

Energy is the Expansion

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Here, using Mach's principle we symmetrize the Schwarzschild solution. It enables to compute the universe densities of baryonic matter, dark matter, and dark energy as distinct effects of the same unique source and the time invariance of the theory naturally gives an inflation period (or its illusion). The theory does not change GR equations but its classical limit is a MOND theory which parameter is predicted. Hence we claim the discovery of a natural law.

1 Introduction

In relativity and cosmology, the mystery of the time is the nature of dark matter and dark energy. Dark matter is inferred from the anomalous galaxies rotation curves and dark energy from the universe accelerated expansion. The debate is long open between dark matter particles and modified gravity; the nature of the dark energy field is unknown. On the other hand of physical theories, quantum gravity which cannot be renormalized and gives absurd predictions.

The purpose of this paper is to provide with a natural solution to the first issue without modifying GR, firstly by computing the amount of matter, dark matter and dark energy from elementary symmetry considerations; thus uncovering a fundamental law of nature. It addresses in the most general manner the long expected rule of energy and metric formation — namely space-time and everything therein. We also show that the classical approximation is a MOND-type theory and compute its parameter. Concerning quantum gravity, it shows why a different approach is needed.

Note that all masses, densities and accelerations in this paper are computed using as input the universe age T given by the Planck mission and two natural constants G , and c . The other Λ CDM parameters output of this mission are only used for comparison.

2 Theory

Theoretical physics works by the study of symmetry; for any variation, compensation exists. The universe expands, therefore compensation exists and then symmetry. Take the Einstein field equation:

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} - \Lambda g_{\mu\nu}, \quad (1)$$

where the term Λ is experimentally justified and is a constant scalar; meaning its density is constant in space. It leads to results which are unique in physics: two kinds of energies do not transform in each other and, as we know from phenomenology, it eventually requires a third kind with the same property, namely dark matter. This is the problem we shall discuss.

On the other hand the Λ CDM model is well verified and it gives no reason to doubt the Friedman-Lemaitre-Robertson-Walker (FRLW) cosmology. Therefore we shall neither modify gravity nor implement ad-hoc fields, but instead discuss energy formation; masses, the scalar Λ , and their relation with G . For this we shall take the problem by the other end and use the standard short distance case with central mass M . The Schwarzschild spherical solution reads:

$$c^2 d\tau^2 = \left(1 - \frac{R_s}{r}\right) c^2 dt^2 - \left(1 - \frac{R_s}{r}\right)^{-1} dr^2 - r^2 (d\theta^2 + \sin^2\theta d\phi^2). \quad (2)$$

This “local” solution does not admit a scalar Λ ; it is not appropriate but we shall make direct use of this defect. If we properly instantiate Mach's principle therein we should get a nice correction, because by definition it should includes all effects. The symmetry in (2) is unbalanced since two of the quantities are not geometrical, namely G and M . Then in an attempt to symmetrize the Schwarzschild solution we write:

$$\frac{R_s}{r} = \frac{R_U M}{M_S r} \rightarrow \frac{2G}{c^2} = \frac{R_U}{M_S}, \quad (3)$$

where M_S and R_U represent respectively the scalar field energy and the distance to the event horizon ($R_U = cT$). Note that this equation instantiates Mach's principle in the most trivial manner. Now compute:

$$M_S = \frac{R_U c^2}{2G} = 8.790 \times 10^{52} \text{ kg}. \quad (4)$$

It looks to the observer like an energy contained in a 3-sphere, but it is actually a conic 4-dimensional structure intersecting the present, the surface of the 4-sphere. Then consider the constancy of Λ : with respect to the 4-sphere volume, and in order to reduce to its surface, we divide M_S by the 4-sphere surface coefficient, namely $2\pi^2$; we get:

$$M_V = \frac{M_S}{2\pi^2} = 4.453 \times 10^{51} \text{ kg}, \quad (5)$$

which corresponds to 4.82% of the total mass and density:

$$M_{total} = M_S + M_V = 9.236 \times 10^{52} \text{ kg}, \quad (6)$$

$$D_{total} = \frac{3(M_S + M_V)}{4\pi R_U^3} = 9.91 \times 10^{-27} \text{ kg/m}^3. \quad (7)$$

All numerical results above are in great agreement with the Planck mission outputs [1] even though we get a single dark field M_S summing dark energy and dark matter.

The Planck mission also gave $H_0 = 67.74$ (46) km/s/Mpc and we use $H = 1/T = 71.10$ km/s/Mpc to compute the distance to the event horizon. Then compare:

$$\frac{M_S + M_V}{M_S} = 1 + \frac{1}{2\pi^2} = 1.0507, \quad (8)$$

with:

$$\frac{1}{H_0 T} = 1.0496. \quad (9)$$

This utterly stunning not only for the right orders of magnitude, but for getting also the first two or three decimals right and multiple coincidences — seemingly coherent — which, in principle, address independent quantities. Considering also that from (3) M_S is the critical density, it suggests that the mass terms are linked to G by geometry in a manner that is consistent with GR; possibly a fundamental law of nature ruling the universe formation. Now the equation (4) also reads:

$$2M_S c^2 = P_p T = \frac{P_p R_U}{c}, \quad (10)$$

where $P_p = c^5/G$ is the Planck power. It looks as though a 4-sphere at the surface of which observable energy lies is either inflated or heated by a constant feed; in other words, it replaces the big bang singularity by a constant power and the correlation is such that we must conjecture the following identification: *energy is the expansion*; meaning that M_S and M_V increase linearly in time. Expansion is observed, and then we shall discuss the conjecture as a new theory which is embodied by the equation (3) and the following premises:

- P1: The scalar Λ is a constant of nature.
- P2: The matter field (all particles) is the surface of a 4-sphere.
- P3: A feed mechanism exists inflating the sphere and expanding its inner metric; both effects are simultaneous.
- P4: The inner metric expansion is the product of inflation of the sphere radius by the reduction of particles wavelengths; both effects have identical coefficients.

Essentially, we states that M_S is the critical density, that the matter field M_V has no effect on the course of the universe expansion, and that the source terms of the Einstein field equation (1) are not identified for what they are. In the following sections we analyze what the new theory predicts.

3 Predictions

3.1 Inflation

Considering P3 and P4 the wavelength of massive particles reduce in time while the 4-sphere expands, the product of this reduction by this expansion gives a linear increase of the universe radius.

But this is considering constant energy; since the wavelengths reduce the relative rate of time is not constant between distinct epochs and reaches zero at the origin. Therefore the theory requires an inflation period; the global curve is a straight line if expressed in “constant” time T , but a logarithmic law if expressed in proper time.

3.2 The dark matter effect

Let us study the effects at different heights in the gravitational pit of a central mass M (the basic test case) and assume the system far away from other gravitational sources. With respect to (2), M_S is variable in time but constant in space ($M_S \sim T$). At the opposite since gravitation is a retarded interaction, the metric in r is retarded and the equation (3) must be modified accordingly. Hence, using P3-P4, since r and M (or R_s) expand, we write:

$$\frac{R_s}{r} \rightarrow \frac{R_s}{r} \times \sqrt{\frac{1 - Hr/c}{1 + Hr/c}}, \quad (11)$$

which second order limited development yields:

$$\frac{2GM}{rc^2} \rightarrow \frac{2GM}{rc^2} - \frac{M}{M_S} + \frac{Mr}{M_S R_U}. \quad (12)$$

Now examine this expression:

- The first term is nominal.
- The middle term cannot be seen negligible since it addresses identically all masses of the universe. Hence it must be identified to the contribution of M_S to the mass M , and then integrated to M_S , giving -1 which is the flat metric. Finding the flat metric here may look stunning but it is coherent with its production.
- Therefore the right hand term must also be integrated to M_S giving Hrc of unit squared velocity, and a cosmological term Hc with unit of acceleration; it comes from the expansion but its effect in the gravitational field is not trivial.

Still, we know that this value is in the range of the anomalous acceleration at galaxies borders. Then let us discuss angular momentum.

Quantum gravity is usually expected to work from the same principles as any other field. But this assumption holds a fundamental contradiction with the spirit of GR and even more with the theory we discuss, because here gravitation defines *entirely* the context in which the rest of physics lives. In this way, the position of M_S at the denominator of (3) is quite evident since like GR it scales the matter field — but globally. Still, the theory is compatible with the SM fields. The bottom line is scale-independence and all SM couplings constants are unitless including mass ratios.

Now on angular momentum, consider simply the Bohr radius for the simplest but most general case:

$$a_0 = \frac{\hbar}{m_e c \alpha} = \frac{1}{2\pi} \times \frac{\lambda_e}{\alpha}. \quad (13)$$

We know that the fine structure constant α did not change during many billion years; then with a linear increase of m_e , the electron wavelength and the Bohr radius decrease together and coherently; but when considering only lengths like in (13) the orbit radius scaling factor is $1/2\pi$.

Expressing this simply, when the electron mass increases in time, the Bohr radius and the first Bohr orbit reduce like:

$$\frac{da_0}{dt} = \frac{d\lambda_e}{\alpha dt} \times \frac{1}{2\pi} \rightarrow \frac{\alpha da_0}{d\lambda_e} = \frac{1}{2\pi}. \quad (14)$$

But this contraction is universal. It addresses all phenomena ruled by quantum physics (rulers, clocks, etc...); *it is not measurable where only quantum physics rules.*

But there is a neat difference with gravitation: with quantum fields, angular momentum quantizes distances as the inverse of mass, but gravity cannot since its classical force is a product of masses. With the product of two masses increasing simultaneously, we get a square and only half the effect is non-measurable. *Hence in the gravitational field a residual term $Hc/2\pi$ gives measurable effects.*

3.3 Dark matter and dark energy

In the spirit of the coincidence in (4), GR (or the Λ CDM model) splits the scalar energy M_S into a massive dark matter field and the scalar field Λ , and we have a compression factor which derivative is Hc applied on any piece of the matter field M_V . But for *any* scalar field X having this double effect, and for any R and $H_R = c/R$, its compression energy M_{Co} (dark matter) at any place is given by:

$$\frac{M_{Co}}{M_X} = \frac{1}{2} \int_0^R \frac{4\pi \rho_X r^2}{M_X c^2} (H_R c r) dr = \frac{3}{8} = 0.375, \quad (15)$$

where in the integral energy is given by acceleration, then kinetic energy $p^2/2m$; thus the factor $1/2$. The kinetic impact of X has effect of pressure and its energy is calculable. Obviously, the Planck mission gave the same result:

$$\frac{\Omega_C}{\Omega_{DE}} = \frac{0.2589}{0.6911} = 0.3746. \quad (16)$$

From this equation the sum $\Omega_C + \Omega_{DE} = \Omega_S$ is not a split but a unique field giving distinct effects ruled by geometry, a consequence of which is M_S :

$$\Omega_S = 2\pi^2 \Omega_V = \frac{11}{8} \Omega_{DE} = \frac{11}{3} \Omega_C. \quad (17)$$

This is not unification of distinct fields, this is unity. In GR:

- Ω_{DE} provides with negative pressure, a repelling force;
- Ω_C is seen as mass but here it must be seen as counterpart, an isotropic stress *and* a positive pressure applied to massive particles by the same repelling force; in the equation (1), stress is part of the stress-energy tensor.
- Ω_V the matter density is the proportion of their sum at the 4-sphere surface.

Here there is no contradiction with (1) nor with the FLRW universe; but the concept appears to imply that dark matter is pressure and that mass is compression work.

3.4 The Hubble parameter

Let a photon be emitted in A at date t_1 with observable energy m , the transit time to the receptor in B is t , and then $t_1 + t = T$. It has no mass, but it takes away a part of the emitter mass m , and then the full energy it transfers includes its share of M_S and corresponds to $m(2\pi^2 + 1)$.

During the transfer, its wavelength increases of a factor $\sqrt{(t_1 + t)/t_1}$. Hence:

$$m_{\text{transfer}} = \frac{(2\pi^2 + 1) \sqrt{t_1}}{\sqrt{t_1 + t}} m.$$

But during the time t , the mass of the receptor evolved by a factor $\sqrt{t_1} \rightarrow \sqrt{t_1 + t}$. Therefore the energy transferred by the photon to the receptor, before it reconstitutes mass in B evolves like:

$$\frac{m_{\text{transfer}}}{m_{\text{receptor}}} \sim (2\pi^2 + 1) \frac{t_1}{t_1 + t}.$$

Once the photon is absorbed, it gives:

$$\frac{m_{\text{absorbed}}}{m_{\text{receptor}}} \sim 1 - Ht, \quad (18)$$

which is standard red-shift for a universe of age T expanding at constant rate c for which $HT = 1$. It fits with observation of type 1A supernova with accelerated expansion due to the scalar field Λ . On the other hand, consider a field of photons created at the origin (not emitted by mass); the term $(2\pi^2 + 1)$ is not present at emission, meaning in facts that the field M_S has decayed of a factor $(1 + 1/2\pi^2)^{-1}$ with mass creation; hence the equation (9). So the theory predicts a discrepancy between measurements of the Hubble parameter from the CMB and type 1A supernovas:

$$H_{1A}^0 = \frac{1}{T} = H_{CMB}^0 \left(1 + \frac{1}{2\pi^2}\right). \quad (19)$$

This equation is in range of the discrepancy given by the Hubble space telescope measurements in [5], which is currently valid at $\sim 3\sigma$, as compared to the Planck mission. Older data is also compatible with the prediction.

3.5 The classical limit

The limited development in (12) also applies in the classical theory provided a retarded field. (Even though we would obtain $M_S \rightarrow 2M_S$ with a classical equation in place of (3) and the same reasoning.) According to (14), the cosmological term to apply is is:

$$S_{HC} = \frac{Hc}{2\pi} = 1.10 \times 10^{-10} \text{m/s}^2, \quad (20)$$

where Milgrom's limit is $a_0 = 1.20 (\pm 0.2) \times 10^{-10} \text{m/s}^2$; so we shall compare with MOND.

But here S_{HC} is a derivative that scales the gravitational field and it cannot be independent of the “normal” acceleration. In a classical manner we need to discuss forces with the following substitution:

$$\frac{G m M}{r^2} \rightarrow \frac{G m M}{r^2} + m S_{HC},$$

which, on circular orbit, corresponds to the Newton acceleration at a distance R such that:

$$\frac{G M}{R^2} = \frac{G M}{r^2} + S_{HC}.$$

Then multiplying this expression by $R^2 r^2$, using $A = G M/r^2$ we get:

$$R^2 = r^2 \left(1 + \frac{S_{HC}}{A}\right)^{-1}.$$

Now this result is the exact opposite of MOND interpolation. This is perfect since we work in forces while MOND modifies the dynamics, namely the effective acceleration a but preserves the Newton force. Then reversing the correction, that is conserving the Newton force in r , using MOND concept that is an anomalous acceleration a and notations with $a_0 = S_{HC}$, we get:

$$\mathbf{F} = m \mathbf{a} \left(1 + \frac{a_0}{a}\right)^{-1}, \quad (21)$$

which is the so called “simple” MOND interpolation function. Hence the classical approximation is MOND [4], which is important considering the wide range of effects it predicts that agree with observation.

It shows, rather stunningly, that MOND and GR as it is are not incompatible, but that the former comes naturally as the classical approximation of the latter if we replace the big bang energy emission by a constant feed. Here again there is no need to choose between modified gravity and dark matter particles; we find that both are irrelevant.

3.6 Other consequences

Firstly the theory does not need dark matter particles nor does it accept any. Considering the “energy feed” a good candidate is a continuous scalar field propagating at light speed — and quantum physics live therein; importantly, the existence of such a field is opposite to the very notion of isolated particle. Secondly, all fields known to particles physics take energy at the same source and they do so permanently; unity is there but theories are not unified. Hence, even though it requires an intuitive leap, the consequence is that all parameters of the SM of particle physics reduce to geometry; a geometry which is scale-independent and fits locally and globally with the new theory. Those parameters need to be natural.

4 Conclusions

It is well known that Einstein was influenced by Mach’s principle when designing general relativity. In this article, the principle is expressed in the most trivial manner and leads to an extended theory enabling to compute the densities of the matter, dark matter, and dark energy fields of the Λ CDM model. Its classical approximation is MOND which parameter and equation are predicted; it shows that the Λ CDM and MOND are discussing the same physics. This is an enlightening surprise for it shows the irrelevance of discussing modified gravity and dark matter particles. The theory is also instructive as to the structure of space-time and imposes constraints to its evolution, but also to its nature and origin. It refutes the existence of a big bang as a huge and final energy emission — the very first issue in cosmology; instead it provides with a first step toward unity.

Hence, considering those results, we claim the discovery of law of nature that rules gravity and the universe formation, including metric and energy.

A first note [6] on this theory was previously published by the same author. With respect to this note the present paper was written based on minimal hypothesis.

5 Addendum

The new theory implies that an almost empty galaxy will be understood as made of close to 100% dark matter. Here, with an estimate of 98% dark matter, the observations of Dragonfly 44 recently reported by Van Dokkum & al. [2] is an important test because it will be systematic. A similar ratio will be found in any galaxy of this type; in a general manner, the lesser the baryonic mass the higher the ratio of dark matter given by the standard theory.

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