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Review

Einstein's equivalence principle has three further implications besides affecting time: T-L-M-Ch theorem ("Telemach")

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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 included). The TeLeMaCh theorem, named onomatopoetically after Telemachus, is bound to transform metrology if correct.

Key words: Equivalence principle, Telemach theorem, Schwarzschild metric, metrology, Large Hadron Collider (LHC).

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 (Rossler, 2007). 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 mentally pictured scenario comprising long hollow cylinders releasable into free fall and sporting hooks and vertical slits in their sides to allow one to put in clocks and sensors at different height levels, before or after the release into free fall, cf. Pais (1982).

More than a half-century later, Rindler (1968) Succeeded in graphically retrieving all pertinent results described by Einstein 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 varying constant accelerations. The most concise description of the resulting 2-D space-time diagram, with its "scrollable" simultaneity axes that all pass through a single point, can be found in Wald's (1984) famous, otherwise algebra-oriented book. For an independent re-discovery see Bell's (1976) intriguing paper.

THE SECRET POWER OF THE EQUIVALENCE PRINCIPLE

Clocks at the end of a long constantly accelerating rocket ship in outer space 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 do not).

We 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, on returning with the same constant speed, possesses an equally accelerated pulse rate, considered in his seminal founding paper of special relativity of two years before: When the twin clock is back after this “symmetric” departure and return, everyone would have bet that the net effect must be zero when placing the two clocks side by side as physical twins. But to everyone's surprise, a net effect (a manifest lower age of the travelled clock) demonstrably remains: the famous "ontological mehrwert" of Einstein.

Here with the constantly accelerating rocketship, the same thing occurs once more: 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,predictably fail to be as old as its stationary twin at the tip (Frolov and Novikov, 1998). This proves that the clocks "downstairs" indeed are ontologically slower-ticking there. Note that the philosophical term "ontological" is totally unfamiliar outside Einsteinian physics.

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 valid at the rear end of the rocketship? This suspicion is justified it turns out. Einstein first found out – as described – that

T_tail = T_tip *(1+z), (1)

where T is the temporal wavelength of the light waves emitted by the equal clocks in question and (z+1) is the local gravitational redshift factor that applies in the Rindler metric; Einstein (1907) called this factor (1+Phi/c^2) with Phi being the gravitational potential.

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

L_tail = L_tip *(1+z), (2)

And so 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 Equation (1) as we saw, L must be equally increased in Equation 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 /(1+z). (3)

This follows from the fact that all locally normal-appearing photons do by Equation 1 have a proportionally decreased frequency f, and hence have a proportionally reduced energy (by Planck's law E = h*f). They have so much less mass-energy by Einstein's E = mc^2. If all locally generated photons have so much less mass at the rocketship's tail in a locally counterfactual manner, it follows from quantum mechanics that all other masses – by virtue of their being locally inter-transformable into photons (like positronium) in principle – are reduced by the same factor. Hence Equation 3 is valid.

From the M of Equation 3, the L of Equation 2 can now be retrieved as announced - via the Bohr radius formula of quantum mechanics: a_0 = h/(m_e*c*2*pi*alpha), where m_e is the mass of the electron and alpha the dimensionless fine structure constant. But if the radius of the hydrogen atom is increased in proportion to 1/m_e, with m_e varying in accordance with Equation 3, then the size of all objects scales linearly with (1+z) and so does space itself. This was the content of Equation 2.

With Equations 1 to 3 we have arrived at the following abbreviated new law valid in the equivalence principle: "T-L-M." Einstein's old finding of T thus 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 locally and if charge stands in a fixed ratio to mass locally, then charge is bound to be counterfactually reduced in proportion for every class of charged particles. This follows – to give only one example – from the fact that locally, still two "511 keV" photons 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 Equation 3 as we saw, they must also have a proportionally reduced charge content, if all laws of nature are to remain intact locally. This latter 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. Note that a freshly released free-falling particle (like our positronium atom) is still locally at rest. Therefore, charge is reduced in proportion to the stationary local mass:

Ch_tail = Ch_tip/(1+z). (4)

The herewith obtained "complete 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 4-letter result can be called the "Telemach theorem." To witness, the gravitational redshift (1+z) 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 enlarged visibly in the vertical direction by a factor of about two which may be measurable (Kuypers, 2005). In the same vein the distance toward and from the horizon of a black hole has become infinite, as the corresponding light travel time is well-known to be (Frolov and Novikov, 1998: 20). Obviously, no known physical phenomenon contradicts the new result, which moreover retrieves angular momentum conservation (Kuypers, 2005).

DISCUSSION

Two points need to be discussed. First: Is the Telemach theorem derived from 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 specifically the science of metrology?

The first point is easy to answer. All arguments used above carry over to the Schwarzschild metric. The L of Equation 2 is nothing but a "poor man's version" of the gothic-R theorem of the Schwarzschild metric (Rossler, 2007). 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 we come to the testable second point announced, a brief digression into the literature is on line. As noted in Rossler (2007), 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 (Hatch, 2001) to come to grips with his own surprise; in one formula (his Equation 9 for the "local rest mass energy"), he is close to Equation 3. More recently, Cox (2009) in a preliminary paper independently arrived (in the present terminology) at T, L and M; he also was the first scientist to explicitly support Ch (personal communication 2010). Cook (2009) arrived independently at T-L-M (in these very symbols) in general relativity deriving in addition a variation in the gravitational constant G (by the factor (z+1)^2). He has since fully agreed to Ch (personal communication 2011). Ch proves to be the real crux in the present return to the roots of Einstein's theory. A discussion with members of the Albert-Einstein Institute in early 2009 highlighted the fact that validity of the Gauss-Stokes theorem of electrostatics (Wald, 1984: 432) is put at stake by any change in Ch. So is the Reissner-Nordström metric which combines the Schwarzschild metric with an added charge and which no general relativist would easily sacrifice. But this is not all. Even a change in L alone is bad enough already since it likely implies invalidity of the famous Kerr metric, as well as of certain cosmological solutions of the Einstein equation. Thus the aforementioned theory – while implicit in the equivalence principle and the Schwarzschild metric as the heart of general relativity – is by no means an easy-to absorb new implication of general relativity. This fact can explain some of the resistance the gothic-R theorem encountered when first proposed.

The announced second point in need of discussion is even more important because it makes the connection to measurement. Newton abandoned the “Ur-pound” as it were, but left the universal second (“Ur-second") unscathed. The latter was only toppled by Einstein's discovery of the gravity-dependent "local second" T of Equation 1. In the same vein, the universal meter ("Ur-meter”) is toppled by the gravity-dependent "local meter" L of Equation 2. The same then holds true for the universal mass ("Ur-kilogram") which is toppled by the gravity-dependent “local mass” M of Equation 3, which now has become different on the moon, too. And finally the universal charge ("Ur-charge") of an electron is toppled by the gravity-dependent “local charge” Ch of Equation 4. The whole to be measured-out cosmos thereby acquires a new face – if Einstein's “happiest thought” (Equation 1) has been correctly elaborated with the newly implied Equations 2 to 4.

In return for this drawback (if it is one), four quantized physical variables must be distinguished, three of them new. Besides

(i) “Kilogram times second” (Leibniz's famous "action"), we now have:
(ii) “Kilogram times meter” ("cession"), Rossler and Giannetti (1997),
(iii) “Coulomb times second” (“el-action”),
and
(iv) “Coulomb times meter” (“el-cession”), Rossler and Fröhlich (2010).

The explanation for (ii) lies in the fact that time and space (Second and Meter) scale in strict parallelism by Equations 1 and 2. The explanation for (iii) and (iv) lies in the fact that rest mass and charge (Kilogram and Coulomb) scale in strict parallelism by Equations 3 and 4. The new quantized magnitudes (iii) and (iv) obey

constants of nature and come in several force-specific varieties (Rossler and Fröhlich, 2010). Note that while both G and epsilon_o (and along with it mu_o) cease to be fundamental constants as a consequence of L-M-Ch, their ratio (more precisely the square root of the product of G and epsilon_o) becomes a new fundamental constant of nature which can be named "G_o":

(v) G_o = sqrt(G*epsilon_0) = 2.4308 *10^(-11) C/kg.

A particle-class-specific splitting of Equation (v) is predictable since there are more charges than the electrical one. Many experiments to test the newly derived results (ii-v) can be devised. Radically noveltechnological applications come in sight. Metrology predictably rises in the hierarchy of sciences.

CONCLUSION

In this study a minor revolution in physics was proposed. The skepticism shown by some members of the experimental profession towards the gothic-R theorem is hoped to be overcome with Equations 2 to 4 in view of their testable implications. A famous experiment is affected by the aforementioned results. Its detectors need replacement before continuation because the infinite distance of the horizon (Equation 2) makes black holes immune to Hawking evaporation, and the new unchargedness of black holes (Equation 4) makes them invisible at first. New dangers – even apocalyptic ones – have become recognizable by the Telemach theorem.

Electrons cannot be point masses any more by Equation 4 in empirical confirmation of string theory. This fact makes black hole production much more probable. And the new unchargedness of black holes renders artificial ones frictionless – until the first quark starts spiraling in at which point an exponentially growing “mini-quasar” is formed inside matter (earth). The super fluidity of neutron stars makes these densest objects immune to any natural fast mini black holes (so that all defenses of the LHC experiment collapse as if premeditated by Nature). However, Telemach's youthful and exotic character lets it still appear possible that he belongs more to Homer than to science. Einstein in the dusk of his life came to doubt everything he had done, the atomic bomb being the reason. Now his better understood “happiest thought” offers a rescuing effect.

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(Remark: Bernhard Umlauf kindly showed that Eq.9 contains a calculation error by stating correctly that "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 leaves the text unchanged.)

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