Einstein's Equivalence Principle Has Three Further Implications Besides Affecting Time: T-L-M-Ch Theorem

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Abstract

General relativity is notoriously difficult to interpret. A "return to the mothers" is proposed to better understand the gothic-R theorem of the Schwarzschild metric of general relativity. It is shown that the new finding is already implicit in Einstein's equivalence principle of 1907 and hence in special relativity (with acceleration). The TeLeMaCh theorem, named onomatopoetically after Telemachus, is bound to transform metrology if correct.

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1. Introduction

Recently it was shown that the Schwarzschild metric of general relativity admits at least one further canonical observable, the so-called gothic-R distance [1]. In terms of this distance, the speed of light c is globally constant. Is this result only a new mathematically allowed physical interpretation, or does it have deeper "ontological" significance?

A convenient way to find out is to pass over to an even more fundamental level of description. The "equivalence principle" between kinematic and gravitational acceleration, which still belongs to special relativity, is the oldest and in a sense most powerful element of general relativity since everything grew out of this "happiest thought of my life" as Einstein used to call it.

A famous "ontological" implication of the equivalence principle is the slower ticking rate of clocks at the rear end of a long constantly accelerating train or rocketship. It was deduced by Einstein in a chain of heuristic mental steps. The latter involved light-pulse emitting clocks and light-pulse detecting devices in a pictured scenario comprising long hollow cylinders releasable into free fall sporting hooks and vertical slits in their sides to allow one to put in clocks and sensors at different height levels before or after release into free fall, cf. [2].

More than a half-century later, Wolfgang Rindler [3] succeeded in graphically retrieving all pertinent results of Einstein's in the famous Rindler metric. The latter describes a long collection of simultaneously ignited infinitesimally short rocketships, or rather hollow rocket-rings, that stay together spontaneously owing to a careful choice of their systematically differing constant accelerations. The most concise description of the resulting 2-D space-time diagram, with its "scrollable" simultaneity axes that all pass through one point, can be found in Wald's 1984 otherwise algebra-oriented book "General Relativity" [4, p. 151]. For an independent re-discovery, see John S. Bell's intriguing paper [5].

2. The Secret Power of the Equivalence Principle

Clocks at the end of a long constantly accelerating rocketship in outer space do have elongated ticking intervals when their light pulses arrive at the rocket's tip because the latter has in the meantime acquired a well-defined positive velocity compared to the point of origin of the light pulses, as Einstein found out in 1907. The resulting special-relativistic redshift at first sight appears to be a mere observational effect: "in reality" the clocks in question ought to tick at their normal rate (but they don't).

We do know how it is with Einstein's deceptively simple gedanken experiments: He has a knack for following them up to a breaking point where something "impossible" occurs. Remember his previous observation of an apparent clock slowdown of a constant-speed departing twin clock which then while with constant speed returning has an equally accelerated pulse rate, in his seminal founding paper of special relativity of 1905 (two years before the equivalence principle was discovered): When the twin clock with its elongated-appearing ticking intervals is turned around and comes back with its apparent ticking rate equally enhanced, one would have bet that the net effect must be zero when the two clocks are re-united as physical twins. However, to everyone's surprise a net effect (a manifest age difference) remains - the "ontological mehrwert" of Einstein's.

Here with the constantly accelerating rocket, the same thing occurs: A clock that is carefully lowered from the tip to the slower-appearing rear-end of the accelerating long rocketship will, after having been hauled back up again, fail to be as old as its stationary twin at the tip [6, p.18]. This proves that the clocks "downstairs" indeed are ontologically slower-ticking there - whereby the philosophical term "ontological" is utterly unfamiliar in non-Einsteinian physics.

3. Three Added Implications of the Equivalence Principle

Everything that has been said so far is well known. If the clocks are genuinely slower-ticking downstairs rather than just looking slower from above: how about the existence of further ontological implications at the rear end of the rocketship? This suspicion is justified as it turns out. Einstein first found out as described that

$$T\text{-tail} = T\text{-tip times } (z+1), \qquad (1)$$

where z+1 is the local gravitational redshift factor that applies in the Rindler metric.

With Einstein's result put into this simple form, one is immediately led to expect a spatial corollary: If all temporal wavelengths T are increased, the very same thing is bound to hold true for the spatial wavelengths L of the same light waves:

$$L\text{-tail} = L\text{-tip times } (z+1), \qquad (2)$$

and by implication for all local lengths since everything appears normal locally as mentioned. Formally, this conclusion follows from the constancy of the speed of light c since L/T = c implies L = cT for light waves. If T is locally counterfactually increased by Eq.(1) as we saw, L must be equally increased in Eq.(2) if c is constant.

Although this is correct and we are here still in the realm of special relativity with its absolutely constant c despite the presence of acceleration, the conclusion just drawn is possibly premature since c is believed to be non-constant in general relativity ("only locally constant"). Therefore it is "safer" to first proceed to M and then from there back to L.

M, the mass of a particle that is locally at rest, is necessarily reduced by the very factor by which T is increased,

M-tail = M-tip divided by (z+1). (3)

This follows from the fact that all locally normal-appearing photons do by Eq.(1) have a proportionally decreased frequency f and hence have a proportionally reduced energy (by Planck's law E = h f). Thus they have equally much less mass-energy by Einstein's E = mc-squared. If all locally generated photons have so much less mass at the rocketship's tail in a counterfactual way, necessarily all other masses - by virtue of their being locally intertransformable into photons (like positronium) - are reduced by the same factor. Hence Eq.(3) holds true.

From the M of Eq.(3), the L of Eq.(2) can now be retrieved - via the Bohr radius formula of quantum mechanics. Note that if all masses are proportionally reduced, both that of the electron in the denominator of the formula and that of the proton (assumed to be infinite in the formula), the size of the hydrogen atom is proportionally increased, and with it is the size of all other atoms and of space itself. The resulting change of length L is the content of Eq.(2) above.

We have with Eqs.(1-3) arrived at the following abbreviated new law valid in the equivalence principle: "T-L-M." Einstein's old finding of T has acquired two corollaries of equal standing, L and M for short. What about the third candidate, Ch for charge?

If mass is counterfactually reduced and if charge stands in a fixed ratio to mass locally, as holds true for a certain type of particle at least (the electron), then charge is bound to be counterfactually reduced in proportion. This follows from the fact that two local "511 keV" photons still suffice to produce a positronium atom consisting of a locally normal-appearing electron and a locally normal-appearing positron. Since both these particles have a reduced mass content by Eq.(3), they must also have a proportionally reduced charge content if all laws of nature remain intact locally. This condition is guaranteed by Einstein's principle of "general covariance" which states that the laws of nature are the same in every locally free-falling inertial system; for a freshly released free-falling particle like our positronium atom is still locally at rest. Therefore, indeed charge is reduced in proportion to the stationary mass. That is,

Ch-tail = Ch-tip divided by (z+1). (4)

The obtained "completed gravitational redshift law of Einstein" comprises 4 individual equations of equal importance. The new law can be condensed into four letters, T,L,M,Ch. Since the very same consonants pertain to a famous personality of mythological history, Ulysses's son Telemach (or Telemachus), the result can be called the "Telemach theorem."

Note that the gravitational redshift (z+1) on the surface of a neutron star is of order

of magnitude 2. And the gravitational redshift on the surface ("horizon" in Rindler's terminology) of a black hole is infinite. By virtue of Telemach, objects on the surface of a neutron star must be visibly enlarged in the vertical direction by a factor of about two [7], which may be measurable. At the same time, the distance toward and from the horizon of a black hole becomes infinite (as the corresponding light travel time is well-known to be [6, p. 20]). Obviously no known physical phenomenon contradicts the new result which can be tested empirically.

4. Discussion

Two points need to be discussed. First: Is the 4-letter result derived in the equivalence principle robust enough to carry over to the Schwarzschild metric and from there on to all of general relativity? Second: Is the result acceptable in principle from the point of view of modern physics and especially the science of metrology?

The first point is easy to answer. All arguments used above carry over to the Schwarzschild metric. The L of Eq.(2) is nothing but the "poor man's version" of the gothic-R theorem of the Schwarzschild metric [1]. Conversely, the Schwarzschild metric would have a hard time if the "gothic-R" did not fit the "L" of the more basic theory of the equivalence principle.

Before coming to the testable second point announced, a brief digression into the literature is on line. As noted in ref. [1], similar propositions (sub-vectors of T,L,M,Ch as it were) are not unfamiliar. An analog of L was quite often conjectured to hold true in general relativity. For example, an engineer of the Global Positioning System who in distrust of Einstein had built-in a special switch in case Einstein's predictions were to prove true, later wrote a paper [8] to come to grips with his surprise; in one formula (his Eq.9 for the "local rest mass energy") he comes close to Eq.(3) above. More recently, George W. Cox wrote an autodidactic paper arriving in the present terminology at T, L and M [9]; he also is the first scientist to explicitly support Ch (personal communication 2010). And professor Richard J. Cook arrived very elegantly at T,L,M (including the symbols) in general relativity [10], but invoked a variation in the gravitational constant G leaving Ch untouched. Ch is the real crux of the present return to the roots of Einstein's theory. A discussion with members of the Albert-Einstein Institute in early 2009 made it clear that validity of the Gausss-Stokes theorem of electrostatics [4, p. 432] is put at stake by any change in Ch. So is the Reissner-Nordström metric which no general relativist would easily sacrifice. But this is not all. A change in L alone is bad enough already because it seems to imply invalidity of the famous Kerr metric and certain cosmological solutions of the Einstein equation. So the above theory, while implicit in the equivalence principle and the Schwarzschild metric, the heart of general relativity, is by no means an easy-to-absorb implication of general relativity. This fact may explain some of the resistance the gothic-R theorem encountered when first proposed.

The second point is even more important because it makes the connection to measurement. Just as Newton's universal second (the Ur-second so to speak) was toppled by Einstein's revolutionary finding of the gravity-dependent "local" second T of Eq.(1), so the famous Ur-meter adhered-to up until now is toppled by the gravity-dependent local meter L of Eq.(2). The same holds true for the Ur-kilogram M which by Eq.(3) now has become different on the moon (much as its once taken-for-granted

universal weight had been dethroned by Newton's law). And the "Ur-charge" Ch of an electron ceases to be universally valid by Eq.(4). The whole to be measured-out cosmos acquires a new face if Einstein's happiest thought (Eq.1) is correctly elaborated in Eqs.(2-4).

In return for this drawback (if it is one), unexpectedly four quantized physical variables arise: (i) “Kilogram times Second” (Leibniz's later famous "action"), (ii) “Kilogram times Meter” ("cession" [11]), (iii) “Coulomb times Second” and (iv) “Coulomb times Meter” [12]. The explanation of (ii) is that time and space (Second and Meter) scale in strict parallelism (by Eqs.1,2). The explanation of (iii) and (iv) is that rest mass and charge (Kilogram and Coulomb) scale in strict parallelism (by Eqs.3,4). The quantization laws (iii) and (iv) have no names yet (pulsion?, gression?); they come in several particle-type specific varieties [12]. Many experiments testing them can be devised with possible foreign technological applications.

To conclude, a minor revolution in physics was tentatively proposed. The skepticism shown by members of the profession including some of its most prestigious experimentalists can be hoped to be overcome with Eqs.(2-4) demonstrated above. Previous efforts to bar the gothic R theorem from the scientific literature belonged to a time of global restauration (now overcome by Stéphane Hessel and his friendly followers). Only the unprecedented determination of the old guard to go ahead with a proven-unsafe experiment while refusing the safety conference called-for, may prove hard to understand in retrospect. On the other hand, Telemach's youthful and surprising character still lets it appear possible - and worth hoping for - that all of the above is "absolute nonsense" (as a colleague who since changed his mind had once called the gothic-R theorem). Einstein in the dusk of his life came to doubt everything he had done; the atomic bomb was the obvious reason. Now his results could for once have the opposite effect since the big experiment mentioned can still be stopped in view of the above 3 corollaries to Einstein's T which taken together totally upset the safety equation of the LHC unless shown otherwise. Is there anyone who does not feel that Einstein should be given this chance to save the earth with his happiest thought?

For J.O.R.

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(Remark: Bernhard Umlauf kindly showed that Eq.9 of ref. [1] contains a calculational error: "the numerator of the fraction under the natural logarithm must read r_0^(1/2)+(r_0-2m)^(1/2) and the denominator analogously must read r_i^(1/2)+(r_i-2m)^(1/2)." This correction has no effect on the text of ref. [1].)

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