The Newton Law

A-1 Introduction

Here we show that the Newton Law can be easily obtained replacing mass by closed volume. This method is much more simpler than getting a particular solution of EFE with a spherical static symmetry and weak field approximation.

A-2 Bulk Modulus

The bulk modulus K_B of a substance measures the substance's resistance to uniform compression. It is defined as the pressure increase needed to cause a given relative decrease in volume (fig. A-1).

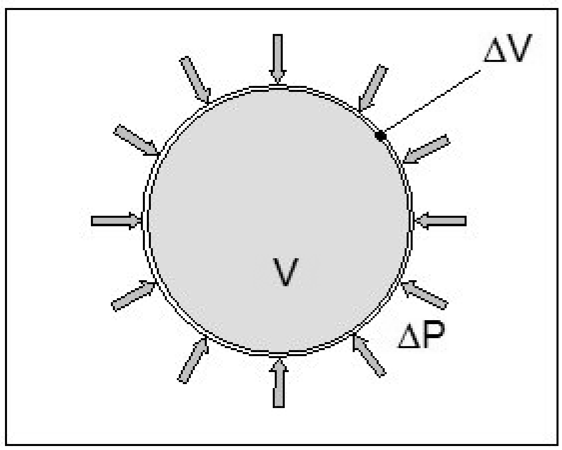

Figure A-1: Bulk modulus

$$K_B = -V \frac{\Delta P}{\Delta V} \qquad (1)$$

Starting with the Fluid Mechanics from 1850's, Einstein, helped by Grossman, demonstrated in 1910's that spacetime:

- Can be identified to a fluid,
- Returns to its rest shape after applied a stress (properties of elasticity).

Therefore, the Bulk Modulus (equ. 1), which also comes from the Fluid Mechanics, can be applied to spacetime. It means that the displacement of spacetime made by a closed volume exerts a pressure on the surface of the latter (fig. A-1). See also Supplementary Information E.

A-3 Elasticity Law

Elasticity phenomena follow the well-known logarithmic law:

$$\epsilon = ln\left(\frac{R - \Delta R}{R}\right) \qquad (2)$$

with ϵ = coefficient of elasticity of spacetime.

The Schwarzschild Metric gives an order of magnitude of the curvature of spacetime, which is infinitesimal. For example, the ratio curvature of spacetime/radius, or $\Delta R/R = GM/Rc^2$, is 1.4166E-39 for the proton, with M = 1.672E-27 kg, R = 8.768E-16 m, G = 6.674E-11, c = 8.987E+16. See Supplementary Information B for the meaning of $\Delta R/R$ and of the factor 2 in $2GM/Rc^2$.

Under these conditions, whatever the formula used, logarithmic or not, the curvature of spacetime can be considered as a linear function since we are working on an infinitesimal segment near to the point zero. So, equation (2) becomes in first order approximation:

$$\epsilon_R \approx \frac{\Delta R}{R} \qquad (3)$$

or, with volumes:

$$\epsilon_V \approx \frac{\Delta V}{V} \qquad (4)$$

For the moment, coefficients of elasticity of spacetime ϵ_R and ϵ_v are unknown.

A-4 Curvature of Spacetime

A closed volume V inserted into spacetime pushes it to make room (Fig. A-2, next page). So the following volumes are identical:

$$V = V_1 = V_2 ... = V_n \qquad (5)$$

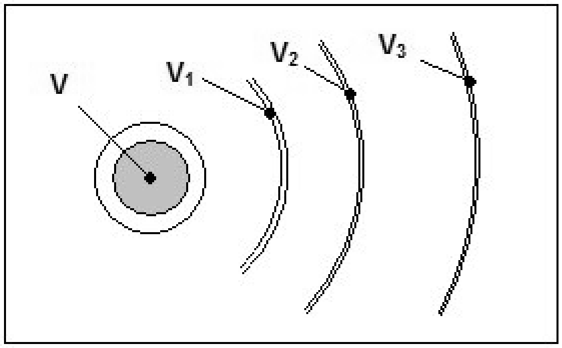

Figure A-2: Volumes V, V1, V2, V3... are identical

Since the curvature is infinitesimal, the coefficient of elasticity of spacetime ϵv can be considered constant. So, combining (4) and (5) gives:

$$\Delta V = \Delta V_1 = \Delta V_2 ... = \Delta V_n \qquad (6)$$

A-5 Curvature vs spacetime displacement

There should not be any confusion between a simple displacement of spacetime, Vx, produced by the insertion of a closed volume into a flat spacetime, and the curvature $\Delta V_x = \epsilon_v V_x$ due to the elasticity of spacetime (fig. A-3).

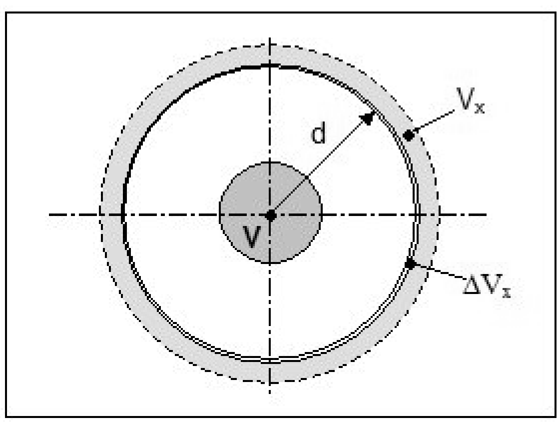

Figure A-3: Simple displacement (V_x) vs curvature of spacetime (ΔV_x)

A-6 Solving $\Delta x = f_{\Delta R}$

Since the ΔV's are infinitesimal, the volume ΔVx is simply the product of Δx by the surface Sx (fig. A-4):

$$\Delta V_x = \ S_x \ \Delta x \ = \ 4\pi d^2 \Delta x \qquad (7)$$

...and the volume ΔV_R is the product of ΔR by the surface S$_R$:

$$\Delta V_R = \ S_R \ \Delta R \ = \ 4\pi R^2 \Delta R \qquad (8)$$

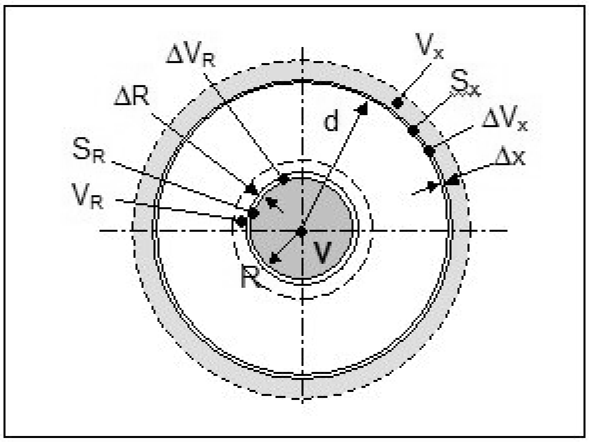

Figure A-4: Displacement and curvature at distances R and d

From (6) we have:

$$\Delta V_R = \Delta V_x \qquad (9)$$

Combining (7), (8) and (9) gives:

$$4\pi R^2 \Delta R = 4\pi d^2 \Delta x \qquad (10)$$

Finally, we get:

$$\Delta x = \frac{R^2}{d^2} \Delta R \qquad (11)$$

Where:
• R is the radius of the closed volume V_R,
•ΔR is the curvature of spacetime on the surface of the closed volume V_R,
• d is the distance of the point of measurement,
•Δx is the curvature of spacetime at distance d.

A-7 Curvature Δx vs Mass M

As explained in the main text, a relation exists between the curvature of spacetime, ΔR (or Δx at a distance "d" from R), and the mass of the object, more precisely its "mass effect":

$$\Delta R = f_{(M)} \qquad (12)$$

It is the pressure that produces the mass effect. This suggests that the latter is inversely proportional to the surface S, or $[1/L^2]$, as any pressure. On the other hand, it is obvious that the mass effect is also proportional to the volume, or $[L^3]$. Therefore, the dimensional quantity of the mass effect is $[1/L^2][L^3] = [L]$. In other words, $[M] \equiv [L]$.

At this point, we don't know the relation between ΔR and M but, in referring to Einstein's works, we have good reasons to believe that this relation is a simple linear function like:

$$\Delta R = KM \qquad (13)$$

... where K is an constant having the dimensional quantity of [L/M].

Here we show that [K] = [L/M], but we will see later that $K = G/c^2$. This result is in line with the dimensional quantity of some terms of the Schwarzschild Metric: $2\epsilon = \frac{2\Delta r}{r} = \frac{2GM}{rc^2}$ (see Supplementary Information B).

The challenge, now, is to calculate K to get the Newton Law of Universal Gravitation.

A-8 The Newton Law

Porting (13) in (11) gives:

$$\Delta x = \frac{R^2}{d^2}\ KM \qquad (14)$$

or

$$\frac{\Delta x}{R^2} = K\frac{M}{d^2} \qquad (15)$$

Since x = ct, replacing R^2 by c^2t^2 gives:

$$\frac{\Delta x}{c^2t^2} = K\frac{M}{d^2} \qquad (16)$$

or :

$$\frac{\Delta x}{t^2} = c^2K\frac{M}{d^2} \qquad (17)$$

The value $\Delta x/t^2$ has the dimensional quantity of an acceleration $[L/T^2]$. So, replacing this fraction by the acceleration symbol "a", we get:

$$a = c^2K\frac{M}{d^2} \qquad (18)$$

Notes: Δx is an infinitesimal quantity, not a differential quantity such as dx. Moreover, we are working in a linear segment of the elasticity of spacetime. In such a situation, $\Delta x/\Delta t = x/t$.

On the other hand, the multiplication of a constant c by a second constant K gives another constant. So, we can replace the product cK by a new and unknown constant for the moment, G for example:

$$c^2 K \ = \ G \qquad (19)$$

or *(this equation isn't necessary here but will be used for the calculation of the Schwarzschild Metric in Supplementary Information B.)*

$$K \ = \ \frac{G}{c^2} \qquad (20)$$

Porting (19) in (18) gives:

$$a = G\frac{M}{d^2} \qquad (21)$$

To be consistent, this new and unknown constant G must have the same dimensional quantity of c^2K:
- c^2 : Dimensional quantity = $[L^2/T^2]$
- K : Dimensional quantity = $[L/M]$ (see paragraph A-7)

So,

The dimensional quantity of this unknown constant G is
$[c^2K] = [L^2/T^2][L/M] = [L^3/MT^2]$.

On the other hand, we know that a force is the product of an acceleration by a mass, here "m". Therefore, (21) can be written as follows:

$$F = G\ \frac{Mm}{d^2} \qquad (22)$$

For the moment, G is unknown but we note that:

- G is a constant,
- Its dimensional quantity is $[L^3/MT^2]$.

So, we can identify G to the constant of gravitation issued from experimentation:

$$G = 6,67428.E - 11$$

In other words,

Equation (22) can be identified to the
Newton Law of Universal Gravitation.

The Schwarzschild Metric

B-1 Introduction

Here we show that the Schwarzschild Metric can be easily obtained using closed volumes instead of masses. This demonstration doesn't require tensor knowledge. This phenomenon is fully explained in section I-6, "Time Dilatation".

B-2 The Minkowski Metric

The expression of the Minkowski Metric, in spherical coordinates, is:

$$ds^2 = -c^2dt^2 + dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (1)$$

The Schwarzschild Metric refers to a static object with a spherical symmetry. It is built from a Minkowski Metric, in spherical coordinates, with two unknown functions: A(r) and B(r):

$$ds^2 = -B_{(r)}c^2dt^2 + A_{(r)}dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (2)$$

Remembering that the Minkowski Equation follows the Lorentz Invariance, the only way to get this invariance is to set A(r) = B(r).

From a mathematical point of view, we get the same result developing and simplifying EFE with correct parameters. Details of calculations are described in many books concerning GR. This conducts to the following equality:

$$B_{(r)}A_{(r)} = 1 \qquad (3)$$

Notes: In order to simplify equations, some Authors replace c and G by 1. To avoid inconsistent expressions, we don't follow this rule in this article because a simple number, "1" in this case, doesn't have a dimensional quantity like c^2*=[*L^2/T^2*], or G=[*L^3/MT^2*].*

B-3 The Schwarzschild Metric

To calculate the Schwarzschild Metric, we can start with fig. B-1 (next page), which is issued from the theory, where:

- d_{rout} is an elementary differential radial variation outside of any mass,
- d_{rin} is an elementary differential radial variation inside a Schwarzschild spacetime,
- r is the point of measurement.

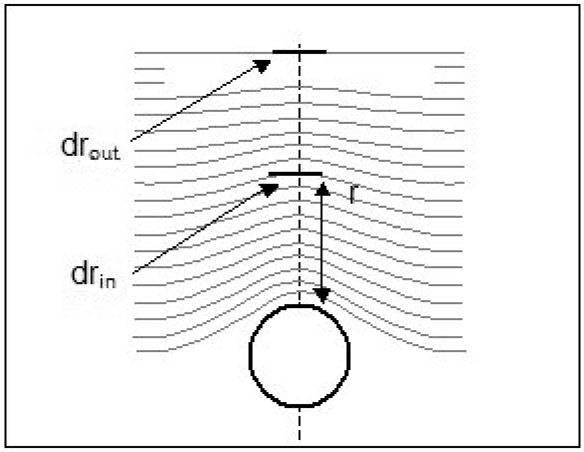

Figure B-1: Spacetime has been reduced to 1D

As in Supplementary Information A, we have:

$$\epsilon = ln\left(\frac{r - \Delta R}{r}\right) \qquad (4)$$

where:

- ϵ is a coefficient of the increase of spacetime curvature at distance r,
- ΔR is the initial curvature of spacetime produced by the closed volume,

The order of magnitude of ϵ is 10E-39. So, we can use the first order approximation from Supplementary Information A, equation 3:

$$\epsilon \approx \frac{\Delta R}{r} \qquad (5)$$

Since ϵ is a simple coefficient, we can calculate the relation between two differential elementary radius dr(out) and dr(in), out and in a gravitational field:

$$dr_{in} = (1 + \epsilon)\ dr_{out} \qquad (6)$$

Since $\epsilon \ll 1$, (6) becomes:

$$dr_{in} = \frac{1}{(1 - \epsilon)}\ dr_{out} \qquad (7)$$

or, elevating in square:

$$dr_{in}^2 = \frac{1}{(1 - \epsilon)^2}\ dr_{out}^2 \qquad (8)$$

Developing the denominator $(1-\epsilon)^2 = 1 - 2\epsilon + \epsilon^2$ and ignoring the last term ϵ^2, we obtain:

$$dr_{in}^2 = \frac{1}{(1-2\epsilon)}\, dr_{out}^2 \qquad (9)$$

This result is nothing but the radial component of the Schwarzschild Metric, that is to say the function A(r) of dr^2 in (2). Then, the calculation of B(r) is immediate, taking into account that A(r)B(r) = 1 from (3).

So:

$$A_{(r)} = \frac{1}{(1-2\epsilon)} \qquad (10)$$

$$B_{(r)} = (1-2\epsilon) \qquad (11)$$

Thus, (2) becomes:

$$ds^2 = -(1-2\epsilon)c^2dt^2 + \frac{1}{(1-2\epsilon)}dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (12)$$

In Supplementary Information A "The Newton Law", we have got the following result: ΔR = KM (equation 13). Since K = $\mathrm{G/c^2}$ (Supplementary Information A equation 20), equation 5 can be rewritten as:

$$\epsilon = \frac{\Delta R}{r} = \frac{KM}{r} = \frac{GM}{rc^2} \qquad (13)$$

Finally, porting this expression in equation 12 gives:

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right)c^2dt^2 + \frac{1}{\left(1-\frac{2GM}{rc^2}\right)}\, dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (14)$$

B-4 Conclusions

As we see, this new calculation of the Schwarzschild Metric, which is exclusively based on closed volumes, gives correct results. This is due to the fact that the origin of EFE is the Fluid Mechanics, which is itself based on volumes, not on masses (see Supplementary Information E).

Mass Effect Calculation

C-1 Expression of "m"

We have seen that the displacement of spacetime V_R is equal to that of the closed volume, V, which produces this displacement (fig. C-1):

$$V_R = V \qquad (1)$$

On the other hand, the curvature of spacetime is:

$$\Delta V_R = \epsilon_v \; V_R \qquad (2)$$

Porting (1) in (2) gives:

$$\Delta V_R = \epsilon_v \; V \qquad (3)$$

The radial curvature of spacetime, ΔR, at the surface of M, is calculated dividing the volume by the surface:

$$\Delta R = \frac{\Delta V_R}{S} \qquad (4)$$

Finally, porting (3) in (4) gives:

$$\Delta R = \epsilon_v \frac{V}{S} \qquad (5)$$

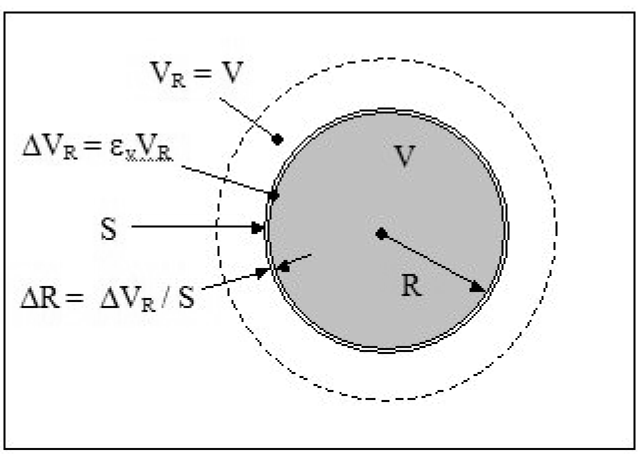

Figure C-1: The curvature of spacetime

On the other hand, we have calculated the Newton Law starting with equation 13 of Supplementary Information A:

$$\Delta R = KM \qquad (6)$$

...where K is an unknown constant having the dimensional quantity of [L/M].

Porting (6) in (5) gives:

$$KM \;=\; \epsilon_v \frac{V}{S} \qquad (7)$$

or

$$M \;=\; \frac{\epsilon_v}{K}\frac{V}{S} \qquad (8)$$

Porting in equ. 8 the expression of K given in equ. 20 of Supplementary Information A gives the expression of the "mass effect", with a new coefficient, ρ (see explanation below):

$$M \;=\; \frac{c^2}{G_0}\epsilon_v \frac{V}{S}\,\rho \qquad (9)$$

with:

M = Mass effect (kg)
V = Volume of the closed volume (m^3)
S = Surface of the closed volume (m^2)
ϵ_v = Coefficient of elasticity of spacetime in a flat spacetime
c = Speed of the light (m/s)
G_0 = Universal constant of gravitation
ρ = Density of surrounding spacetime relative to a flat spacetime.

It seems useful to differentiate ϵ_v, the coefficient of elasticity of spacetime in a flat spacetime, and ρ, the density of surrounding spacetime. We could merge these two parameters in one common parameter since we are faced with two coefficients. In both cases, result is the same. However, we must note that the *"proper coefficient of elasticity of spacetime"*, as proper length in special relativity, must be measured in a flat spacetime. This is why the two parameters have been separated.

The coefficient of elasticity of spacetime ϵ_v is unknown but can be calculated from tha mass/diameter of spherical particles such as leptons. See paragraph C-3 "Nuclei".

C-2 Case of a sphere

In the particular case of a sphere, we have $V = 4/3\pi R^3$ and $S = 4\pi R^2$. Thus, equation (9) becomes:

$$M \;=\; \frac{\epsilon_v R c^2}{3\;G_0}\,\rho \qquad (10)$$

C-3 Nuclei

Nuclei aren't spherical generally. Since we don't know exactly their shape, it is not possible to apply equation (10) to calculate their mass effect.

The semi-empirical mass formula (SEMF), sometimes called the Bethe-Weizscker mass formula, is used to approximate various properties of an atomic nucleus. It is based partly on the liquid drop model proposed by George Gamow, and partly on empirical measurements. From the SEMF formula, the radius R is defined as $R = 1.2A^{1/3}$, A being the mass number. The right member doesn't mean necessarily that the mass vs the radius follows a $A^{1/3}$ law. In reality, it is the arrangement of nucleons inside the nucleus that follows this rule. Result is equivalent but the signification is totally different.

We must also note that in the Bethe-Weizscker expression, a surface component also exists, as the volume component. It means that, early in 1937, Bethe and Weizscker predicted, without knowing, equation (9) here demonstrated.

We must keep in mind that nuclei are made of open and closed volumes. The space between nucleons may vary from one nucleus to another. Thus, it is necessary to know the arrangement of nucleons with accuracy before any calculations. A particular case are magic nuclei (nuclei having a null quadripolar moment) because they are supposed to be spherical. It will be interesting to make accurate experiments on the relation volume/surface/mass effect of magic nuclei.

On the other hand, some nuclei have a halo made of open volumes that are not relevant in mass calculation. This is the case for example of the ^{11}Li (3p8n), which has open volumes between the ^{9}Li and the 2n orbitals. These exceptions highlight the difficulty to make accurate calculations of the mass effect. In all cases, before any calculation, we must know exactly the geometry of closed and open volumes inside the nucleus. It means that equations (9) or (6) are not so simple than it sounds.

As a direct consequence of the proposed theory, it could be possible that a relationship exists between the sphericity of particles or nuclei and the accuracy of measurements. This deduction suggests that leptons could be spherical since their mass effect is known with an excellent accuracy. This is also the case of some particles such as the proton, neutron, or π meson. Inversely, this is not the case of quarks. It means that quarks could have a non-spherical or complex shape.

Mass of Relativistic Particles

D-1 Introduction

Increase of the mass of relativistic particles is covered by special relativity. However, this phenomenon remains particularly obscure and no one can explain it with simple words. The proposed theory gives a simple and rational explanation of this strange phenomenon.

D-2 Length contraction

Special relativity states that, at relativistic speed, times *expand,* lengths *contract* and angles *are modified.* A simple demonstration is given in 1923 by Einstein himself in his book "The theory of special and general relativities". Length contraction is defined by the following formula

$$l_m \;=\; l_0\,\sqrt{1-\frac{v^2}{c^2}} \qquad (1)$$

with

- l_m = Measured length
- l_0 = Proper length
- v = Speed of object
- c = Speed of light

D-3 Mass increase

Lets consider a particle at rest (fig. D-1a next page). Its closed volume produces a curvature of the spacetime. Geodesics are spaced of l_0.

If this particle moves at a relativistic speed "v" (fig. D-1b), spacetime geodesics seems to shrink. This is the well-known phenomenon of length contraction. More the geodesics are close to each other, more the density of spacetime is important. In other words, the curvature of spacetime is inversely proportional to the space between two geodesics (see note 1). So, relation (1) becomes:

$$\Delta R_m \;=\; \frac{\Delta R_0}{\sqrt{1-v^2/c^2}} \qquad (2)$$

with

- ΔR_m = Infinitesimal element of the curvature of spacetime measured (external observer)
- ΔR_0 = Infinitesimal element of the proper curvature of spacetime
- v = Speed of the particle
- c = Speed of light

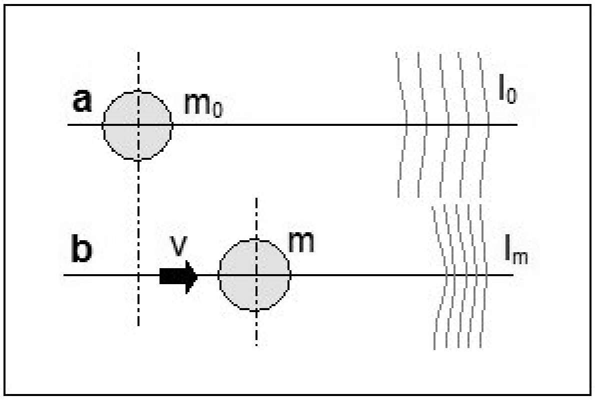

Figure D-1: Particle at v = 0 (a) and at relativistic speed (b)

Since the curvature is function of mass $\Delta R = KM$ (Supplementary Information A), we can replace the curvature of spacetime of equation (2) by the mass effect "m", vs the proper mass "m_0" (see notes 2 and 3).

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}} \qquad (3)$$

Thus, the theory presented in this paper, based on closed volumes instead of masses, gives a very simple and rational explanation of the mass increase of relativistic particles. This is due to the linear relation between ΔR and M as shown in Supplementary Information A and B.

Note 1: The spacetime curvature is the difference of displacement ΔR of a geodesic vs to the same geodesic in a Minkowski space. As shown in this article, the Schwarzschild metric gives an order of magnitude of this spacetime curvature: 1.4166 E-39 meters for the proton on its surface. This value is much smaller at distance r. Thus, regardless of the function used, the portion of the curve on which we work is linear. Taking into account this linearity, there is no objection to consider that the curvature is inversely proportional to the space between two geodesics.

Note 2: The nature of expression $\Delta R = KM$ *is not relevant because this section covers exclusively the calculation of the coefficient to be applied to a proper value to get the measured value. This coefficient is noted* γ *(or* $1/\gamma$*) in scientific literature. It means that the relationship between the spacetime curvature and mass is not affected by this study. For example, if we make 5 measurements of the curvature of spacetime at different speeds, we will not have 5 different relationships between* ΔR *and M, but only one applicable in all cases, ...but we will have 5 different coefficients* γ*.*

Note 3: The principles of special relativity state that the measurement of the mass of a relativistic particle increases. However, the converse is also true if we swap the reference systems. If we could pick up a measuring device on a particle in movement, this device would indicate that our spacetime, that in which we live, is much more dense as we see it. Thus, a section of the LHC for example, with a mass of 3 tons, measured from a device located on the particle in motion, would have a mass of 3000 tons if $\gamma = 1000$*. From our point of view, the mass of a relativistic particle increases, but from the particle's point of view, it is our world that increases. In all cases, the proper mass of the particle or that of our world remains unchanged. This "relative view" is often misunderstood.*

Note 4: Many physicists think that the mass, so the "volume" (more exactly the closed volumes), of relativistic particles increases. In reality, it is the mass effect due to the apparent compression of spacetime that increases. The volume remains unchanged. On Earth, we consider that "mass" is an intrinsic value of a particle, such as the volume. It is not true. Since the mass effect comes from the pressure of spacetime on the particle, it is a virtual effect, such as speed, force, energy... The mass effect depends of the surrounding density of spacetime. Thus, for example, if the spacetime density was two times higher, the mass effect would be twice as important as well, but the intrinsic characteristics of the particle would remain unchanged. This explanation is shown in the graphic of fig. D-1.

Energy-Momentum Tensor

E-1 Introduction

We have demonstrated that gravitation is a pressure force exerted by the spacetime curvature on closed volumes. Here we show that this explanation is in perfect accordance with EFE and the energy-momentum tensor.

E-2 Mass vs. spacetime curvature

We could think that the spacetime curvature "C" depends on mass "m" since the expression of the energy-momentum tensor is C = f(m):

Mass → Spacetime curvature

Since, to date, the mass is supposed unknown, this expression is incomplete and should be written as

??? → Mass → Spacetime curvature

The present theory explains the mass and proposes to replace "???" by the group in italics:

Closed volumes →
Spacetime curvature →
Pressure on the body →
Produces a mass effect...

→ Mass → Spacetime curvature

We see that the spacetime curvature is redundant. So, it is not necessary to specify the last line since the spacetime curvature has already been calculated (second line in italics).

It is important to note that this scheme is static. Its purpose is nothing but to calculate the mass effect, as shown in Supplementary Information C.

Once the static mass effect known in a flat spacetime, if we need to know the dynamic spacetime curvature in a particular situation, we must use the following scheme:

Step 1
Closed volumes →
(static) Spacetime curvature →
Pressure on the body →
Produces a mass effect

Step 2
Dynamic spacetime curvature

Step 1: Calculation of the mass effect of the body from the static curvature of spacetime, as Supplementary Information C shows.

Step 2: The knowledge of the static mass effect "m" allows calculation of the spacetime curvature in a particular dynamic context. To do that, we must use EFE with correct parameters or one of its known solutions.

For example, for a rotating sphere, we must use:

- Step 1: to calculate the static mass effect "m" from closed volumes,
- Step 2: to calculate the dynamic spacetime curvature applying the Kerr Metric.

E-3 The Schwarzschild Metric

To calculate the spacetime curvature with a static body having a spherical symmetry, we must use the Schwarzschild Metric. In that particular case, step 2 isn't necessary since the spacetime curvature has been already calculated from closed volumes in step 1 (see Supplementary Information B).

Using this principle of calculation in two steps, here we show that the theory presented in this paper is in perfect accordance with EFE.

E-4 EFE and mass

Einstein devised his field equations (EFE) from the fluid mechanics of 1850's (fig. E-1, next page). Without enter in the build of these two tensors, the following points must be highlighted:

- In the constraint tensor (fig. E-1a), the trace T_{00}, T_{11}, T_{22} defines the isostatic pressure,
- In the energy tensor (fig. E-1b), the trace has necessarily the same signification, i.e. *a pressure*,
- Fluid mechanics, and therefore the constraint tensor, concerns volumes, not masses.

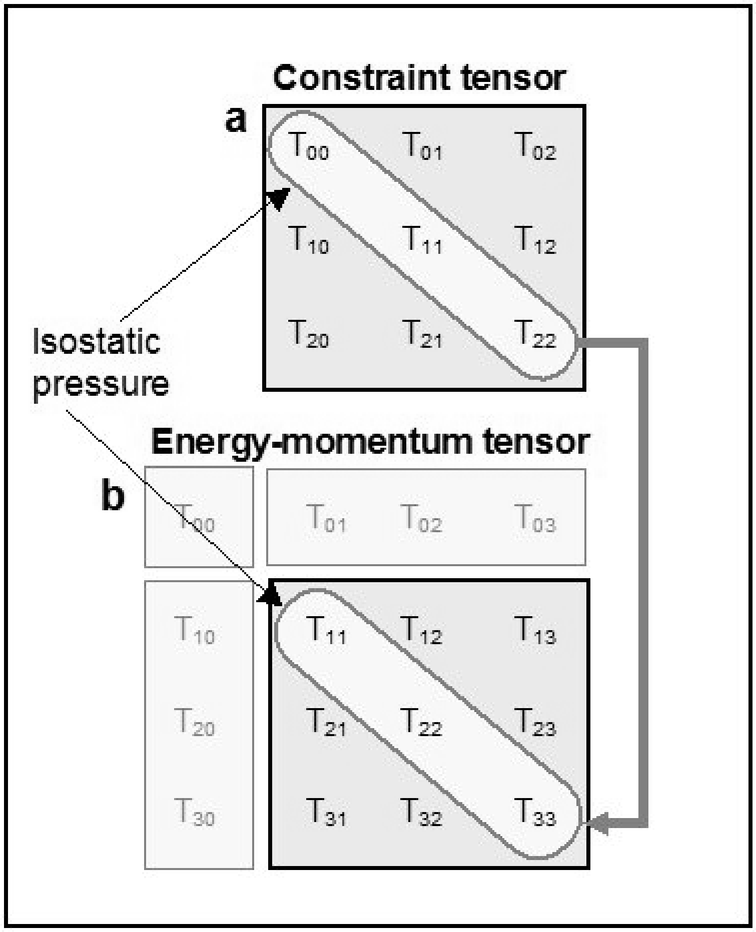

Figure E-1: Constraint tensor vs Energy-momentum tensor

We must have in mind that **the fluid mechanics always applies to volumes, not to masses**, even if the mass parameter is intrinsically present in many equations of the fluid mechanics such as in the Reynolds Number, Xavier-Stokes equation, or more simply the force [ML/T^2]. As shown in this paper, this is due to the relation M = f(x,y,z,t). These points shows that the energy tensor is related to a pressure on (closed) volumes, not to an attractive force between masses.

Finally, the proposed theory is nothing but an extension of the fluid mechanics, as demonstrated by Einstein in 1910's, but keeping original significations. Indeed, Einstein and Grossman had no reason to replace volumes of the Fluid Mechanics by mass. It is obvious that if the constraint tensor applies to volumes, the energy tensor must do likewise.

On the other hand, we can note that the reduction of the isostatic pressure of theses tensors to 1D (the radial component) conducts to the Bulk Modulus theory as described in Supplementary Information A. It means that the theory presented here is perfectly homogeneous because we explain mass and gravitation by two different ways.

E-5 EFE and gravitation

Einstein Field equations (EFE) has been validated many times since 1915's. Does the proposed theory match EFE about gravitation?

Yes, for the following reason.

In physics, we consider that a normal attracting constraint is positive by convention, and a pressure constraint is negative. It means that gravitation is "+" and the pressure exerted by spacetime on closed volumes, as the proposed theory shows, is "-".

On the other hand, to date, the curvature of spacetime is supposed to be concave (fig. E-2).

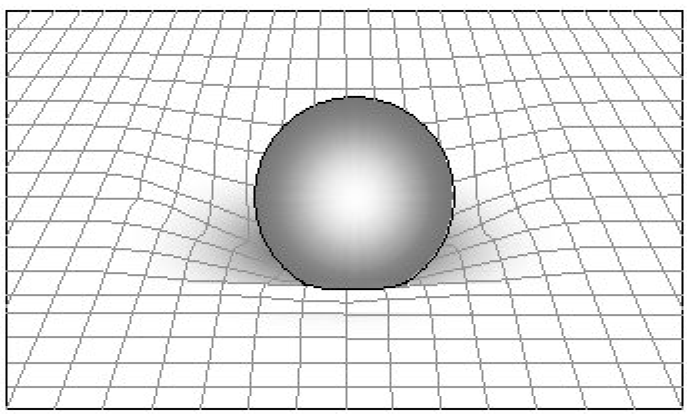

Figure E-2: Current representation of the curvature of spacetime

We can consider, by convention, that a concave curvature has the "-" sign, and a convex curvature, as shown in the proposed theory, has the "+" sign. This conducts to four combinations:

1 - Attraction and concave curvature: (+ -)
2 - Attraction and convex curvature: (+ +)
3 - Pressure and concave curvature: (- -)
4 - Pressure and convex curvature: (- +)

These four combinations can be interpreted as:

• Combination 1 (+ -) is that of Newton-Einstein. It works perfectly and doesn't need validation. However, it doesn't explain how a mass can curve spacetime,
• Combinations 2 (+ +) and 3 (- -) have no physical significance and must be rejected,
• Combination 4 (- +) is that of the proposed theory. It conducts to an identical result as the first combination because (+ -) = (- +). However, this combination is much more credible than the first one because, for identical results, it gives a rational explanation of the spacetime curvature.

E-6 Conclusions

A close examination of the constraint and energy-momentum tensors shows that:

• The curvature of spacetime is caused by volumes, not by mass ...
• ... it is convex, not concave ...
• ... which conducts to consider that gravitation is a pressure force, not an attractive force.

Von Laue Geodesics

F-1 Introduction

A set of concentric circles is drawn in (fig. F-1a). These lines represent the geodesics of spacetime far from any mass, in a Minkowski spacetime. If a static spherical symmetry closed volume is inserted in the centre (fig. F-1b), spacetime will be curved, as explained in the main text.

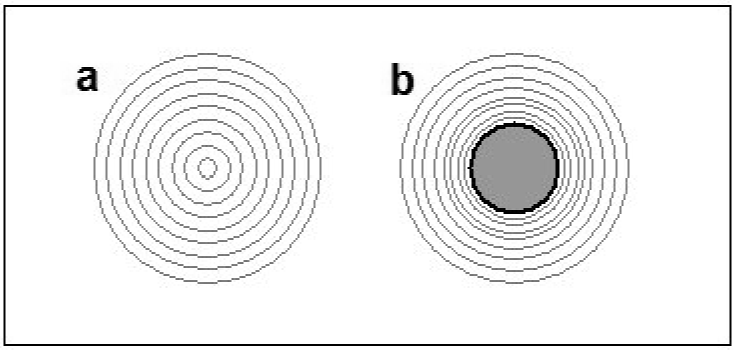

Figure F-1: Curvature of spacetime

Fig. F-1b has been duplicated in fig. F-2.

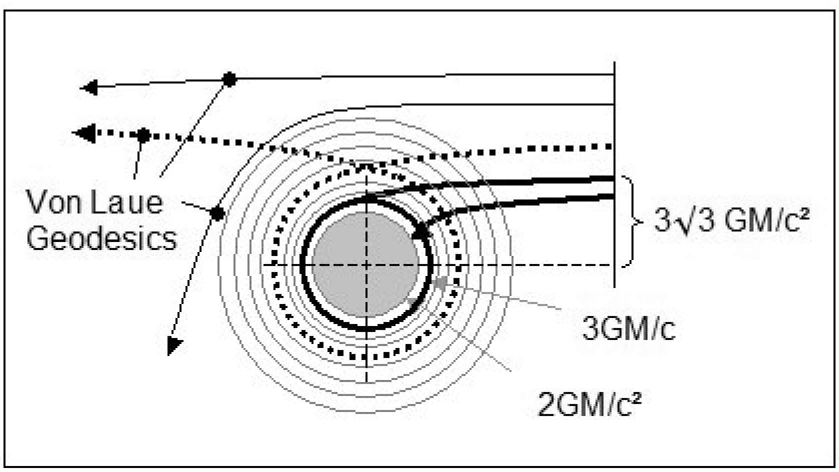

Figure F-2: Von Laue Geodesics

The Von Laue Geodesics has been drawn over the concentric circles of fig. F-1b.

We see that the Von Laue Geodesics match EXACTLY the concentric circles.

In other words, it seems that Von Laue, early as 1927's, predicted the theory presented here. It is obvious that **his diagram shows volumes, not masses,** even if the Von Laue Formulas are related to the mass of the body.

Equivalence Principle

G-1 Demonstration

Lets consider a static object on Earth (fig. G-1). Closed volumes of this object cause a curvature of spacetime that exerts a gravitational force on this object. $g = 9.81 m.s^{-2}$ on the surface of Earth.

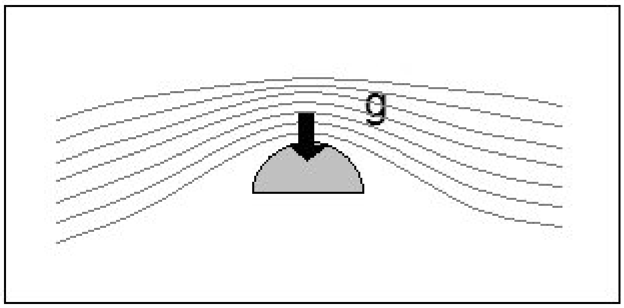

Figure G-1: Gravitationnal acceleration

Lets now consider the same object accelerated out of any gravitational field. We can represent this object in two different views (fig. G-2a and G-2b).

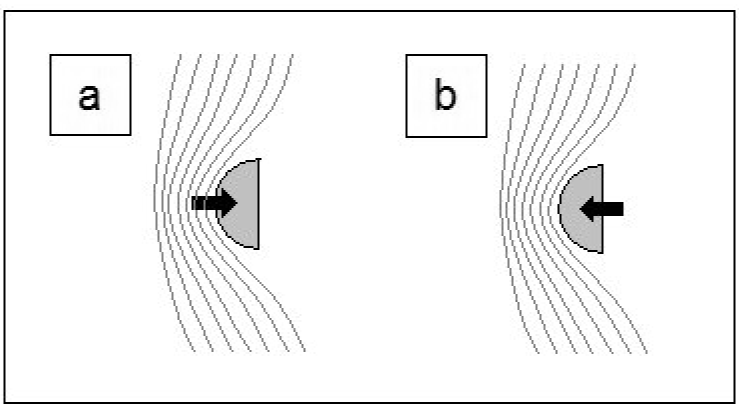

Figure G-2: Inertial acceleration

In both cases, acceleration "a" is supposed to be identical to g:

$$a = g = 9.81 m.s^{-2}$$

Without any reference, a local observer cannot know if the curvature of spacetime is due to a pressure on the object (fig. G-2a) or to its acceleration (fig. G-2b). In fact, these two figures are identical and depend on where the observer stands, as described in Special Relativity.

Since:

• By definition, g = 9.81 m.s^{-2} (fig. G-1) is identical to a = 9.81 m.s^{-2} (fig. G-2a and G-2b).
• These examples uses the same object. Therefore, the curvature of spacetime produced by the closed volume of this object is identical.
• The two precedent points show that the "mass effect" produced by these curvatures will be necessarily identical in both figures.

We deduce that the "gravitational mass effect" (fig. G-1) is identical to the "inertial mass effect" (fig. G-2):

Gravitational mass effect
=
Inertial mass effect
=
Effect from spacetime curvature

Black Holes Simulation

H-1 Introduction

The purpose of this simulation is to show that **replacing mass by (closed) volume** conducts to a consistent explanation of the Schwarzschild Metric and black holes.

This experiment should not be considered as a validation of the theory. However, it is not less credible as those concerning the Big Bang, Higgs boson, or other debatable simulations or experimentations conducted in large laboratories. All these "official" experiments and simulations (Big-Bang...), including the present one, must be taken with great care.

H-2 Simulation

The curvature of spacetime explained in the main text has already been mathematically demonstrated in Supplementary Information B "The Schwarzschild Metric". Figure B-1 of this section has been duplicated on the left of fig. H-1 below. The right part of fig. H-1 shows a simulation of the left part made with an EPP foam. A set of lines, spaced 5 mm apart, has been drawn on an EPP foam which simulates spacetime (See GR for elasticity properties of spacetime). A half-cylinder with a radius of 22 mm. simulates a closed volume. This volume is inserted into the foam.

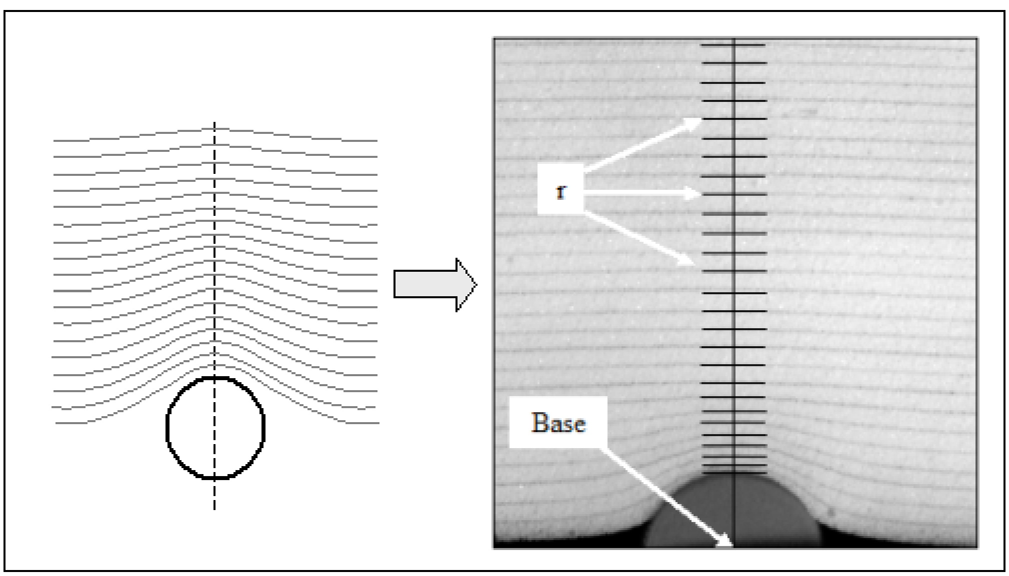

Figure H-1: Simulation of spacetime in 1D

The gaps between two adjacent lines are computed from the Schwarzschild Metric (see supplementary information B), which has been reduced to the radial component:

$$y_{r\ exp} = \frac{1}{\left(1 - \dfrac{2.2}{r}\right)} \qquad (1)$$

The constant 2.2 is calculated from:
- R = 22 mm. Radius of the closed volume of fig. H-1,
- $\epsilon = 0.1$. Arbitrary EPP foam coefficient,
- ϵR = 0.1 x 22 mm = 2.2 mm. (ϵR = ΔR, see the Schwarzschild Metric)

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
n	**$r_0 = 5n+22$**	**$\Delta r = 0.1\ r_0$**	**$r = r_0 - \Delta r$**	**$y_{(r)}$**
1	27	2,70	24,30	**1,10**
2	32	3,20	28,80	**1,08**
3	37	3,70	33,30	**1,07**
4	42	4,20	37,80	**1,06**
5	47	4,70	42,30	**1,05**
6	52	5,20	46,80	**1,05**
7	57	5,70	51,30	**1,04**
8	62	6,20	55,80	**1,04**
9	67	6,70	60,30	**1,04**
10	72	7,20	64,80	**1,04**
11	77	7,70	69,30	**1,03**
12	82	8,20	73,80	**1,03**
13	87	8,70	78,30	**1,03**
14	92	9,20	82,80	**1,03**
15	97	9,70	87,30	**1,03**
16	102	10,20	91,80	**1,02**
17	107	10,70	96,30	**1,02**
18	112	11,20	100,80	**1,02**
19	117	11,70	105,30	**1,02**
20	122	12,20	109,80	**1,02**
21	127	12,70	114,30	**1,02**
22	132	13,20	118,80	**1,02**
23	137	13,70	123,30	**1,02**
24	142	14,20	127,80	**1,02**
25	147	14,70	132,30	**1,02**
26	152	15,20	136,80	**1,02**

Figure H-2: Theoretical data from formula (1)

Fig. H-2 (previous page) shows data using an incremental index "n" and the above formula (1) where:

- Col. 1: "n" is the rank of each line,
- Col. 2: Lines "r_0" are spaced 5 mm. apart, out of gravitation, with an offset of 22, as that of the radius of the closed volume of fig. H-1,
- Col. 3: Δr is calculated using the elasticity of spacetime, ϵ, supposed to be 0.1,
- Col. 4: Finally, the distance between the base and the point of measurement of the spacetime curvature, r, is computed from ΔR and r_0,
- Col. 5: Result.

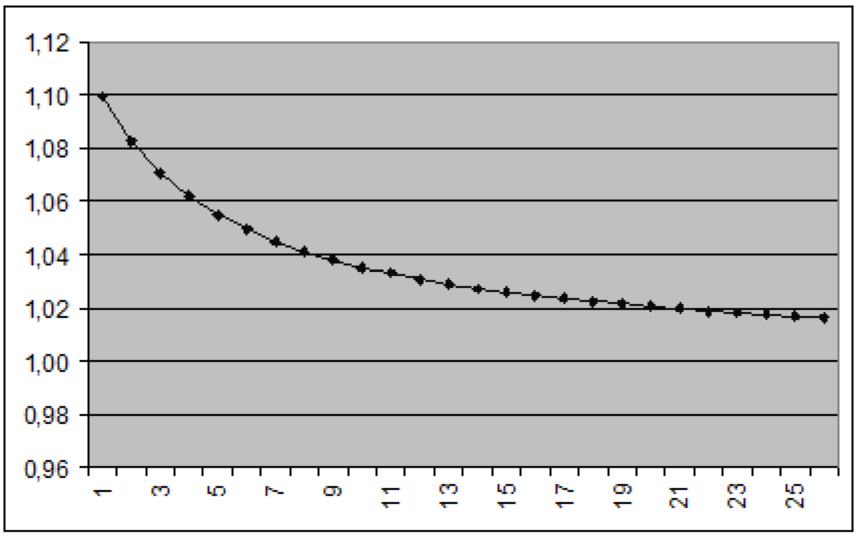

Figure H-3: Graphic from table H-2

H-3 Black holes

If the radius of the closed volume 22 mm. is increased to 40 mm., a singularity appears under 40 mm. (fig. H-4 and H-5, next page). Above 40 mm., we get a curve as that of fig. H-3.

The table and the curves (fig. H-4 and H-5) show an asymptote when r = 40 mm.. They match exactly that of the behaviour of the Schwarzschild Metric around Rs (Schwarzschild Radius).

We can also remark that the signature is changed from + to -, as inside a black hole. However, the negative part shown by the curve is a "fictive" part that doesn't exist. It's only a mathematical object since below the radius, 40 mm, nothing happens.

To date, no one knows exactly what's inside a black hole. This simulation tends to prove that a black hole is a large closed volume. Moreover, the Schwarzschild Radius is the limit of the closed volume. Inside a closed volume, as inside a black hole, nothing happens.

The light doesn't exist and, therefore, can't escape from the center of a black hole. However, this explanation, as any explanation of black holes, will never be validated by experimentation. It is obvious that no one will never answer the question: "What's inside a black hole?".

Rank	r	$y = f_{(r)}$
	22	
1	24,4	-1,56
2	26,8	-2,03
3	29,4	-2,77
4	32,2	-4,13
5	35,2	-7,33
6	38,3	-22,53
8	41,8	23,22
9	45,9	7,78
10	50,4	4,85
11	55,1	3,65
12	59,9	3,01
13	64,6	2,63
14	69,3	2,37

Rank	r	$y = f_{(r)}$
15	74,4	2,16
16	79,3	2,02
17	84,4	1,90
18	89,5	1,81
19	94,5	1,73
20	99,5	1,67
21	104,2	1,62
22	108,8	1,58
23	113,6	1,54
24	118,4	1,51
25	123,2	1,48
26	128	1,45
27	132,9	1,43

Figure H-4: Data, increasing the radius to 40mm

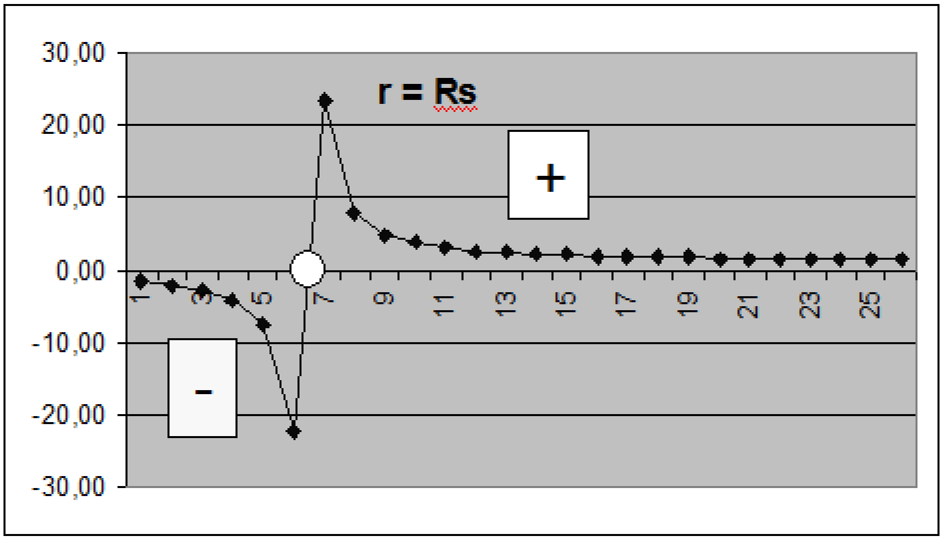

Figure H-5: Graphic related to data of fig. H-4

H-4 Conclusions

These simple simulations and explanations show the black hole behaviour. Results are **EXACTLY identical** as in conventional physics using EFE solutions.

This section shows, one more time, that spacetime is curved by (closed) volume, not by mass.

Effectively, during all these simulations and explanations, only lengths have been considered. Mass has been totally ignored. It is the radius, not the mass, which has been increased to 40 mm. in order to calculate a black hole behaviour.

Applications

In his books, Einstein presented relativity using metaphors such as a train (lengths dilatation) or a lift (equivalence principle). Here we use the same pedagogical method.

I-1 Particles crossing a crystal

One of the Higgs Basis is: "Particles get mass when they move in an Higgs Field". Peter Higgs' idea is correct but, in reality, the Higgs Field is nothing but spacetime. The following experimentation confirms this point of view .

Why does the mass of a particle moving inside a crystal increase?

The presented theory gives the solution to this strange phenomenon. The lattice of a crystal is an array of tunnels. The particle moves inside one of these tunnels. Closed volumes of each atom of the crystal (nucleons and electrons) curve the spacetime located inside the tunnel, on the path of the particle. Therefore, the density of spacetime will be higher inside the tunnel than outside.

Since *"spacetime curvature = mass effect"*, an increase of spacetime curvature inside the tunnel produces an increase of the mass effect of the particle crossing the crystal . This is also confirmed by equation 1 in the main part of the article where M is directly function of δ, the density of spacetime.

This experiment also tends to show that the Higgs Field is nothing but spacetime.

I-2 Superluminal neutrinos

Note: The following explanation is deliberated simplified for teaching purposes.

In OPERA experimentation, physicists sent neutrinos from CERN CNGS, Geneva, toward the Gran Sasso Laboratory LNGS, Italia [1]. It appears that the neutrinos travel at a velocity 20 ppm above the speed of light. Going faster than light is something that is just not supposed to happen, according to Einstein's special relativity.

In reality, this anomaly is a direct consequence of the theory explained here and has been predicted by the author as early as 2008 in several official papers and in his book [3][4].

Figure I-1 (next page) shows the Earth and the Moon in 1D. The curvature of spacetime produced by the Earth annihilates that produced by the Moon in the white area. Spacetime is flat in this area. The path of neutrinos from the CERN to Gran Sasso divides the Earth into two unequal parts that can be identified to the Earth and the Moon. The principle is identical. The white area continues to exist, but since masses, more exactly closed volumes, each side of the path of neutrinos are unequally distributed, the curvature of spacetime is no longer zero in that zone.

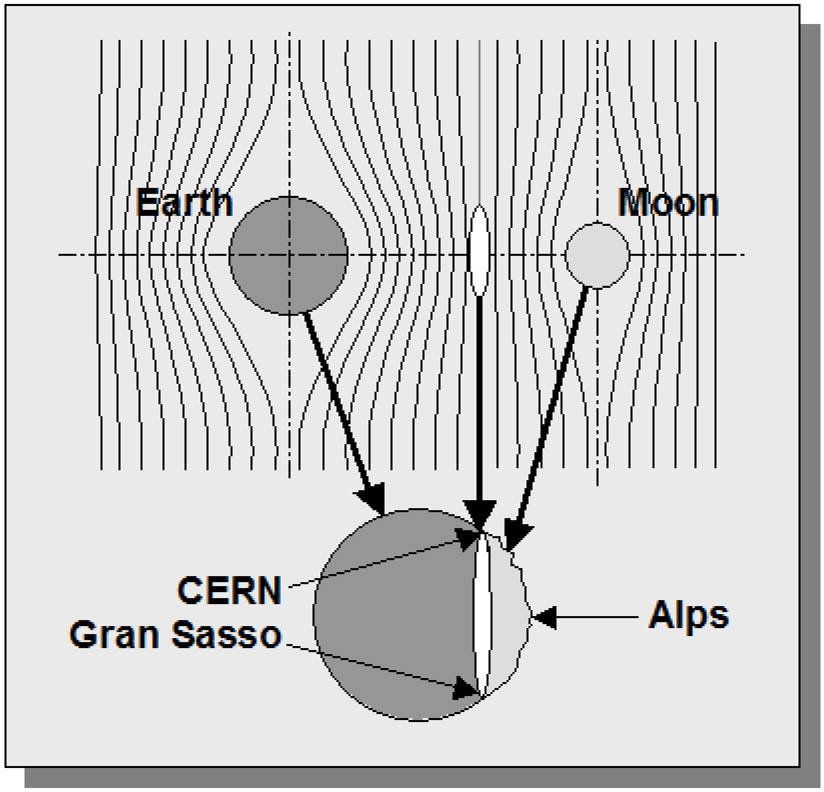

Figure I-1: Superluminal neutrinos anomaly

In this white zone, the curvature of spacetime is a slightly smaller than that on the surface of the sea. This is due to the presence of the Alps between Geneva and Gran Sasso. The decrease of the spacetime density in the white zone leads necessarily to a decrease of the "mass effect" of neutrinos, as previously explained.

Another experiment conducted by ICARUS Collaboration [2] shows that the energy of the neutrinos is constant. In such a situation, since no external forces affect the neutrinos, a decrease of their mass effect conducts automatically to an increase of their speed.

Finally, the CERN-Gran Sasso experiment is exactly the opposite effect than that explained in paragraph I-1: "Particles in a crystal". Both experiments are based on the same principle which is summarized as follow :

Any modification of the density of spacetime conducts to a modification of the mass effect of the particles.

Notes: Here, we don't take into account the curvature of spacetime made by the sun and other planets or galaxies. Moreover, we also ignore the centripetal force due to the Earth-Moon movements. This subject is covered by Newtonian physics.

Lastly, since the photon is an elementary particle, it is not absurd to think that the speed of light could also increase in such situations. In other words, there is a possibility that the speed of light would be also function of the curvature of spacetime. Its maximum speed would be in a vacuum AND in a flat spacetime (far from any mass). This suggestion must be verified.

I-3 Mass Excess

Note: The following explanation is deliberated simplified for teaching purposes. It is not in contradiction with quantum chromodynamics (QCD) because this explanation covers the principle of the mass excess, not the behaviour of closed volumes (gluons) enclosed inside the nucleus.

Let's consider the simplified case of a nucleus having 19 nucleons (fig. I-2). As shown in equ. 1 of the main text, the "mass effect" is function of the volume and surface of closed volumes. So, fig. I-2 shows three cases:

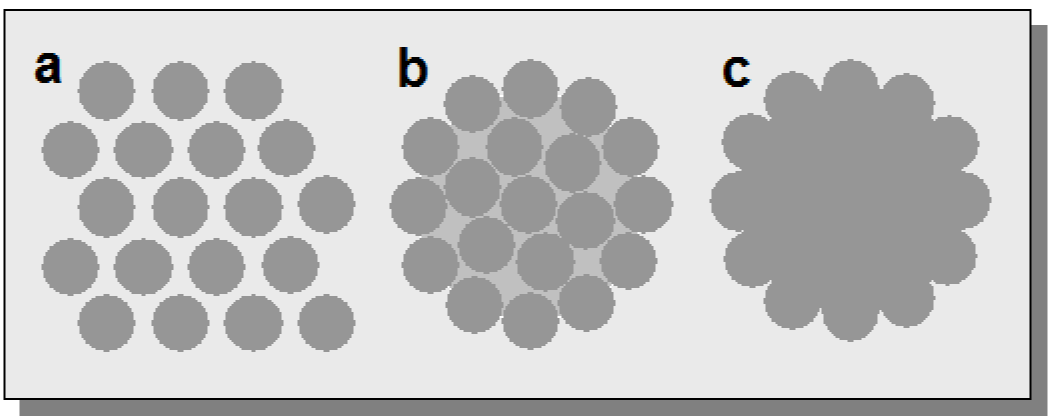

Figure I-2: Pedagogical explanation of the mass excess

a/ Independent nucleons: The total volume is 19V and the total surface 19S, V and S being respectively the volume and surface of each nucleon (for teaching purposes, here we consider that a proton is equal to a neutron).

b/ Nucleus: The 19 nucleons are linked to make a nucleus. The gray surface represents a vacuum enclosed into the nucleus. Therefore, this open volume becomes closed volume and curves spacetime as any closed volume would do.

c/ Nucleus: From an external view, figure (c) looks like (b). Since the global volume of (c) is greater to that of (a), and the global surface is smaller too, the curvature of spacetime is greater. This conducts to an increase of the mass effect. This difference of mass effect is nothing but what we call "mass excess".

Notes: This simplified figure is not quite accurate for many reasons.
a - This 2D scheme fully explains the basic principle but needs adjustments in 3D.
b - We do not know whether or not the nucleus contains open volumes in periphery. The "raindrop" or Jensen and Goeppert-Mayer models do not show anything about that.
c - Some irregularities, such as the size of the triton vs. the deuteron, raise questions. However, these exceptions do not question the basic principle described here.

I-4 Nuclear fission

Note: The following explanation is deliberated simplified for teaching purposes.

If an nucleus is broken into independent nucleons (fig. I-2, b to a), closed volumes in gray become open volumes. This transformation produces a depression in spacetime since closed volumes disappear. A kind of "seism in spacetime" appears.

The basic principle of nuclear fission is exactly the same as that of a tsunami. On Earth, a release of tectonic volumes produces high energy waves. In spacetime, when a closed volume is released and becomes open volume, energy (gammas/particles) is produced.

I-5 Mass defect

Note: The following explanation is deliberated simplified for teaching purposes.

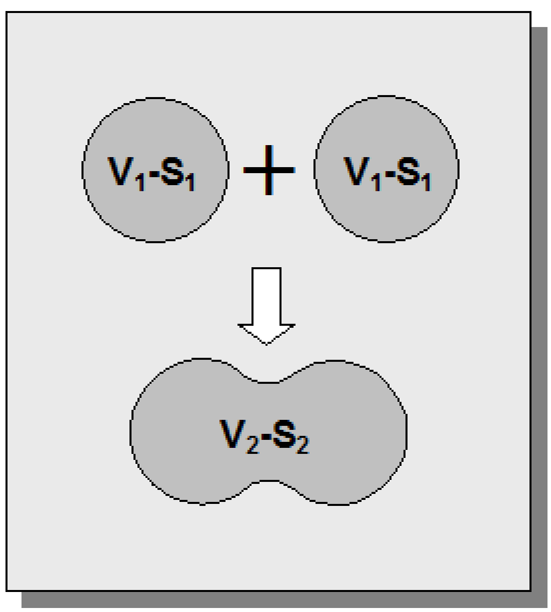

Figure I-3: Simplified explanation of the mass defect

Mass defect is in the heart of nuclear fusion. The latter is a process by which some light atomic nuclei join together to form a single heavier nucleus. A rearrangement of nuclei takes place. The volume and surface of the new nucleus are modified.

Figure I-3 (previous page) shows a fusion of two nuclei with a volume V1 and a surface S1. Result is a nucleus with a different volume V2 and surface S2. Since the ratio volume/surface is different, the mass effect is different too. This explains the mass defect.

However, the rearrangement of the nuclei is a process far more complex than this figure shows. In another study, the author has highlighted that a binary cycle exists inside nuclei. It means that probably a rearrangement of quarks also takes place in the nuclear fusion.

I-6 Dilatation of time

Note: The following explanation is deliberated simplified for teaching purposes.

The twin paradox is a "thought experiment" in which a twin makes a journey into space in a high-speed rocket and returns home to find he has aged less than his identical twin that stayed on Earth. This phenomenon of time dilatation/contraction is covered by special and/or general relativity as appropriate.

To date, using general relativity, we can predict with an excellent accuracy the dilatation or contraction of time in a particular situation. However, no one really understand the phenomenon. This enigma is quite simple to understand with the proposed theory. Here, we cover only the general relativity angle (see the note).

Let's consider two times, "t1" and "t2", in a flat Minkowski spacetime (fig. I-4a) and in a curved spacetime (fig. I-4b).

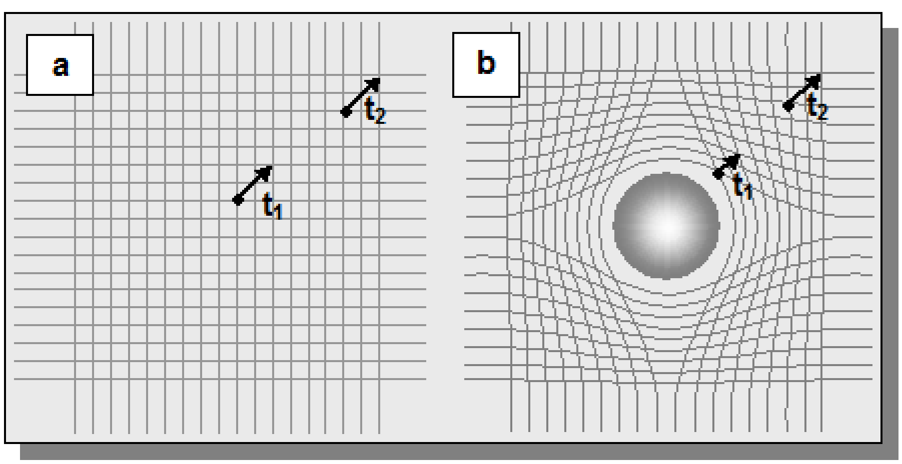

Figure I-4: Simplified explanation of the dilatation of time

Fig. I-4 shows that:
a/ In a flat spacetime far from any object, times t1 and t2 are identical.
b/ In a spacetime curved by a **closed volume**, time t2 is greater than time t1.

Supplementary Information B gives a mathematically demonstration of the curvature of spacetime produced by a closed volume with a spherical symmetry (Schwarzschild Metric). This mathematical demonstration is necessary, but the knowledge of this phenomenon is also necessary. This is why this section have been written. Fig. I-4 (previous page) gives a simple and consistent explanation of this phenomenon.

Notes:
If the volume is static with a spherical symmetry, the mathematical expression of t1 = f(t2) is given by the Schwarzschild Metric (see Supplementary Information B).
On the other hand, this section concerns general relativity (GR), not special relativity (SR). However, if we are moving at relativistic speed relative to a local observer, in this case, we will have a GR + SR combination.

I-7 $E = mc^2$

Note: The following explanation is deliberated simplified for teaching purposes.

Since 1905's, this equation has been successfully verified many times. However, no one can explain this phenomenon, i.e. how mass can be transformed into energy. The theory described here proposes an easy-to-understand solution to this enigma.

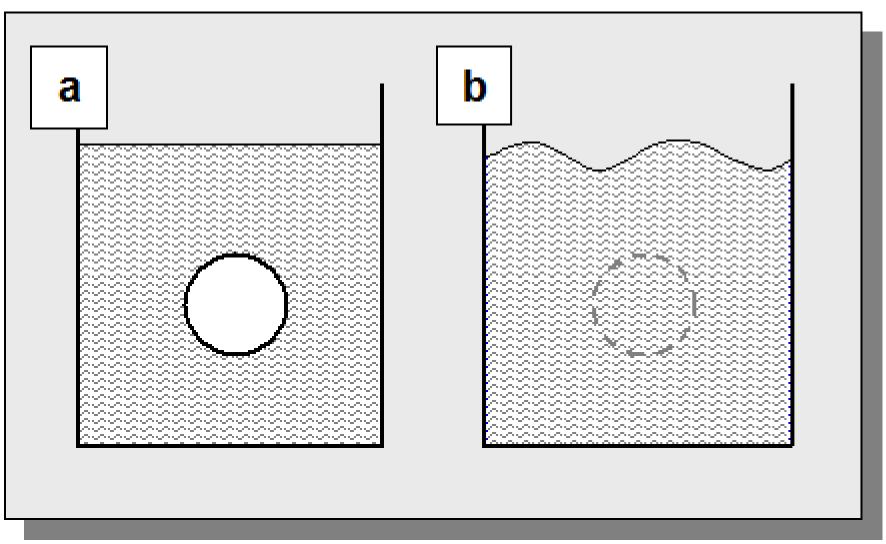

Figure I-5: Simplified explanation to $E=mc^2$

Let's consider the following experimentation (fig. I-5, previous page).

a/ An empty sphere is immersed into a container filled with water.
b/ If the closed volume of the sphere disappears by a thought experiment, the depression will make eddies.

To fully understand E = mc^2 and how mass can be transformed into energy, we must think in "closed volumes" instead of "mass".

Converting a closed volume, into energy follows the same principle. This phenomenon has been explained in the mass excess section:

If a closed volume is transformed into an open volume, "eddies" in spacetime appear, mostly gamma radiations.

Note: Converting gammas into particles is covered by wave-particle duality. In officially registered papers [3], the author explains the wave-particle duality and how gammas can be converted into particles and conversely. The $E = mc^2$ explanation developed in this section therefore can be extended to all particles, fermions and bosons.

I-8 Light deviation

Note: The following explanation is deliberated simplified for teaching purposes.

During a total solar eclipse in 1919, Sir Arthur Eddington observed a light deviation made by the Sun. Here we simulate this phenomenon replacing elasticity of spacetime by that of an expanded polypropylene foam.

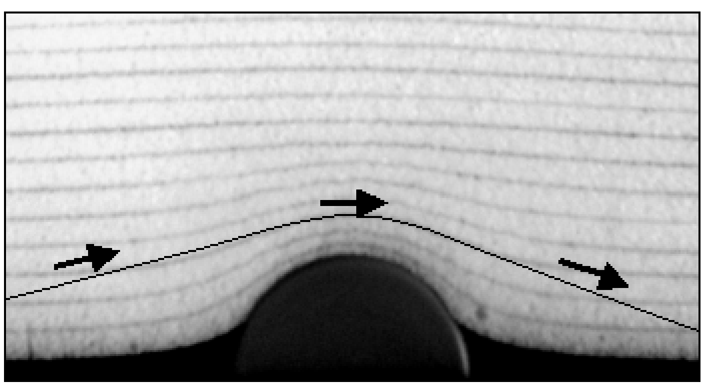

Figure I-6: Light deviation

A set of lines is drawn on the foam and a half-cylinder, acting as a closed volume, is placed under these lines (please see the note concerning the replacement of elasticity of spacetime by that of an EPP foam). Fig. I-6 (previous page) shows that lines are curved. We have exactly the same phenomenon in spacetime. The light follows geodesics of spacetime, as predicted by Einstein, but this curvature of spacetime is not a consequence of the mass - which is nonsense -, but of closed volumes (please remember that Closed Volumes conducts to a Mass Effect).

Notes:

No one knows exactly the structure of spacetime. It is probably more complex than it seems. Some arguments suggest that spacetime could be a part of continuum mechanics, more exactly rheology, despite the fact that this science is applied to non-Newtonian fluids.

Obviously, spacetime isn't a "solid body" as the EPP foam used in this simulation, but could have however the behaviour of rheology. The magnitude of curvature of spacetime is very small, $\Delta R/R$ *= 1.4166 E-39 for the proton. We are therefore working in a linear part of the elasticity curve in common situations. Whatever the kind of fluid mechanics spacetime applies, Newtonian or non-Newtonian, this elasticity exists. It has been shown by Einstein in his EFE and verified many times since 1915's. In conclusion, despite the fact that no one knows exactly what spacetime is, this simulation clearly shows that the light isn't curved by mass, a theory that no one can explain, but by closed volumes, which is much more logical and consistent.*

Suggestions of Predictions

J-1 Introduction

The proposed theory has already be confirmed by a prediction on superluminal neutrinos. More confirmations can be made by simple experimentations such as:

J-2 Particle behavior near a surface

Since the density of spacetime is higher near atoms, the "mass effect" of a particle moving near the surface of an high density object must increase too.

J-3 The moon influence

The curvature of spacetime produced by the moon is added to that produced by Earth. Therefore, the mass of a particle should depend of the position of the moon during the measurement since the spacetime density varies. If two accurate measurements of the mass of a particle are conducted a) when the moon is at zenith and b) 12 hours after, we should note a very light difference in results. Thus, if a continuous measurement is made during 7 days, we must note a sinusoid with 7 periods.

J-4 Crystals

The enigma of a particle crossing a crystal has been already discussed. The proposed theory predicts that the mass, more exactly the "mass effect" of the particle, is directly related with the density of spacetime inside a tunnel, more particularly:

1/ the structure of the lattice of the crystal,
2/ the number of nucleons of atoms of the crystal,
3/ the space between atoms.

The density of spacetime can be theoretically calculated with different crystals. Appropriate experimentations should confirm this calculation.

References

[1] ArXiv 1109.4897, OPERA Collaboration.
[2] ArXiv 1110.3763, ICARUS Collaboration.
[3] Copyright: INPI references: 238268, 238633, 244221, 248427, 258796, 261255, 268327, 297706, 297751, 297811, 297928, 298079, 298080, 329638, 332647, 335152, 335153, 339797, 12/01112.
[4] Prediction: Theory of Everything, ISBN 978 2953 1234-0-1, version 2,53, prediction on page 209, printed on April, 11, 2008, published on May, 3, 2008.