

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

Nicolas Poupart, Independent Researcher (2013)
12269 rue Lévis, Mirabel, Québec, Canada (J7J 0A6)
(450) 939-2167
nicolas.poupart@yahoo.fr

Introduction

Since Einstein and a century's 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 a fact perfectly anecdotal, to remember that Lavoisier was finally in error, but 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 $E = \frac{1}{2} m_0 c^2$, 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 $M + m_0$ to $M + 3m_0/2$ 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) :

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

To know the energy loss by the system as radiation when it reaches the state of a pseudo-compact body, this 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 sphere of final state its known, that n is very large and $m_i \ll M_0$ 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 his 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. Similarly, the mass $M_0 - m_i$ and M_0 are practically the same. The distance of m_i to the mass center of the system is defined by d_i . The calculation 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. Indeed, 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 necessarily been spent or saved during the transition from the initial state to the intermediate state. The following rule still applies: *if do work A prior to the work B facilitates the work B is that the work A was harder; conversely, if do work A prior to work B makes the 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 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.

i See here Carnot principle and also Hawking and Bekenstein theory who demonstrate the existence of black hole thermodynamics. Also, view here the holographic principle of Hooft and Susskind. The decisive step was made by 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: $R_s = 2GM_0/c^2$. The 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 to become significant. In this case, it is convenient to write the ratio of the mass-energy induced by the inert mass as follows $\Delta E_i/m_i c^2 = GM_0/R_s c^2 - GM_0/d_i c^2$ it follows that $m_i'/m_i = 1/2 - GM_0/d_i c^2$. Here, the second term is negligible and corresponds to values of low energy. By summing all the mass ($\sum m_i' = \sum m_i/2$), 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 $m = \sum m_0 (1/2)^n = 2m_0$. 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 $m = \sum m_0 \Phi^n$ 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 factor can vary is R_s ; and this is the one is affected by self-induction. Therefore, the absolute limit of the radius with $\Phi \in [0,1[$ because a negative radius would be meaningless is $R_h = R_s/2\Phi$ so $R_h \in]\frac{1}{2}R_s, \infty[$. This limit is exactly that predicted⁴ 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:

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

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	1.05	2.11	Sagittarius A* :Kato, Miyoshi, Takahashi, Negoro, Matsumoto ⁵
0.97	1.61	5.11	The Milky Way compacted in a black hole to explain dark matter.
0.99995	1.98	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 ($\Phi = m'/m = \Delta E/mc^2 = GM_0/R_h c^2 - GM_0/dc^2$) 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/dc ²
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 Hoyle⁶ $M_0 = 4/3\pi\rho_c r^3$ and our GM_0/rc^2 term then:

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

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 $\Phi = -1/2$. 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: $M = M_0 + \bar{M}_0/3 = 2M_0/3$. By cons, by considering that the inert mass M_0 is only the baryonic mass then we must multiplied this mass by a dark matter factor k and therefore $M/kM_0 = 1/(1-k\Phi)$. With $k=4$ this gives $M = kM_0 + 2k\bar{M}_0/3 = kM_0/3$ or 66.7% of dark energy, 25% of dark matter and 8.3% of baryonic matter. With $k=5$ this gives $M = kM_0 + 5k\bar{M}_0/7 = 2kM_0/7$ 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 data⁷ 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 $\Phi \in]-\infty, \infty[$.

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 $\Phi(d) = GM_0/R_h c^2 - GM_0/dc^2 = R_s/2R_h - R_s/2d$ but the first term is a renormalization term depending 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 force us to set the following equivalence:

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

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

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

These equations, although different, 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	1.000500000	1.0005003753	3.8×10^{-7}
1 / 987456	1.0000005063517	1.0000005063521	3.8×10^{-13}

Here, more the space is flat, more the equations converge to the same value, which is normal since the Schwarzschild metric uses the "weak field approximation" and that our simplification $R_h \gg R_s$ 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. Because 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 measurably.

By posing $R_h = R_s$ then $\omega = 1/2$, which normalizes the equation at the static black holes 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. Here, the horizon of a black hole is a place without any distortion of space-time and the accretion disks are probably less energetics.

The comparaisn when the 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 is 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, permit to use conventional methods for treating the gravitational field ϕ using the Laplace equation or the Legendre' polynomials, the geodesics are simply calculated using the relativistic Lagrangian :

$$L = -m_0 c^2 \sqrt{1 - \left(\frac{v}{c}\right)^2} = -m_0 c^2 (\omega + \phi); E = \frac{m_0 c^2}{\omega + \phi}$$

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 $m = E/c^2 = (\mathbf{p} \cdot \mathbf{v} - L)/c^2 = m_0 / (\omega + \phi)$.

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

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; just pose the escape velocity $V = (2GM/R)^{1/2}$ equals to c which gives well: $R = 2GM/c^2$.

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.

The black hole entropy is also easily explained by this theory, if a set of body $\{m_i\}$ collapses into a black hole, the resulting mass of the black hole is $M = \sum m_i + \frac{1}{2} \sum m_i + \frac{1}{2} \sum m_i$ this is the inert mass added to the mass directly induced and transformed into velocity and added to the mass induced by the induced mass probably remaining outside the horizon of the black hole in the form of a gravitational field. This residual amount is well $\frac{1}{4}$ of the total mass.

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 matter⁸ tends to cause to believe that a self-induction of the mass, as presented, exist in the phenomenon. This theory, unlike an ad hoc modification of the dynamics⁹, helps to explain the origin of this renormalization and can be integrated consistently into physics.

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 general relativity at our experimental scale. By cons, regarding black holes, they are very quiet compared to that predicted by the theory of general relativity, accretion disks are slower and there is no wormhole nor white hole. What seems to be confirmed by the non-observation of these phenomena.

For cons, the real difference is that the gravitational field produce mass or in generalized way that 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 Newtonian classical physics, the singularity occurs only at a nul 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.

- 1 Léon Brillouin (1964), “*L’énigme $E = Mc^2$: énergie potentielle et renormalisation de la masse*”, Journal de Physique, France, Volume 25, Number 10.
- 2 Léon Brillouin (1965), “*The actual mass of potential energy, a correction to classical relativity*”, Proceedings of the National Academy of Sciences, Volume 53, Number 3.
- 3 Erik Peter Verlinde (2011), “*On the Origin of Gravity and the Laws of Newton*”, Journal of High Energy Physics, Volume 4, Number 29.
- 4 Roy Kerr (1963), “*Gravitational field of a spinning mass as an example of algebraically special metrics*”, Physical Review Letters, Volume 11, Number 5, p.237–238.
- 5 Y. Kato, M. Miyoshi, R. Takahashi, H. Negoro, R. Matsumoto (2010), “*Measuring spin of a supermassive black hole at the Galactic Centre – Implications for a unique spin*”, arXiv:0906.5423v2 [astro-ph.GA]
- 6 Valev, Dimitar (2010), “*Estimation of the total mass and energy of the universe*”, arXiv:1004.1035v [physics.gen-ph].
- 7 P.A.R Ade, N. Aghanim, C. Armitage-Caplan, and al. (Planck Collaboration) (2013), “*Planck 2013 results. I. Overview of products and scientific results – Table 9*”. arXiv:1303.5062. Bibcode:2013arXiv1303.5062P.
- 8 Gianfranco Gentile, Benoit Famaey, HongSheng Zhao, Paolo Salucci (2009), “*Universality of galactic surface densities within one dark halo scale-length*”, Nature, Volume 461, p.627-628.
- 9 M. Milgrom (1983), “*A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis*”, Astrophysic Journal, Volume 270, p.365–370.