Einstein's Method of the 'Thought Experiment'

by Judy Hodgkiss

Jan. 31—Even the best of our modern scientists speak of Einstein's scientific discoveries as if those ideas could be encapsulated in the mathematics associated with those discoveries. For example:

- Atomic physicists repeat the mantra of "$E=mc^2$," as if that "formula" had emerged from Einstein's head as an isolated idea;
- Quantum physicists speak of Einstein's radiation equations, while totally ignoring Einstein's Riemannian hypothesis of the electron's quantum action;
- Astronomers today insist that it was the "mathematics" of general relativity that predicted A. Eddington's demonstration of the ability of the sun's gravity to bend starlight;
- Those same scientists insist that it was general relativity's "mathematics" that predicted such astrophysical phenomena as black holes.

Commenting later on his effort at four-five years of age to figure out how a compass worked, Einstein concluded "Something deeply hidden had to be behind things." From 12-16 years of age he studied advanced mathematics using books "that were not too particular regarding logical rigor, but that permitted the principal ideas to stand out clearly," he said. He is 14 years old in this picture.

The source of our problem here is the ubiquitous influence of Bertrand Russell's reductionist educational methods in the physics departments of the Twentieth Century.[1] We find that, today, even those researchers who might genuinely admire Albert Einstein have no comprehension of the nature of the methods he used to make his discoveries.

Compounding the problem is that Einstein, himself, never comprehensively described his own methodology. We find only an occasional glimpse, here and there, in his many books, lectures, and articles, as to how his mind actually worked. He is especially difficult to fathom when it comes to how he discovered the 1915 general relativity out of the preliminary form of special relativity, which he had discovered in 1905.

Here we will focus on the method of thinking that Einstein had called a *Gedankenexperiment*, a "thought experiment." We concede, of course, that the "thought experiment" was not an invention of Einstein's: It has always been the true scientific method of the great thinkers from Plato of the ancient Greeks to Bernard Riemann of Nineteenth-century Germany. But the spectacular aspect of Einstein's experimental "thoughts" was, that they were specific types of images which, understood in the proper context, were capable of overthrowing centuries of Newtonian reductionist

1. http://www.larouchepub.com/other/2016/4305russell_made_us_stupid.html

dogma, and, at the same time, millennia of Euclidean dogma.

Einstein came to the conclusion that the "dogmatic rigidity" with which physics held on to Newton's laws as if they had been "created by God," and that solutions could be made by means of deduction, had to be overthrown as the foundation for all physics, which led to his development of relativity theory. In response to Einstein's work, in 1919 The Times *in Britain warned in a headline: "Newtonian ideas Overthrown." At right, Euclid, Newton's predecessor as a deductive "thinker."*

Riding a Light Wave

Einstein famously said that "imagination is more important than knowledge." Certainly, the attainment of knowledge will always be a prerequisite for resolving certain questions in a finalized form; but, imagining the right question in the first place is a much more important—and rare—capability.

Einstein called the initial process a certain kind of "wondering." In his *Autobiographical Notes,*[2] Einstein recalled:

> I have no doubt that our thinking goes on for the most part without use of signs (words) and beyond that to a considerable degree unconsciously. For how, otherwise, should it happen that sometimes we "wonder" quite spontaneously about some experience? This "wondering" appears to occur when an experience comes into conflict with a world of concepts already sufficiently fixed within us. Whenever such a conflict is experienced sharply and intensively it reacts back upon our world of thought in a decisive way. The development of the world of thought is in a certain sense a continuous flight from "wonder."
>
> A wonder of this kind I experienced as a child of four or five years when my father showed me a compass. That this needle behaved in such a determined way did not at all fit into the kind of occurrences that could find a place in the unconscious world of concepts (efficacy produced by direct 'touch'). I can still remember—or at least believe I can remember—that this experience made a deep and lasting impression upon me. Something deeply hidden had to be behind things.

And, in 1895, long before Einstein had attained a level of education thorough enough to explore the question in depth, he had had an intimation—at the age of *sixteen*—of what became his theory of special relativity, as laid out in 1905. Einstein described that 10-year-long struggle:

> At the age of twelve through sixteen I familiarized myself with the elements of mathematics, including the principles of differential and integral calculus. In doing so I had the good fortune of encountering books that were not too particular regarding logical rigor, but that permitted the principal ideas to stand out clearly . . . .
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> At the age of seventeen, I entered the Polytechnic Institute of Zurich as a student of mathematics and physics. There I had excellent teachers . . . so that I should have been able to obtain a mathematical training in depth. I worked most of the time in the physical laboratory, however, fascinated by the direct contact with experience . . . .
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> "[Perhaps] my intuition was not strong enough in the field of mathematics to differentiate clearly the fundamentally important, that which is really basic, from the rest of the more or less dispensable erudition… [In physics,] however, I soon learned to scent out that which might lead to fundamentals and to turn aside from everything else, from the multitude of things that clutter up the mind and divert it from the essentials . . . .
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> Now, to the field of physics as it presented itself at that time. In spite of great productivity in particulars, dogmatic rigidity prevailed in mat-

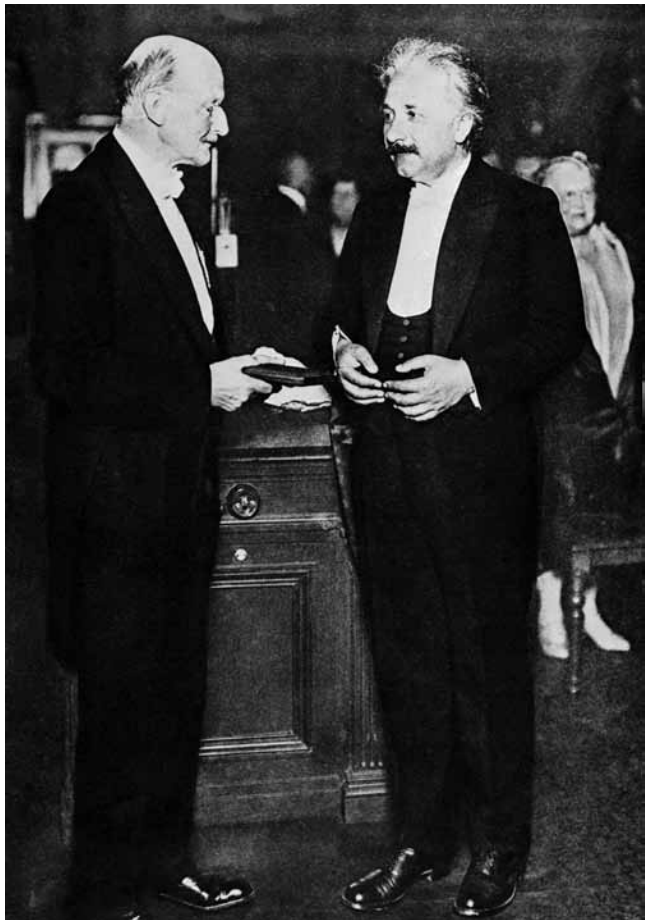
2. Einstein, *Autobiographical Notes,* translated and edited by Paul Arthur Schilpp, 1949.

ters of principle: In the beginning (if there was such a thing), God created Newton's laws of motion together with the necessary masses and forces. This is all; everything beyond this follows from the development of appropriate mathematical methods by means of deduction . . . .

We must not be surprised, therefore, that, so to speak, all physicists of the previous century saw in classical mechanics a firm and definitive foundation for all physics, indeed for the whole of natural science, and that they never grew tired in their attempts to base Maxwell's theory of electromagnetism, which, in the meantime, was slowly beginning to win out, upon mechanics as well. Even Maxwell and H. Hertz, who in retrospect are properly recognized as those who shook the faith in mechanics as the final basis of all physical thinking, in their conscious thinking consistently held fast to mechanics as the confirmed basis of physics . . . .

The most fascinating subject at the time that I was a student was Maxwell's theory. What made this theory appear revolutionary was the transition from [Newton's] action at a distance to fields as the fundamental variables . . . .

[But it became] clear to me as long ago as shortly after 1900, i.e., shortly after Planck's trailblazing work, that neither mechanics nor electrodynamics could (except in limiting cases) claim exact validity. Gradually I despaired of the possibility of discovering the true laws by means of constructive efforts based on known facts. The longer and the more desperately I tried, the more I came to the conviction that only the discovery of a universal formal principle could lead us to assured results. . .How then could such a universal principle be found? After ten years of reflection such a principle resulted from a paradox upon which I had already hit at the age of sixteen: If I pursue a beam of light with the velocity "c," I should observe such a beam of light as an electromagnetic field at rest though spatially oscillating. There seems to be no such thing, however, neither on the basis of experience nor according to Maxwell's equations. From the very beginning it appeared to me intuitively clear that, judged from the standpoint of such an observer, everything would have to happen according to the same laws as for an observer who, relative to the earth, was at rest. For how should the first observer know, or be able to determine, that he is in a state of fast uniform motion?



Einstein said that after Max Planck's "trailblazing work," he gradually came to the conclusion that he could not come to a solution only "based on known facts."

One sees that in this paradox the germ of the special relativity theory is already contained. Today everyone knows, of course, that all attempts to clarify this paradox satisfactorily were condemned to failure as long as the axiom of the absolute character of time, or of simultaneity, was rooted unrecognized in the unconscious. To recognize clearly this axiom and its arbitrary character already implies the essentials of the solution of the problem.

And, so it was that from there, after reflecting on the *Gedankenexperiment* of his youth—of the *16-year-old Einstein*—that the *26-year-old* Einstein could then proceed to proclaim his new theory of relativity: Einstein found that not only were space and time variable in any calculations concerning action in the physical universe, but also that *time* varied according to the reference frame, i.e., that there was no absolute "time," no absolute notion of simultaneity; but that "time" itself was relative to the reference frame of the observer.

The only thing "constant" in this system is the speed of light.[3] As for the idea of "catching up" with a light wave, where the observer might see an electromagnetic field in a state of rest: the very idea would violate the "law" of conservation of energy. Therefore, that principle of "conservation of energy" must be fused with the principle of the "conservation of linear momentum," whereby the inert "mass" of an isolated body is identical with its "energy." Here, mass is eliminated as an *independent* concept: hence, we come to $E=mc^2$ (or, $m=E/c^2$).

All of this was verified when, with the development of the particle accelerator, a particle accelerating to near the speed of light was found to be gaining "mass" as it accelerated, as measured by the observer, who was at rest. And, inversely, as when a radioactive substance loses a minute amount of mass that is proportional to the *energy* required for it to eject its decay substance. And, of course, mass can be converted to energy in an explosive manner, with nuclear reactions.

A Man Falling From a Roof

By 1907, after the dust had settled around the 1905 publication of what was later called, the "special" theory of relativity, Einstein began the difficult process of "generalizing" those special cases to which his theory had been limited, i.e., going from a system where observers were always in *uniform* motion in relation to each other, but to now expand it to include *all* cases of relative motion between the observers, however arbitrary the motion might be.

At the same time that Einstein was working on this problem, he was contemplating a related one: why did Newton's force laws seem to work, even though they violated the theory of relativity? Newton believed in the action-at-a-distance law of gravity, whereby bodies could sense changes in motions of another body exerting a gravitational pull on it, as if the timing of its "reacting" was *simultaneous* with the generating action itself. *Gravity,* itself, had to be redefined—Einstein would later call it an "apparent" force, not a "real" one in the sense of Newton's laws of mechanics.

As we will see later, Einstein ultimately found that, in order to resolve these paradoxes, he must replace Euclidean with Riemannian geometry, to which he was introduced in 1912.[4] But it was even before that, back in 1907, that Einstein had the original *Gedankenexperiment*, that spurred him in the direction of the Riemannian solution. Einstein describes that *Gedankenexperiment,* that moment of insight, as the "happiest thought" of his life. Below are several different descriptions by Einstein of how that "happiest" of thought experiments came to him:

"I was sitting in a chair in the patent office at Zurich [where he was still working at the time] when all of a sudden a thought occurred to me: If a person falls freely he will not feel his own weight. I was startled. This simple thought made a deep impression on me. It impelled me toward a theory of gravitation."[5]

"I was occupied (in 1907) with a comprehensive survey of the special theory for the 'Yearbook for Radioactivity and Electronics.' I also had to attempt to modify Newton's theory of gravitation in such a way that its laws fitted into the theory. Attempts along these lines showed the practicality of this enterprise, but did not satisfy me, because they had to be based on physical hypotheses that were not well-founded. Then there came to me the happiest thought of my life in the following form:

> Like the electric field generated by electromagnetic induction...the gravitational field only has a relative existence. Because, for an observer freely falling from the roof of a house, during his fall there exists—at least in the immediate vicinity—no gravitational field. Indeed, if the observer lets go of any objects, relative to him they remain in a state of rest or uniform motion, independently of their particular chemical or physical composition

3. That is, the speed of light in a perfect vacuum.

4. From Cornelius Lanczos, *Albert Einstein and the Cosmic World Order,* New York, John Wiley and Sons, 1965:
"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 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 ...."

5. Dec. 14, 1922 lecture, "How I Created the Theory of Relativity," Kyoto University, Japan.

> [note by AE: air resistance is naturally ignored in this argument]. The observer is thus justified in interpreting his state as being at rest."[6]

"Imagine a great lift at the top of a skyscraper much higher than any real one. Suddenly the cable supporting the lift breaks and the lift falls freely toward the ground. Observers in the lift are performing experiments during the fall. In describing them, we need not bother about air resistance or friction, for we may disregard their existence under our idealized conditions. One of the observers takes a handkerchief and a watch from his pocket and drops them. What happens to these two bodies? For the outside observer, who is looking through the window of the lift, both handkerchief and watch fall toward the ground in exactly the same way, with the same acceleration. We remember that the acceleration of a falling body is quite independent of its mass and that it was this fact which revealed the equality of gravitational and inertial mass. We also remember that the equality of the two masses, gravitational and inertial, was quite accidental from the point of view of classical [Newtonian] mechanics and played no role in its structure. Here, however, this equality reflected in the equal acceleration of all falling bodies is essential and forms the basis of our whole argument."[7]

Thus, Einstein—long before there was space travel and the demonstration of "weightlessness" in space—conceived of the freely falling body as having no sensation of a gravitational pull. The next step was to imagine the lift in space, outside of the earth's gravity, and being accelerated upwards with the uniform acceleration of 32 feet per second squared, thereby simulating earth's gravitational pull. The observer inside the elevator could not tell if he were stationary on earth and feeling the pull of its gravity, or whether it was merely his relative motion that caused him to feel the sensation of gravitation pull.

Einstein concluded from all this, with the help of Riemannian geometry, that planets do not carve out their elliptical paths around the sun because they feel a "force" acting upon them; but that the planets are merely following the straight path defined by their inertial momentum, and that the straight line that they seem to be following carries them around a curved portion of space defined by the mass of the sun.

6. 1920 unpublished draft of article for *Nature* magazine.

7. Einstein and Infeld, *The Evolution of Physics,* 1938. A note of caution: The wording here is more likely to be that of Infeld, than Einstein.

Don't 'Just Do the Math'

One additional aspect of the "lift" thought experiment should be mentioned, in order to dispel the notion that it was general relativity's "mathematics" that predicted the results of the 1919 Eddington experiment that showed starlight is bent by the gravitational pull of the sun. Again, it was a thought experiment—this time an extension of the accelerating lift experiment—which predicted that such a phenomenon would exist. Here Einstein imagines a light beam which cuts across the lift from one side to the other as the lift is accelerating. An outside observer would see that that beam had come across initially intersecting the lift at its center-point on the left side. But as the lift moves upward, the beam continues on towards the right side of the lift, but changing constantly in relation to the floor of the lift. The beam will carve out a (curved) path, relative to its initial crossing point of the moving lift, and will finish crossing the path of the lift, on its right side, at a point much closer to its floor.

Because this happens in the reference frame of the simulation of gravity (in the accelerating lift), it must also be the case that the same thing will happen in the stationary reference frame on earth in response to "real" gravity: light must be bent as it traverses a gravitational field. But—one might object—isn't there a problem with the idea of gravity being able to have an effect on an electromagnetic wave? Einstein answers:

> But there is, fortunately, a grave fault in the reasoning of [such a person], which saves our previous conclusion. He said: 'A beam of light is weightless and, therefore, will not be affected by the gravitational field.' This cannot be right! A beam of light carries energy and energy has mass. But every inertial mass is attracted by the gravitational field, as inertial and gravitational masses are equivalent. A beam of light will bend in a gravitational field exactly as a body would if thrown horizontally with a velocity equal to that of light. If [such an] observer had reasoned correctly and had taken into account the bending of light rays in a gravitational field, then his results would have been exactly the same as those of an outside observer.
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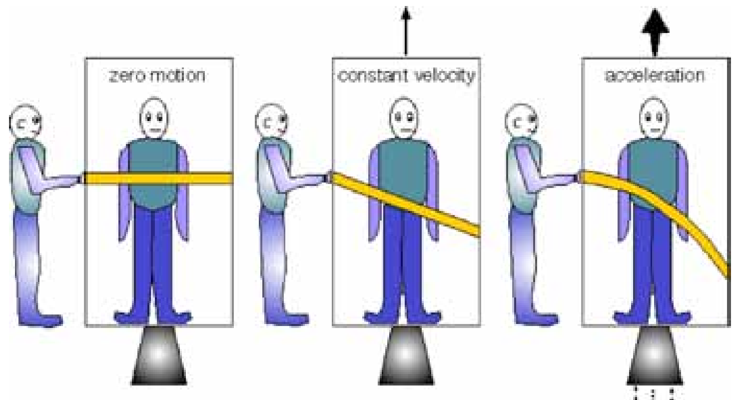
> The gravitational field of the earth is, of course, too weak for the bending of light rays in it to be proved directly, by experiment. But the famous experiments [the Eddington experi-



The path of a light beam in three different types of reference frames that are moving with respect to the person *outside* the elevator. The light path shown is what the person ***inside*** the elevator sees. Under large acceleration, the beam of light will curve downward. It should also do that in a region of strong gravity.

The lift (elevator) thought experiment demonstrates Einstein's thought process.

> ments] performed during the solar eclipses show, conclusively though indirectly, the influence of a gravitational field on the path of a light ray.[8]

Another myth that should be dispelled here is that the "mathematics" of general relativity has "predicted" such phenomena as "black holes." Einstein made clear, on more than one occasion, that the formal mathematics of general relativity is incomplete, and therefore liable to breaking down.[9] Einstein explains that, although he was able to find a Riemannian geometry for matter/space/time applicable to gravitational fields, he could *not* discover how to apply it to electromagnetic fields. Hence, Einstein's lifetime search for a unified field theory.

Einstein's mathematics will predictably break down (the equations going to infinity) anywhere that strong electromagnetic fields are encountered—as is the case with the entire spectrum of phenomena which ranges from black holes, to active galactic nuclei, to quasars. None of these phenomena are merely gravitationally anomalous—which might indeed test the true limits of general relativity theory as it relates to gravity—but these phenomena are all energetically anomalous, and therefore Einstein's *incomplete* theory of relativity cannot tell you anything definitive about them.

Unfortunately, there are modern astronomers who jump to the conclusion that these energetic phenomena prove relativity theory, in its premises, to be wrong; but these gentlemen are only proving their ignorance of the true nature of relativity theory and of the Leibniz/Gauss/Riemann tradition upon which it is based.

For us to move beyond Einstein, to a comprehensive Larouchian/Vernadskian/Riemannian notion of an anti-entropic universe, we must thoroughly familiarize ourselves with the method of the "thought experiment." And we must never become embroiled in arguments that revolve around interpretations of the "mathematics of Einstein."

Instead, we might consider a "thought experiment" connected with an hypothesis of how electromagnetism (light) mysteriously interacts with chlorophyll. Consider that kind of interaction, and then compare the way that gravity interacts with biological systems, where we find nothing nearly so stark or so interesting. That gives us a clue as to why gravitational fields are more easily modeled compared to electromagnetic fields. One approach that might help us in this effort, is to look at Einstein's attempt to develop a Riemannian model for the electron's quantum behavior, which was presented in a largely neglected lecture in 1917.[10]

We must learn to think as Einstein thought. Then, bringing in our LaRouchian perspective, we may find our own happy *Gedankenexperiment.*

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8. *Ibid.*

9. From *Autobiographical Notes:*

"Not for a moment…did I doubt that this formulation was merely a makeshift in order to give the general principle of relativity a preliminary closed-form expression. For it was essentially no more than a theory of the gravitational field, which was isolated somewhat artificially from a total field of as yet unknown structure …

"The *universal* law of physical space must be a generalization of the [previous field-free case]. I assumed that there are two steps of generalization: [emphasis in the original]

a) the pure gravitational field

b) the general field (which is also to include quantities that somehow correspond to the electromagnetic field).

"The case (a) was characterized by the fact that the field can still be represented by a Riemann metric …. [But] it seemed hopeless to me at the time to venture the attempt of representing the total field (b) and to ascertain field laws for it. I preferred, therefore, to set up a preliminary formal frame for the representation of the entire physical reality; this was necessary in order to be able to investigate, at least preliminarily, the effectiveness of the basic idea of general relativity."

10 . "On the Quantum Theorem of Sommerfeld and Epstein," May 11, 1917, in *The Collected Papers of Albert Einstein*, vol. 6, Princeton University Press, 1997.

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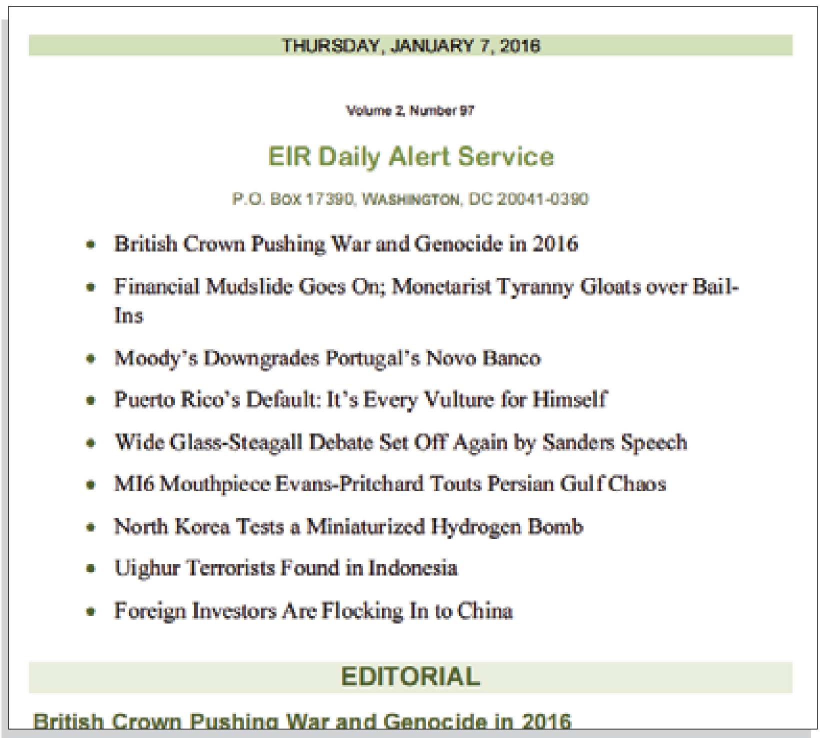
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