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The Question of E = mc^2 and Rectification of Einstein's General Relativity

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Abstract- The formula E = mc^2 is a speculation that was confirmed by Nuclear fission and fusion, but is not valid for the electromagnetic energy alone because the electromagnetic energy-stress tensor is traceless. On the other hand, for the light rays satisfying E = mc^2 necessitates the existence of a photonic tensor with an anti-gravity coupling added to the Einstein equation with the source of an electromagnetic wave. This is consistent with the massive dynamic case that the Einstein equation must be rectified to the Lorentz-Levi-Einstein equation. Moreover, because the couplings in the Einstein equation must have different signs for the dynamic case that involves gravitational waves, the space-time singularity theorems of Hawking and Penrose actually are irrelevant to physics. The misinterpretation of E = mc^2 as generally valid, is responsible for overlooking the charge-mass interaction, which is crucial for the unification of gravitation and electromagnetism. General validity of E = mc^2 is also in disagreement with experiments. It is pointed out that the interpretations of E = mc^2 of both Nobel Laureates, 't Hooft and Wilczek, just like many others, are also incorrect.

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THEQUESTIONOFEMC2ANDRECTIFICATIONOFEINSTEINSGENERALRELATIVITY

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The Question of $E = mc^2$ and Rectification of Einstein's General Relativity

C. Y. Lo

Abstract- The formula $E = mc^2$ is a speculation that was confirmed by Nuclear fission and fusion, but is not valid for the electromagnetic energy alone because the electromagnetic energy-stress tensor is traceless. On the other hand, for the light rays satisfying $E = mc^2$ necessitates the existence of a photonic tensor with an anti-gravity coupling added to the Einstein equation with the source of an electromagnetic wave. This is consistent with the massive dynamic case that the Einstein equation must be rectified to the Lorentz-Levi-Einstein equation. Moreover, because the couplings in the Einstein equation must have different signs for the dynamic case that involves gravitational waves, the space-time singularity theorems of Hawking and Penrose actually are irrelevant to physics. The misinterpretation of $E = mc^2$ as generally valid, is responsible for overlooking the charge-mass interaction, which is crucial for the unification of gravitation and electromagn-etism. General validity of $E = mc^2$ is also in disagreement with experiments. It is pointed out that the interpretations of E = mc^2 of both Nobel Laureates, 't Hooft and Wilczek, just like many others, are also incorrect.

Keywords: einstein's equivalence principle; dynamic solution; gravitational wave; $E = mc^2$.
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I. Introduction

The formula $E = mc^2$ can be traced back to special relativity, which suggested a rest inertial mass m_0 of a particle that has the rest energy of m_0c^2. This is supported by the nuclear fissions (or fusions) with $\Delta E = \Delta mc^2$, where Δm is the mass difference after the fission (or fusion) and ΔE the total energy created and is usually a combination of different types of energy. However, the general validity of the formula $E = mc^2$ is only a speculation that has never been verified [1]. In fact, Einstein had tried very hard for years (1905-1909) to prove this formula to be generally valid, but failed [2].

Experimentally, it has been observed that the particle π^0 meson decays into two photons (i.e.,$\pi^0 \rightarrow \gamma + \gamma$). This was mistakenly considered as evidence that the electromagnetic energy is equivalent to mass. However, there would be a conflict if a photon includes only electromagnetic energy since the electromagnetic energy-stress tensor is traceless. Therefore, this experiment means only that the photons must consist of non-electromagnetic energy.

Some define an electromagnetic mass for a photon in terms of $m = E/c^2$. However, in physics, a definition must be supported with experiments. Thus, it would be necessary to show that the electromagnetic mass can generate the same gravity that would have been generated by the inertial mass. However, when Einstein proposed the notion of photon [2; p. 177], Einstein had not yet conceived general relativity then. Moreover, according to general relativity, such a claim is incorrect for electromagnetic energy. The Einstein field equation [3, 4] is,

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = - K\, T_{\mu\nu}\,, \qquad (1)$$

where the energy stress tensor $T_{\mu\nu}$ is the sum of any type of energy-stress tensor. The electromagnetic energy-stress tensor, being traceless, cannot affect R in eq. (1). Therefore, the electromagnetic energy is not equivalent to mass.

Nevertheless, since Hawking and Penrose claimed that general relativity was not applicable in microscopic scale [5],1) the possibility of including gravitational energy in photons was ignored. It will be shown that Hawking and Penrose are incorrect (see section 2). Moreover, the energy of photons is, indeed, the sum of the energies of the electromagnetic wave component and that of the gravitational wave component [6]. Since a charged particle has mass, it is natural that the non-electromagnetic energy is the gravitational energy.

From the Reissner-Nordstrom Metric [7], it is clear that the electromagnetic energy is not equivalent to mass [1]. However, because of the misinterpretation of $E = mc^2$ as generally valid, the charge-mass interaction [8] that can lead to prove the non-equivalence between mass and electromagnetic energy experimentally was overlooked for more than 80 years.

It will be shown the fact that $E = mc^2$ demands a photonic Energy-Stress Tensor, is also required by general relativity. On the other hand, it can be shown also that $E = mc^2$ is not generally valid experimentally. However, theorists including some Nobel Laureates (see Section 4), still misinterpreted this formula as unconditional.

II. Necessity of a Photonic Energy-Stress Tensor and the Anti-Gravity Coupling

To have a solution of gravity for an electro-magnetic wave, it turns out that the Einstein equation

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$G_{\mu\nu} = - K\, T(E)_{\mu\nu}$ is inadequate because it is impossible to have a meaningful solution in physics (see section 2.1). Then, the calculation for the bending of light could be invalid since it was implicitly assumed that the gravity due to the light is negligible [3].

To have a meaningful solution, it is necessary to modify the Einstein equation [6] to

$$G_{\mu\nu} = - K\, [T(E)_{\mu\nu} - T(P)]_{\mu\nu} = Kt(g)_{\mu\nu}, \qquad (2)$$

where $T(E)_{\mu\nu}$ is the energy-stress tensor of the electromagnetic wave, and $T(P)_{\mu\nu}$ is the photonic energy-stress tensor. Thus, the existence of the photonic energy-stress tensor is a necessary result of general relativity, that is consistent with $E = mc^2$. Moreover, the necessity of the anti-gravity coupling is not limited to the case that involves an electromagnetic wave. The anti-gravity coupling is necessary when the gravitational wave is involved [9]. To have a physical solution for massive sources, it has been shown that a gravitational energy-stress tensor with an anti-gravity coupling sign must be added [10-12], i.e., the massive Einstein equation must be modified to the Lorentz-Levi-Einstein equation,[2)]

$$G_{\mu\nu} = - K\, [T(m)_{\mu\nu} - t(g)]_{\mu\nu} \qquad (3)$$

where $T(m)_{\mu\nu}$ is the massive energy-stress tensor, and $t(g)_{\mu\nu}$ is gravitational energy-stress tensor.

It should be noted that the linearized equation in general relativity is a valid linearization of the Lorentz-Levi-Einstein equation [13], but is not a valid linearization of the Einstein equation that has no bounded dynamic solution.

In short, for the dynamic case when gravitational wave is involved, Einstein was wrong. However, Gullstrand [14], Chairman (1922-1929) of the Nobel Committee for Physics is right. Thus, the long dispute on Einstein's calculation on the perihelion is settled as invalid because it is not possible to derive his calculation from a many-body problem although the results are correct [9]. In conclusion, general relativity is incomplete although it has a good start. Nevertheless, Einstein is a winner because his conjecture, the unification of electromagnetism and gravitation is confirmed [15].

a) Physical Gravitational Solutions for Electromagnetic Plane-Waves

Analysis indicates that an electromagnetic wave would generate an accompanying gravitational wave [7, 16, 17]. The calculation of the bending of light assumes that such gravitational waves are very weak and negligible [3, 4]. To verify this, one should calculate such a gravitational wave with the Einstein equation that has the electromagnetic wave as the source. For this case, Einstein [18] believed the field equation is

$$G_{ab} = -KT(E)_{ab} \text{ where } T(E)_{ab} = - g^{mn}F_{ma}F_{nb} + (1/4)g_{ab}F^{mn}F_{mn} \qquad (4)$$

and F_{ab} is the electromagnetic field tensor. Thus, $R = 0$ since the trace of $T(E)_{ab}$ is zero.

Now, let us consider a ray of uniform electromagnetic waves (i.e. a laser beam) propagating in the z-direction. Within the ray, one can assume that the wave amplitude is independent of x and y (see also [7, 17]). Thus, the electromagnetic potentials are plane-waves, and in the unit that the light velocity c = 1,

$$A_k(x, y, z, t) = A_k(t - z), \text{ where } k = x, y, z, \text{ or } t\,. \qquad (5)$$

Due to the principle of causality [10], the metric g_{ab} is functions of u (= t - z), i.e.,

$$g_{ab}(x, y, z, t) = g_{ab}(u)\,, \quad \text{where } a, b = x, y, z, \text{ or } t\,. \qquad (6)$$

Let P^k be the momentum of a photon. Then, one obtains the conditions,

$$P^z = P^t,\ P^x = P^y = 0, \text{ and } P^m g_{mk} = P_k = 0\,, \text{ for } k = x, y, \text{ or } v, \qquad (7a)$$

where $v \equiv t + z$. Compatibility with weak gravity is used [17] in deriving eq. (7a) which is equivalent to

$$g_{xt} + g_{xz} = 0\,,\ g_{yt} + g_{yz} = 0\,, \text{ and } g_{tt} + 2g_{tz} + g_{zz} = 0\,, \qquad (7b)$$

or

$$g^{xt} - g^{xz} = 0\,, g^{yt} - g^{yz} = 0\,, \text{ and } g^{tt} - 2g^{zt} + g^{zz} = 0\,. \qquad (7c)$$

Note that eq. (7) implies that the harmonic gauge may not be valid. The wave transversality implies

$$P^m A_m = 0\,, \quad \text{or equivalently} \quad A_z + A_t = 0\,. \qquad (8)$$

Eqs. (6) to (8) imply that not only the geodesic equation, the Lorentz gauge, but also Maxwell's equation are satisfied. Moreover, the Lorentz gauge becomes equivalent to a covariant expression.

The above analysis suggests that an electromagnetic plane-wave can be an exact solution in a non-flat manifold. In a coordinate system where P_m are constants, the scalar $\int P_m\, dx^m$ would equal to $P_m x^m$. Moreover,

$$R_{tt} = - R_{tz} = R_{zz} , \quad (9a)$$

because $F^{mn}F_{mn} = 0$ due to eq. (7). The other components give eq. (7), and are zero [8]. Then, we have

$$R_{tt} \equiv -\partial\Gamma^{m}{}_{tt}/\partial x^{m} + \partial\Gamma^{m}{}_{mt}/\partial t - \Gamma^{m}{}_{mn}\Gamma^{n}{}_{tt} + \Gamma^{m}{}_{nt}\Gamma^{n}{}_{mt} = -KT(E)_{tt} = K g^{mn}F_{mt}F_{nt}. \quad (9b)$$

After some lengthy algebra [17], eq. (9b) is simplified to a differential equation of u as follows:

$$G'' - g_{xx}'g_{yy}' + (g_{xy}')^2 - G'(g'/2g) = 2K (F_{xt}{}^2 g_{yy} + F_{yt}{}^2 g_{xx} - 2F_{xt}F_{yt}\, g_{xy}) \quad (10)$$

$$= 2GR_{tt}, \quad \text{where} \quad G \equiv g_{xx}\, g_{yy} - g_{xy}{}^2, \quad \text{and} \quad g = |g_{ab}|$$

is the determinant of the metric. The metric elements are connected by the following relation:

$$- g = G\, g_t{}^2, \quad \text{where} \quad g_t \equiv g_{tt} + g_{tz}; \quad (11)$$

and

$$g^{xx} = g_{yy}/G, \quad g^{yy} = g_{xx}/G, \quad \text{and} \quad g^{xy} = -g_{xy}/G \quad (12)$$

Note that eqs. (35.31) and (35.44) in reference [7] and eq. (2.8) in reference [19] are special cases of eq. (10). However, their solutions are unbounded [17]. On the other hand, compatibility with Einstein's notion of weak gravity is required by the light bending calculation and is implied by the equivalence principle [11].

Equations (5), (6), (8), and (9) allow A_t, g_{xt}, g_{yt}, and g_{zt} to be set to zero. In any case, these assigned values have little effect in subsequent calculations. For the remaining metric elements (g_{xx}, g_{xy}, g_{yy}, and g_{tt}), it will be shown, however, eq. (10) is sufficient to show that there is no physical solution for an Einstein equation. In other words, in contrast to Einstein's belief [18], the difficulty of this equation is not limited to mathematics.

Now, let us consider a circularly polarized monochromatic electromagnetic plane-wave,

$$A_x = (1/\sqrt{2})\, A_0 \cos \omega u, \text{ and } A_y = (1/\sqrt{2})\, A_0 \sin \omega u . \quad (13)$$

Then $P_t = \omega$ (since h = 1). The rotational invariants with respect to the z-axis are constants. These invariants are: R_{tt}, $T(E)_{tt}$, G, $(g_{xx} + g_{yy})$, g_{tz}, g_{tt}, g, and etc. Let us assume the invariant,

$$g_{xx} + g_{yy} = -2 - 2C, \text{ then } g_{xx} = -1 - C + B, \text{ and } g_{yy} = -1 - C - B. \quad (14)$$

Thus,

$$B^2 + g_{xy}{}^2 = (1+C)^2 - G, \text{ and } (B')^2 + (g_{xy}')^2 = 2GR_{tt} \geq 0 \quad (15)$$

obtained from $G = gxx\, gyy - gxy^2$ and eq. (10), are constants. It follows that eq. (15) implies

$$B = B_\alpha \cos(\omega_1 u + \alpha), \quad \text{and} \quad g_{xy} = \pm B_\alpha \sin(\omega_1 u + \alpha) , \quad (16a)$$

where

$$\omega_1{}^2 = 2R_{tt}\, G/B_\alpha{}^2 , \quad \text{and} \quad B_\alpha{}^2 = (1+C)^2 - G \geq 0. \quad (16b)$$

Thus, it is proven that the metric is a periodic function. Also, as implied by causality, the metric is not an invariant under a rotation (since a transverse electromagnetic wave is not such an invariant).

On the other hand, since $T(E)_{tt}$ is a constant, it is necessary to have

$$\omega_1 = 2\omega , \quad \text{and} \quad T(E)_{tt} = (1/2G)\, \omega^2 A_0{}^2 (1 + C - B_\alpha \cos \alpha) > 0. \quad (16c)$$

Eq. (16a) implies that the metric is a circularly polarized wave with the same direction of polarization as the electromagnetic wave (13). However, it is not possible to satisfy Einstein's equation because both $T(E)_{tt}$ and R_{tt} have the same sign. Thus, there is no possibility, within the current theory, to construct an acceptable metric representing the accompanying gravitational wave for a circular polarized electromagnetic plane-wave.

Now, consider also a wave linearly polarized in the x-direction,

$$A_x = A_0 \cos \omega(t - z) . \tag{17a}$$

Then, one has

$$T_{tt} = - (g_{yy}/2G)\omega^2 A_0^2 [1 - \cos 2\omega(t - z)] . \tag{17b}$$

If a circularly polarized electromagnetic plane-wave results in a circularly polarized gravitational wave, one may expect that a linearly polarized electromagnetic plane-wave results in a linearly polarized gravitational wave. From the viewpoint of physics, the principle of causality would require that, for an x-directional polarization, gravitational components related to the y-direction, remains the same. In other words,

$$g_{xy} = 0 , \text{ and } g_{yy} = -1 . \tag{18}$$

Mathematically, condition (18) is compatible with semi-unitary (i.e., g is a constant).
Equation (18) means that the gravitational wave is also linearly polarized. It follows that equation (10) becomes

$$G'' = - 2 K G T_{tt} \text{ and } G = - g_{xx}. \tag{19}$$

Then, different from the circular polarization, eq. (19) would have a solution

$$-g_{xx} = 1 + C_1 - (K/4) A_0^2\{2\omega^2(t - z)^2 + \cos [2\omega (t - z)]\} + C_2(t - z) , \tag{20}$$

where C_1 and C_2 are constants. However, (20) is invalid in physics since $(t - z)^2$ grows very large as time goes by.

On the other hand, since physical influences can be propagated at most with a light speed, the influence of an electromagnetic wave on its accompanying gravitational wave would essentially be spatially local. This means that the electromagnetic plane-wave, a well-tested spatial local idealization, is a valid physical modeling for gravity. Thus, if general relativity is fundamentally valid, there must be a way in physics to modify the equation such that a physical solution can be obtained for a plane-wave. Otherwise, general relativity would not be a valid theory in physics.

The formula $E = mc^2$ gives us a clear suggestion. Since the Einstein tensor is supported by causality, it would be sufficient to modify the source tensor [6]. The additional energy term should be a constant of different sign, and is larger in absolute value. Moreover, calculation shows that a physical solution requires that in the flat metric approximation, an electromagnetic wave energy tensor and the unknown tensor with an antigravity coupling carry, on the average, the same energy-momentum [6]. This is expected for a photonic energy tensor, according to experiments.

Thus, physics requires that the unknown tensor must be the energy-stress tensor of photons. Given that an electromagnetic wave moving with the velocity of light, its gravitational influence must be moving along according to special relativity. This means that the photonic energy-stress tensor would be the sum of the electromagnetic energy-stress tensor and the gravitational energy-stress tensor, i.e., $T(P)_{ab} = T(E)_{ab} + T(g)_{ab}$.

b) *A Photonic Energy-Stress Tensor and the Anti-Gravity Coupling*

As required by the bending of light, one must show that a valid modification can be obtained with a photonic energy-stress tensor, i.e. it would also lead to a physical solution and generate a geodesic equation for photons. From the previous analysis, the appropriate Einstein equation would be

$$G_{ab} = -K[T(E)_{ab} - T(p)_{ab}], \text{ and } T_{ab} = - T(g)_{ab} = T(E)_{ab} - T(P)_{ab} , \tag{21}$$

where $T(E)_{ab}$ and $T(P)_{ab}$ are the energy-stress tensors for the electromagnetic wave and the related photons.

Note that the energy-stress tensor of photons has an anti-gravity coupling. Since both $T(E)_{ab}$ and $T(g)_{ab}$ (due to $\nabla^c G_{cb} \equiv 0$ and eq. [7a]) are divergence free and traceless, $T(P)_{ab}$ must also be divergence free and traceless.

Given that a photonic energy tensor should produce a geodesic equation, for a monochromatic wave, the tensor form should be similar to that of massive matter. Observationally, there is very little interaction, if any, among photons of the same ray. Theoretically, since photons travel at the velocity of light, there should not be any interaction among them. Therefore, the photonic energy tensor should be dust-like as follows:

$$T^{ab}(P) = \rho P^a P^b, \tag{22a}$$

where ρ is a scalar which, according to causality, is a function of u. The geodesic equation, $P^c\nabla_c P^b = 0$, is implied by $\nabla c(\rho P^c) = 0$, and $\nabla c\, T(P)^{cb} = 0$. ρ (u) should be a non-zero function of the electromagnetic potentials and/or fields. This implies $\rho = \lambda A_m g^{mn} A_n$, where λ is a scalar constant to be determined.

Since light intensity is proportional to the square of the wave amplitude, ρ can be considered as the density function of photons if $\lambda = -1$. Due to R = 0 and eqs. (5) and (6) remain valid, $\rho(u)$ is Lorentz gauge invariant. Then, one obtains

$$T_{ab} = T(E)_{ab} - T(P)_{ab} = T(E)_{ab} - \lambda A_m g^{mn} A_n P_a P_b . \quad (22b)$$

Thus, a photonic energy tensor changes nothing in calculation, but gives another term for eq. (10) only. To determine λ , let us consider a circularly polarized monochromatic wave (10). Then, we have,

$$T_{tt} = (1/2G)\, \omega^2 A_0^2 [(1 + C)(1 + \lambda) - (1 - \lambda) B_\alpha \cos\alpha] \leq 0 \quad (23)$$

since $P_t = \omega$ (in the units $c = h = 1$) and eq. (16b) requires R_{tt} to be of second order and positive. Eq. (23) requires that $\lambda \leq -1$ because the constants C and B_α are much smaller than 1. Causality requires that, in a flat metric approximation, the time average of T_{tt} is zero. This implies that, as expected,

$$\lambda = -1, \quad T_{ab} = T(E)_{ab} - T(P)_{ab} = T(E)_{ab} + A^m g^{mn} A_n P_a P_b$$

and

$$T_{tt} = -(1/G)\, \omega^2 A_0^2 B_\alpha \cos\alpha \leq 0, \quad \text{since} \quad B_\alpha = (K/2) A_0^2 \cos\alpha . \quad (24)$$

Thus, the energy density of the photonic energy tensor is indeed larger than that of the electromagnetic wave. Then, (16a) and (16b) are valid for eq. (10). Note that, pure electromagnetic waves can exist since $\cos \alpha = 0$ is possible.

To confirm the general validity of $\lambda = -1$, consider also the wave linearly polarized in the x-direction,

$$A_x = A_0 \cos \omega(t - z) . \quad (17a)$$

Then, one has

$$T_{tt} = (g_{yy}/2G)\, \omega^2 A_0^2 (-\lambda - 1) + (1 - \lambda)\cos[2\omega(t - z)] . \quad (25a)$$

Thus, the flat metric approximation again requires that $\lambda = -1$. Then,

$$T_{tt} = (g_{yy}/G)\, \omega^2 A_0^2 \cos [2\omega (t - z)] . \quad (25b)$$

Eq. (25b) implies $(g_{xx} + g_{yy})'$ to be of first order [8], and therefore its polarization has to be different. Note that T_{tt} is allowed to be positive, since the gravitational component is not an independent wave. Then the solution is

$$-g_{xx} = 1 + C_1 - (K/2) A_0^2 \cos [2\omega(t - z)], \text{ and } g_{tt} = -g_{zz} = (g/g_{xx})^{1/2}, \quad (26)$$

where C_1 is a constant. The frequency ratio is the same as the other case and, as expected, the average of T_{tt} is negative.

Thus, T_{ab} (P) has been derived from the electromagnetic wave. In spite of the demanding physical requirements, a photonic energy tensor has been obtained. Note that the photonic energy tensor of Misner et al. [7, Section 22], is an approximation of the time-average of $T_{ab}(P)$. For a circularly polarized electromagnetic wave, the phase difference controls the amplitude of the gravitational wave (see eq. [24]), and the amplitude of the electromagnetic wave gives an upper bound. This is different from the case of linearly polarized waves for which the amplitude of gravity is fixed.

Most important, it is the anti-gravity coupling of the photonic energy-stress tensor that illustrates general relativity to be a viable theory. Thus, what Einstein has missed is that *the anti-gravity coupling is necessary in general relativity*. Accordingly, the space-time singularity theorems of Hawking and Penrose are actually irrelevant to physics since the physical assumption of their energy conditions will not be satisfied.

Historically, the existence of the antigravity coupling was first proposed for the gravitational energy-stress tensor $t(g)_{\mu\nu}$ [2)] by Lorentz [20] in 1916 and Levi-Civita [21] in 1917. However, Einstein [22] incorrectly rejected their proposal on the ground that $t(g)_{\mu\nu} = 0$ in his equation. In 1995, Lorentz and Levi-Civita are proven right [10-12]

III. The Reissner-Nordstrom Metric and the Repulsive Effect

A problem of the above analysis is that it is difficult to verify experimentally. In this section, we shall discuss the experimental verification of the non-equivalence between mass and electromagnetic energy.

General relativity makes it explicit that the gravity generated by mass and that by the electromagnetic energy are different, as shown by the existence of repulsive effect in the Riessner-Nordstrom metric [15],

Global Journal of Science Frontier Research (A) Volume XIV Issue II Version I Year 2014 11

$$ds^2 = \left(1 - \frac{2M}{r} + \frac{q^2}{r^2}\right)dt^2 - \left(1 - \frac{2M}{r} + \frac{q^2}{r^2}\right)^{-1} dr^2 - r^2 d\Omega^2, \quad (27)$$

where q and M are the charge and mass of a particle and r is the radial distance, in terms of the Euclidean-like structure [23] from the particle center.

In metric (27), the gravitational components generated by electricity have not only a very different radial coordinate dependence but also a different sign that makes it a new repulsive gravity [1].

Some argued that the effective mass in metric (27) is $M - q^2/2r$ (in the units, the light speed $c = 1$) since the total electric energy outside a sphere of radius r is $q^2/2r$. However, from metric (27), the gravitational force is different from the force created by the "effective mass" $M - q^2/2r$ because

$$-\frac{1}{2}\frac{\partial}{\partial r}\left(1 - \frac{2M}{r} + \frac{q^2}{r^2}\right) = -\left(\frac{M}{r^2} - \frac{q^2}{r^3}\right) > -\frac{1}{r^2}\left(M - \frac{q^2}{2r}\right). \quad (28)$$

They achieved only exposing further an inadequate understanding in the theory of relativity. Some theorists claimed that M should include the electric energy, and this exposes an even deeper error related to the derivation.

a) Derivation of the Reissner-Nordstrom Metric

It seems that mass M in (2) as a "total mass" that includes the electric energy, would be allowed if you were careless. However, a close examination shows that this is invalid.

According to Einstein, for the Reissner-Nordstrom metric, the static field equation includes at least the massive energy-stress tensor and the electromagnetic energy-stress tensor. They differ by that the electromagnetic energy-stress tensor is traceless whereas the massive energy-stress tensor is not.

If one assumes that the metric has the following form,

$$ds^2 = f\,dt^2 - h dr^2 - r^2(d\theta^2 + \sin\theta^2 d\phi^2), \quad (29)$$

then, as shown by Wald [5], at the region outside the particle ($r > r_0$) we have

$$-R_{00} = \frac{1}{2}(fh)^{-1/2}\frac{d}{dr}\left[(fh)^{-1/2} f'\right] + (fhr)^{-1} f', \quad (30a)$$

$$-R_{11} = -\frac{1}{2}(fh)^{-1/2}\frac{d}{dr}\left[(fh)^{-1/2} f'\right] + (h^2 r)^{-1} h', \quad (30b)$$

$$-R_{22} = -\frac{1}{2}(rfh)^{-1} f' + \frac{1}{2}(h^2 r)^{-1} h' + r^{-2}(1 - h^{-1}) \quad (30c)$$

Moreover, outside the particle we have

$$T(m)_{\mu\nu} = 0 \qquad \text{for} \qquad r > r_0 \quad (31a)$$

But

$$T(m)_{00} = \rho(r), \quad T(m)_{11} = T(m)_{22} = T(m)_{33} = P(r), \quad \text{when } r < r_0 \quad (31b)$$

where P(r) is the pressure of the perfect fluid model.

Because the electric energy-stress tensor $T(E)_{\mu\nu}$ is traceless, we also have, for $r > r_0$,

$$R_{00} = -R_{11} = R_{22} = -E^2, \quad \text{where } \vec{E} = \frac{q}{r^3}\vec{r} \quad (32)$$

is the electric field, according to Misner et al. [7; p. 841]. If $h = 1/f$ in metric (29), then (30) is reduced to

$$-R_{00} = R_{11} = \frac{1}{2} f'' + r^{-1} f' = E^2 \quad (33a)$$

And

$$-R_{22} = -r^{-1} f' + r^{-2}(1 - f) = E^2 \quad (33b)$$

Moreover, if $f = \left(1 - \frac{2M}{r} + \frac{q^2}{r^2}\right)$ as in metric (27), then we have, in consistent with (32),

$$\frac{q^2}{r^2} = r^2 E^2 \tag{34}$$

Thus, it might seem there is no restriction on the mass M of metric (29). However, from (32), it is clear that M in metric (29) cannot include the electric energy (outside the particle) since it has been represented in (32).

b) Misinterpretations of the Reissner-Nordstrom Metric

Nevertheless, Herrera, Santos, & Skea [24], argued that M in (27) involves the electric energy. They follow the error of Whittaker [25] and Tolman [26]. They defined the active gravitational mass density μ with the electromagnetic energy tensor $E^{\alpha}{}_{\beta}$ as $\mu = E_0^0 - E_i^i$ and the active mass in a volume V_a is given by

$$m_a(r) = \int_{V_a} \mu(-g)^{1/2} dx^1 dx^2 dx^3 , \tag{35}$$

where g is the determinant of the metric $g_{\mu\nu}$. It thus follows that, for a particle with charge Q, one has

$$m_a(\infty) - m_a(r) = \int_r^\infty \frac{Q^2}{r^2} dr , \quad \text{and} \quad m_a(r) = M - \frac{Q^2}{r} , \quad \text{where} \quad m_a(\infty) = M \tag{36}$$

Thus $m_a(r)$ would be in agreement with that the total force is proportion to

$$\frac{1}{2}\frac{\partial}{\partial r}\left(1 - \frac{2M}{r} + \frac{Q^2}{r^2}\right) = (M - \frac{Q^2}{r})\frac{1}{r^2} = \left(m_a(r_0) + Q^2(\frac{1}{r_0} - \frac{1}{r})\right)\frac{1}{r^2} \tag{37a}$$

$$\text{since } M = m_a(r) + Q^2/r = \left(m_a(r_0) + Q^2/r_0\right), \tag{37b}$$

where r_0 is the radius of the particle. However, (36) does not agree with (28) since

$$-2(M - \frac{Q^2}{r})\frac{1}{r} \neq \left(-\frac{2M}{r} + \frac{Q^2}{r^2}\right) \tag{37c}$$

Eq. (37a) implies that the weight of a charged metal ball would increase when the charge Q is increased. According to eq. (35), $m_a(r_0)$ would increase as the charge Q increases. Thus, no repulsive effects can be detected.

However, it should be noted that as shown in (37b), M includes energy outside the particle, in conflict with (32). On the other hand, if the mass M is the inertial mass of the particle, the weight of a charged metal ball can be reduced [27] (see Appendix). Thus, as expected [8], experiments of two metal balls [28] reject eq. (36). The repulsive force on a charged ball is an important experiment to be completed for the details *since it is a test of general relativity*.

The inertial mass of the particle should be smaller than M defined in (37b) since an acceleration of the charged particle would not immediately affect the electric energy at long distances. However, 't Hooft also claimed in his Nobel Lecture [29] that M in (37c) is the inertial mass subjected to Newton's second law. Thus, it is clear that 't Hooft is only an excellent applied mathematician, but a questionable physicist. Understandably, 't Hooft also does not understand the principle of causality adequately [30, 31]. Note that the radius r_e of an electron *e* is about a half of its classical radius e^2/m_0c^2 [32], where m_0 is its inertial mass. Thus, the electric energy e^2/r_e would be larger than m_0.

The problem started from the assumption of equivalence between mass and electric energy. Should the electric energy be considered as part of the gravitational mass of the particle? If it is, then gravitational mass and inertial mass are different. If it is not, then any electromagnetic energy should assign a mass. However, this is invalid because it is not supported by experiments. Thus, the electric energy should not be equivalent to mass. Unfortunately, 't Hooft is not alone, and Wilczek [33] also mistaken $m = E/c^2$ as unconditional in his Nobel speech (see Section 4).[3)]

The above approach is essentially the same as that of Pekeris [34], who gets a similar metric as follows:

$$ds^2 = e^{\nu} dt^2 - e^{-\nu} dR^2 - R^2 d\Omega^2 \quad \text{where} \quad R^3 = r^3 + r_0^3 \tag{38a}$$

$$e^{\nu} = \left(1 - \frac{2M_{mat}}{R} - \frac{2M_{em}}{R} + \frac{Q^2}{R^2}\right) = \left(1 - \frac{2M}{R} + \frac{Q^2}{R^2}\right), \quad \text{where } M_{em} = Q^2/r_0, \text{ and } M = M_{mat} + M_{em} \qquad (38b)$$

The difference is due to that Pekeris [34] requires that $|g_{\mu\nu}| = g = -1$. Thus, what Herrera et al. [24] does is essentially what Pekeris had done. Apparently, theorists have run out of ways that can be used against the repulsive force.

In summary, misinterpretations of the Riessner-Nordstrom metric delay the recognition of the charge-mass interaction for more than 80 years. An experimental verification of the charge-mass repulsive interaction gives a clear statement that the electro-magnetic energy and mass are not equivalent. The charge-mass interaction leads to the necessity of unification. However, for the case of such force acting on a charged capacitor, this is beyond general relativity.

Nevertheless, the necessary existence of the anti-gravity coupling shows that the theoretical developments without the anti-gravity coupling are incorrect. This is an important development because it is beyond Einstein.

c) The Charge-mass Interaction and Five-Dimensional Theory

To show the repulsive effect, one needs to consider only g_{tt} in metric (27). According to Einstein [3, 4],

$$\frac{d^2x^{\mu}}{ds^2} + \Gamma^{\mu}{}_{\alpha\beta}\frac{dx^{\mu}}{ds}\frac{dx^{\nu}}{ds} = 0, \quad \text{where} \quad \Gamma^{\mu}{}_{\alpha\beta} = (\partial_{\alpha}g_{\nu\beta} + \partial_{\beta}g_{\nu\alpha} - \partial_{\nu}g_{\alpha\beta})g^{\mu\nu}/2 \qquad (39)$$

and $ds^2 = g_{\mu\nu}dx^{\mu}dx^{\nu}$ are defined by the metric $g_{\mu\nu}$. Consider the static case, $dx/ds = dy/ds = dz/ds = 0$. Thus,

$$\frac{d^2x^{\mu}}{ds^2} = -\Gamma^{\mu}{}_{tt}\frac{dct}{ds}\frac{dct}{ds}, \quad \text{where} \quad -\Gamma^{\mu}{}_{tt} = -\frac{1}{2}\left(2\frac{\partial g_{t\nu}}{\partial ct} - \frac{\partial g_{tt}}{\partial x^{\nu}}\right)g^{\mu\nu} = \frac{1}{2}\frac{\partial g_{tt}}{\partial x^{\nu}}g^{\mu\nu} \qquad (40)$$

since $g_{\mu\nu}$ would also be static. (Note that the gauge affects only the second order approximation of g_{tt} [35].) For a particle P with mass m at **r**, the force on P is

$$-m\frac{M}{r^2} + m\frac{q^2}{r^3} \qquad (41)$$

in the first order approximation since $g^{rr} \cong -1$. Thus, the second term is a repulsive force.
If the particles are at rest, then the force acts on the charged particle Q has the same magnitude

$$\left(m\frac{M}{r^2} - m\frac{q^2}{r^3}\right)\hat{r}, \quad \text{where } \hat{r} \text{ is a unit vector} \qquad (42)$$

since the action and reaction forces are equal and in the opposite directions. However, for the motion of the charged particle with mass M, if one calculates the metric according to the particle P of mass m, only the first term is obtained. Thus, the geodesic equation is inadequate for the equation of motion. Moreover, it is necessary to have a repulsive force with the coupling q^2 to the charged particle Q in a gravitational field generated by masses. In conclusion, force (42) to particle Q is beyond current theoretical framework of gravitation + electromagnetism.

However, this problem would be solved in a five-dimension theory [36], where the geodesic equation would include the coupling of q^2. The geodesic is

$$\frac{d}{ds}\left(g_{ik}\frac{dx^k}{ds}\right) = \frac{1}{2}\frac{\partial g_{kl}}{\partial x^i}\frac{dx^k}{ds}\frac{dx^l}{ds} + \left(\frac{\partial g_{5k}}{\partial x^i} - \frac{\partial g_{5i}}{\partial x^k}\right)\frac{dx^5}{ds}\frac{dx^k}{ds} - \Gamma_{i,55}\frac{dx^5}{ds}\frac{dx^5}{ds} - g_{i5}\frac{d^2x^5}{ds^2} \qquad (43a)$$

$$\frac{d}{ds}\left(g_{5k}\frac{dx^k}{ds} + \frac{1}{2}g_{55}\frac{dx^5}{ds}\right) = \Gamma_{k,55}\frac{dx^5}{ds}\frac{dx^k}{ds} - \frac{1}{2}g_{55}\frac{d^2x^5}{ds^2} + \frac{1}{2}\frac{\partial g_{kl}}{\partial x^5}\frac{dx^l}{ds}\frac{dx^k}{ds}, \qquad (43b)$$

where $ds^2 = g_{\mu\nu}dx^{\mu}dx^{\nu}$, $\mu, \nu = 0, 1, 2, 3, 5$ $\quad (d\tau^2 = g_{kl}dx^k dx^l;\ k, l = 0, 1, 2, 3)$.

If instead of s, τ is used in (43), the Lorentz force suggests

$$\frac{q}{Mc^2}\left(\frac{\partial A_i}{\partial x^k} - \frac{\partial A_k}{\partial x^i}\right) = \left(\frac{\partial g_{i5}}{\partial x^k} - \frac{\partial g_{k5}}{\partial x^i}\right)\frac{dx^5}{d\tau}$$

Thus,

$$\frac{dx^5}{d\tau} = \frac{q}{Mc^2}\frac{1}{K}, \qquad K\left(\frac{\partial A_i}{\partial x^k} - \frac{\partial A_k}{\partial x^i}\right) = \left(\frac{\partial g_{i5}}{\partial x^k} - \frac{\partial g_{k5}}{\partial x^i}\right) \quad \text{and} \quad \frac{d^2x^5}{d\tau^2} = 0 \tag{44}$$

where K is a constant. It thus follows that

$$\frac{d}{d\tau}\left(g_{ik}\frac{dx^k}{d\tau}\right) = \frac{1}{2}\frac{\partial g_{kl}}{\partial x^i}\frac{dx^k}{d\tau}\frac{dx^l}{d\tau} + \left(\frac{\partial A_k}{\partial x^i} - \frac{\partial A_i}{\partial x^k}\right)\frac{q}{Mc^2}\frac{dx^k}{d\tau} - \Gamma_{i,55}\left(\frac{q}{Mc^2}\right)^2\frac{1}{K^2} \tag{45a}$$

$$\frac{d}{d\tau}\left(g_{5k}\frac{dx^k}{d\tau} + \frac{1}{2}g_{55}\frac{q}{KMc^2}\right) = \Gamma_{k,55}\frac{q}{KMc^2}\frac{dx^k}{d\tau} + \frac{1}{2}\frac{\partial g_{kl}}{\partial x^5}\frac{dx^l}{d\tau}\frac{dx^k}{d\tau} \tag{45b}$$

One may ask what the physical meaning of the fifth dimension is. Some claim that those higher dimensions are curl up. Our position is, however, that the physical meaning the fifth dimension is not yet very clear, except some physical meaning is given in equation (44). The fifth dimension is assumed as part of the physical reality, and the metric signature is (+,-,-,-,-). However, our approach is to find out the full physical meaning of the fifth dimension as our understanding gets deeper. Unlike mathematics, in physics things are not defined right at the beginning. For example, it took us a long time to understand the physical meaning of energy-momentum conservation.

For a static case, it follows (42) and (45) that the forces on the charged particle Q in the ρ-direction are

$$-\frac{mM}{\rho^2} \approx \frac{Mc^2}{2}\frac{\partial g_{tt}}{\partial \rho}\frac{dct}{d\tau}\frac{dct}{d\tau}g^{\rho\rho}, \text{ and } \frac{mq^2}{\rho^3} \approx -\Gamma_{\rho,55}\frac{1}{K^2}\frac{q^2}{Mc^2}g^{\rho\rho} \tag{46a}$$

and

$$\Gamma_{k,55}\frac{q}{KMc^2}\frac{dx^k}{d\tau} = 0, \quad \text{where} \quad \Gamma_{k,55} \equiv \frac{\partial g_{i5}}{\partial x^5} - \frac{1}{2}\frac{\partial g_{55}}{\partial x^k} = -\frac{1}{2}\frac{\partial g_{55}}{\partial x^k} \tag{46b}$$

in the (*-r*)-direction. Here particle P is at the origin of spatial coordinate system (ρ, θ', φ'). The meaning of (46b) is the energy momentum conservation. Thus,

$$g_{tt} = 1 - \frac{2m}{\rho c^2}, \quad \text{and} \quad g_{55} = \frac{mMc^2}{\rho^2}K^2 + \text{constant} \tag{47}$$

In other words, g_{55} is a repulsive potential. Since g_{55} depends on *M*, it is a function of local property, and thus is difficult to calculate. This is different from the metric element g_{tt} that depends on a distant source of mass m.

Since g_{55} is independent of q, $(\partial g_{55}/\partial\rho)/M$ depends only on the distant source with mass m. Thus, this force, though acting on a charged particle, would penetrate electromagnetic screening. This would make such a force easier to be identified. From (47), it is possible that a charge-mass repulsive potential would exist for a metric based on the mass *M* of the charged particle *Q*. However, since *P* is neutral, there is no charge-mass repulsion force (from $\Gamma_{k,55}$) on *P*.

In terms of physics, since the static repulsive force is independent of the charge sign, it should not be subjected to electromagnetic screening. From the viewpoint of the five-dimensional theory, the charge would create an independent field to react with the mass. To test this, one should observe whether there is a repulsive force from a charged capacitor to a mass particle since a capacitor would screen out the electromagnetic field outside the capacitor in current theories. Experimentally, such a force is observed since a charge capacitor reduces its weight [37-40].

It should be noted that Einstein and Pauli [41] had investigated the five-dimensional relativity. However, they failed because they did not recognize the emerging of new interactions as Maxwell did. Thus they failed to see the existence of a coupling with the charge square from the metric element g_{55}.

IV. Conclusions and Discussions

In physics, the most famous formula is probably $E = mc^2$. Ironically, it is also this formula that many physicists do not understand properly. This formula means that there is an energy related to a mass, but it does not necessarily mean that, for any type of energy, there is a related mass. It is interesting that $E = mc^2$ demands that the light must include non-electromagnetic energy. On the other hand, general relativity naturally requires that a photonic energy-stress tensor, which is different from the electromagnetic energy-stress tensor, must have an anti-gravity coupling.

An anti-gravity coupling implies that the energy-conditions in the singularity theorems of Penrose and Hawking are invalid, and thus these theorems are irrelevant in physics. The existence of anti-gravity coupling is crucial in general relativity. For this is a major problem that many theorists overlooked. In fact, the existence of the antigravity coupling was first proposed by Lorenz [20] and Levi-Civita [21]. However, Einstein incorrectly rejected their proposal, and Einstein was wrong in his claim on the existence of dynamic solutions [10-12].

Because of the blind faith on Einstein, Misner et al. [7] claimed to have an explicit bounded wave solution and supported their errors with invalid mathematics [9]. Wald [5] claimed to be able to solve a second order equation, but without any solution. Christodoulou and Klainerman [42] have mistaken that they could construct the dynamic solutions [43]. Taylor [44] claimed to have a bounded dynamic solution and won a Nobel Prize [45], but failed to justify his calculation [46]. 't Hooft [30, 31] come up with an explicit solution that cannot have appropriate sources, etc. This is also why the positive mass theorem of Schoen and Yau [47] (and Witten [48]) is misleading in physics.[4)]

General relativity also makes it explicit that the gravity generated by mass and that by the electromagnetic energy are different as shown by the Riessner-Nordstrom metric. Since not every type of energy is equivalent to mass, the study of gravity must be extended beyond massive sources. It is the recognition of non-equivalence between electromagnetic energy and mass that naturally leads to unification of electromagnetism and gravitation.

It should be noted that Wilczek also misinterpreted in his Nobel lecture [33] that $m = E/c^2$ is generally valid. He claimed, "Stated as $m = E/c^2$, Einstein's law suggests the possibility of explaining mass in terms of energy. That is a good thing to do, because in modern physics energy is a more basic concept than mass. He further claimed, "In fact, the title is a question: 'Does the Inertial of a body Depend upon its energy content?' From the beginning, Einstein was thinking about the origin of mass ... Modern QCD answer Einstein's question with a resounding "Yes!" Indeed, the mass of ordinary matter derived almost entirely from energy-the energy of massless gluons and nearly massless quarks, which are the ingredients from which protons, Neutrons and atomic nuclei are made." Thus, 't Hooft is not the only Nobel Laureate who made an incorrect interpretation of $E= mc^2$.

However, the formula $E = mc^2$ has already answered Einstein's question affirmatively. The equivalence of a particular energy to mass is beyond the issue of whether the mass of a body depends on its energy contents. Wilczek was aware that there are difference between $E = mc^2$ and $m = E/c^2$, but failed to see the crucial difference. Thus, modern QCD did not answer Einstein's question, but only uses his formula as he speculated. Since electromagnetic energy is not equivalent to mass, to use the formula $m = E/c^2$ needs justifications in physics that Wilczek [33] failed to provide.

Moreover, the notion of photon is established not as an assumption, but as a necessary consequence of general relativity. Concurrently, the notion of anti-gravity coupling is naturally established. So, Einstein is still the final winner. Had Einstein known that his conjecture of unification was that close, he might have the desire to live longer [49]. Einstein was right that he should have more mathematics [49]. Einstein's weakness is that he had too much confidence on himself. His curiosity did not help him to discover his own errors. In any case, it is up to us to complete what he started.

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Appendix A

Experimental Verification of the Mass-Charge Repulsive Force

The repulsive force in metric (27) can be detected with a neutral mass. To see the repulsive effect, one must have

$$\frac{1}{2}\frac{\partial}{\partial r}\left(1-\frac{2M}{r}+\frac{q^2}{r^2}\right)=\frac{M}{r^2}-\frac{q^2}{r^3}< 0 \qquad \text{(A1)}$$

Thus, repulsive gravity would be observed at $q^2/M > r$. For the electron the repulsive gravity would exist only inside the classical electron radius $r_0 (= 2.817 \times 10^{-13} cm)$. Thus, it would be very difficult to test a single charged particle.

However, for a charged metal ball with mass M and charge Q, the formula is similarly $0 > M/R^2 - Q^2/R^3$, where R is the distance from the center of the ball [27]. Consequently, the attractive effect in gravity is proportional to mass related to the number of electrons, but the repulsive effect in gravity is proportional to square of charge related to the square of the number of electrons. Thus, when the electrons are numerous enough accumulated in a metal ball, the effect of repulsive gravity will be shown in a macroscopic distance.

Consider Q and M consist of N electrons, i.e., $Q = Ne$, $M = Nm_e + M_0$, where M_0 is the mass of the metal ball, m_e and e are the mass and charge of an electron. To have sufficient electrons, the necessary condition is

$$N > \frac{R}{r_0}, \quad \text{when} \quad r_0 = \frac{e^2}{m_e c^2} = 2.817 \times 10^{-13}\,\text{cm}. \tag{A2}$$

For example, if $R = 10\ cm$, then it requires $N > 3.550x10^{13}$. Thus $Q = 5.683 \times 10^{-7}$ *Coulomb*. Then, one would see the attractive and repulsive additional forces change hands. For this case, the repulsive force is

$$\frac{Q^2 m_p}{R^3} \quad \text{where} \quad m_p \text{ is the mass of the testing particle P.} \tag{A3}$$

And the total force is

$$\left(\frac{M_0 + Nm_e}{R^2} - \frac{N^2 e^2}{R^3}\right) m_p \tag{A4}$$

When condition (A2) is satisfied for a certain R, the repulsive effect will be observed as the charge increases. The verification of this formula also disproves the equivalence between mass and electric energy. However, the majority of theorists failed gravity by following Einstein's error.

However, since the repulsive force is very small, for a large charge, the interference of electricity would be comparatively large. Thus, it would be desirable to screen the electromagnetic effects out. The modern capacitor is such a piece of simple equipment. When a capacitor is charged, it separates the electron from the atomic nucleus, but there is no change of mass due to increase of charged particles. Before such separation the effect of the charge-mass interaction is cancelled out by the current-mass interaction (see Appendix B). Thus, after charged, the capacitor would have less weight due to the charge-mass repulsive force, a nonlinear force towards charges.

One may ask whether the lighter weight of a capacitor after charged could be due to a decrease of mass. Such a speculation is ruled out. Inside a capacitor the increased energy due to being charged would not be pure electromagnetic energy such that, for the total internal energy, Einstein's formula is valid.

Thus, this simple experiment would confirm the mass-charge repulsive force, and thus the unification.

In the case of charged capacitor, the repulsive force would be proportional to the potential square, V^2 where V is the electric potential difference of the capacitor. This has been verified by the experiments of Musha [38]. However, the weigh reduction phenomenon is currently mixed up with the B-B effect which is directional to the electric field applied. However, the weight reduction effect is not directional and it stays if the potential does not change. This is verified by Liu [40], who measured the effect of weight reduction with the roll-up capacitors.

Appendix B

The Current-Mass Interaction

If the electric energy leads to a repulsive force toward a mass, the magnetic energy would lead to an attractive force from a current toward a mass [50, 51]. The existence of such a current-mass attractive force has been verified by Martin Tajmar and Clovis de Matos [52] from the European Space Agency.

They found that a spinning ring of superconducting material increases its weight much more than expected. Thus, they believed that general relativity had been proven wrong. However, according to quantum theory, spinning super-conductors should produce a weak magnetic field. Thus, they are also measuring the interaction between an electric current and the earth, i.e. an effect of the current-mass interaction!

The existence of the current-mass attractive force would solve a puzzle, i.e., why a charged capacitor exhibits the charge-mass repulsive force since a charged capacitor has no additional electric charges? In a normal situation, the charge-mass repulsive force would be cancelled by other forms of the current-mass force as Galileo, Newton and Einstein implicitly assumed. This general force is related to the static charge-mass repulsive force in a way similar to the Lorentz force is related to the Coulomb force.

One may ask what is the formula for the current-mass force? However, unlike the static charge-mass repulsive force, which can be derived from general relativity; this general force would be beyond general relativity since a current-mass interaction would involve the acceleration of a charge, this force would be time-dependent and generates electromagnetic radiation. Moreover, when the radiation is involved, the radiation reaction force and the variable of the fifth dimension must be considered [36].

Nevertheless, we may assume that, for a charged capacitor, the resulting force is the interaction of net macroscopic charges with the mass [52]. A spinning ring of superconducting material has the electric currents that are attractive to the earth. This also explains a predicted phenomenon, which is also reported by Liu [39] that it takes time for a capacitor to recover its weight after being discharged [53]. This was observed by Liu because his rolled-up capacitors keep heat better. A discharged capacitor needs time to dissipate the heat generated by discharging, and the motion of its charges would accordingly recover to normal. Thus, it is natural to predict that a piece of heated up metal would have reduced weight, and this has been verified by experiments [53].

Endnotes

1. Hawking in his visit (June 2006) to China, still misleadingly told his audience that his theory was based on general relativity only. The root of his problem would be that he still does not understand the formula $E = mc^2$.
2. This equation was first proposed by Lorentz [20] and later Levi-Civita [21] as a possibility in the following form,

   $$\kappa t(g)_{ab} = G_{ab} + \kappa T_{ab} \qquad \text{(LL)}$$

   where $t(g)_{ab}$ is the gravitational energy-stress tensor, G_{ab} is the Einstein tensor, and T_{ab} is the sum of other massive energy-stress tensors. Then, the gravitational energy-stress tensor takes a covariant form, although they have not proved its necessity with calculations.
3. An independent evidence for the absence of a bounded dynamic solution for the Einstein equation is that the calculated gravitational radiation would depend on the approach used [54].
4. Many theorists such as Hawking & Penrose have also mistaken that $m = E/c^2$ is unconditionally valid.
5. S. T. Yau won a Fields Medal in 1982 and Witten won a Fields Medal in 1990. Their works on the positive mass (or energy) were cited as an achievement because the mathematicians do not understand the related physics [54].
6. The correct formula would be the single-directional mc^2 => E, but not necessarily E/c^2 => m.

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