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## Gravitational Model of the Three Elements Theory: Formalizing

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The method used for the construction of this model is to start from special relativity (SR), and to introduce general relativity (GR) in a different way. That's why four assumptions are first assumed in the sole context of SR. Then a new tensorial equation is found. It acts like a discrete version of GR equation. It's also a global equation in the sense that it involves the gravitational waves which are generated by matter over the Universe. It yields a spacetime structure via the successive determination of a privileged frame. This equation is the formalization of the Gravitational Model of the Three Elements Theory (GMTET),<sup>1</sup> and suggests the construction of surrounding.<sup>2</sup> This formalized GMTET model might deal with the GR theoretical polemics, puts forward a replacement of dark matter and dark energy by a modification of Newton's law.

*Keywords:* relativity; gravitation; dark matter

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### 1. Introduction

Nowadays the question arises about the ability of GR to predict each of the gravitational mysteries.<sup>3</sup> Moreover from a theoretical perspective, some information has been lost during the creation of Einstein equation. Indeed the stress-energy tensor is created from the equation  $\rho = ml$  where  $\rho$  is matter density,  $m$  the mass of a particle, and  $l$  the particle density. The result is the stress-energy tensor  $T_{\mu\nu} = M_\mu L_\nu = mU_\mu lU_\nu = \rho U_\mu U_\nu$ , and either  $m$  or  $l$  has been lost during the process.  $U_\mu$  is the four-velocity vector. The existence and locations of the particles have also been lost. Another theoretical issue about GR is the polemic about whether or not it complies with Mach's principle. For example the issue appears in the case of a static spherically symmetric Universe. If  $\rho$  is the matter density filling the Universe, then one can distinguish two assumptions. The first one is  $\rho > 0$ , the second is  $\rho = 0$ . Close to the object,  $\rho$  appears insignificant in both cases. Therefore, there, the spacetime deformations will be approximately the same for the two assumptions. But in the first assumption it is possible to find an inertial frame,  $R$ , at rest with the object, which is not in rotation with respect to the Universe. In  $R$ , there are no fictitious forces such as centrifugal forces. But in the second assumption it is not possible to find such a frame. Supposing that  $R$  is at rest with

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respect to the object is not enough. It is not possible to know if  $R$  remains inertial or not. One cannot say if in  $R$  it will appear fictitious forces or not. Existence of closed time-like curves<sup>4</sup> is also a weird theoretical aspect of relativity. Therefore it might be interesting to search for another equation than GR equation, following those remarks. And for ensuring a coherent research, the complete ignorance of GR equation is mandatory. That's why the starting point for such a try will be SR, "spacetime deformation by energy" and "following geodesics" GR principles. But moreover this study will be based on the following set of assumptions, assumed under this context.

- (i) Matter is made up of indivisible particles always moving at the speed of light along geodesics. Let's name "IP" such a particle.
- (ii) The spacetime structure is determined by a set of successive deformations, each of them is described by a boost. Let's name "boost-like deformation" such a deformation.
- (iii) Each IP is propagating a boost-like deformation through spacetime. This propagation evolves at the speed of light. An energy is propagated along this propagation. Let's name "IP gravitational wave" such a wave.
- (iv) The spacetime structure is determined only at the intersections of the future light cones of the IPs. The rule yielding the final spacetime deformation resulting from numerous IP gravitational waves, occurring in the same spacetime event, is dictated by the principle of energy conservation.

In the description of the fourth assumption the expression "future light cone of an IP" means the envelope of the future light cones which are moving along with the IP. This expression will be used like this in the present document.

Those assumptions will be refined further in the present document. Using them, a new tensorial equation will be found, and then applied to the spherically symmetric static case. Then more ambitious considerations will be tried.

## 2. First assumption

The first assumption is that matter is made up of indivisible particles (IP) always moving at the speed of light. Though the idea of this assumption is not new<sup>1</sup> and is used in the present document inside of a set of four assumptions, it has standalone motivations, for example explained at the end of the conclusion of Ref. 3. Another motivation is to find a solution to the coherence problem arising from the second assumption. This is explained in Ref. 1. This assumption is also motivated by the attempt of writing another GR equation, but this will appear further in the present document.

An IP is a point particle. This implies the following discrete energy-momentum distribution in a well chosen frame.

$$D^\mu(y) = \delta(y - y_0) \frac{E}{c} (1, 1, 0, 0) \quad (1)$$

$\delta$  is the Dirac function,  $E$  is the energy of the IP in this frame.  $y_0$  is the location of the IP.  $y$  is the generic location of a spacetime event.

The first step in the present study will consist in characterizing the spacetime structure in  $y_0$  only. This will be done with the help of the second assumption. The second step will consist in characterizing the spacetime structure globally in  $y$ . This will be done with the help of assumptions 3 and 4.

### 3. Second assumption

The second assumption is the following.

“The spacetime structure is the result of the determination of a locally inertial frame which motion counteracts the motion of matter. The time line of this set of frames is a geodesic“.

The ”time line of a set of frames” is supposed to be the envelope of the time axis of these frames (the time axis are tangent to this time line). The particular ”counter-acting” local inertial frame of this assumption will be called CF (for counteracting frame).

Let’s try to calculate the resulting metric from this assumption. For this let’s suppose a continuous distribution of energy and let’s write  $D^\mu(x)$  the density of four-momentum at a given  $x$  event. Let’s suppose that in  $x$  the CF has been determined. Let’s write it  $R_0$ . Then let’s write  $cd\tau$  the positive infinitesimal displacement along the  $R_0$  time axis in  $x$ . The four-momentum in  $x' = x + cd\tau$  is now  $D^\mu(x') = D^\mu(x) + dD^\mu(x)$ .  $dD^\mu(x)$  is a given infinitesimal added energy between  $x$  and  $x'$ . It is always possible to chose the  $R_0$  space axis in  $x$  in such a manner that  $dD^\mu(x)$  is written the following way.

$$dD^\mu(x) = \gamma \frac{dE}{c} \left( 1, \frac{v}{c}, 0, 0 \right) \quad (2)$$

$v$  and  $dE$  are respectively the speed and the energy at rest of the added matter. It has been used  $\gamma = 1/\sqrt{1 - v^2/c^2}$ . First a  $B_\nu^\mu(x)$  boost is deduced from  $dD^\mu(x)$  by the following  $B$  function, also written in  $R_0$ .

$$B_\nu^\mu(x) = B(dD^\mu(x)) = \gamma \begin{pmatrix} 1 & -\frac{v}{c} & 0 & 0 \\ -\frac{v}{c} & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (3)$$

The second assumption tells that this  $D^\mu(x)$  four-vector determines the new metric in  $x'$ , from the old one in  $x$ , the following way. The new CF in  $x'$ , let’s write it  $R'_0$ , is obtained by transforming the old one  $R_0$  in  $x$  by the  $B_\nu^\mu(x)$  boost, and then rescaling the lengths of the time axis and the ”boosted” space axis (the boosted space axis is the space axis which has been modified by the boost, in its state after the boost). The rescaling is done in such a way that the resulting time line described

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by the  $R_0$  and  $R'_0$  frames is a geodesic. This is detailed by the following equations, relating  $X'^{\nu}$  the coordinates after the boost, to  $X^{\mu}$  the coordinates in  $R_0$ , and then relating  $X'^{\rho}$  the coordinates in  $R'_0$  to  $X'^{\nu}$ .

$$X'^{\nu}(x') = B_{\mu}^{\nu}(x)X^{\mu}(x) \quad (4)$$

$$X'^{\rho}(x') = S_{\nu}^{\rho}(x')X'^{\nu}(x) \quad (5)$$

$$g_{\alpha\beta}(x) = B_{\alpha}^{\rho}(x)B_{\beta}^{\sigma}(x)S_{\rho}^{\mu}(x')S_{\sigma}^{\nu}(x')g_{\mu\nu}(x') \quad (6)$$

$S_{\rho}^{\mu}(x')$  is a symmetric transform which has the ability of being diagonalized in the frame in which  $X'$  are the coordinates. Its value is determined by the constraint of the time line of the set of CF being a geodesic. Equation (6) shows how  $g_{\mu\nu}(x')$  the new metric is deduced from  $g_{\alpha\beta}(x)$  the old one, due to the  $dD^{\mu}(x)$  added energy.

The counteracting feature of CF does not appear yet in those equations and will appear further on in the present document. The used  $D^{\mu}(x)$  four vector will counteract the motion of matter.

As it has been noticed in Ref. 1, now incoherence arises. Indeed, summing successive  $dD^{\mu}(x)$  between  $x$  and  $x'$  will lead to different results if the second assumption is applied only once at the end, or for each  $dD^{\mu}(x)$ . Either the composition of boosts will be applied, or the barycentric operation of the speeds will be applied. Hopefully, the first and the second assumptions altogether will solve this incoherence, adding to them the rule of applying the second assumption at each added IP. Because this coherence problem can't be solved using different fundamental particles than IPs.

This is shown in the case of three particles, named for example  $P_1$ ,  $P_2$ ,  $P_3$  and having respectively the  $E_1$ ,  $E_2$ , and  $E_3$  energies in the  $R_0$  CF frame in  $x$ . They are supposed to be located close to the  $x$  event. Their speeds are supposed to be colinear and sharing the same direction. Let's write  $dD_1^{\mu}(x)$ ,  $dD_2^{\mu}(x)$ , and  $dD_3^{\mu}(x)$  their respective four-momentums. It is supposed  $E_3 = E_1 + E_2$  therefore  $dD_3(x) = dD_1(x) + dD_2(x)$ . Now the time order of appearance of those particles in  $x$  must not lead to different spacetime structures in  $x$ . Otherwise, the conservation of energy principle would not be satisfied because the generated geodesics would be different and a fourth particle coming in the vicinity of  $x$  would follow different trajectories and therefore different evolution of its energy in  $R_0$ . It means that  $P_1$  and  $P_2$  without  $P_3$ , or  $P_3$  alone, must yield the same metric. The result is  $B(dD_1^{\mu}(x)) \circ B(dD_2^{\mu}(x)) = B(dD_1^{\mu}(x) + dD_2^{\mu}(x))$ . And the domain of this morphism is the set of IP four-momentums.

But adding only one IP will yield singularities in the resulting metric. Therefore the second assumption will have to be applied for each IP encounter, that is, for the case of two IPs located in the same spacetime event.

So let's study the case of two  $A$  and  $B$  IPs, located in the same spacetime event. They are moving at different light speeds in a given  $R$  inertial frame. Conservation of energy tells us the following. The object  $O$  which is composed of  $A$  and  $B$  gets a speed in  $R$ , which is obtained by calculating the barycentric operator of the speeds of  $A$  and  $B$  in  $R$ . For this barycentric operation, the weights are the total energies

of the objects.

$$\mathbf{D} = \mathbf{D}_A + \mathbf{D}_B \quad (7)$$

$\mathbf{D}_A$ ,  $\mathbf{D}_B$  and  $\mathbf{D}$  are respectively the four-momentums of the objects  $A$ ,  $B$ , and  $O$  in  $R$ . Equation (7) is interesting because it shows the features of the  $B_v^\mu(x)$  boost of equation (3) when applied at the encounter of two IPs. And equation (7) is well illustrated when the speeds of  $A$  and  $B$  are colinear. Then there is only one degree of freedom, only one dimension is left free which is the space direction of the speed of  $O$  in  $R$ . Then the following set of equations, valid in  $R$ , is obtained from equation (7).

$$E_t \frac{1 + \frac{v}{c}}{2} = a \quad (8)$$

$$E_t \frac{1 - \frac{v}{c}}{2} = b \quad (9)$$

$$E_t = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}} = a + b \quad (10)$$

$$E_{mvt} = \frac{mvc}{\sqrt{1 - \frac{v^2}{c^2}}} = a - b \quad (11)$$

$$E_m = mc^2 = 2\sqrt{ab} \quad (12)$$

$$\frac{v}{c} = \frac{a - b}{a + b} \quad (13)$$

$$\sqrt{1 - \frac{v^2}{c^2}} = \frac{2\sqrt{ab}}{a + b} \quad (14)$$

$$d = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} = \sqrt{\frac{a}{b}} \quad (15)$$

$$i = \sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}} = \sqrt{\frac{b}{a}} \quad (16)$$

In those equations,  $c$  is the speed of light,  $a$  and  $b$  are representing the total energies of respectively  $A$  and  $B$ .  $E_t$ ,  $E_m$ ,  $E_{mvt}$  are representing respectively the total energy, the energy at rest, the energy of motion of the  $O$  object in  $R$ .  $d$  and  $i$  are the Doppler amplification factors. This set of equations (8) to (16) can be interpreted from the geometry representing the surfacic version of the Pythagore theorem,  $E_t^2 = E_m^2 + E_{mvt}^2$ , which is the SR equation of energy. This has been discussed in Ref. 1. This set shows a direct link between boosts and Doppler factors.

Now it is possible to determine the spacetime structure locally, that is, in the  $y_0$  event of equation (1).

#### 4. Third assumption

Now what is going on globally? In other words the question is now the determination of the spacetime structure in the random  $y$  event of equation (1). For answering this question, the following step studies the gravitational waves which are generated by the IPs. As usual, using GR equation will be forbidden. That's why here it's allowed to assert assumptions which are in contradiction with what GR equation predicts.

The third assumption has been defined in the introduction. But it remains to describe the trajectory of the propagation. Let's write  $(c, c, 0, 0)$  the four-velocity vector of a given IP in a well chosen  $R_1 = (x^0, x^1, x^2, x^3)$  frame. Let's write  $R_n$  any other frame having a speed colinear to  $x^1$ . There exists of course many such  $R_n$  frames. Then basically the space directions of the propagation are the space vectors which are perpendicular in  $R_n$  space with  $x^1$ . This determination does not depend of the choice of the  $R_n$  frame. But the motion of the IP will generate in fact an envelope of this propagation, having the shape of a three dimensional space cone. Now the angle of this cone depends of the choice of the  $R_n$  frame. Finally the real speed of the propagation is normal to this envelope.

In the third assumption the boost-like deformation generated by the IP is propagated in a parallel transport manner along the geodesic which is normal to the envelope of the propagation. For the sake of simplicity the speed of the real propagation along the normal of the envelope will be supposed to be equal to the speed of light. Also the speed which is associated to the propagated boost is equal to the speed of light.

But the associated speed of the boost is in the opposite sense to the propagation speed. For example in a  $R'_1 = (x'^0, x'^1, x'^2, x'^3)$  frame, such as the real speed of the propagation is written  $(1, 1, 0, 0)$ , it is noticed that the speed of the propagation is  $x'^1$  increasing. But the speed of the propagated boost is given by the following formula.

$$B_{\nu}^{\mu}(x) = \lim_{v \rightarrow c} \gamma \begin{pmatrix} 1 & \frac{v}{c} & 0 & 0 \\ \frac{v}{c} & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (17)$$

And this boost describes a frame in motion  $x'^1$  decreasing, therefore in opposite sense to the propagation.

#### 5. Fourth assumption

The fourth assumption is the following.

“The spacetime structure is calculated, once again, only in the spacetime events where two IP gravitational waves are located. The spacetime structure is calculated in those events by using equations (7), (2), (3) and (6) in this order“.

Therefore this assumption extends the domain of validity of the second assump-

tion from local ( $y_0$ ) to global ( $y$ ) (using the notations of equation (1)). This assumption imposes the spacetime structure to be calculated only at the intersections of the IP gravitational waves, because of the solution of the coherence issue studied in paragraph 3.

From those four assumptions, one can derive the following equation. It calculates the final spacetime deformation occurring in a given  $x$  event, from the IPs over the Universe which are located along the past light cone of  $x$ .

$$D^\mu(x) = \sum_{n=0}^{\infty} \delta(\|x - y_n\|_3 - x^0 + y_n^0) \delta_E(u_n \cdot u - \frac{\sqrt{2}}{2}) f(\|x - y_n\|_3) C^\mu(y_n) \quad (18)$$

The fourth assumption says that equation (18) determines the spacetime structure only for those events which are located at the intersections of the future light cones of the IPs. The second and fourth assumptions altogether tell the following. At first is interpolated in  $x$  the metric, from the spacetime grid included in the volume of the past light cone centered in  $x$ . From it the CF was evaluated in  $x$ . Then the  $D^\mu(x)$  four-vector is yielded by equation (18) and equations (2) and (3) are applied to it ( $D^\mu(x)$  replacing  $dD^\mu(x)$  in those equations). Then it results the  $B_\nu^\mu(x)$  boost which describes the evolution of the spacetime structure through  $x$  with the help of equation (6).

$n$  is the number which has been given to an IP which is located in  $y_n$ .  $C^\mu(y_n)$  is the four-momentum of this IP.  $D^\mu(x)$  is homogeneous to a four-momentum. There is  $D^\mu(x) = (E(x)/c^2)U^\mu(x)$  where  $E(x)$  is the resulting “energy at rest” in  $x$ .  $U^\mu(x)$  is the four-velocity vector representing the new spacetime structure. In the calculation  $E(x)$  behaves algebraically like an energy. But it is not the energy of any particle or any group of particles. It is an energy which is associated with the  $x$  event and which allows to calculate the metric in  $x$ . Let’s write  $c_n$  the space vector of the speed of the IP located in  $y_n$  in a given  $R_n$  frame (the  $R_n$  frames have been defined above in the description of the third assumption). Then,  $u_n = c_n/\|c_n\|_3$  is the corresponding unit vector.  $u$  is the unit space vector pointing in the direction of the geodesic relying  $y_n$  to  $x$ .  $\delta_E$  is the Dirac symbol evaluated in a  $R_n$  inertial frame such as the total energy of the IP located in  $y_n$  is equal to  $E$  where  $E$  is a universal pre-defined energy. Therefore the  $\delta_E(u_n \cdot u - \sqrt{2}/2)$  term means that the envelope of the spacetime propagations generated by the IP is having a  $45^\circ$  angle with  $c_n$  in this specific frame. The  $\delta(\|x - y_n\|_3 - x^0 + y_n^0)$  term tells that the IPs which are intervening in the sum are located on the surface of the past light cone centered on  $x$ . For the calculation of  $\|x - y_n\|_3$ , the space is evaluated at first in a  $R_n$  frame.  $\|x - y_n\|_3$  is the spatial length of the geodesic of the propagation of  $C^\mu$  from  $y_n$  to  $x$ . It is the integrated space length in a parallel transport manner along the geodesic. This integration starts in  $y_n$  by the infinitesimal displacement of  $R_n$  space in  $y_n$  which is the projection on the  $R_n$  space of the geodesic direction. Then, this space direction is propagated in a parallel transport manner and the integrated length is calculated infinitesimally on this transported vector. This evaluation is independent



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of the choice of  $R_n$ .  $f$  is the attenuation function during the propagation, it's a scalar positive decreasing function which remain to be calculated. This propagation is supposed to remain unmodified and to go through after each encounter (each encounter in a  $x$  event, described by equation (18)). Satisfying the third assumption, the  $C^\mu(y_n)$  four-momentum of the IP gravitational wave generated by  $y_n$  in equation (18) is propagated in a parallel transport manner from  $y_n$  to  $x$ , along a geodesic. Its Minkowskian square remains null during the propagation. Now let's write  $C^\mu(y_n)$  in a particular frame.

$$C^\mu(y_n) = \frac{E_t(y_n)}{c}(1, -1, 0, 0) \quad (19)$$

Let's write  $R_2$  this frame. If  $(x^0, x^1, x^2, x^3)$  are its spacetime directions,  $x^0$  is the time axis, and  $x^1$  is in the direction in  $R_2$  of the geodesic relying  $y_n$  to  $x$ . In other words,  $x_1$  increasing, and the space speed of the real propagation of the spacetime deformation generated by the IP, are also in the direction of the  $u$  vector used in equation (18).  $E_t(y_n)$  is the total energy of the IP in  $R_2$ . A " - 1" is noticed as the second component of  $C^\mu(y_n)$ , following the rule of the third assumption and equation (17): the speed associated to the boost is in opposite sense to the speed of the propagation.

Applying equation (18) in a common way does not produce a valid gravitational law. This is because in most of the cases, only zero or one IP is located on a given past light cone centered in  $x$ . And many of them are needed in order to yield symmetric contributions on  $x$ , and therefore to reveal a valid law. But this equation (18) determines the spacetime structure only for those events which are located at the intersections of the future light cones of IPs. This overall set of intersections form a grid of spacetime having the dimension of a surface. Once this equation has determined the spacetime metric for this discrete grid of events, then the metric coefficients for all spacetime events must be interpolated between those discrete events. Due to Universe expansion,  $l_0$ , the mean value of the spacetime width of the cells of this grid can be calculated the following way. An IP inside matter is forced to follow cyclic trajectories. For each such IP, at each of its orbital cycle a wave is emitted, therefore this yields the number of waves coming from this IP and entering a four dimensional, 1 meter large cube. Then the total number of intersection points of the grid in this cube is  $\binom{N}{4}$  as a function of  $N$  the total number of waves in the cube, then it goes the following result.

$$l_0 \simeq \frac{3}{2} 24^{\frac{1}{4}} \frac{e}{3(2e-5)} \frac{a_{IP}}{N_{IP}} \simeq 10^{-93} m \quad (20)$$

$a_{IP}$  is the mean value of the ray of an orbital trajectory of an IP. It has been used the ray of a nucleus  $10^{-15} m$ .  $N_{IP} = lR_U^3$  is the number of IPs in the Universe.  $l$  is the mean density of IPs in the observable Universe, which was supposed to be equal to the density of hydrogen, the value of  $5 m^{-3}$  was used. The

value  $R_U = c/H_0 = 14,4 \cdot 10^9 \text{ LY}$  has been used for the particle's horizon. Indeed, "surrounding" or "SMT model"<sup>2</sup> predicts a de Sitter cosmological model. In the present document this SMT model will now be named simply "surrounding" without any more precision or reference. The notation "LY" means light year. The value  $H_0 = 67,80 \text{ km s}^{-1} \text{ Mpc}^{-1}$  has been used. The  $e/(3(2e - 5))$  coefficient is due to Universe expansion. The extremely low value of equation (20) might suggest that the model's behavior is continuous. So let's try to interpret equation (18) in a continuous way. The result might be the following.

$$D_\nu^\mu(x) = \int_{C^-} f(\|x - y_n\|_3) C_\nu^\mu(y) dy \quad (21)$$

$C^-$  is the past light cone centered in  $x$ .  $D_\nu^\mu(x)$  and  $C_\nu^\mu(y)$  are respectively the continuous versions of  $D^\mu(x)$  and  $\delta(u_n, u - \sqrt{2}/2) C^\mu(y_n)$ . An indice is added for the formulation of the space density of particles.

## 6. Spherically symmetric static case

A result of equation (18) is a modification of Newton's law in the static spherically symmetric case, and this is the Newton's law modification described in Ref. 1. Let's write  $O$  the point object located in the center of the spherical space symmetry.

It will be supposed that the propagation of the spacetime deformations generated by the IPs belonging to  $O$  are done spherically. This is relevant in this case because of the spherical symmetry. It means that the trajectories of the IPs belonging to  $O$  are supposed to be circular orbital.

Let's imagine that this "point" object in  $O$  modelizes a macroscopic particle (a particle composed of many IPs). Inside of this particle the IP trajectories are cyclic and then the CF stays globally at rest within the particle located in  $O$ . What remains to determine is the CF outside of  $O$ . For those events which are outside of  $O$  the initial CF will be supposed to be at rest with  $O$  and to coincide with the "frame of the fixed stars". This frame is called sometimes the frame which is "attached to" the Universe. As usual the CMB can be used for the determination of this particular frame. Then this frame is determined without ambiguity.

Passing from the real microscopic spacetime structure to the macroscopic structure given by the mean values of the metric coefficients will not change the results of the following calculations. Indeed if  $\alpha$  is the relative number of IP gravitational waves generated by  $O$ , over the total number of IP gravitational waves, then there is  $\alpha = kM_O/M_U$ , with  $k = (3/4\pi)24^{1/4}e/(3(2e - 5))$ .  $M_O$  is the mass of  $O$  and  $M_U$  is the mass of the Universe. This results from equation (20) and also uses the fact that the intervals between the IP gravitational waves generated by an IP pertaining to  $O$  are constant. Therefore  $\alpha$  does not vary along the propagation of those IP gravitational waves.

Let's give an  $x$  spacetime event. The aim is the calculation of the metric in  $x$ , resulting from the possible IP gravitational waves encounters in  $x$ .

The rigorous calculation would be to calculate for each configuration of 2 or 3 IP waves encounter, the resulting four-momentum in  $x$ , then the resulting metric evolution, and then the mean value of these evolutions, this "mean" value being calculated over the different existing configurations, taking care of their existence density. This is not done in the present document. What is done is an immediate projection of the four-momentums along the line relying  $x$  to  $O$ , and the calculation in one dimension only.

The first step is the calculation of the encounter of 2 IP gravitational waves. But this will lead to irrelevant results, such as a negative value of  $G$ . A possible physical assumption leading to this might be the following. "Any IP wave merges quickly with another one". This rough sentence remains to be refined and this is not done in the present document. It will be motivated more clearly further in the present document. The first calculation will be based on the relevant case of the encounter of 3 IP waves, and then this calculation of 2 IP waves will be reviewed quickly.

There are 9 possible cases for a 3 IP waves encounter. They are listed in table 1. In this table, it is supposed that along the space axis relying  $O$  to  $x$ :

- $IP_1$  is located on the left side of  $x$  (negative coordinate),
- $IP_2$  and  $IP_3$  are located on the right side of  $x$  (positive coordinate).

The different configurations are listed and their respective frequency of occurrence in space are compared.

Configuration number	$IP_1$	$x$ event <sup>a</sup>	$IP_2$	$IP_3$	Frequency of occurrence
1	U <sup>b</sup>		U	U	High
2	O <sup>c</sup>		U	U	Medium
3	U		O	U	Medium
4	U		U	O	Medium
5	O		O	U	Null
6	O		U	O	Null
7	U		O	O	Low
8	O		O	O	Null

<sup>a</sup> the  $IP_1$  is supposed to be located on the left side of the  $x$  event, and the  $IP_2$  and  $IP_3$  are supposed to be located on the right side of the  $x$  event. <sup>b</sup> U means that this IP is located outside of  $O$ . <sup>c</sup> O means that this IP is located inside of  $O$ .

The configurations 5, 6, and 8 are impossible, because this would mean that  $x$  is located inside of the  $O$  object. Of course the configuration number 1 having no IP pertaining to  $O$  is the most frequent one and yields a flat Minkowskian metric.

For the configuration 7,  $IP_2$  and  $IP_3$  are both pertaining to  $O$ . Let's study the grid of the intersections of their gravitational waves. Let's prove that the mean width of the cells of this grid increases proportionally with the  $O$  to  $x$  distance. For this purpose, let's choose a  $(y, z)$  space basis centered on the  $x$  event. Let's suppose that

$IP_2$  and  $IP_3$  are located respectively at the  $(r, h)$  and  $(r, -h)$  coordinates in this basis. Therefore  $r$  is the distance between  $x$  and  $O$  and  $2h$  is the distance between the 2 IPs. Then let's suppose that the  $IP_2$  to  $x$  line, figuring the propagation of the wave from  $IP_2$  to  $x$ , makes an  $\alpha$  angle with the  $IP_3$  to  $x$  line. Now let's write  $t$  the time duration between this wave generated by  $IP_2$ , and the last one still generated by  $IP_2$ . For easing the demonstration, it will be supposed that  $IP_2$  has been returning exactly to the same location in space after this  $t$  time duration. This scenario is coherent since  $IP_2$  is supposed to allways pertain to the  $O$  object. Then let's write  $d = ct$  the distance between those 2 waves in  $x$ . Let's write  $x'$  the event located at the new intersection of this second  $IP_2$  wave and the  $IP_3$  wave. Let's write  $l$  the distance between  $x$  and  $x'$ . Then for the low deformation regime since  $r \gg h$ , there is  $\sin(\alpha) \simeq 2h/r$  and also  $\sin(\alpha) \simeq d/l$ , therefore  $l \simeq dr/(2h)$ . Therefore the  $l$  length varies proportionally with  $r$ .

This means also that the configuration 7 is far less frequent than the configuration 3 (or configuration 4 which is physically the same as configuration 3). Indeed, for configuration 3, the figure would be similar but  $IP_2$  and  $IP_3$  would not be close to each other in most cases.  $IP_3$  would be outside of  $O$  and its location would be random. It would result that the mean width of the cells of the resulting grid of  $IP_2$  and  $IP_3$  wave encounters would be much weaker than the one generated by the configuration 7 in the case  $r \gg h$ .

Then it remains to study the configurations 2, 3 and 4. The configuration number 2 yields the same result as the encounter of 2 IPs, one pertaining to  $O$ , and one located outside of  $O$ . But it will be checked further that this case yields irrelevant result. That's why the first calculation will be based on configuration 3 (or configuration 4 which is physically the same one).

Let's assign the numbers  $n$  from 0 to  $N$ , to the IPs which are part of  $O$  and also located on the past light cone centered in  $x$ . Let's assign the numbers from  $N + 1$  to  $M$  to the IPs which are out of  $O$  and located on the past light cone centered in  $x$ . Therefore the IPs numbered from  $M + 1$  to  $\infty$  are those which are out of the past light cone centered in  $x$ . This allows to decompose the lhs of equation (18) into the three following terms.

$$D^\mu(x) = D_a^\mu(x) + D_s^\mu(x) + D_0^\mu(x) \quad (22)$$

$$D_a^\mu(x) = \sum_{n=0}^N \mathbb{1}(x, y_n, u_n) f(\|x - y_n\|_3) C^\mu(y_n) \quad (23)$$

$$D_s^\mu(x) = \sum_{n=N+1}^M \mathbb{1}(x, y_n, u_n) f(\|x - y_n\|_3) C^\mu(y_n) \quad (24)$$

$$D_0^\mu(x) = \sum_{n=M+1}^{\infty} \mathbb{1}(x, y_n, u_n) f(\|x - y_n\|_3) C^\mu(y_n) \quad (25)$$

It has been used  $\mathbb{1}(x, y_n, u_n) = \delta(\|x - y_n\|_3 - x^0 + y_n^0) \delta_E(u_n \cdot u - \sqrt{2}/2)$ . The "a" in  $D_a^\mu(x)$  means "asymmetrical contributions". The "s" in  $D_s^\mu(x)$  means "symmetrical contributions". Symmetry implies  $\langle D_s^\mu(x) \rangle = (\langle D_s^0(x) \rangle, 0, 0, 0)$  written in the frame of the fixed stars.  $\langle . \rangle$  means that a mean value is taken into account. The window length of spacetime for the calculation of this mean value can be for example  $10^{-3} m$  which is enough for getting rid of the microscopic effects of the

model. From now on in the present document, the mean values will always be considered as replacing the initial one, without using the  $\langle . \rangle$  notation. There is also  $D_0^\mu(x) = 0$ . This is written in the discrete context of equation (18) but it could be written equivalently in the continuous context of equation (21).

The result is  $g_{00} = (1 + 2e)/(1 + e)^2$  where  $g_{\mu\nu}$  is the resulting metric. This is what results from application of equations (7), (2), (3) and (6). It is used  $e = D_a^0(x)/D_s^0(x)$ . In other words,  $e$  is the ratio of asymmetric contributions over symmetric contributions. By other means the geodesic trajectory of a test particle at rest when located infinitely far away from  $O$ , is described by the equation  $\partial^2 r / \partial t^2 = -(c^2/2) \partial g_{00} / \partial r$ . This geodesic is also the time line of the CF as stated by the second assumption.  $r$  and  $t$  are respectively the spatial and time lengths integrated over the diagonalized coordinates of the metric. From now on, the calculation will be done in those coordinates. Combining those equations yields the following one for the trajectory of this free falling particle.

$$\frac{\partial^2 r}{\partial t^2} = c^2 \frac{e}{(1+e)^3} \frac{\partial e}{\partial r} \quad (26)$$

Equation (26) is not exactly the equation written in Ref. 1 because there was a mistake involving only the strong deformations. For the calculation of Ref. 1 it was supposed that the  $f(r)$  evolution is in  $1/\sqrt{r}$  at each  $r$  distance. Then it goes  $e = \sqrt{R/r}$  for retrieving Newton's law asymptotically (that is, for  $r \gg R$ ) with equation (26).  $R = 2M_O G/c^2$  is the Schwarzschild ray. It has been supposed that the mean "macroscopic" metric  $\langle g_{\mu\nu} \rangle$  calculated from  $g_{\mu\nu}$ , which is more a "microscopic" metric, is simply equal to  $g_{\mu\nu}$ . This is due noticeably to a supposed homogeneity of matter distribution inside of  $O$  and also outside of  $O$ .

But of course Newton's law must be supposed to be valid because this law is validated with high accuracy at least in the solar system.<sup>5</sup> Let's write  $s = D_s^0(x)/D_{s_0}^0(x)$ , where  $D_{s_0}$  is the value of  $D_s$  in solar system. Let's first suppose that Newton's law is retrieved by the model for  $s = 1$ . Then for  $s = 1$  equation (26) implies  $e = D_a^0(x)/D_{s_0}^0(x) = (R + \sqrt{Rr})/(r - R)$ , and if it's supposed to be independent of  $s$  then for any value of  $s$  there is  $e = (1/s)(R + \sqrt{Rr})/(r - R)$  and  $\partial^2 r / \partial t^2 = -(M_O G/r^2)(s + 2yr \partial s / \partial r)(1 + (s - 1)y)^{-3}$  with  $y = (r - R)/(r + \sqrt{Rr})$ , which will lead asymptotically to equation (27). Of course the most realistic choice is to suppose that Newton's law is retrieved for any constant  $s$ , although allowing an equivalent  $G$  value to replace the  $G$  value in this law. If it's supposed that the derivative of  $D_a^0(x)$  with respect to  $r$  is asymptotically independent of a constant value of  $D_s^0(x)$  then for any constant value of  $s$  the Newton's law is  $\partial^2 r / \partial t^2 = -M_O G/(r^2 s^2)$ , and the solution of equation (26) for  $s$  constant is now  $e = (R + s\sqrt{Rr})/(rs^2 - R)$ . Supposing that this equation remains valid for a varying  $s$ , then the result is the following equation, now valid for any  $r$  and for  $s$  constant or not.

$$\frac{\partial^2 r}{\partial t^2} = -\frac{M_O G}{r^2} \frac{s + 2r \frac{\partial s}{\partial r}}{s^3} \quad (27)$$

The resulting value of  $f(r)$  is the following.

$$f(r, E_t) = \frac{2G}{c^4} D_s^0(x) \frac{1 + s\sqrt{\frac{r}{R}}}{rs^2 - R} \quad (28)$$

It has been written  $E_t$ , the energy of the IP, introduced in equation (19). In equation (28) it has been used  $R = 2E_t G/c^4$ . Here the macroscopic version of this equation is different,  $R$  must be replaced by  $R/\alpha$ . But the important result is that the rule leading the evolution of the  $f$  attenuation function is the conservation of the GR Lagrangian in vacuum, namely the scalar curvature, after each calculation of the discrete metric along the propagation. This rule is compatible with the above assumption (the assumption that the derivative of  $D_a^0(x)$  with respect to  $r$  is asymptotically independent of a constant value of  $D_s^0(x)$ ).

This ends the calculation which yields the same metric as GR in the  $s = 1$  particular case. The CF has been shown to be the local frame of the test particle being at rest when located infinitely far away from  $O$ .

For this calculation the initial CF was supposed to be at rest with  $O$ . If it's supposed to be in constant motion at a  $V$  speed with respect to  $O$ , then the result would be also the GR prediction in the  $s = 1$  case. The resulting metric would be described by the same matrixes but converted by the boost corresponding to the motion of  $O$ , that is the  $-V$  speed. The set of CF of the initial problem would be converted by this boost.

Equation (27) suggests that a simpler model can be derived, "surrounding", which starts from this equation. Indeed, the remark that  $\Phi = -Rc^2/(2rs^2)$  and  $\partial^2 r/\partial t^2 = -\partial\Phi/\partial r$  allows to retrieve equation (27), induce the idea of a general equation  $\partial^2 r/\partial t^2 = -\nabla\Phi$ , and therefore suggests  $\Phi$  as a simple gravitational classical potential for surrounding. That's why for surrounding,  $C_{GMTET} = (s + 2r\partial s/\partial r)/s^3$ , the modifying coefficient of equation (27), is replaced by the following  $C_{SMT}$  factor, which is inserted now directly into Newton's gravitational potential.

$$C_{SMT} = \frac{1}{s^2} \quad (29)$$

But second-hand calculations integrating the  $e$  asymmetric contribution shows that  $s^2$  behaves like a ratio of matter densities. This leads to the creation of surrounding. The final  $C_{SMT}$  factor of surrounding is more complicated than a ratio of local matter densities because it has been slightly fitted to experimental data using a homographic function, and the role of Universe density has been involved too. Answering one of the theoretical issues presented in the introduction, an interesting behavior of surrounding is that closed time cycle loops are avoided at astronomical

scale. One could even guess that this avoidance would be valid in the context of GMTET.

Now let's go back to the study of an encounter of 2 IPs. The most frequent configuration is the usual "outside of  $O$  - outside of  $O$ " configuration, still leading to a flat Minkowskian metric. The most frequent configuration involving  $O$  is "outside of  $O$  - inside of  $O$ ". The same calculation as above yields now  $g_{00} = 4e/(1+e)^2$ ,  $d^2r/dt^2 = 2c^2((e-1)/(1+e)^3)de/dr$ , and  $e(x) = (s/(M_0G))(c\sqrt{(c^2x^2 + 2M_0Gx/s) - c^2x} - 1$  for retrieving Newton's law when  $s$  is constant. The asymptotic value of  $e$  is now  $e(x) \simeq -M_0G/(2sc^2x)$ , which is negative. And this is irrelevant, among others it yields a negative value of  $G$ . Nevertheless the surrounding effect is still occurring, with  $C_{SMT} = 1/s$ .

The configurations 2 and 7 of the encounter of 3 IPs will yields exactly the same irrelevant results. Indeed, for these configurations the waves coming from  $IP_2$  and  $IP_3$  are adding their contributions in  $x$ .

The final result is that irrelevant results are obtained only in those configurations in which a wave generated by an IP pertaining to  $O$  is alone on one side of the  $x$  event. In other words, everything behaves as if an IP gravitational wave generated by a given  $O$  object could not "stay alone". A possible physical assumption leading to this might be the following. "Any IP wave merges quickly with another one, generated by some other IP in the Universe".

Therefore and for the sake of simplicity it will be supposed the following.

- The metric still results from the calculations of the model at the encounter of 2 IPs gravitational waves,
- Any IP gravitational wave does not stay alone long but merges quickly with another one.

Of course the word "quickly" here remains to be quantified. The  $md$  distance over which the merge must occur is weaker than  $mid$  the minimum interaction distance for which Newton's law is proven experimentally to be valid. Therefore  $md$  is weak in the solar system.

What is quite sure is that for an interaction distance weaker than this unknown  $md$  value (below  $md$ ) the Newton's law is no longer valid. Nevertheless the equations shows that even below  $md$  and even under the supposition of a Newton's law being valid, the equations still lead to the surrounding effect. This should tend to suggest that the surrounding effect is always active, independently of the interaction distance and of the respective energies. Among other remarks, this suggests that there might be a mathematical proof that this surrounding mechanism results directly from equation (18).

## 7. Gravitational constant

For  $s = 1$  the asymptotic value of  $f$  from equation (28) is the following.

$$f(r, E_t) \simeq D_s^0(x) \frac{2G}{c^4 \sqrt{Rr}} \quad (30)$$

Then, equation (18) with its lhs restricted to  $D_s^0(x)$  allows to calculate an approximated value of  $G$ .

$$G \simeq \frac{c^4}{2 \left( \sum_{n=N+1}^M \mathbb{1}(x, y_n, u_n) \sqrt{\frac{E_t(y_n)}{\|x - y_n\|_3}} \right)^2} \quad (31)$$

This equation is a good approximation in most of the cases as it will be seen further in this document when calculating the order of magnitude of the different contributions in  $D_s^0(x)$ . It is valid for  $x$  in the solar system. In other case an equivalent  $G$  is calculated. From this is derived the following new formulation of equation (18).

$$U^\mu(x) = \frac{c}{\sqrt{1 - \left( \frac{A(x)}{S(x)} \right)^2}} \left( 1, \frac{A(x)}{S(x)}, 0, 0 \right) \quad (32)$$

$$A(x) \simeq \sum_{n=0}^N \mathbb{1}(x, y_n, u_n) \sqrt{\frac{E_t(y_n)}{\|x - y_n\|_3}} \quad (33)$$

$$S(x) \simeq \sum_{n=0}^M \mathbb{1}(x, y_n, u_n) \sqrt{\frac{E_t(y_n)}{\|x - y_n\|_3}} \quad (34)$$

The space axis of the frame in which these equations are written have been chosen in a particular way. It has been written  $U^\mu(x)$  the four-velocity vector determining the spacetime structure, related to  $D^\mu(x)$  of equation (18) by the  $D^\mu(x) = (E(x)/c^2)U^\mu(x)$  equation. The  $A(x)$  and  $S(x)$  energy terms give to the  $U^\mu(x)$  geometrical term its asymmetrical part,  $v/\sqrt{1 - v^2/c^2}$  with  $v/c = A(x)/S(x) = e/(e+1)$  like in equation (13). In these energy terms,  $S(x)$  is a scalar yielding the equivalent  $G$ . Equations (32) and (34) are valid in a more general case than the static spherically symmetric case. The approximation (33) is valid only in the static spherically symmetric case. In the general case the identification of the IPs associated to  $A(x)$  would be different, a Doppler amplification factor and a  $\cos(\theta_n)$  would be added in front of each  $\sqrt{E_t(y_n)/\|x - y_n\|_3}$  term of equation (33).  $\theta_n$  would be the angle of the direction of the incoming IP gravitational wave of the IP located in  $y_n$ , with respect to the direction of the resulting  $v$  speed in  $x$ .



## 8. Linearity of the gravitational force

Due to the extremely low value of  $l_0$  in equation (20), one might suppose that the future light cones of the IPs could merge themselves after a while. This might happen for example if the model would be incompletely discrete. This would not change the results of the present document, except for the expansion of the Universe which would be weakened in the cosmological case and for the following. More than two IP gravitational waves would encounter themselves in the same spacetime event. As a result equations (18) and (32) would yield a gravitational force which would be non-linear with respect to matter. Let's take the example of the static spherically symmetric distribution of matter. This yields the Schwarzschild metric as it has been studied above, metric in which asymptotically the resulting diagonal time-time component is  $g_{00} = 1 - e_1^2$  with  $e_1 = \sqrt{R_1/r}$  and  $R_1 = 2M_1G/c^2$ .  $M_1$  is the mass of the object located in the center of the space symmetry. Therefore there is  $g_{00} = 1 - R_1/r$  as expected. Now let's imagine adding a second point object close to the first one. Then the spacetime deformations coming from the two objects will not add their masses if they are received in the  $x$  event. Their effect will be combined by adding the energies of their respective IP gravitational waves. That's what is calculated by equation (18). The diagonal time-time component of the metric is now asymptotically  $g_{00} = 1 - e^2$  with  $e = e_1 + e_2 = \sqrt{R_1/r} + \sqrt{R_2/r}$ . It has been used  $e_2 = \sqrt{R_2/r}$  and  $R_2 = 2M_2G/c^2$ , where  $M_2$  is the mass of the added object. The result is  $g_{00} = 1 - R_1/r - R_2/r - 2\sqrt{R_1R_2}/r$  where the linear result would be  $g_{00} = 1 - R_1/r - R_2/r$ . Therefore the model would be valid only under one of the following suppositions: either the future light cones of the IPs could not merge themselves, either the distribution of those IPs would be scattered enough in order to ensure that there are no or few couples of IPs located on a given past light cone, at solar distance from the center. But each of those suppositions are impossible to obtain with equation (21), which is the continuous version of equation (18), and which shows therefore a strong non-linearity of the gravitational force. Needless to add that this is ruled out by experimental data.

Although equation (32) is only a good approximation of equation (18), it is not using the  $G$  constant, that's why from now on in the present document when possible equation (32) will be referred to in place of equation (18).

## 9. Frames

A particular inertial frame is used and then modified by equations (7), (2), (3) and (6). It is the frame which is counteracting exactly the motion of matter. This frame was named CF by the second assumption. The CF is counteracting the motion of matter because in equation (32) and  $v/c = A(x)/S(x)$  it is " $-v$ " which represents the speed of "matter of the Universe", not " $v$ ". This counteracting feature of the propagated spacetime deformation is given by equation (17), and then by equation (19).

However, the determination of this set of frames is only done successively. Indeed,

the second assumption determines only its evolution, not any absolute identification. The implicit assumption there is that this set of CF has been identified correctly in the past.

Lorentz Transform creates naturally a partition of the set of frames. In a given  $x$  spacetime event, only one of these classes is the class of inertial frames. In this class, only one frame is the inertial CF in  $x$ .

But GR equation does not determine any privileged frame from its equations. Indeed GR is only calculating a curvature, that is, the “derivative of a slope”, not the identification of a frame or a space slope or even a boost. In some way using the words of differential equations, there is a lack of initial conditions. SR does not determine it neither, despite recent developments around this theme.<sup>6,7</sup> Nevertheless the concept of privileged time foliation exists in SR and is related to the SR synchronization of clocks.<sup>8</sup>

What is missed here in relativity appears conspicuous when reading equation (32): it is the identification of an inertial privileged frame with its validity local in  $x$ .

Practically speaking, it seems that the literature solves this issue of the determination of a possible privileged frame by implicit “common sense”. This frame is sometimes supposed to be the one which is “attached to matter”. It is not said what is the scale used for determining this attached matter. Would it be the scale of solar system, a galaxy, the Universe ? It is sometimes determined by the absence of acceleration. But this would imply that the spacetime structure would be calculated, hence from the distribution and motion of matter. But the motion of matter depends of the spacetime structure. Therefore what is found here is a definition, not a determination.

The same ambiguity appears initially in the theoretical definition of a “comoving” frame, used for example in cosmology. Of course one solution is to state that this frame is the frame of the fixed stars, hence the CMB is used for the determination of this frame. Nevertheless the ambiguity might remain if there were no CMB. Then again, what would be the scale for determination of this frame (solar system, galaxies, large scale structures)?

A positive result from this is that GR will never be invalidated by any experimental data proving that such or such frame is privileged or not. This is not the case with GMTET which is more predictive here than GR.

Now could it be possible to answer this quest in the context of GR ? GR principles might suggest that identifying the privileged frame would be done through a more precise determination of spacetime in which curvature would be integrated. Therefore not only spacetime curvature but also the privileged frame would be determined both with the same equation. This means identification of the boost determining the spacetime deformation in a tensorial and relativity compliant manner. The result of this reasoning would be the search of an equation similar to equation (32), if not equation (32) itself. Hence a global remark here is that this GMTET model can be reached by the following different ways.

- This one, searching to identify a privileged frame in relativity.
- Another one was discussed in Ref. 1 and is based on the try to interpret a boost as being a deformation of spacetime by energy. Then incoherence arises, a solution is to suppose the first assumption of the present document, and so forth.
- Another way might be starting from surrounding and then trying to refine the model.
- Another mean is trying to solve the wave-particle duality and the unification of the four forces, by stating the first assumption. Then, for retrieving GR a boost is seen as being a spacetime deformation.

Let's try to apply equation (34) taking into account only the contributions coming from the IPs belonging to the earth. Let's write  $S_w(x)$  this weakened value of  $S(x)$ .  $x$  is located in the center of a sphere filled with a matter density  $\rho$  and having a ray  $R$ .  $S_w(x)$  will sum the contributions coming from this sphere only. As usual let's write  $l$  the density of IPs, supposed to be constant. For easing the calculation let's suppose that each IP has the same energy  $E$ . There is  $\rho = lE$ , and the calculation is the following.

$$S_w(x) = \int_{r=0}^R 4\pi r^2 l \sqrt{\frac{E}{r}} dr = \frac{8\pi}{5} \frac{\rho}{\sqrt{E}} R^{\frac{5}{2}} \quad (35)$$

$$S_{Universe} = \int_{r=0}^{R_U} 4\pi r^2 l \sqrt{\frac{E}{r}} e^{-\frac{H_0 r}{c}} \sqrt{\frac{1 - \frac{H_0 r}{c}}{1 + \frac{H_0 r}{c}}} dr = \frac{8\pi}{5} \frac{\rho_{Universe}}{\sqrt{E}} R_U^{\frac{5}{2}} Ex \quad (36)$$

$S_{Universe}$  is the value of  $S_w(x)$  for the visible Universe, hence taking into account expansion.  $Ex \simeq 0,22$  is the coefficient for density decrease and Doppler effect due to expansion. Once again a de Sitter cosmological model was used in this calculation since it is what predicts surrounding.  $\rho_{Universe}$  is matter density over the Universe. Simpler are the ratios of symmetric contributions.

$$\frac{S_w(earth)}{S_w(laboratory)} = \frac{\rho_{earth}}{\rho_{laboratory}} \left( \frac{R_{earth}}{R_{laboratory}} \right)^{\frac{5}{2}} \simeq 10^{15} \quad (37)$$

$$\frac{S_w(galaxy)}{S_w(earth)} = \frac{\rho_{galaxy}}{\rho_{earth}} \left( \frac{R_{galaxy}}{R_{earth}} \right)^{\frac{5}{2}} \simeq 10^{11} \quad (38)$$

$$\frac{S_{Universe}}{S_w(galaxy)} = \frac{\rho_{Universe}}{\rho_{galaxy}} \left( \frac{R_U}{R_{galaxy}} \right)^{\frac{5}{2}} Ex \simeq 10^7 \quad (39)$$

It has been used  $\rho_{laboratory} = 10^3 \text{ kg/m}^3$ ,  $\rho_{earth} = 5,5 \cdot 10^3 \text{ kg/m}^3$ ,  $R_{laboratory} = 10 \text{ m}$  which is a high value, for a laboratory dedicated to decreasing the ratio of equation (37),  $\rho_{galaxy} = 0,003 M_0/LY^3$  where  $M_0$  is the mass of the sun,  $R_{galaxy} = 15 \text{ kpc}$ , and  $\rho_{Universe} = 9,24 \cdot 10^{-27} \text{ kg/m}^3$ . The behavior of surrounding suggests that the gravitation law would be weaker than Newton's law for interacting distances greater than  $15 \text{ kpc}$ . This would yield a much weaker result for equation (39). Therefore, the window for the surrounding effect of the laboratory and the earth

are the following.

$$10^{-33} < \frac{S_w(\text{laboratory})}{S_{\text{Universe}}} < 10^{-26} \quad (40)$$

$$10^{-18} < \frac{S_w(\text{earth})}{S_{\text{Universe}}} < 10^{-11} \quad (41)$$

This might be compared to the precision of the measurement of a force in particle physics. Equation (40) shows that any experiment done on earth could hardly detect any variation of the CF. But equation (41) suggests the idea of an experiment partly done far away from earth. The values given by equations (37), (38) and (39) shows that the CF is the frame of the fixed stars. In other words this frame is dictated by matter distributed over cosmological distances. But even there this might not be a fundamental result. For example another value of the  $f$  function of (18) would lead to a different determination of this frame.

From now on in the present document, the CF will be renamed "privileged frame".

Of course the Dirac distribution of matter yielding the Schwarzschild metric does not play the central role that it gets in the context of a linear model. Nevertheless, it still plays an interesting role for the study of a new model which is linear in the case of small deviations from the non-relativistic case. After the Dirac distribution of matter, another simple matter distribution which can be studied is the constant and homogeneous distribution of matter.

## 10. Cosmology

Applying equation (21) in this case will yield simply a constant privileged frame and therefore a flat Minkowskian metric. And expansion of the Universe is not obtained by the continuous version of equation (32). Also using equation (32) with a rough mean value might yield the same result. Using this equation (32) directly, without mean values, in the case of a constant and homogeneous repartition of IPs would yield the following mechanism. For each IP, the IP gravitational wave yields a curved spacetime. This mechanism might lead to Universe expansion. But this remains to be studied.

## 11. Back to General Relativity

The process giving rise to GR equation might give rise to a slightly different equation. Let's start with the Poisson's formulation of Newton's law.

$$\nabla^2 \Phi = 4\pi G \rho \quad (42)$$

$\Phi$  is a Newtonian gravitational potential.  $\rho$  is matter density. Let's remind that the classical result of the "comma-goes-to-semicolon rule" is Einstein equation.

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad (43)$$

$G_{\mu\nu}$  and  $T_{\mu\nu}$  are respectively Einstein and stress-energy tensors. But one can legitimately insert a coupling mixed tensor, let's write it  $C_\mu^\lambda$ , when transforming equation (42) into its tensorial formulation, yielding the following equation.

$$G_{\mu\nu} = \frac{8\pi G}{c^4} C_\mu^\lambda C_\nu^\rho T_{\lambda\rho} \quad (44)$$

And this is the shape of the surrounding equation. In surrounding,  $C_\mu^\lambda C_\nu^\rho$  is the relativistic version of  $C_{SMT}$ . Of course from the point of view of mathematics this approach is equivalent to the calculation which is done in Ref. 2. Nevertheless this is an approach of a research in physics which might be explored further. The idea here is not trying to modify the Lagrangian, but directly to insert a modifying factor in the rhs of Einstein equation. Of course,  $C_\mu^\lambda C_\nu^\rho$  in equation (44) might be constructed differently than the relativistic version of  $C_{SMT}$ . But conservation of energy, noticeably conservation of momentum, restricts the choice of this inserted factor to high scale evolving factors.

Another interesting work which might be done in the context of GR would be to check whether or not the four assumptions are true under the context of GR. The second assumption (a boost is a really occurring spacetime deformation) might be already more than a assumption, when it comes to find a determination of the privileged frame.<sup>8</sup> But this would need further debate. The third assumption (about propagation of spacetime deformations) seems to be difficult to obtain under the context of GR, even for a boost having a speed equal to the speed of light. But the spacetime metric generated by an IP in a Universe filled with a constant matter density might be calculated. The fourth assumption is impossible to assert in the context of GR. Indeed it would imply the non-linearity of the gravitational force with respect to attracting matter, even in the low deformation regime, if the IPs were not sparsely distributed. This shows that the model exposed here is not only different but also strongly incompatible with GR.

The relevance of the first assumption can be discussed in the context of GR. Classical mechanics predicts only one type of matter, whereas SR predicts two types of matter. There is ordinary matter, for which it always exists an inertial frame in which matter is at rest. For this reason let's call "matter at rest" this type of matter. But there is also matter in motion at the speed of light, for which it is impossible to find an inertial frame in which matter would be at rest. For this reason let's call it "matter in motion". Applying the spacetime deformation principle to matter at rest leads to GR equation. This is the path to GR. Applying this principle to matter in motion the same way can't lead to anything relevant. Indeed, for this type of matter the stress-energy tensor is degenerated. This would imply spacetime singularities everywhere. In contrast, this type of matter allows to assert the second

assumption in a coherent way, as shown in paragraph 3. This is the path which is tried in the present document. This fundamental duality of matter in SR still appears between GR equation and equation (32). Noticeably the following dualities are noticed.

- Continuous-discrete.
- Local-global.
- Determining a curvature or a derivative.

Those remarks constitute a backward theoretical motivation for the first assumption: if another GR equation were to be found, let's try the other type of matter.

## 12. Discussion

In this document an attempt of writing GR equation in a different way is suggested, which starts from SR, and avoids completely GR equation. Four assumptions are asserted, and from those assumptions results equation (32), a tensorial equation which relies spacetime geometry with matter distribution. It is a discrete equation, compared to GR equation which is a continuous one. The model determines the spacetime structure only for those events describing the nodes of a two dimensional grid of spacetime. The calculated width of the cells of this grid is extremely low,  $10^{-93}$  m. Nevertheless, turning the model into a continuous one does not allow to retrieve Universe expansion and induces a strong violation of the linearity of the gravitational force. It respects Mach's principle. It does not use the gravitational constant but calculates this constant from matter distribution over the Universe. Applying this equation to the spherically static case yields the generating idea of surrounding.<sup>2</sup> Many ways can lead to this GMTET model. But the approach of the present document shows that the search of a privileged frame can lead to it. Equation (32) determines exactly this privileged frame. This addresses, if it does not solve, the possible ambiguities in relativity about the concepts of comoving frame, more generally frame which is "attached to matter". This privileged frame is shown to be the frame of the fixed stars.

The calculation of the spherically symmetric static case was done under the supposition that the size of the attracting object is far weaker than the distance between this object and the location where the force is evaluated. Also it has been supposed the rule in which an IP gravitational wave always merges quickly with another one. The word "quickly" remains to be quantified. Strictly speaking those calculations were valid only in the low deformation regime. To say the least, very high energies would probably mean further developments even in this spherically symmetric case.

Another further development would be calculating Universe expansion generated by equation (32) in the case of a constant and homogeneous repartition of matter. Another simple development consists in simplifying the model in order to get a

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macroscopic behaviour of gravitation only. This has been tried with surrounding, which has been constructed exactly in this aim of avoiding the complexities of the initial model, without losing its main behaviour in the context of macroscopic gravitation.

Among the four assumptions the first one is probably the most involving one. It can equivalently be formulated the following way: “matter is made up of indivisible particles sharing the same constant speed“. An immediate result after this formulation is that this shared speed must be the speed of light. A motivation for this assumption is the remark that in relativity there exists two types of matter, and only one type leads to GR equation.

This study suggests the idea of a possible extension of relativity, and puts forward a replacement of dark matter and dark energy by a modification of Newton’s law.

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