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Relativity in Motion: Short Version

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Abstract. In General Relativity, Einstein equation is constructed under an implicit assumption. It is that in regular matter, energy of particles in motion can be completely discarded. This article studies the consequences of the opposite assumption in relativity. The predictions of the cumbersome following calculations in GR are approximated using a new and discrete equation. An unexpected consequence is that strong theoretical arguments exist for the replacement of today's assumption by the new one. Another consequence is that the "surrounding effect", which is the central concept of a previous work, is in the inner part of this new GR. But in most of the cases the two assumptions predictions are the same, and GR lagrangian in vacuum remains the fundamental equation common to the two assumptions. A direct result is that a surrounding effect arises in gravitation and this gives an explanation to the gravitational issues of today. And under a second assumption which is a unifying one, it explains also the Millenium Yang-Mills problem.

1 Introduction

This study follows from previous works [1–3]. The didactic motivation is to solve the following slight flaws of General Relativity (GR).

- Mach's principle.
- Loss of information in the construction of a stress-energy tensor.
- Retardation of gravitational interaction [4, 5].
- Implicit assumption of GR.

The latest is the main one and induces to try the opposite assumption in a purely theoretical discussion.

For helping the calculations in GR a discrete approximating equation is found first. It is based on GR features, concerning the behaviour of the frame in which time elapses the most, and concerning a particle in motion which modifies space-time structure locally by a modification of this privileged frame. Under the new assumption, this equation arises which relies energy to space-time structure. It allows to have a macroscopic approximation of GR predictions under this new assumption. This equation is scale invariant, it does not use the G constant.

On the contrary, this constant derives from this equation. It predicts fully a retardation of the gravitational force.

Finally, the predictions of GR under the new assumption are studied.

2 The Assumption

This is the actual assumption of physics which is implicity assumed for the construction of Einstein equation:

(i) Inside regular matter the energy of motion can be completely discarded.

Here the term “regular matter” refers to any kind of energy which is not light. In other words, for energy which is not light but regular matter, the particles are supposed to be at rest with respect to one another. Their energy of motion is considered as negligible with respect to their total energy. The speed of the quarks is known to be close to the speed of light but the gravitational waves they generate are not completely taken into account in the context of GR. The present document will try to show that but in a general manner.

They are also supposed to be solid blocks of matter without any kind of internal motion inside of them. This is of course a very natural implicit assumption. But rigourously and strictly speaking, this is an arbitrory assumption which does not rely on any experimental data.

That’s why in the present study, the exact opposite assumption will be used:

(ii) In regular matter the particles are composed of extremely small quantums of energy allways moving at the speed of light.

The term “quantum of energy” is used because those are not new particles of the standard model and they do not interact directly with the particles of particle physics. Their existence is supposed to induce absolutely no modification of standard model. It can be supposed that their size is hugely below the size of any knowned particles which are composed of such extremely small quantums of energy, moving inside of them. Since the word “quantum” relies to a reserved meaning in quantum mechanics, in the present document the word “quant” will be used for identifying those “quantums of energy”.

Under this new assumption, as usual the cumbersome calculations of GR must be simplified. Fortunately a discrete equation appears naturally under this assumption. Each quant generates permanently a gravitational wave. It results that now space-time is full of such microscopic gravitational waves.

3 Reminders about the Privileged Frame of Relativity

In GR there exists a privileged frame. Moreover, the boost which is associated to the motion of matter in this frame, describes the evolution of this privileged frame. Let’s remind this with a thought experiment, avoiding then any complicated and tedious calculation.

This thought experiment is simply imagining the energy at rest of a particle increasing progressively, and at the same time the whole energy of the universe decreasing. At the end of the experiment the universe and the particle have their roles permuted. Now the particle contains the energy of the previous universe, and the universe contains the energy of the previous particle. The first result is that the frame in which time elapses the most is no longer the frame attached to the universe. Now this frame is the frame attached to the particle. It means that the space-time structure is now the symmetrical result of a permutation of those two frames. It means also that during the experiment, the space-time structure has been modified progressively from the first state to the final one. And this operation has allowed to revert the time dilatation. For example, if this was a twin paradox configuration, at the end of his brother's journey, the older twin would become the youngest after the thought experiment. Therefore this space-time modification is simply described by the boost transporting one frame into another. It can be noticed that this reasoning is using the well established supposition that GR is coherent.

Now the need of naming the frames appears. Let's call Ru a frame attached to the universe. It can be supposed that the universe is filled with a constant, homogenous distribution of matter, therefore this matter is supposed to be at rest in Ru. Let's call Rp a frame attached to the particle. The second result of the thought experiment is that the particle generates locally a space-time deformation which is described by the boost from Ru to Rp. Of course, this deformation is local to the particle but the more energy at rest of the particle, the more this deformation is valid around the particle. A "more valid deformation" means that the space-time deformation exists significatively over a larger space-time domain.

The space-time deformation appearing in the experiment is described by a boost which allows to transform progressively this privileged frame from Ru to Rp. And it means that this frame remains privileged during the whole process, even though it is no longer the frame in which time elapses the most between the two extreme situations. This frame is simply a frame in which the particle is at rest. Its physics relevance is only local to the particle. The result is that it is possible to extend this identification of the priviliged frame of relativity to any space-time event in which there exists matter. And this identification can be extended even further to events in which vaccum prevails, by interpolation between those events in which there is matter.

This ends the reminders about GR. The conclusion is that it exists a privileged frame in any space-time event. And for any particle located in a given x event, this privileged frame exists in x and is transformed by the particle, using the boost which is associated with the four-momentum of the particle. Roughly speaking for the understanding, let's write that this boost is calculated in the "old privileged frame", that is, the one "just before the particle", and that it transforms this old privileged frame into the new one, that is, the one "just after the particle".

4 Resulting Equation

The first step of the study is to get a macroscopic approximated equation of the metric under assumption (ii).

For this only energies are considered. The energy which is propagated by a plane wave is described by a stress-energy tensor associated to matter in motion at the speed of light [6]. Therefore, null four-momentums can describe this energy in a discrete manner. The direction of this four-momentum is the speed of the wave. But the speed of the wave generated by a quant is not speed of light because the wave is globally the enveloppe of its fundamental waves. And the resulting speed of the "global" wave is the speed of this enveloppe, not the speed of the fundamental wave. Nevertheless, this speed is close to the speed of light (between c and $c/\sqrt{(}2)$). At the encounter of the waves, the simple addition of energies prevails. The result is the following equation, valid at each such encounter, and calculating the resulting energy.

$$D^\mu(x) = \Sigma_{n=0}^{\infty} 1_w(x, y_n) f(x, y_n) C^\mu(y_n) \,. \tag{1}$$

In equation (1), $1_w(x, y_n)$ is equal to 1 if x and y_n events are connected by a null geodesic and if x is located after y_n along this geodesic. It means that the gravitational wave generated by the quant located in y_n is received in x. $f(x, y_n)$ is the scalar positive function equal to 1 if y_n is equal to x, and which expresses the attenuation of the gravitational wave energy generated by the quant located in y_n. $C^\mu(y_n)$ is a four-vector which represents the four-momentum of the gravitational wave which is generated by the quant which is located in the y_n event. Under assumption (ii), this quant is moving at the speed of light therefore the speed which is associated to $C^\mu(y_n)$ is between c and $c/\sqrt{(}2)$. If $f(x, y_n) < 1$, then $f(x, y_n)C^\mu(y_n)$ represents in x the four-momentum of the gravitational wave which is generated by the quant located in y_n. Once received in the x event, those gravitational waves add their four-momentums. The final sum is $D^\mu(x)$. Let's write this four-momentum.

$$D^\mu(x) = \gamma \frac{E}{c} \left(1, \frac{v}{c}, 0, 0\right) \,, \tag{2}$$

In equation (2) it has been written $D^\mu(x)$ in such a frame that its two last components are null. E and v are respectively the energy at rest of the four-momentum and its speed in this frame. It has been used $\gamma = 1/\sqrt{1 - v^2/c^2}$. Then, from $D^\mu(x)$ is calculated the space-time structure. In accordance with the reminders above, this is done by using the boost described by the following equation.

$$B^\mu_\nu(x) = \gamma \begin{pmatrix} 1 & -\frac{v}{c} & 0 & 0 \\ -\frac{v}{c} & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \,. \tag{3}$$

From this boost the evolution of space-time structure can be derived in x.

5 Resulting Metric

5.1 From four-momentum to space-time metric

Now it is possible to derive the space-time metric from $D^{\mu}(x)$, therefore from $B^{\mu}_{\nu}(x)$. Let's call R_0 the privileged frame in x, before the reception of the gravitational waves of equation (1). Let's call R'_0 this privileged frame after the action of the boost of equation (3) which results from equations (1) and (2). Therefore, R_0 is the "old privileged frame", and R'_0 is the "new privileged frame". Let's write x' the first event in which this transformation takes place, along the time of R_0. R'_0 is obtained by transforming R_0, in x, using the $B^{\mu}_{\nu}(x)$ boost. It is required to rescale the lengths of the "boosted" time and space axis. The boosted time and space axis are the time and space axis which have been modified by the boost, in their states after the boost. The rescaling is done in such a way that the resulting time line described successively by those successive steps is a geodesic. Equivalently this constraint is that the privileged frame must be inertial. This is detailed by the following equations, relating X'^{ν} the coordinates after the boost, to X^{μ} the coordinates in R_0, and then relating X''^{ρ} the final rescaled coordinates in R'_0 to X'^{ν}.

$$X'^{\nu}(x') = B^{\nu}_{\mu}(x)X^{\mu}(x)\,, \tag{4}$$

$$X''^{\rho}(x') = S^{\rho}_{\nu}(x')X'^{\nu}(x)\,, \tag{5}$$

$$g_{\alpha\beta}(x) = B^{\rho}_{\alpha}(x)B^{\kappa}_{\beta}(x)S^{\mu}_{\rho}(x')S^{\nu}_{\kappa}(x')g_{\mu\nu}(x')\,. \tag{6}$$

$S^{\mu}_{\rho}(x')$ is a symetric transform which has the ability of being diagonalized in R'_0. Its value is determined by the constraint above (the time line of the set of successive privileged frames must be a geodesic). Equations (4), (5) and (6) show how $g_{\mu\nu}(x')$ the new metric is deduced from $g_{\alpha\beta}(x)$ the old one, due to the action of $B^{\nu}_{\mu}(x)$, which results from the $D^{\mu}(x)$ added energy.

These equations have been obtained by discretizing simply the spherically symmetric static case. In the Schwarzschild metric, a free falling particle, being at rest when located infinitely far from the center of the symmetry, follows a time line which is transformed by those equations [7]. Finally, from this discrete metric the continuous metric might be interpolated. For example, this can be done by using the sinc function. This yields a continuous metric which is valid at the microscopic scale. From it, for gravitation, an average value might be calculated, resulting in a metric more relevant for the macroscopic scale.

5.2 The calculation for regular matter

The two assumptions do not predict the same microscopic space-time structure. Indeed, at their scale the quants induce space-time deformations which do not exist under assumption (i). But at the macroscopic scale, those small space-time deformations cancel themselves, and the results are the same for the two assumptions. Let's prove this.

For this it will be considered a R privileged frame in which some regular matter is at rest in a given x event. Then let's consider two waves encountering themselves in x, such as the sum of their four-momentums gets a null spatial part in R. The privileged frame after the encounter must be calculated by composing the boosts corresponding to the waves. Most of the time the result is not R after the encounter. Some time, the new privileged frame will move on some space direction, some time on its opposite direction. But the mean value of the speeds in R of those new privileged frames will be null. This is because the distribution of those waves is symmetric with respect to R time axis. Depending of the order in which the compositions are done, Wigner rotations might appear [8, 9]. But this does not change the mean value for the same reason of symetry.

Outside from the waves encounters, the mean and macroscopic privileged frame is calculated with the barycentric operation of the boosts of the waves associated with their total energy [2, 3]. The result is still an unchanged macroscopic privileged frame.

The result is that for regular matter at macroscopic scale, the specific effect of the motion of the quants disappears and the two assumptions can agree to the same space-time deformation.

5.3 The surrounding effect as an inner part of this new relativity

Let's rewrite equation (1), shifting the total energy from left to right, and isolating the resulting speed.

$$\frac{v}{c} = \frac{\sqrt{\sum_{i=1}^{3} (\sum_{n=0}^{\infty} 1_w(x, y_n) f(x, y_n) C^i(y_n))^2}}{\sum_{n=0}^{\infty} 1_w(x, y_n) f(x, y_n) C^0(y_n)} . \tag{7}$$

Equation (7) derives directly from equation (1), and shows that the space velocity of the resulting four-velocity is inversely proportional to the total surrounding energy. It is noticed that the denominator of the right-hand side of this equation is a sum of positive scalars calculated in an isotropic manner.

It has been illustrated in Ref. [1], that such an equation predicts a particular effect. This effect was called "surrounding" in Ref. [10]. It is an increase of the equivalent G constant (that is, an increase of the gravitational force), in a way which is inversely proportional with the energy of matter surrounding the location where the force is exerted.

The result of the present paragraph is that the surrounding effect is an inner part of GR under assumption (ii). In gravitation, such a modification has been described in Ref. [10]. It shows that the surrounding effect suggests a solution to the most important gravitational issues of today.

5.4 Equivalent G

From equation (1) or from equation (7), the evolution of the G constant can be calculated as follows:

$$G_{\text{new case}} = G_{\text{solar system}} \left(\frac{\sum\limits_{n=0,\text{solar system}}^{\infty} 1_w(x, y_n) f(x, y_n) C^0(y_n)}{\sum\limits_{n=0,\text{new case}}^{\infty} 1_w(x, y_n) f(x, y_n) C^0(y_n)} \right)^2 . \quad (8)$$

Obvious notations are used for the G values. The denominator of this equation (8) is the surrounding energy. Now the gravitational force of actual physics must be multiplied by the surrounding factor which is equal to this new value of G divided by its value in solar system. It results an isotropic behaviour of the surrounding effect: this surrounding factor does not depend of the direction of the force which is modified. Let's call this different value of G "equivalent G".

6 Required Replacement of the Old Assumption

Let us remind the process constructing Einstein equation from GR lagrangian [6]. In vaccum the result is Einstein equation with a null rhs term. In the general case of matter, the action of matter is related to the stress-energy tensor via an equation which is constructed by sounded theoretical means. But a purely physics assumption implies another equation which links action of matter to action in vaccum with a plus operator and using a constant which is the G constant. Of course this is mandatory if one wants to retrieve Einstein equation. But still assuming this equation but with a G value varying slowly would be a weaker assumption. In other words the purely mathematical process would suggest such a relation but used with a variable G. That is a first argument for replacing assumption (i) by assumption (ii).

For regular matter, in the particular case where the surrounding value is constant, the two assumptions can agree about the same macroscopic results, used with a constant G value (but different from the solar system value in most of the cases). Indeed, the macroscopic stress-energy tensors are the same for the two assumptions. And it has been seen above that the specific effects due to assumption (ii) disappear. Therefore they yield the same macroscopic space-time structure. In solar system they allow the same construction of Einstein equation as being the relativistic version of the Poisson's formulation of Newton's law. And outside of solar system, the two assumptions can still agree about Einstein equation used with a possibly different G value. The result is that it is possible to replace assumption (i) by assumption (ii) without changing the GR macroscopic predictions in those cases. But then assumption (i) predicts theoretically a universe in which different arbitrory values of the G constant can coexist at great distances without any theoretical contradiction, and without any theoretical mean for calculating those values. In front of that, assumption (ii) yields the result of a variable G which is mandatory and calculated. Therefore GR under assumption (i) appears theoretically inconsistent with respect to GR under assumption (ii). This is a second argument for replacing the old assumption by the new one. And this is a radical argument because the slightest kind of matter which is not moving, even internally, at the speed of light would yield this inconsistence. It means that even the speed of quarks which is not exactly equal to the speed of light would require an assumption about their internal constitution.

Also it appears that the four slight flaws of GR which were the motivation of this study are solved. This is a third argument.

Those three arguments are an indication that assumption (i) must be replaced by assumption (ii). And that is only the result of purely theoretical study.

7 A Development in Particle Physics

7.1 A physics picture

Figure 1 shows the architecture of physics in a simple manner. Gravitation uses the mathematical features of SR and GR. But particle physics uses more math-

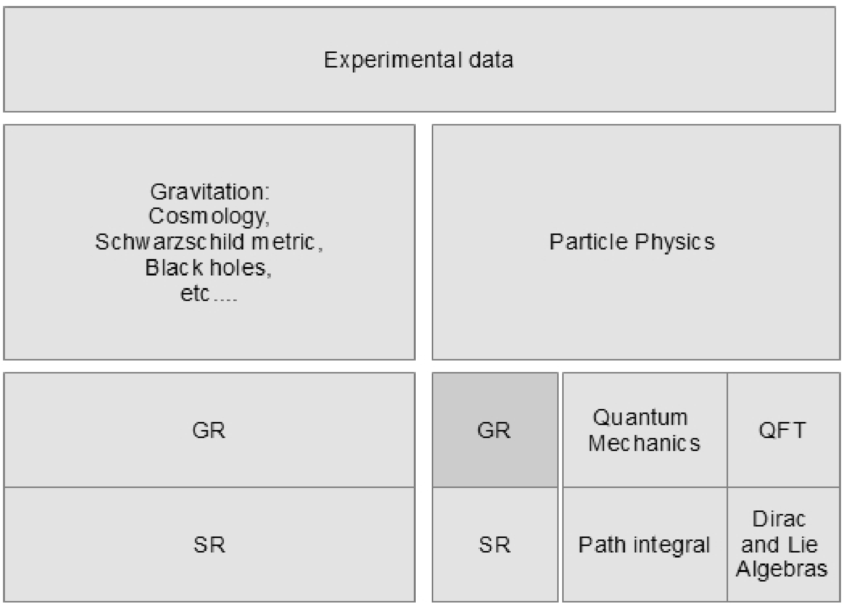

Figure 1. This rough and simple picture of today's physics is presented in order to remind the role of relativity in gravitation and in particle physics. Only some components are presented. The "GR" and "SR" rectangles are representing only the mathematical models related to "GR" and "SR", respectively. The "GR" rectangle on the right is grayed because GR is not used in today's particle physics.

ematical models. This picture shows that if SR is used by particle physics, GR is not. But under some particular assumptions, GR might have a role to play in particle physics.

7.2 "Awakening" GR in particle physics

A simple way to have particle physics affected by GR is to assume the following assumption.

(iii) "There are no four forces but only one which is gravitation. The three other forces are only macroscopic effects of gravitation in the particular context in which they operate".

Under this assumption, it is more than a guess that any increase or decrease of the underlying gravitation would be immediatly and proportionally, or almost proportionally, transfered to each of the three other forces. The term "macroscopic" which is used in the formulation of assumption (iii) is coherent with this assumption (iii). Indeed, the size of the quants must be weaker than the size of any knowned particle.

Now under assumptions (ii) and (iii), the surrounding effect plays a central role in GR, and particle physics is modified: the surrounding effect arises. This would modify noticeably the physics predictions in the case of triple nuclear collisions [11]. Indeed those collisions would be predicted to behave in a completely different manner. This would be hardly noticeable for the electromagnetic and weak forces because they involve only two incoming particles in close interactions. But this would imply an important modification of the strong force because this one involves also three body interactions. Any group of three particles closed to each other would experience low values of the strong force between them, because the surrounding effect would be strong, due to their close proximity to one another. But any group of two particles, or any group of three particles having one of them far enough from the two others, would experience stronger values of the strong force, because the surrounding effect would be weak.

It results a very simple scheme for a possible solution of the Millennium problem [12, 13].

8 Conclusion

An assumption is made, which is the opposite of the implicit assumption of actual GR. It is that the particles of the standard model of particle physics are made of extremely small quantums of energy allways moving at the speed of light. Their existence is supposed not to modify standard model. For studying the consequences of this assumption in GR, the resulting macroscopic metric is calculated more easily with a new and discrete equation. It uses a four-momentum in place of the stress-energy tensor for calculating space-time structure. But the most practical way in most of the cases is to calculate space-time structure with Einstein equation but with the new value of G given by this discrete equation.

Then it appears that the surrounding effect of the surrounding model is an inner part of GR under this new assumption. And the cases in which the surrounding value is constant yields macroscopically the same result as today's GR. A surrounding effect arises in gravitation: a new gravitational model, the surrounding model, is derived.

It follows that the slight flaws of GR which were motivating the study are solved.

Finally the assumption that the four forces derive from the gravitational force allows this new GR to apply in particle physics. The surrounding effect arises also in particle physics. A confinement of the strong force appears immediatly.

There are strong theoretical arguments for the replacement of the implicit assumption done by today's GR about regular matter, by its exact opposite. Experimental data gives also a strong argument with the speed of quarks. And choosing this opposite assumption explains the dark matter and dark energy issues. Under another assumption which is a unifying assumption, it explains also the Millenium Yang-Mills problem.

References

[1] F. Lassiaille, *Int. J. Mod. Phys. E* **20** (2011) 78-83.

[2] F. Lassiaille, "Gravitational Model of the Three Elements Theory: Formalizing", 8th International Conference on New Frontiers in Physics (ICNFP 2019), Aug 2019, Kolymbari, Greece. ffhal-03041623f

[3] F. Lassiaille, "Surrounding Matter Theory: first mathematical developments", 2022. ffhal03676686f. Submitted for publication.

[4] A. Yahalom, *Acta Phys. Pol. A* **131** (2017) 1285-88.

[5] S. Rajput, A. Yahalom, H. Qin, *Symmetry* **13** (2021) 420.

[6] S. Carroll, *Space time and geometry, An introduction to General Relativity* (San Francisco: Addison-Wesley, 2004).

[7] F. Lassiaille, *J. Mod. Phys.* **4** (2013) 1027-1035.

[8] J. Rhodes, M. Semon, *Am. J. Phys.* **72** (2005) 943.

[9] K. O'Donnell, M. Visser, *Eur. J. Phys.* **32** (2011) 10331047.

[10] F. Lassiaille, *EPJ Web of Conf.* **182** (2018) 03006.

[11] O.V. Vitiuk, V.M. Pugatch, K.A. Bugaev, et al., *Eur. Phys. J. A* **58** (2022) 169.

[12] A. Jaffe, E. Witten, *Quantum Yang-Mills Theory* (Clay Math Institute).

[13] L.D. Faddeev, In: Benedicks M., Jones P.W., Smirnov S., Winckler B. (eds) *Perspectives in Analysis. Mathematical Physics Studies* **vol 27** (Springer, Berlin, Heidelberg, 2005); arXiv:0911.1013 [math-ph].