General Relativity Theory – Well Proven and Also Incomplete Further Arguments

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There are two contradictory formulas of the total energy of a particle resting in the gravitational field [1]-[3]. From the formulas of radial free fall one gets:

$$E_G = mc^2\left(1-\frac{2GM}{c^2 r}\right)^{1/2} \tag{2}$$

On the other side, there is the equivalence principle. A particle resting in its local inertial system (i.e. the freely falling particle) has a total energy equal to its rest mass:

$$E_G = mc^2 \tag{3}$$

Both of the formulas contradict each other. This remains true though formulas (2) and (3) refer to different coordinate systems. Formula (2) refers to the coordinate system resting in the gravitational field at position r and formula (3) refers to the local inertial system and this coordinate system is accelerated relative the coordinate system of (2). The experimental proof of formula (2) and (3) gives the same result regardless whether the particle is at rest in the gravitational field $t = 0, v = 0, b = 0$ or becomes accelerated $t = 0, v = 0, b \neq 0$ as well as whether the measuring instruments are at rest in the gravitational field $t = 0, v = 0, b = 0$ or become accelerated $t = 0, v = 0, b \neq 0$ [2], [3]. This can be seen by the measuring procedure. Transfer an antiparticle to the resting particle and perform the measurement of the annihilation frequency of the two resulting photons. One gets:

$$\begin{aligned} E_{G,measured} &= mc^2 \\ &= h\nu_{\tau,measured} \end{aligned} \tag{4}$$

$\nu_{\tau,measured}$: annihilation frequency measured by a clock resting in the gravitational field, $t = 0, v = 0, b = 0$, or by a clock which is accelerated, $t = 0, v = 0, b \neq 0$. Further, the measurement proves formula (2) otherwise the equivalence principle would be wrong.

Insteadt of this measuring result, as was shown in [1]-[3], formula (2) is the correct one since it contains the contribution of what is called in Newtonian gravity the (negative) potential energy. So, Classical GRT has two rational but contradictious energy formulas and no theoretical concepts to decide between them.

Lorentz-interpretation of GRT (LI of GRT) expands classical GRT by two assumptions.

(a) The equvalence principle becomes reworded. “For *measurements* within gravitational fields the *measuring results* within local inertial systems are predicted by special relativity.”

Concerning our application this means: The *measurement* of E_G using measuring instruments resting in the gravitational field yields formula (3). This is no contradiction to (2) any longer if one can assume that measuring instruments become modified by gravitational fields and this is what is postulated by (b).

(b) Standard clocks in gravitational fields run slower by a factor

$$\frac{d\tau}{dt} = \left(1-\frac{2GM}{c^2 r}\right)^{1/2} \tag{6}$$

This factor is derivable from the Schwarzschild metric and therefore in agreement with classical GRT but it gets another meaning. By LI of GRT factor (6) is no longer a philosophical statement about curved space and time but a physical one about the action of gravitational fields on standard clocks.

Using assumptions (a) and (b) LI of GRT explains the contradictious formula (2) and (3). Formula (3) is the measuring result using standard clocks, formula (2) is the correct formula and derivable from (3) if one takes into consideration that standard clocks slow down by factor (6). One aim of this contribution is to prove this assumption in a larger context considering the energy relation of arbitrarily moving particles.

Formula (2) is generalised to

$$E_G^2 = \left(mc^2\right)^2 \left(\left(1 + \frac{r^2 \dot{\varphi}^2}{c^2} \right) \left(1 - \frac{2GM}{c^2 r} \right) + \frac{\dot{r}^2}{c^2} \right) \tag{9}$$

which is derived from the general formula of free fall. Generalisation of formula (3) results from the equivalence principle and becomes

$$E_G = mc^2 / \sqrt{1 - \frac{v^2}{c^2}} \tag{10}$$

The experimental verification of E_G in the case (9) and (10) remains similar to the case of (2) and (3). One measures the annihilation frequency when particle m and antiparticle $\overline{m}$ hit one another with opposite velocities v and $-v$. The measured annihilation frequency gives the total energy E_G. Since it is the same clock which measures the annihilation frequency in the case of (2) and (3) or (9) and (10) both of the formulas should differ by the same factor (6). In other words: the assumption that a clock resting in the gravitational field is slowed down by a factor (6) should explain both of the cases (2) and (3) or (9) and (10). Since formulas (2) and (3) differ from one another by a factor (6) the same has to be true for formula (9) and (10). The prove of this is done by some straightforword calculation and becomes part of the complete contribution. By this, LI of GRT remains able to explain the contradiction between the generalised formulas (9) and (10), too.

These considerations prove some differences between classical GRT and LI of GRT:

Classical GRT is correct since for all the measuring results there are well derived formulas. On the other side classical GRT might be wrong since there are other well derived formulas which are contradictious. E. g. formula (10) refers well to the measurement with standard clocks but contradicts fornula (9) which is well derived, too. But it is not appropriate to call classical GRT wrong. Classical GRT is *incomplete* since it is missing concepts to explain those contradictions, e. g. between (9) and (10).

This situation is similar to classical SRT and Lorentz interpretation of SRT. Take the twin paradox. The traveling twin remains yonger, this is predicted correctly but by similar arguments this prediction becomes a contradiction. So, classical SRT gives many conflicting solutions to the twin paradox and therefore none [4] but on account of this classical SRT is not wrong. It is incomplete like classical GRT [1].

Adding new concepts to classical GRT leads to the question whether there is new testable physics. Some relating ideas are part of [1], [2].

1. Brandes, J.; Czerniawski, J. (2010): *Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen – Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente.* (German-language), Karlsbad: VRI, 4. extended edition, 404 pages, 100 figures, ISBN 978-3-930879-08-3
2. Brandes, J. (2013) GRT - well proven and also incomplete? and Fireballs of GRBs and Lorentz-Interpretation (LI) of GRT http://www.grt-li.de/
3. Brandes J. (2012) GRT - well proven and also incomplete? in R. L. Amoroso, L. H. Kauffman, P. Rowlands (eds) The Physics of Reality - Space, Time, Matter, Cosmos. Proceedings of the 8th Symposium Honoring Mathematical Physicist Jean-Pierre Vigier. World Scientific Publishing Co.Ptc. Ltd. Singapore (2013) 120-122.
4. Percival, J. N. (2012) Both the Twin Paradox and GPS Data Show the Need for Additional Physics in R. L. Amoroso, L. H. Kauffman, P. Rowlands (eds) The Physics of Reality - Space, Time, Matter, Cosmos. Proceedings of the 8th Symposium Honoring Mathematical Physicist Jean-Pierre Vigier. World Scientific Publishing Co.Ptc. Ltd. Singapore (2013) 183-188.