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(Cosmology and) Lorentz-Interpretation (LI) of GRT

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Introduction

We investigate some features of Lorentz-Interpretation (LI) of GRT. The originally planned complete talk was the talk before. There you will find applications to cosmology. This restricted talk is a short introduction to LI of GRT. LI expands GRT to overcome some of its imperfections. GRT is well proven by many experiments. None of them are questioned by LI of GRT. Also all the formulas remain the same for GRT and LI of GRT but some of them are interpreted differently which is explained by the following thought experiment.

Contradictory results of total energy

Let us start with a simple thought experiment. Put a clock into a gravitational field and keep another one outside of the gravitational field. Compare the clocks later on. The clocks run different by

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

With words. Time passing of $dt = 1s$ of a clock outside the gravitational field means time passing of a clock inside the gravitational field less by a factor

(7) $$\left(1-\frac{2GM}{c^2 r}\right)^{1/2}$$

This can be derived from Schwarzschild metric (SM)

(1) $$ds^2 = \left(1-\frac{2GM}{c^2 r}\right)^{-1} dr^2 + r^2(d\theta^2 + \sin^2\theta d\varphi^2) - \left(1-\frac{2GM}{c^2 r}\right)c^2 dt^2$$

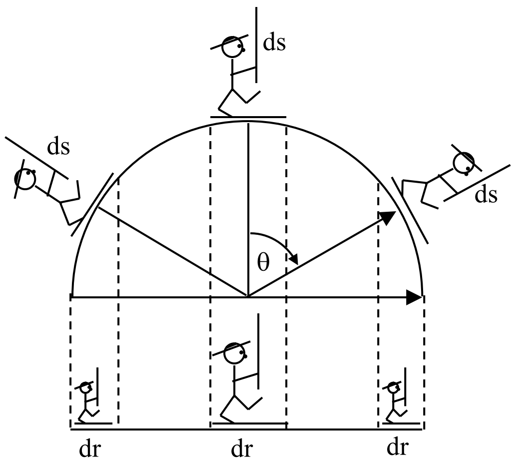

Fig. 1. Curved spacetime versus contracting measuring rods

What does formula (6) mean? Within GRT this is interpreted as: ‘time is curved’ or ‘time elapses slower within the gravitational field than outside of it’. Lorentz interpretation (LI) of GRT says: ‘standard clocks are slowed down inside the gravitational field’ [2].

The picture illustrates this for measuring rods. Within gravitational fields one can argue - as GRT does: measuring rods don’t change but space is curved, or – as LI of GRT does: space remains flat but measuring rods contract.
Now some citations of Thorne [4] a well-known gravitational physicist: “Is spacetime really curved? Isn`t it conceivable that spacetime is actually flat, but the clocks and rulers … are actually rubbery?” “Wouldn’t such distortions of our clocks and rulers make a truly flat spacetime appear to be curved? Yes.” and later: “What is the real, genuine truth? Is spacetime really flat, as the above paragraphs suggest, or is it really curved? To a physicist like me this is an uninteresting question because it has no physical consequences … Both viewpoints … give precisely the same predictions for any measurement … They disagree as to whether that measured distance is the “real” distance, but such a disagreement is a matter of philosophy, not physics. … it is a matter for philosophers to debate, not physicists.”
In German [4]: „Ist die Raumzeit *wirklich* gekrümmt? Kann man sich nicht auch vorstellen, die Raumzeit sei flach, während unsere Uhren und Maßstäbe ... in Wirklichkeit gummiartig verformbar sind?“ „Die Antwort lautet: ja.“ and later: „Doch wie verhält es sich nun wirklich? Ist die Raumzeit flach, wie es in den vorigen Abschnitten angenommen wurde, oder ist sie gekrümmt? Für mich als Physiker ist diese Frage ohne Belang ... Beide Sichtweisen ... führen zu denselben Vorhersagen und Messungen ... Die beiden Beschreibungen unterscheiden sich nur in der Frage, ob die gemessene Distanz der ‚Wirklichkeit’ entspricht, doch ist dies keine physikalische, sondern eine philosophische Frage. ... Darüber sollen sich die Philosophen Gedanken machen.“
Not quite correct. It is the ‘trademark’ of SRT and GRT to explain to mankind the deeper meaning of time and space and they don´t leave it to philosophers. But Thorne is correct in an important point. Both of the interpretations lead to the same formulas, predictions and measuring results. Unfortunately, he has overlooked an important point. The assumption of curved spacetime inducts a contradiction into theory. This will be shown now.
We start with the elementary question: What is the total energy E_G of a particle resting in the *r,t*-reference system of Schwarzschildmetrik (SM)?
Derived from the formulas of free, radial fall one gets [1], [3], [2] 312:

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

This is at least qualitatively correct since removing the particle from the gravitational field needs energy. Doing this the total energy E_G of the particle becomes mc^2 and therefore within the gravitational field E_G has to be lower. On the other side, there is the equivalence principle. A particle resting in its local inertial system (e. g. the free falling particle) has a total energy equal to its rest mass:

(3) $$E_G = mc^2$$

Formula (2) and (3) contradict each other.
Certainly, they belong to different reference systems with one of them being accelerated, in fact. But: At time point $t=0$ the free falling particle is also a resting one within the *r,t*-reference system since its velocity $v=0$. Only its acceleration $b \neq 0$. Special theory of relativity is applicable and therefore the free falling particle at $t=0$ and an always resting particle at the same place possess identical total energies (3). Analog: Compare a starting rocket with a resting one. Total energies of both are the same at $t=0$ $v=0$ and it doesn’t matter that $b \neq 0$ of one of them. Formula (2) and (3) contradict each other.

On account of the qualitative argument above, formula (2) is the correct one. One can see it more precisely by series expansion of (2):

(4) $$E_G = mc^2 - \frac{GmM}{r} \pm ...$$

The second term describes the negative potential energy. Approximately formula (2) becomes the rest mass minus Newtonian potential energy. Therefore, formula (2) meets the Newtonian limit of GRT but formula (3) does not. Within LI there is no contradiction – on account of the reasons of the next chapter.

Rewording of equivalence principle

It is obvious that the equivalence principle is tried and tested and so formula (3) should be correct. This remains true even by rewording this principle a little and this leads to the solution. The equivalence principle now reads: "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 with measuring instruments resting in the gravitational field yields mc^2. This is no contradiction to (2) any longer if one can assume that measuring instruments become modified by gravitational fields.

Modification of measuring instruments within gravitational fields

Let us consider possible modifications of measuring instruments during measurement of E_G. Let us choose some intellectually simple measuring procedure. Transfer an antiparticle to the resting particle and perform the measurement of annihilation frequency of the two resulting photons. One gets:

(5) $$E_{G,measured} = mc^2 = h\nu_{\tau,measured}$$

$\nu_{\tau,measured}$: Annihilation frequency, measured by a clock resting in the gravitational field

τ: proper time of a clock resting in the gravitational field (τ-clock, standard clock). On the other side, it is derivable from SM:

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

Since $\nu = \frac{dN}{d\tau}$ with dN number of wave crests during $d\tau$ the measured frequencies are:

(8) $$\nu_{\tau,measured} = \nu_t\left(1 - \frac{2GM}{c^2 r}\right)^{-1/2}$$

ν_t: 'real' frequency, slowing down of clocks by gravitational fields being eliminated.

$E_G = h\nu_t$: 'real' energy

(8) inserted into (5) yields

$$E_G = mc^2\left(1 - \frac{2GM}{c^2 r}\right)^{1/2}$$, identical with formula (2).

With words: Taking into account the modification of measuring instruments by gravitational field – in this case the slowing down of clocks – makes it possible to derive the total energy of a resting particle by use of the equivalence principle. The contradiction of (2) and (3) is solved.

Potential energy

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

and

$$E_G = mc^2 - \frac{GmM}{r} \pm \ldots \tag{4}$$

show what Newton's potential energy means. The negative potential energy of a particle is equal to the reduction of its rest mass.

Since Higgs bosons became verified such an assumption is allowed: Higgs fields *give* elementary particles a rest mass and gravitational fields *take* rest mass *away*.

This allows applications to cosmology, see article before. An important difference between LI and GRT is that gravitational forces originate from objects with rest mass only.

Summary

Classical general theory of relativity knows two formulas of total energy of a particle resting within gravitational fields contradicting each other. This contradiction is resolved if one can assume that measuring instruments become modified by gravitational fields. This is done by LI of GRT.

Literature

[1] Schutz, B. (2003): *Gravity from the ground up.* Cambridge University Press, see p 232ff. Formula (2) is evaluated but with restricted range of validity.

[2] J. Brandes, J. Czerniawski: *Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen - Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente,* 2010 Karlsbad: VRI, 4. erweiterte Auflage, 404 Seiten, 100 Abbildungen, ISBN 978-3-930879-08-3 Näheres (Preis, Inhaltsverzeichnis etc.): http://www.buchhandel.de/ oder http://www.amazon.de/ Suchen mit 9783930879083

[3] Dragon, Norbert (2012): *Geometrie der Relativitätstheorie*. http://www.itp.uni-hannover.de/~dragon. pdf-file on homepage of the author. There equation (6.24) with dr/dtau = 0 and L=0 results in formula (2) without restricted range of validity.

[4] Thorne, Kip, *Black Holes and Time Warps: Einstein's Outrageous Legacy*, New York 1994, Reprint 1995, page 397, 400. Deutsche Ausgabe: *Gekrümmter Raum und verbogene Zeit. Einsteins Vermächtnis.* München 4. Auflage 1994, Seite 457, 460.