An explanation of the entropic nature of the mass using classical physics

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Introduction

After a century of relativity theory it is now indisputable that energy can be stored in matter. The combined mass of the decay products of an uranium atom is less than the mass of the latter and the energy is indeed proportional to the mass-energy relationship $E = mc^2$.

The mass-energy equivalence should logically apply to any scale. At the chemical level, that energy is stored as mass after an endothermic reaction is in fact perfectly anecdotal; even though Lavoisier was finally wrong, in practice, it's always right. At the mechanical scale, this phenomenon seems so insignificant that it is difficult to conceptualize. At the level of galactic mechanics this phenomenon seem also so insignificant that astrophysicists tend to ignore it completely to rely solely on Newtonian physics. The goal of this paper is to demonstrate that this is not the case and that after reaching a minimum value in systems of common sizes, the importance of the mass-energy balance become increasingly significant with size.

This mass-energy balance is present within potential energy field, and the fact that it has remained so long invisible and intangible is a mystery, it is possible to quote here Leon Brillouin[1,2]

"There is no energy without mass, but it seems that most authors simply ignored the case of potential energy. The founders of Relativity keep silent about it. As a matter of fact, the corresponding energy is spread all around in space, and so is the mass. Symmetry properties of this distribution suggests splitting the mass fifty-fifty between interacting particles. It is necessary to re-evaluate the values of masses, even in the classical theory of relativity, where this consideration was simply ignored. *Renormalization* is absolutely essential, before quantum theory, and must start at the beginning of Einstein's relativity."

Assumptions

1. The relationship of mass-energy equivalence $E = mc^2$ must imperatively be interpreted as follows: *no physical system can gain or lose mass without gain or loss of energy and vice versa*. Here, the energy is composed of exchange particles with energy but without the associated mass like the photon, the gluon or the hypothetical graviton.
2. Nothing suggests that the potential energy of the gravitational field does not have mass. The Higgs boson, likely mediator in the heart of the mechanism of gravitation, is very heavy.

Lets explore the example of a body being absorbed by a black hole within the framework of these two assumptions. It is known that a massive black hole of mass M will attract a mass m_0 initially at rest at a distance d from the outer limit of the black hole, as defined by the Schwarzschild radius. The kinetic energy achieved by this mass before disappearing behind the horizon is $E = ½\, m_0\, c^2$, which implies a 50% increase in mass. The speed of the body is calculated by the relativistic equation of the mass $3m_0/2 = m_0/[1 - (v/c)^2]^{1/2}$ or $v/c = (5/9)^{1/2} = 0.745$. Curiously, in considering the potential as having no mass, an external observer of the system would see a gradual increase of the whole mass of the system $\mathrm{M} + m_0$ to $\mathrm{M} + 3m_0/2$ then stabilize after issuing 10% of kinetic energy in form of radiation. Thus, a fundamental physical system could increase its mass without any external energy input; this situation is in complete disagreement with the relationship of mass-energy equivalence. The most straightforward solution to this would be that the mass is simply stored in the field of gravitational potential energy and was gradually transferred to the system.

The storage of potential energy in gravitational systems of common sizes

Consider now the example of several balls, perfectly isolated and floating in space, possessing no relative speed and arranged a few meters from each other. It is known that after some time, gravity will bring these balls into a larger compact ball, whose state is the lowest possible energy state [i,3]. It is also known that energy is released as heat by the system during the inelastic collision of the balls. Furthermore, the system of the larger compact ball is necessarily lighter than the original system because heat radiation was emitted.

The gravitational potential energy of a system of n balls of mass m_i at the distance r_{ij} from each other is given by this equation (this is the sum of the $(n^2 - n)/2$ potential energy relationship between the balls) :

$$E = -\sum_{i=1,\, j=i+1}^{n-1,\, n} G m_i m_j / r_{ij}$$

To determine the energy loss by the system as radiation when it reaches the state of a pseudo-compact body, that state must be known. The only exact solution is given by a simulation of the system evolution. Even if all balls are perfectly spherical, with the same mass and the same radius, a final compact spherical state composed of balls is not so simple to calculate.

Let us now assume that the radius R and the mass M_0 of the final state sphere is known, that n is very large and $m_i << M_0$ for all balls. Furthermore, the mass center of the final state ball is the same as the original system. Now imagine the almost final compact state of mass $M_0 - m_i$ composed of the meeting of all the small balls except for a single m_i which is kept in its place. The mass center of the almost final compact state is very near to the final compact state but slightly separated from it, and located on the line joining the two bodies. The distance of m_i to the mass center of the system is defined by d_i and the mass $M_0 - m_i$ and M_0 are practically the same. So the calculation of the part of m_i in the energy difference between the final state and the initial state is given by $\Delta E_i = GM_0 m_i / R - GM_0 m_i / d_i = GM_0 m_i (d_i - R) / d_i R$. Thus the total energy difference (entropy) is given by the following equation:

$$\Delta E = \sum_{i=1}^{n} GM_0 m_i (d_i - R) / d_i R$$

This is the total amount of energy lost as radiation, to permit passing from the initial state to the final spherical state. To achieve this, it is necessary to consider that the system is conservative because the gravitational field is conservative. Let us consider the mechanical work w_i of moving a ball m_i from the surface of the final compact state to its initial position. By the law of the conservation of energy, if the same work is performed to another step of the process (intermediate state) and that if the work w'_i is different from w_i then the difference $\Delta w_i = w_i - w'_i$ has been spent or conserved during the transition from the initial state to the intermediate state. The following rule still applies: *if doing work A prior to work B facilitates doing work B, is that the work A was harder, conversely, if doing work A prior to work B makes work B more difficult is that the work A was easier.* It is also necessary to use the permutation symmetry of identical particles (the balls) to accept the fact that moving m_i to the surface of the final state is strictly equivalent to its natural position in the pseudo-sphere letting the system evolve naturally. The thought experiment is much simpler with balls of liquid, the final state is a homogeneous sphere of mass M_0.

The link with the theory of black holes seems obvious; the entropy is necessarily proportional to their surfaces because it's simply the application of the Carnot principle to the phenomenon of gravitation.

This illustrates why physical systems of common sizes (Human scale) do not have much mass-energy induced by the gravitational potential energy; the induced mass $M = \Delta E / c^2$ is small because of the c^2 denominator. However, the mass is inversely proportional to the radius of the final minimal energy compact state.

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i See here Carnot principle and also the black hole thermodynamics and the holographic principle. The decisive step was made by Erik Peter Verlinde who has deduced Newton's laws of the holographic principle; in a formal system, the theorems can always be reused as axioms.

The storage of potential energy in the gravitational systems at a galactic scale

The big difference between galactic systems and mechanical systems of common sizes is that the minimum energy compact state is a black hole; and the radius R is defined by the equation of Schwarzschild: $R_s = 2GM_0/c^2$. Black holes illustrate that it is the existence of the other forces at the level of mechanical systems of common sizes which, against gravity, prevents the potential energy of the gravitational field from being significant. In this case, it is convenient to write the ratio of the mass-energy induced by the inert mass as follows $\Delta E_i/m_ic^2 = GM_0/R_sc^2 - GM_0/d_ic^2$ it follows that $m_i'/m_i = 1/2 - GM_0/d_ic^2$. Here, the second term is negligible and corresponds to values of low energy. By summing all the masses ($\sum m_i' = \sum m_i/2$), the result is $M'/M_0 = 1/2$. Therefore, it is necessary to consider that at least one third of the total mass of the galactic systems is in the form of mass-induced energy.

The self-induction of the mass

The major problem with the phenomenon of gravitational potential energy that can generate mass, is that this new mass must also generate induced gravitational potential energy and therefore additional mass, and so on. This phenomenon does not occur for the other fields such as the electric field, which, by the principle of mass-energy equivalence, also generates induced mass by potential energy. It is also important to note that unlike the magnetic field that is induced by variations of the electric field, the induced mass is constrained to not grow too quickly because otherwise it would tend to infinity. The equation of the mass induced, without the low-energy term, allows to obtain $m_i' = m_i/2$. Thus, curiously, the mass-induced part of the system is independent from the total inert mass of this system, and therefore it is easy to calculate the total mass of a part m_0 which is defined by $m = \sum m_0\,(1/2)^i = 2m_0$. Therefore, the sum of all the parts is $M = 2M_0$. Consequently it seems necessary to consider that at least half, by the principle of self-induction, of the total mass of the galactic systems is in the form of induced mass-energy.

It would be useful to know how the potential energy can diverge; to that end, a self-induction factor Φ can be introduced, therefore $m = \sum m_0\Phi^i$ and this geometric series converges to $m = m_0/(1-\Phi)$ and $M = M_0/(1-\Phi)$. However, it diverges when $\Phi = 1$ and tends to produce a negative mass for values greater than 1 and a mass less than the inert mass for values less than 0; therefore $\Phi \in [0,1[$. By cons, contraction of the relativistic mass only signifies a loss of energy, then let us stay open-minded to $\Phi \in]-1,1[$ which is the convergence limits of geometric series.

Relationship between self-induction and kinetic momentum

The introduction of the self-induction factor Φ in the original formula gives $m_i'/m_i = 1/2 = \Phi = (GM_0/c^2)(2\Phi/R_s)$. In this equation, the only variable factor is R_s and is affected by self-induction. Therefore, the absolute limit of the radius with $\Phi \in [0,1[$ is $R_h = R_s/2\Phi$ so $R_h \in]\tfrac{1}{2}R_s,\infty[$. This limit is exactly that predicted[4] by Kerr using the theory of general relativity. In the case of a Kerr black hole, the radius of the event horizon R_h is written:

$$R_h = \frac{R_s}{2\Phi} = \frac{R_s}{2}[1+\sqrt{1-a^2}];\ a = \frac{Jc}{GM^2} \quad \text{thus} \quad \Phi = \frac{1}{1+\sqrt{1-a^2}} \quad \text{and} \quad a = \sqrt{\frac{2}{\Phi} - \frac{1}{\Phi^2}}$$

Where $a \in [0,1[$ represents the spin of the black hole, J is the black hole momentum and M the black hole mass.

These equations make the link between the mass induced to the angular velocity of the black hole and, by the law of the conservation of the kinetic momentum, to the equivalent system of higher potential energy. For a given spin, its possible to calculate the self-induction as well as the ratio of the total mass to their inert mass:

a	Φ	M/M_0	Values calculated or required for:
0.44	0.53	2.11	Sagitarius A* :Kato, Miyoshi, Takahashi, Negoro, Matsumoto[5]
0.97	0.80	5.11	The Milky Way compacted in a black hole to explain dark matter.
0.99995	0.99	101	Some galaxy clusters compacted in a black hole to explain dark matter.

Induction of dark energy

Dark energy could also be the product of the gravitational potential field. The negative term of the fundamental equation of the induced mass-energy ($\Phi = m'/m = \Delta E/mc^2 = GM_0/R_hc^2 - GM_0/dc^2$) which was negligible at the galactic level becomes important to the superior scales. The following table shows the value of this term at different scales:

Object	Mass (kg)	Radius (m)	-GM/dc²
Sun	2×10^{30}	7×10^{8}	-2×10^{-6}
Galaxy	2×10^{42}	2×10^{21}	-7×10^{-7}

The value used is the radius of the body, however, in spherical shells extremely close to the mass center of the system, Φ value could be negative.

The study of the universe as a whole is extremely interesting. If we consider the critical density ρ_c, radius $r = c/H$ and the mass of the stationary universe of Fred Hoyle[6] $M_0 = 4/3\pi\rho_c r^3$ and our GM_0/rc^2 term then:

$$\rho_c = \frac{3H^2}{8\pi G} \quad , \quad M_0 = \frac{4\pi\rho_c c^3}{3\mathrm{H}^3} \quad \text{and so} \quad M_0 = \frac{c^3}{2\mathrm{GH}} \quad \text{and consequently} \quad GM_0/rc^2 = \frac{1}{2}$$

It is remarkable that the black hole equivalent to the universe does not have spin, which is consistent with Mach's principle. It is possible to calculate the negative side of the equation by assuming that the universe is homogeneous and by setting the average position of the mass at $r/2$ which gives $2GM_0/rc^2$ therefore 1 so $\Phi = -1/2$. Since the common ratio of a geometric series may be negative, the symmetry breaking which occurs when $\Phi < 0$ is more easily treatable by introducing no absolute value in this equation, in this case $M = M_0/(1-\Phi) = 2M_0/3$ but the physical meaning of an alternating series is strange. Consider that if the positive mass-energy has induced a negative mass-energy then, this in turn, the negative mass-energy induces a positive mass-energy and so on.

By considering that the $2M_0/3$ result shall be read as a contraction of the inert mass and like with a positive Φ value it comes to the total mass then: $M = M_0 + \overline{M_0}/3 = 2M_0/3$. By cons, by considering that the inert mass M_0 is only the baryonic mass then we must multiply this mass by a dark matter factor k and therefore $M/kM_0 = 1/(1-k\Phi)$. With k=4 this gives $M = kM_0 + 2k\overline{M_0}/3 = kM_0/3$ or 66.7% of dark energy, 25% of dark matter and 8.3% of baryonic matter. With k=5 this gives $M = kM_0 + 5k\overline{M_0}/7 = 2kM_0/7$ or 71.4% of dark energy, 22.8% of dark matter and 5.7% of baryonic matter. These results are very similar to the dark energy inferred from the Plank satellite data[7] estimated at 68.3% and the ratio of dark matter to baryonic matter evaluated between 4 and 6 according to the different measures. These equations seem to make possible to establish a functional relationship between the amount of dark energy and the ratio of dark matter to baryonic matter. All this suggests that potentially $\Phi \in \,]-\infty,1[$ and by symmetry $\Phi \in \,]-\infty,\infty[$ with a singularity at $\Phi = 1$.

Comparison with general relativity

The self-induction factor is logically necessary: if a body of mass m_0 exposed to a physical factor directly induces a mass m' then this new induced mass exposed to the same physical factor, should also induce a proportional mass. This seems comparable to the expansion of the mass produced by relativistic speed. It is possible to write $\Phi(d) = GM_0/R_hc^2 - GM_0/dc^2 = R_s/2R_h - R_s/2d$ where the first term is a renormalization term dependent on the size and kinetic momentum of the system and is independent of d, therefore, it is practical to define $\omega = 1 - R_s/2R_h$, $\phi = \phi(d) = R_s/2d$ and $\Phi(d) = (1-\omega) - \phi(d)$, which gives $m_0/m_d = 1 - \Phi = \omega + \phi$. The conjecture of the equivalence between gravitational mass and inertial mass forces us to set the following equivalence:

$$\frac{m_0}{m_d} = \frac{t_0}{t_d} = \frac{l_d}{l_0} = \sqrt{1-\left(\frac{v}{c}\right)^2} = \sqrt{(\omega+\phi)^2} = \sqrt{\omega^2 + 2\omega\phi + \phi^2}\,;\, 1-\left(\frac{v}{c}\right)^2 = (\omega+\phi)^2 = \omega^2 + 2\omega\phi + \phi^2$$

By posing $R_h >> R_s$ then $\omega \to 1$, which simplifies the equation at the scale of stellar mechanics, this allows comparison of the mass-energy equation to the Schwarzschild metric:

$$\frac{m_0}{m_d}=\frac{t_0}{t_d}=\frac{l_d}{l_0}=1+\phi=1+\frac{R_s}{2d}=\sqrt{1+2\phi+\phi^2}=\sqrt{1+\frac{R_s}{d}+\left(\frac{R_s}{2d}\right)^2}\ versus\ \frac{t_d}{t_0}=\frac{l_0}{l_d}=\sqrt{1-\frac{R_s}{d}}$$

Although different these equations have numerically the same behavior. Indeed, $1+R_s/2d$ is the second order development of a Maclaurin series of $(1-R_s/d)^{-1/2}$:

$\frac{R_s}{d}$	$1+\frac{R_s}{2d}$	$\frac{1}{\sqrt{1-\frac{R_s}{d}}}$	**Relative Differences**
1 / 2	1.2500	1.4142	1.2×10^{-1}
1 / 10	1.0500	1.0541	3.4×10^{-3}
1 / 100	1.0050000	1.0050378	3.8×10^{-5}
1 / 1000	1.0005000000	1.0005003753	3.8×10^{-7}
1 / 987456	1.0000005063517	1.0000005063521	3.8×10^{-13}

Here, the more space is flat, the more the equations converge to the same value, which is expected since the Schwarzschild metric uses the "weak field approximation" and that our simplification $R_h >> R_s$ did the same thing. The deduction of a fundamental theorem of general relativity without using the Schwarzschild metric is a strong argument in favor of the theory of self-induction of the mass. Since the curvature of space-time predicted by self-induction and that predicted by general relativity are perfectly in agreement at our experimental scale, it is not possible to distinguish both at this scale. Furthermore, the variation of the mass produced by a massive body is completely insignificant at our experimental scale and does not appear to be measurable.

By posing $R_h = R_s$ then $\omega = 1/2$, which normalizes the equation at the static black hole scale, which gives: $1/2+R_s/2d$. There is no singularity here before $d = 0$ and so there is no wormhole as predicted by the Kruskal-Szekeres geometry. Moreover, the time dilation and lengths contraction are infinitely less close to the horizon such that the horizon of a black hole is a place without distortion of space-time.

The case where self-induction is high, consequence of the entropic factor when the body rotates rapidly and has enough mass to collapse into a Kerr black hole, makes comparison much harder. Indeed, it is difficult to address the problem of contraction of bodies with self-induction and complexity of general relativity is the most serious handicap of this theory. The simplicity of the theory of the entropic self-induction permits the use of conventional methods for treating the gravitational field ϕ using the Laplace equation or Legendre[i] polynomials, the geodesics are simply calculated using the relativistic Lagrangian :

$$L=-m_0c^2\sqrt{1-\left(\frac{v}{c}\right)^2}=-m_0c^2(\omega+\phi)\,;\,E=\frac{m_0c^2}{\omega+\phi}$$

Here, the relativistic Lagrangian L is perfectly consistent with our theory and the total mass produced by the free body m_0, calculated relativistically, is indeed $m = E/c^2 = (\mathbf{p}\cdot\mathbf{v} - L)/c^2 = m_0/(\omega+\phi)$.

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i $(\partial_1^2+\partial_2^2+\partial_3^2)V=G\int_M(\partial_1^2+\partial_2^2+\partial_3^2)r^{-1}dM=0 \qquad V(\vec{x})=-\frac{G}{|\vec{x}|}\int_{n=0}^{\infty}\left(\frac{|\vec{r}|}{|\vec{x}|}\right)^n P_n(\cos\theta)\,dm(\vec{r})$

Black hole and relativistic sphere

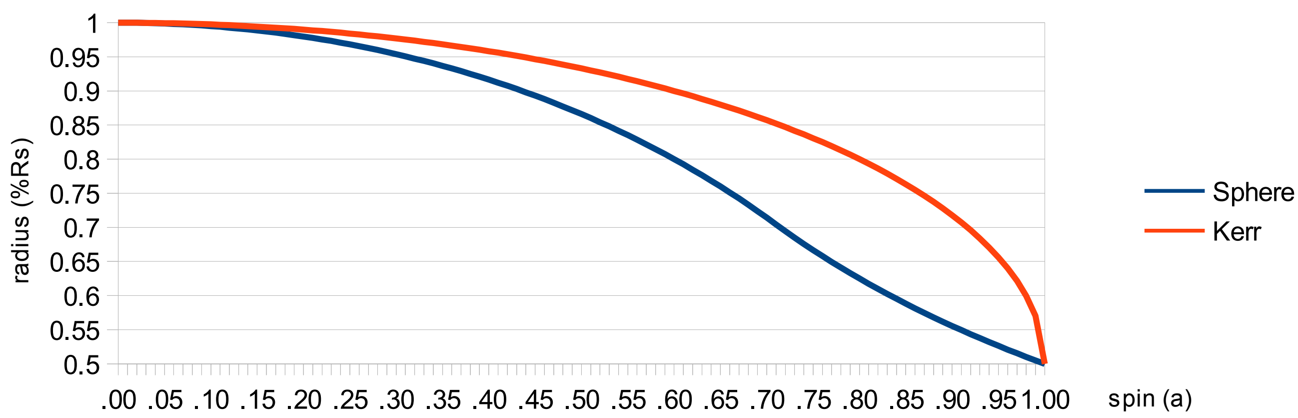
The theory exposed here is derived from Newtonian physics, the fundamental theorem of mass-energy equivalence of special relativity and from the limit theorem of the Schwarzschild radius which can also be derived from Newtonian physics; just pose the escape velocity $V = (2GM/R)^{1/2}$ equals to c which gives well: $R = 2GM/c^2$. The deflection of light produced by a massive body is given by the two equations of Newton $F = ma$ and $F = GMm/R^2$ so $a = GM/R^2$. Thus, it is perfectly clear that light is attracted by a massive body and this notwithstanding the fact that the mass of the photon is zero, the only thing that Newton's equations say is that two photons do not attract each other. Thus, the phenomena of black holes and gravitational lenses are necessary consequences of the Newtonian theory. It is important to remember this fact because many authors neglect it; a theory of relativistic gravitation requires only a proper correction of the Lagrangian.

Currently, the theory of self-inductive entropic gravity (GEST, Gravitational Entropic Self-inductive Theory) uses the characteristics of Kerr black holes deducted from the general theory of relativity. This situation is unpleasant and should be corrected using classical mechanics and special relativity. The only necessary assumption is that the rotating black hole is equivalent to a rigid sphere of radius Rs and therefore it is completely described by a mass M and angular velocity ω or spin $a = \omega/\omega_{max}$. Since the sphere is a stack of disks, the equatorial disk, turning more rapidly, itself determines the minimum radius.

In a circle of radius R and circumference $C = 2\pi R$ in rotation over its center with an angular velocity ω any differential length ∂C of the circumference C can be viewed as moving linearly with velocity $v = \omega R$ and R is therefore contracted to an external inertial observer by a relativistic factor $\partial C'/\partial C = (1\text{-}v^2/c^2)^{½}$. Thus, for the inertial observer, the entire circumference is reduced by this same factor $C'/C = (1\text{-}v^2/c^2)^{½}$ and is the same for the measurement of the radius $R'/R = (1\text{-}v^2/c^2)^{½}$. It should be understood here that this is a thin ring rotating around its mass center and thus there is no physical reality to the radius; the radius measurement is simply deducted from circumference.

A circle of radius Rs can be viewed as a collection of nested circle of radius $R < Rs$ and the maximum angular velocity is determined by the maximum speed of the outer circle $\omega_{max} = c/Rs$. The maximum contraction of all circles occurs when the angular velocity of the disk is ω_{max}. Thus, the relativistic radius R_{rel} of the radius at rest R when the disk has a spin $a = \omega/\omega_{max}$ is $R_{rel}(R,a) = R(1\text{-}\omega^2R^2/c^2)^{½} = R(1\text{-}\omega^2R^2/\omega_{max}{}^2Rs^2)^{½} = R(1\text{-}a^2R^2/Rs^2)^{½}$. The calculation of the derivative gives $\partial R_{rel}(R,a)/\partial R = (1\text{-}a^2R^2/Rs^2)^{½}\text{-}a^2R^2/[Rs^2(1\text{-}a^2R^2/Rs^2)^{½}]$ and by posing $\partial R_{rel}(R,a)/\partial R = 0$ then $R = |Rs/a\sqrt{2}|$ and $R_{rel}(Rs/a\sqrt{2},a) = Rs/2a$.

The maximum contraction of the disk when $a = 1$ is $Rs/2$ but what is surprising is that the circles of radii $R \in [Rs, Rs/\sqrt{2}[$ are found contracted inside the disk and the border is actually made by the circle of radius $Rs/\sqrt{2}$ of the disk at rest. These equations show that for $a \in [0, 1/\sqrt{2}]$ it is the outer circle of radius Rs at rest who determines the radius of the disk by a contraction $R \in [Rs, Rs/\sqrt{2}]$ given by $R = Rs(1\text{-}a^2)^{½}$ while when $a \in [1/\sqrt{2}, 1]$ the radius R of the disk is determined by $R \in [Rs/\sqrt{2}, Rs/2]$ given by $R = Rs/2a$. This relationship is to be compared with the Kerr relationship $R = ½Rs[1+(1\text{-}a^2)^{½}]$:



Conclusion

This paper develops a theory that is the logical extension of two assumptions perfectly consistent with modern physics. This theory is derived from Newtonian physics, from the fundamental theorem of mass-energy equivalence of special relativity and from the limit theorem of the Schwarzschild radius which can also be derived from Newtonian physics. To remain consistent, this theory must introduce the concept of self-induction of the gravitational field energy. This phenomenon of self-induction is used to calculate an absolute limit of contraction of bodies perfectly consistent with our knowledge of the dynamics of black holes, which is also derived from the general relativity.

This theory generates naturally, without the introduction of any constant, dark matter and dark energy at the galactic scale and universal scale respectively. In addition, the order of magnitude predicted by theory for the amount of dark matter and dark energy seems consistent with current measures. The strange coupling relationship between ordinary matter and black matter[8] tends to cause to believe that a self-induction of the mass, as presented, exists in the phenomenon. This theory, unlike an ad hoc modification of the dynamics[9], helps to explain the origin of this renormalization and can be integrated consistently into physics. The development of the theory of relativistic sphere, as the calculation of its moment of inertia, would probably link the galactic mechanics to the black holes one and accurately calculate the self-induction of the galactic mass. Currently, we can only sketch that the galaxies bursting by the centrifugal force are prevented by a negative feedback mechanism; the more rapidly a galaxy rotates, the more it generates mass, slowing by inertia and counteracting by gravity the centrifugal force.

By using the conjecture of equality between the heavy and the inertial mass, it is possible to pose the equality between the expansion of the mass produced by the self-induction to that produced by special relativity, then it is obtained a relativistic field producing the same distortions of time and space that does general relativity at our experimental scale. For cons, the real difference is that the gravitational field produces mass or in a generalized way is itself the mass. If it is not very difficult to accept the idea that electricity is the electric field or magnetism is the magnetic field, the same thinking as regards the mass seems more difficult. However, the theory of general relativity is the answer to the following constraint: *a measure of the mean curvature of spacetime = a measure of the energy density.* If we incorporate the assumption of heavy potential energy in theory of general relativity, we obtain: *the mass is strictly equivalent to the mean curvature of spacetime and vice versa*. It is important to note that without the self-induction phenomenon, general relativity underestimates necessarily the energy density.

This theory having a much simpler mathematical structure than the general relativity is probably much easier to integrate into the standard model and in a grand unified theory. In addition, as for classical Newtonian physics, the singularity occurs only at a null distance from the center of the system, like for all other fields. It is also important to note that the induced laws, used to build this theory, are only the Newton law of the universal gravitation and the invariance of the speed of light used to deduce the special relativity. This is simply the strengthening of the principle of universality of the mass-energy equivalence which forces the logical deduction of this theory.

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Marie-Andrée Cormier (2011), “*Paysage Humain*”, Montreal Museum of Contemporary Art

In this installation, two orthogonal screens show a 3D world perfectly representative of the holographic model of the universe of Verlinde. Characters evolve moving boxes, producing inelastic collisions, the only possible source of photons and therefore of the information on the screen of the universe.