mathematics is, indeed, a domain of lower order, and should be regarded as in service to a higher domain, that of physics.

Sixty years after Riemann's presentation, it was the physics of Albert Einstein that answered Riemann's challenge. Einstein's biographer, and personal assistant in Berlin in 1928-1929, Cornelius Lánczos, wrote of the Einstein/Riemann relationship:

> Riemann saw further than his contemporaries.... [Riemann] points out that some day the physicist of the future may see himself compelled to go beyond the framework of Newtonian concepts. His work has purely the purpose of clearing the way to a broader approach so that, when that time comes, science should not be hamstrung by traditional prejudices. No words could



Courtesy of Charlotte von Conta

Max Planck (right) and violinist Karl Klingler. Planck performed with professional musicians throughout his life.

have expressed more adequately the historical destiny which was in store for Einstein.

Riemann's prophetic utterance was spoken at the end of his "inaugural address," given on the occasion of his election to the mathematical faculty of the University of Göttingen (1854). . . . [His advisor], Gauss, found the topic, entitled, "On the Hypotheses Which are at the Foundation of Geometry," particularly to his taste. . . .[7]

Why 'Finite but Unbounded'?

Einstein discusses the concept of a finite but unbounded universe in two locations: in his 1916 book, *Relativity: The Special & General Theory*, in the chapter called "The Possibility of a 'Finite' and Yet 'Unbounded' Universe," in an appendix written in 1935, and in a lecture titled "Geometry and Experience," given in 1921 at the Prussian Academy of Sciences in Berlin.

The first treatment is more limited, and will not be discussed here, as it is subsumed by the second. The second is highly ironical in nature, and therefore must be approached carefully. Also, it is in translation, and, as is the case in all translation of highly ironical works, such as poetry, it must be approached doubly carefully.

Einstein begins by praising mathematics. But watch out—it turns out that this lecture is the place where Einstein states his famous maxim:

> As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.

Einstein's next highly ironical assertion is that he agrees with "that acute and profound thinker, H. Poincaré." Henri Poincaré was known for his philosophy, called "conventionalism," which says that there is no real "truth" in science, only an agreement among scientists as to what will be acceptable and agreed to by convention. It was widely known that Einstein viewed such philosophy with disdain.

Einstein says,

> If we deny the relation between the body of axiomatic Euclidean geometry and the practically-rigid body of reality, we readily arrive at the following view, which was entertained by that acute and profound thinker, Henri Poincaré:—Euclidean geometry is distinguished above all other axiomatic geometries by its simplicity. Now since axiomatic geometry by itself contains no assertions as to the reality which can be experienced, but can do so only in combination with physical laws, it should be possible and reasonable—whatever may be the nature of reality—to retain Euclidean geometry. For when contradictions between the theory and experience manifest themselves, we should rather decide to change physical laws than to change axiomatic Euclidean geometry. . . .

Einstein then defines how both a "practical" geometry and an "ideal" axiomatic geometry (Euclidean) would allow for the following:

> We will call that which is enclosed between two boundaries, marked upon a practically-rigid body, a tract. We imagine two pro-rigid bodies, each with a tract marked out on it. These two tracts are said to be "equal to one another" if the boundaries of the one tract can be brought to coincide permanently with the boundaries of the other.
>
> We now assume that: If the two tracts are found to be equal once, and anywhere, they are equal always and everywhere. . . .
>
> This is the ultimate foundation in fact which enables us to speak with meaning of the mensuration, in Riemann's sense of the word, of the four-dimensional continuum of space-time. . . .

7. Lánczos wrote two biographies of Einstein, *Albert Einstein and the Cosmic World Order*, consisting of six lectures delivered at the University of Michigan in the spring of 1962, Interscience, New York, 1965; and *The Einstein Decade: 1905-1915*, Academic Press, New York, 1974.

FIGURE 1A

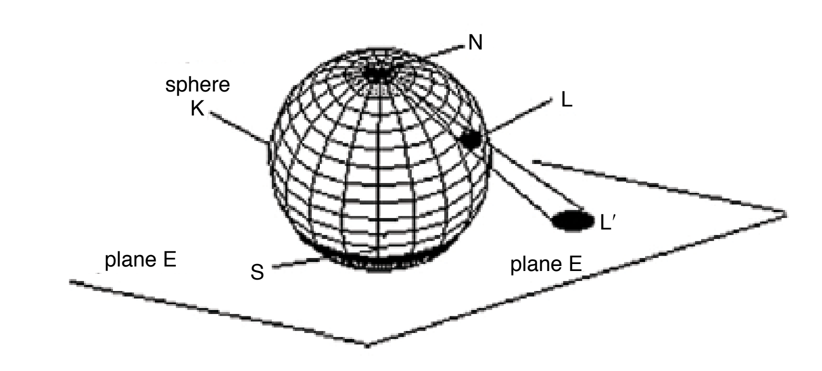
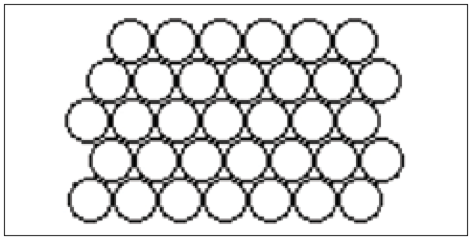


FIGURE 1B



> The question whether the structure of this continuum is Euclidean, or in accordance with Riemann's general scheme, or otherwise, is, according to the view [now] being advocated, properly speaking a physical question which must be answered by experience, and not a question of mere convention.

Einstein then proceeds to make several theoretical arguments about the nature of the cosmos and whether it were possible to make measurements of the average spatial density of the matter in universal space (as concentrated in the stars), and therefore decide if the density falls off as one goes out in some direction to infinity. He can come to no conclusion on the question. He asserts that were it possible to show that the mean density remains the same in all directions, he could show that the universe must be finite. But, he says, he can offer no solution to the problem, at this time.

Then he comes to a most interesting point: Using the system of "equal tracts" which he has developed earlier, he claims to be able to demonstrate that—in spite of the fact that it cannot now be proven whether the universe is finite, or not—that a mental image of a finite but unbounded universe were possible. Einstein says:

> This is where the reader's imagination boggles, "Nobody can imagine this thing," he cries indignantly. "It can be said, but cannot be thought. [Sound familiar?] I can represent to myself a spherical surface [which is two-dimensional] well enough, but nothing analogous to it in three dimensions."

But We Need Three Dimensions

Einstein, first, shows us why a sphere is finite but unbounded in two dimensions. He says to imagine the surface of a large globe [**Figure 1A**], and a quantity of small paper discs, all of the same size [**Figure 1B**]. One disc can be picked up and placed on the globe's surface, anywhere, and moved around without encountering a boundary or limit. The globe's surface is an *unbounded continuum*.

If we stick the paper discs to the globe, with no disc overlapping another, the surface of the globe finally becomes so full that there is no room for another disc. It is, therefore, also a *finite continuum*.

We now use the globe and the attachable discs, to demonstrate the direction we must go for 3-D visualization. Set the globe on a plane surface, with one disc, which we will call *L*, attached to the globe. Shine a light down from point *N* at the top of the globe—point *N* being opposite to point *S*, which is the point of the globe resting on the plane. The light will shine through paper disc *L*, throwing a shadow *L*′ onto the plane surface.

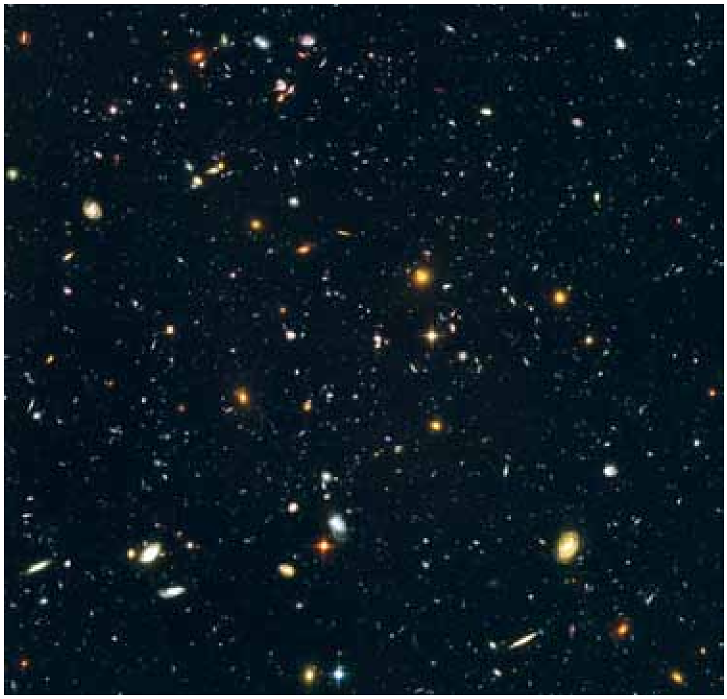
Move the *L* disc around. Its *L*′ shadow moves on the plane accordingly. As you move the disc upward on the globe towards point *N*, the disc shadow on the plane moves outwards from point *S*, growing bigger and bigger. As the disc approaches *N*, the shadow moves off to infinity, and becomes infinitely great.

But! What appears to be infinite in the Euclidean space of the plane surface is actually merely the shadow of a real rigid body on a finite surface in Riemannian space.

Now, stick multiple discs to the globe, and look at the shadows: If two discs on the globe are touching, their shadows on the plane also touch. The shadow-geometry on the plane agrees with the disc-geometry on the globe. You can now see that the plane is finite with respect to the disc-shadows, since only a finite number of the shadows can find room on the plane, just as only a finite number of discs can find room on the globe.

Someone objects: "I can take a ruler and measure the shadows and show that they are not rigid figures, since they change in size." Einstein answers: We can imagine the ruler may behave on the plane the same way as the disc shadows. Then the fact that the disc shadows grow in size has no meaning. They live in the same Riemannian universe as the discs on the globe.

Next, discard the globe and discs, and, instead, imagine a point *S*, somewhere in space, and a great number of small spheres, which we will also call L', to point out their analogy with our disc-shadows. These spheres are not rigid bodies like the globe was. Their radius can increase when they move away from point *S* towards infinity. Imagine bringing these spheres into contact with each other, so that point *S* is at the center of the inner spheres. Then allow all of the spheres to move outwards, maintaining contact with their surrounding spheres as they are all increasing in size in accordance with the same law as applies to the increase of the radii of the disc-shadows on the plane.



NASA/ESA/S. Beckwith (STScI)/HUDF Team

An image from the Hubble telescope's Ultra Deep Field Camera: A view of 10,000 galaxies, cutting across billions of light-years.

As before, no "ruler" is allowed, that does not have the same behavior as our L' spheres. The spheres are, therefore, in regard to this Riemannian space, rigid bodies within a finite universe that has no physical boundary.

Such a universe is bounded only by the universal physical laws which govern its behavior.

What About Einstein in 1935?

The reader with a science background has probably been asking all along (maybe even screaming all along): "Isn't all of this irrelevant? Didn't Edwin Hubble demonstrate that, since spectral lines from distant galaxies show a redshift, that can only mean an expansive motion of star systems out towards infinity, that we have therefore proven that there was a big bang explosion 13.7 billion years ago, and all matter is now entropically dissipating towards heat death? Why talk about Einstein's old ideas of a physically stationary universe that might be dominated by anti-entropic principles? In fact, isn't it Einstein's own Riemannian, nonlinear field equations that prove the big bang theory to be true?"

In 1935, Einstein did write that he believed that his equations might lead to such a conclusion. He wrote a short appendix to his 1920 book, cited above, in which he acknowledged that "Hubble's discovery can, therefore, be considered to some extent as a confirmation of the theory [that his own field equations might predict an expanding universe]."

But Einstein did not care to continue the discussion. This was Einstein's last comment on cosmological questions. He went silent on the subject for the final twenty years of his life. Also, 1935 was the same year that Einstein published the famous EPR paper, "Can Quantum-Mechanical Description of Physical Reality be Considered Complete?"—on quantum entanglement, which, similarly, was Einstein's last article critiquing the Heisenberg-Born version of quantum physics. He withdrew from that debate, just as he did from any further debate on cosmology.

In either case, whether the question of the day concerned the very large, or concerned the very small, Einstein had no further interest in debating the implications of mere mathematical formalisms. As he had insisted from the very beginning, both his field equations and the mathematics that govern quantum mechanics, are *incomplete*, and therefore, nothing conclusive can be drawn from them, in themselves. It didn't matter to him if the debaters wanted to "agree" with his "side" of the debate, or not—he was fed up with them all.

His private comments on the publication of the EPR quantum paper (EPR indicating the names of the joint authors, Einstein, Podolsky, and Rosen) are indicative.

That same year, in a June 19 letter to Erwin Schrödinger, Einstein wrote:

> For reasons of language this [paper] was written by Podolsky after several discussions. Still, it did not come out as well as I had originally wanted; rather, the essential thing was, so to speak, smothered by formalism.

Most cosmologists today are so obsessed with the incongruities in the formalisms of what they call the Standard Model (which they blame on Einstein!), that they account for those incongruities by making up ideas of "dark matter" and "dark energy." And, on the other side, those who count themselves as the critics of the Standard Model, are generally only too eager to build their careers around anti-Einstein/anti-Riemann theories, such as the modern-day promoters of the pro-Euclid/pro-Newton hoax known as the Le Sagian theory of gravity.

Quantum physics is in the same mess. The quantum mechanists of today are obsessing about the qualities of so-called "quarks"—those "things" that are supposed to be the constituents of elementary particles. They have even concocted various "flavors" and "colors" to describe their quarks, calling them "up-quarks" and "down-quarks." Why not throw in some "sideways-quarks," since they are all nothing but mathematical constructs anyway? As for those who argue for a deterministic approach, rather than the Standard Model statistical approach to quantum physics, unfortunately most often hark back to theories that depend on a revival of an ether medium, or the invention of a so-called "subquantal" realm, where just about any flight-of-fancy interactions are possible.

This is not to say that research in all these fields should not continue—many interesting things tend to pop out here and there. It's just that, until we change the overall environment within which such research takes place, any debates on theory are likely to resemble the babblings among the inmates of an insane asylum.

Cornelius Lánczos proceeded with the appropriate caution, in 1924, when he published the first solutions to Einstein's field equations (in the form later found, independently, by Kurt Gödel). He ended his article humbly expressing his joy at being able to work on such beautiful ideas, and acknowledging that his mathematical formalisms were only preliminary, and perhaps merely ephemeral. It was particularly on the basis of this article that Einstein chose Lánczos to be his assistant at Berlin. Lánczos wrote:

> Perhaps the here considered cosmology is only a considerable simplification, a first rough approximation to reality. Even then, it seems to me that to let ourselves into these possibilities is not without interest. After all, we deal here with the archetype of a stationary, rotationally symmetric world structure as a solution of Einstein's fundamental equations, and, at the same time, with an example of the world-wide beauty of the geometrical way of looking at things and of the broad outlook that will open up on these paths.[8]

We close with the following question and answer by Lánczos, excerpted from his 1974 biography of Einstein, which demonstrates the wide gulf between the Einstein-Lánczos perspective on the one side, and that of modern cosmologists on the other:

Q: How about the so-called "cosmologists," who derive their wisdom directly from Einstein?

Lánczos: Yes, "cosmology!" In the last few years "cosmology" has obtained the stamp of approval. It is now a respectable chapter of physics. Einstein himself recognized in 1917 that General Relativity necessarily changes our ideas concerning the universe at large. The curved geometry of space made a *finite* universe possible, which avoids the conceptual difficulties associated with an infinitely extended universe of infinite energy content. However, the detailed cosmological speculations, which are so popular today, are hardly justifiable, as long as we know so little about the role of the "matter tensor"—either in the small or in large regions. The real strength of the theory has to demonstrate itself first in the atomistic region, before we can hope to make predictions about what the universe is doing in immense distances of either space or time. And yet, here are the great geniuses of our day, who seem to know precisely, what the universe was doing billions of years ago, or what it will do billions of years from now.

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8. Cornelius Lánczos, *Zeitschrift für Physik*, 1924, Vol. 21. Translated and published in *Cornelius Lánczos: Collected Published Papers with Commentaries*, in 6 volumes, William Davis, ed., North Carolina State University, 1998.