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DISCRETE SYMMETRIES AND GENERAL RELATIVITY, THE DARK SIDE OF GRAVITY

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The parity, time reversal and space/time exchange invariant actions, equations and their conjugated metric solutions are obtained in the context of a general relativistic model modified in order to suitably take into account discrete symmetries. The equations are not covariant however the predictions of the model, in particular its Schwarzschild metric solution in vacuum, only start to differ from those of General Relativity at the Post-Post-Newtonian order. No coordinate singularity (black hole) arises in the local privileged coordinate system where the energy of gravity is found to vanish. Vacuum energies cancel as gravitational sources in the global privileged coordinate system where a flat universe accelerated expansion phase is obtained without resorting to inflation nor a cosmological constant. The context may be promising to help us elucidate several outstanding enigmas such as the Pioneer anomalous blue-shift, flat galactic rotation curves or the universe voids. A gravitational wave solution of a linear equation is obtained with the same binary pulsar decay rate as observed and predicted in GR.

Keywords: Negative energy; time reversal, tachyon.

1. Introduction

We might summarize the point of view developed in Ref. 1 as follows: any physicist would agree that symmetries are fundamental in contemporary physics. They both allow to constrain the form assumed by the actions and the properties of the basic objects such as fields from which the actions are built and the phenomenology is derived. If we miss some fundamental symmetry of mother nature or misunderstand the way it works, the physical world description we will derive might be either totally wrong or in the best case incomplete. As is well known, a discrete operator such as the time reversal one in Quantum Field Theory may be either unitary or anti-unitary. The anti-unitary choice for it is the conventional one, and the commonly accepted derived picture undoubtedly constitutes an important part of our culture. However, our starting point in Ref. 1 was to take serious the other mathematical possibility for the time reversal operator, e.g. that it be unitary and see how far we could follow this theoretical option. Then a very different conception of time reversal arises together with negative energy fields. However, at some point we found that

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there is no way to reach a coherent description in flat space-time. But fortunately, we know that the complete picture should include gravity and this, as we shall show, naturally allows us to achieve our primary goal: understand time reversal and by the way the negative energy representations of the Lorentz group. The reader is referred to Ref. 1 for our investigation of negative energies and time reversal restricted to QFT in flat space-time but an interesting analysis can also be found in Ref. 2.

2. Negative Energies in Quantum Field Theory

Let us gather the main information we learned from our investigation in Ref. 1 of negative energies in Relativistic QFT indicating the the correct theoretical framework for handling them should be found in a modified GR.

- **The Theoretical Viewpoint**

In second quantification, all relativistic field equations admit genuine negative energy field solutions creating and annihilating negative energy quanta. Unitary time reversal links these fields to the positive energy ones. The unitary choice, usual for all other symmetries in physics also allows to avoid the well known paradoxes associated with time reversal. Positive and negative energy fields vacuum divergences we encounter after second quantization are unsurprisingly found to be exactly opposite. The negative energy fields action must be maximised. However there is no way to reach a coherent theory involving negative energies in flat-spacetime. Indeed, if positive and negative energy scalar fields are time reversal conjugated, their Hamiltonian densities and actions must also be so which we find to be only possible in the context of general relativity thanks to the metric transformation under discrete symmetries.

- **The Phenomenological Viewpoint**

In a mirror negative energy world which fields remain non coupled to our world positive energy fields, stability is insured and the behavior of matter and radiation is as usual. Hence, it's just a matter of convention to define each one as a positive or negative energy world. Only if they could interact, would we expect hopefully promising new phenomenology since many outstanding enigmas, among which are the flat galactic rotation curves, the Pioneer effect, the universe flatness, acceleration and its voids, indicate that repelling gravity might play an important role in physics. On the other hand, negative energy states never manifested themselves up to now, strongly suggesting that a barrier is at work preventing the two worlds to interact except through gravity.

- **The Main Issues**

A trivial cancellation between vacuum divergences is not acceptable since the Casimir effect shows evidence for vacuum fluctuations. But in our approach, the positive and negative energy worlds are maximally gravitationally coupled in such a way as to only produce exact cancellations of vacuum

energies gravitational effects. Also, a generic catastrophic instability issue arises whenever quantum positive and negative energy fields are allowed to interact. If we restrict the stability issue to our modified gravity we will see that this disastrous scenario is also avoided. At last, allowing both positive and negative energy virtual photons to propagate the electromagnetic interaction simply makes it disappear. The local gravitational interaction is treated very differently in our modified GR so that this unpleasant feature will also be avoided.

- Outlooks

A left-handed kinetic and interaction Lagrangian can satisfactorily describe all known physics (except mass terms which anyway remain problematic in modern physics). This strongly supports the idea that the right handed chiral fields might be living in another world (where the 3-volume reversal under parity presumably would make these fields acquire a negative energy density) and may provide as shown in Ref. 1 an interesting explanation for maximal parity violation observed in the weak interaction.

If the connection between the two worlds is fully reestablished above a given energy threshold, then loop divergences naturally would get cancelled thanks to the positive and negative energy virtual propagators compensation. Such reconnection might take place through a new transformation process allowing particles to jump from one metric to the conjugated one presumably at places where the conjugated metrics meet each other.

3. Conjugated Worlds Gravitational Coupling

From Ref. 3 we learn that if Parity and Time reversal transform the general coordinates, this will not affect a scalar action however if the inertial coordinates ξ^α are also transformed in a non-trivial way:

$$\xi^\alpha \xrightarrow{T} \tilde{\xi}_T^\alpha, \quad \xi^\alpha \xrightarrow{P} \tilde{\xi}_P^\alpha, \quad (1)$$

non-trivial in the sense that in general $\tilde{\xi}^\alpha \neq \xi_\alpha$, our metric terms will be affected and our action is not expected to be invariant under P or T. Having two conjugated inertial coordinate systems, we can build, following the usual procedure, two time or parity reversal conjugated metric tensors:

$$g_{\mu\nu} = \eta_{\alpha\beta} \frac{\partial \xi^\alpha}{\partial x^\mu} \frac{\partial \xi^\beta}{\partial x^\nu}, \quad \tilde{g}_{\mu\nu} = \eta_{\alpha\beta} \frac{\partial \tilde{\xi}^\alpha}{\partial x^\mu} \frac{\partial \tilde{\xi}^\beta}{\partial x^\nu}. \quad (2)$$

Then, a new set of fields will couple to our new $\tilde{g}_{\mu\nu}$ metric field. The total action will be the sum of I_M , the usual action for matter and radiation in the external gravitational field $g_{\mu\nu}$, \tilde{I}_M the action for matter and radiation in the external gravitational field $\tilde{g}_{\mu\nu}$ and the actions $I_G + \tilde{I}_G$ for the gravitational fields alone. The conjugated actions are separately general coordinate scalars and adding the two pieces is necessary to obtain a discrete symmetry reversal invariant total action.

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$g_{\mu\nu}$ and $\tilde{g}_{\mu\nu}$ are linked since these are symmetry reversal conjugated objects explicitly built out of space-time coordinates. We postulate that there exists a general coordinate system such that $\tilde{g}_{\mu\nu}$ identifies with $g^{\mu\nu}$ where for instance a discrete time reversal transformation applies as $x^0 \rightarrow -x^0$. In this system, varying our action, applying the extremum action principle and making use of the relation $\delta g^{\rho\kappa}(x) = -g^{\rho\mu}(x)g^{\nu\kappa}(x)\delta g_{\mu\nu}(x)$ would lead us to a modified Einstein equation (with $c = 1$) :

$$-8\pi G \left(\sqrt{g(x)} T_{\rho\sigma} - \sqrt{g^{-1}(x)} \tilde{T}^{\rho\sigma} \right) = \sqrt{g(x)} \left(R_{\rho\sigma} - \frac{1}{2} g_{\rho\sigma} R \right) - \sqrt{g^{-1}(x)} \left(R^{\rho\sigma} - \frac{1}{2} g^{\rho\sigma} R \right) \Big|_{g^{\rho\sigma} \rightarrow g_{\rho\sigma}, g_{\rho\sigma} \rightarrow g^{\rho\sigma}}. \quad (3)$$

This equation, only valid as it stands in our privileged working coordinate system, is not general covariant and not intended to be so. Indeed, it follows from both an extremum principle of our general covariant and discrete symmetry invariant action and a noncovariant relation between one metric and its discrete symmetry reversal conjugated. The straightforward interpretation of the Left hand side is that fields living in the reversed metric world are seen from our world as negative energy density fields. However, living in the conjugated metric prevents them from interacting with our world fields except through gravitation. The above equation is neither unic nor valid in such a general form. Indeed, we shall identify various (local or global) privileged coordinate systems. In each one, the solution of a single independent equation will be derived. Therefore, several metrics and their discrete symmetry conjugated fields will all together compose the complete gravitational picture.

4. The metrics in their privileged coordinate systems

The isotropy condition for both conjugated metrics determines their general form:

$$d\tau^2 = B(r, t) dt^2 + A(r, t) dx^2, \quad d\tilde{\tau}^2 = \frac{1}{B(r, t)} dt^2 + \frac{1}{A(r, t)} dx^2. \quad (4)$$

In the following sections we will further require that either the metric elements are a priori linked by $A(r, t) = -B(r, t)$ or $A(r, t) = B^{-1}(r, t)$ so that a single degree of freedom eventually remains and we shall investigate the form of its solution in each case. Later on, we shall derive these requirements from a new very powerful symmetry principle exchanging the roles of space and time coordinates. Now, the metric elements being related can no longer be varied independently. Therefore, given any tensor $T_{\mu\nu}$ and making use of $\frac{\delta g_{x'x'}}{\delta g_{xx}} = \frac{g_{x'x'}}{g_{xx}}$ in case B=-A, a typical action variation will be proportional to a scalar trace:

$$\delta g_{rr} T^{rr} + \delta g_{tt} T^{tt} + \delta g_{\theta\theta} T^{\theta\theta} + \delta g_{\phi\phi} T^{\phi\phi} = \frac{\delta g_{rr}}{g_{rr}} T$$

When $B=-A$, the trace will be the usual one, while in case $B=1/A$ an additional minus sign gives us a modified trace:

$$T_{B=1/A} = g_{rr}T^{rr} + g_{\theta\theta}T^{\theta\theta} + g_{\phi\phi}T^{\phi\phi} - g_{tt}T^{tt}$$

Eventually, we will find ourselves with a single equation of gravity in each case. Its conjugated metric solutions should transform into one another under $r \rightarrow -r$ or $t \rightarrow -t$.

5. $B=1/A$: The Schwarzschild Solution and Space Reversal

When $B=1/A$, we obtain the following equation:

$$R_{B=1/A} - \frac{1}{A^2}\tilde{R}_{B=1/A} = n\pi G(T - \frac{1}{A^2}\tilde{T})$$

with $\tilde{R} = R_{A \rightarrow 1/A}$. The left hand side yields:

$$R_{B=1/A} - \frac{\tilde{R}_{B=1/A}}{A^2} = 4\frac{A''}{A^2} - \frac{4}{A}\left(\frac{A'}{A}\right)^2 + 8\frac{A'}{A^2r} - \frac{3}{2}\left(1 - \frac{1}{A^2}\right)\left(\frac{\dot{A}}{A}\right)^2$$

and the right hand side is null because we are in vacuum. We easily get a static Schwarzschild-like solution:

$$\Rightarrow A = e^{\frac{2MG}{r}} \approx 1 + 2\frac{MG}{r} + 2\frac{M^2G^2}{r^2}, \quad (5)$$

$$\Rightarrow B = \frac{1}{A} = e^{-\frac{2MG}{r}} \approx 1 - 2\frac{MG}{r} + 2\frac{M^2G^2}{r^2} - \frac{4}{3}\frac{M^3G^3}{r^3}. \quad (6)$$

different from the GR one though in good agreement up to Post-Newtonian order. No black hole type singularity arises in our isotropic system. The phenomenology is simple: objects living in the same metric attract each other. Objects living in different metrics repel each other. Because, the conjugated metrics can be transformed into one another through $r \rightarrow -r$, the discrete transformation involved here is a parity transformation rather than a time reversal one. We could show in Ref. 1 that a left-handed Lagrangian could satisfactorily describe all known physics (at least kinetic and interaction terms) and provide an interesting explanation for maximal parity violation. This strongly supports the idea that the right handed chiral fields are living in another metric and acquire thanks to the 3-volume reversal a negative energy density. We postulate that we can divide any source distribution into mass point sources (isotropic and static), each having its local restframe privileged coordinate system where the above Schwarzschild treatment always applies in vacuum. Hence gravitational energy associated with each individual metric solution vanishes. The pseudo energy-momentum tensor defined with respect to a local metric solution does not happen to be meaningful. Indeed, here this object is not even a Lorentz tensor. Eventually, because the solution is unpropagated in the privileged coordinate system (was Newton right ?) the usual stability issues reviewed in Refs. 5–8 are avoided. The instability is usually seen in the phenomenology of a positive energy

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mass interacting with a negative energy mass through an interaction propagated by positive energy virtual interaction particles. The negative energy object is being attracted by the positive energy object, the latter being repulsed by the former. They then accelerate together for ever this resulting in an obviously instable picture. But here the gravitational interaction of two masses living in different metrics exhibits no such instability since they just repel each other. Yet, from the point of view of one of the two metrics, this is really the interaction between a positive energy mass and a negative energy mass.

The weak equivalence principle is obviously not menaced since once the metric field solution is established the behavior of matter and radiation in it is described by the same action as in GR. But, because of the non covariance of our equation, a violation of the strong equivalence principle seems unavoidable. The Post-Newtonian formalism considering extended source distributions does not apply here. But the metric solution can be exported via a Lorentz transformation into any frame moving at constant velocity relative to the metric point mass source comoving frame so that again the discrepancy with GR does not arise before the PPN order. In a next section, the model remains to be completed by clarifying how a test body should move under the gravitational influence of many sources.

6. B=-A: Cosmology and Time Reversal

We just saw that local gravity is always static in its privileged frame. Global gravity (this is cosmology) will only depend on time. Indeed, there also exists a global privileged coordinate system where a couple of time reversal conjugated purely time dependent solutions can be derived from a new couple of conjugated actions. The existence of a time reversal conjugated universe was also suggested a long time ago in Ref. 8. Notice that even if we did not impose the B=-A condition, the only possible privileged coordinate system with both metrics spatially homogeneous and isotropic would be a flat Cartesian one. When B=-A, our equation for gravity now reads:

$$\sqrt{A^4}R - \frac{1}{\sqrt{A^4}}\tilde{R} = n\pi G(\sqrt{A^4}T - \frac{1}{\sqrt{A^4}}\tilde{T})$$

with $\tilde{R} = R_{A \rightarrow 1/A}$. For a cosmological homogeneous source we will get purely time dependent background solutions and can keep only the time derivatives leading in the cold-cold regime to:

$$3A \left(-\frac{\ddot{A}}{A} + \frac{1}{2} \left(\frac{\dot{A}}{A} \right)^2 \right) - \frac{3}{A} \left(\frac{\ddot{A}}{A} - \frac{3}{2} \left(\frac{\dot{A}}{A} \right)^2 \right) = n\pi GM \left(\frac{1}{A} - A \right)$$

The solutions such that the right hand side vanishes describe worlds where only light can live. Its trivial A=1 solution thus describes a self conjugated light world. The background matter worlds have simple evolution laws for $n\pi GM \ll \frac{\ddot{A}}{A}, \left(\frac{\dot{A}}{A} \right)^2$ in the particular ranges $A \ll 1, A \approx 1, A \gg 1$. Indeed, the scale factor evolution

is then driven (here nondimensional time unit is used) by the following differential equations in the three particular domains:

$$a \ll 1 \Rightarrow \ddot{a} \propto \frac{3}{2} \frac{\dot{a}^2}{a} \Rightarrow a \propto 1/t^2 \text{ where } t < 0, \quad (7)$$

$$a \approx 1 \Rightarrow \ddot{a} \propto \frac{\dot{a}^2}{a} \Rightarrow a \propto e^t, \quad (8)$$

$$a \gg 1 \Rightarrow \ddot{a} \propto \frac{1}{2} \frac{\dot{a}^2}{a} \Rightarrow a \propto t^2 \text{ where } t > 0. \quad (9)$$

We can check that $t \rightarrow -t$ implies $1/t^2 \rightarrow t^2$ but also $e^t \rightarrow e^{-t}$ thus $A \rightarrow 1/A, B \rightarrow 1/B$ when t reverses as required. Let us stress that the couple of cosmological metric solutions does not imply any local gravitational interaction between objects but only a global one between the two conjugated universes as in Ref. 9. A striking and very uncommon feature is that the evolution of the scale factor is mostly driven by the gravitational energy exchange between the coupled universes almost independently of the universes matter and radiation content. In particular, the observed flatness can no longer be translated into the usual estimation $\Omega_m = 1$ from the WMAP data. The t^2 evolution is one of the very few possibilities. Thus, we are most probably living in a constantly accelerating universe. Our and the conjugated universe will cross each other and time reversal will occur in the future. Then, the two metrics might exchange their roles and our universe start contracting. Neglecting the slow evolution of the cosmological metrics, just as in a Minkowski space we may define energy and momentum Lorentz tensors conserved in the usual sense in the global privileged coordinate system. The energy sign from a given metric point of view of a point mass living in the other metric makes it contribute with an opposite sign to the global energy densities and pressures of the universe and its rest energy is also the required source for the local couple of parity conjugated metric solutions in its comoving frame. At last, not only our universe is accelerated without any need to a cosmological constant or dark energy component but such source terms can easily be made to vanish provided cosmological constant terms satisfy :

$$d^4\xi(x)\Lambda = d^4\tilde{\xi}(x)\tilde{\Lambda}. \quad (10)$$

7. Test Mass Motion

To understand the motion of a test mass we need to combine the various local metrics induced by their point-mass sources and the cosmological metric into a single one. In principle, the local metrics could all be exported into the global coordinate system by Lorentz transformations because they were all evaluated in the comoving frames (unaccelerated with respect to the global privileged coordinate system) of their source bodies. However, because the local metric is Euclidian ($B=1/A$), its local time is Wick rotated with respect to the global time. Thus, we should export it by a Wick rotated Lorentz matrix into the global privileged coordinate system where it will assume the form of a unit matrix instead of a Minkowski matrix in

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the flat case. This allows to combine there all local metrics multiplicatively. This can work because thanks to the exponential form of our solution, adding to m1 another contribution m2 makes the metric solution simply become the product of $e^{\frac{m_1 G}{r}}$ and $e^{\frac{m_2 G}{r}}$. Multiplying the metrics amounts to consider that we must compose several successive coordinate transformations to go from the privileged coordinate system to the inertial one. Subsequently, another multiplication with the Minkowski global metric then leads to the final Minkowskian metric where the motion of our test body can be determined. We thus have reached a complete picture of how the model works allowing us to apply it to any many body configuration.

If it happens that at some particular spacetime point, we have an equality between metric tensors such as $\tilde{g}_{\mu\nu} = g_{\mu\nu} = \eta_{\alpha\beta}$, this being locally valid in any general coordinate system, we may say that there is no gravitational field in an absolute way. This opens the interesting perspective that then fields (particles) may be able to jump from one metric to its conjugated identical metric.

8. Space/time Exchange and Tachyons: a New Synthesis

We now want to investigate the space/time exchange symmetry in order to derive the constraints $B=-A$ or $B=1/A$ on our metric elements but also understand the tachyonic Lorentz group representation. Indeed, the symmetry linking tachyons to bradyons is the transformation exchanging the roles of space and time coordinates r and t following Ref. 11 12 13 (we call it r/t symmetry) or alternatively Wick rotating the coordinates. As a generalisation of this idea, it is thus natural to allow our metrics to be complex, the phases corresponding to rotations in the complex plane transforming the inertial coordinates into general coordinates. Also, it will be judicious to introduce a new kind of conjugated metric: $\hat{g}_{\mu\nu}(r, t) = -g_{\mu\nu}(t, r)$.

The trivial Euclidian metric has the desired symmetry since it is obviously self conjugated under space/time exchange:

$$d\tau^2 = d\tilde{\tau}^2 = [dx^2 + dt^2]$$

But in general we shall need the inverse metric to restore the space/time exchange symmetry. Indeed, the most general expression being

$$d\tau^2 = C(r, t) \left(\frac{1}{A(r, t)} dt^2 + A(r, t) dx^2 \right), \quad (11)$$

$$d\tilde{\tau}^2 = \frac{1}{C(r, t)} \left(A(r, t) dt^2 + \frac{1}{A(r, t)} dx^2 \right). \quad (12)$$

only $C(r, t)$ violates the r / t symmetry so that in general, as we already noticed, such term is not allowed and the conjugated metrics verify $A(r, t) = B^{-1}(r, t)$. However, in the special case where A is a pure phase with angle: $\theta(r, t) = \pi/2$ it is possible to keep the $C(r, t)$ term and respect the r/t symmetry by introducing our conjugated metrics $\hat{g}_{\mu\nu}(r, t) = -g_{\mu\nu}(t, r)$. Then we have four conjugated metrics:

- $g_{\mu\nu}$
- $\tilde{g}_{\mu\nu} = g_{\mu\nu}^* = g_{\mu\nu}^{-1}$
- $\hat{g}_{\mu\nu}(r, t) = -g_{\mu\nu}(t, r)$
- $\tilde{\hat{g}}_{\mu\nu}(r, t) = \hat{g}_{\mu\nu}(t, r)$

Explicitly:

$$\begin{aligned} d\tau^2 &= iC(r, t) [-dx^2 + dt^2] \\ d\tilde{\tau}^2 &= i\frac{1}{C(r, t)} [dx^2 - dt^2] \\ d\hat{\tau}^2 &= iC(r, t) [dx^2 - dt^2] \\ d\tilde{\hat{\tau}}^2 &= i\frac{1}{C(r, t)} [-dx^2 + dt^2] \end{aligned}$$

Thus we could show that we only have two kinds of metrics: the local real "euclidian" ones satisfying $B=1/A$ and the global imaginary Minkowskian one with $B=-A$. A stronger version of the r/t symmetry imposes that the space-space and time-time elements possess the same modulus and be invariant under r/t , so that these metric elements are pure phases and the inverse metric is nothing but the complex conjugated metric. As far as the strong r/t symmetry applies, we saw that a $\theta(r, t) = \pi/2$ phase rotation can transform the Euclidian into the imaginary Minkowskian ones and we get our r/t conjugated light worlds. Then, a breakdown of the strong r/t symmetry produces the emergence of two couples of time reversal conjugated matter worlds with local fluctuations in these worlds being parity conjugated Schwarzschild solutions. We thus have conjugated tachyonic/bradyonic worlds as well as positive/negative energy worlds but the r/t conjugated worlds are decoupled since there is no simple algebraic relation between $f(r, t)$ and $f(t, r)$ and we can vary their actions separately.

9. Gravitational Waves

We have shown that the non-dynamical Euclidian metric preexists and that pure phases perturbations give rise to light universes. Then strong r/t violating perturbations can produce matter universes: this is the birth of times. The matter objects living in these universes represent sources for local strong r/t violating Schwarzschild Left/Right symmetric perturbations in the matter worlds but also, as we shall now show, gravitational wave strong r/t symmetric perturbations of the light universes metric. Indeed, the light worlds perturbed conjugated metrics read:

$$\begin{aligned} d\tau^2 &= (1 + h(r, t)) [dx^2 - dt^2] \\ d\tilde{\tau}^2 &= (1 + h(r, t))^{-1} [dx^2 - dt^2] \end{aligned}$$

And neglecting the very slow variations of the background, the left hand side of our modified Einstein equation yields:

$$R - \tilde{R} = 6 \left(h'' - \ddot{h} + 2\frac{h'}{r} - h'^2 + \dot{h}^2 \right)$$

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and we easily obtain the evolution equation for the perturbation:

$$6 \left(\diamond h + \dot{h}^2 - h'^2 \right) = n\pi G \delta T$$

For a generic impulse source term $\delta T = \frac{\delta(r)\delta(t)}{A}$, $h(r,t)$ is the classical spherical wave solution of $\diamond h(r,t) = n\pi \frac{G}{6} \delta(r)\delta(t)$ making $\dot{h}^2 - h'^2$ vanish so that the energy carried by the wave is not a source for gravity.

We shall now show that we predict the same energy lost through gravitational waves radiation of the binary pulsar as in GR in good agreement with the observed decay of the orbit period. We follow Weinberg's computation of the power emitted per unit solid angle and adopt the same notations. For any extended non relativistic source the solution is the retarded potential:

$$h(x,t) = n\pi \frac{-G}{4\pi} \frac{1}{6} \int d^3x' \frac{\delta T_{00}(x', t - |x - x'|)}{|x - x'|}$$

The radial momentum component of our gravitational wave energy momentum tensor reads:

$$T_{r0} = \frac{1}{n\pi G} \sum_{\sigma=0,3} \frac{\partial R}{\partial \left(\frac{\partial A_\sigma}{\partial r} \right)} \frac{\partial A_\sigma}{\partial t} = \frac{1}{n\pi G} \frac{\partial R}{\partial \left(\frac{\partial h}{\partial r} \right)} \frac{\partial h}{\partial t}$$

where,

$$\forall \sigma, A_\sigma = h = \sum_{\omega, k} h(\omega, k) e^{i(\omega t - kr)} + h^*(\omega, k) e^{-i(\omega t - kr)}$$

$$\langle T_{r0}(\omega, k) \rangle = \frac{6}{n\pi G} (-2) \langle h' \dot{h} \rangle_{\omega, k} = \frac{6}{n\pi G} 4\omega^2 |h(\omega, k)|^2$$

Thus the power emitted per unit solid angle in the direction k is:

$$\frac{dP}{d\Omega}(\omega, k) = r^2 \langle T_{r0}(\omega, k) \rangle = r^2 \frac{24}{n\pi G} \omega^2 |h(\omega, k)|^2$$

$$\begin{aligned} \frac{dP}{d\Omega}(\omega, k) &= 24 \frac{\omega^2}{n\pi G} \left(n\pi \frac{-G}{4\pi} \frac{1}{6} \right)^2 \delta T_{00}^2(\omega, k) \\ &= \frac{n}{24} \frac{\omega^2 G}{\pi} \delta T_{00}^2(\omega, k) \\ &= \frac{2}{\pi} G \omega^2 \delta T_{00}^2(\omega, k) \\ &= \frac{G\omega^6}{2\pi} k_i k_j k_l k_m D_{ij}(\omega) D_{lm}(\omega) \end{aligned}$$

Where n has been given the numerical value 48 taking account of the fact that in the Newtonian limit our equation $6^2 h = 48\pi G \delta T$ must give again $\nabla^2 g_{00} = -8\pi G T_{00}$ (the same straightforward reasoning allows to determine n in all the other gravitational equations of the theory!). Then following Weinberg, we may write in terms of the moment of inertia Fourier transforms in the observer coordinate system:

$$\begin{aligned} P &= \frac{2}{15} G \omega^6 \left[\left(D_{ii}(\omega) \right)^2 + 2 D_{ij}(\omega) D_{ij}(\omega) \right] \\ P &= \frac{2}{15} G \omega^6 12 D_{11}^2(\omega) \end{aligned}$$

For a rotating body with angular speed Ω , equatorial ellipticity e , moment of inertia I in the rotating coordinates, $\omega = 2\Omega$, $D_{11}(\omega) = \frac{eI}{4}$ and the radiated power reads:

$$P = 2\frac{12}{15}G64\Omega^6e^2\frac{I^2}{16} = \frac{32}{5}G\Omega^6e^2I^2$$

as in General Relativity. The main difference is that our gravitational wave is found to propagate pure monopole modes linked by $-g_{00} = g_{11} = g_{22} = g_{33} = A$. But these cannot be excited independently whatever the source configuration since we have the single degree of freedom $A(r,t)$.

10. Phenomenological Outlooks

We now show that the new context may hopefully provide a very powerfull alternative to dark matter models and a seductive common explanation to various outstanding enigmas after carefull study of the postulated mechanisms.

10.1. *An Alternative to Dark Matter*

It is very tempting to interpret the universe voids as being filled with invisible matter living in the conjugated metric and repelling our matter at the frontier of what eventually appears to us as empty bubbles. On the other hand a massive structure in our metric repels the matter living in the conjugated metric creating there an attracting void for our structure which might help to explain the flat galaxy rotation curves and other gravitational lensing effects.

10.2. *The Black Hole Horizon*

Our exponential solution tells us that there is no more BH singularity in our theory. However a test mass approaching the Schwarzschild radius of a massive body at rest with respect to the global coordinate system is propagating in a local and global superposition:

$$d\tau^2 = \frac{1}{A(r)}R(t)^2dt^2 - A(r)R(t)^2dx^2. \quad (13)$$

with conjugated proper time:

$$d\tilde{\tau}^2 = \frac{1}{R^2(t)}A(r)dt^2 - \frac{1}{A(r)R^2(t)}dx^2. \quad (14)$$

But for a strong enough gravitational field, e.g probably not much below the Schwarzschild radius thanks to the exponential regime, the $A(r)$ term is expected to "cross" the scale factor term so that the r/t symmetry (hence a more stable configuration) of the euclidian metric could be restored provided one metric could flip locally from a $B=-A$ solution to a $B=1/A$ solution. Reaching this radius the test mass would be transfered in the Euclidian world or possibly via an extra rotation in the r/t conjugated light world. As well as a genuine black hole horizon this mechanism would account for the absence of thermonuclear bursts from BH candidates.

10.3. *The Pioneer Effect*

If the two cosmological conjugated metrics crossed each other recently it is possible that the cosmological metric have switched to the contraction regime. Alternatively the above described mechanism where in the vicinity of a massive body, the cosmological metric would flip locally from a $B=-A$ solution to a $B=1/A$ solution can switch the cosmological metric to a contracting regime. But unlike in General Relativity, there is a superposition principle of the cosmological gravitational field and the local one. Then, perhaps we should not be surprised to receive the photons from an object at several Astronomical Units as are the Pioneer aircrafts slightly blue-shifted if they propagate in a locally contracting cosmological metric, an effect which according to Ref. 10 has been measured to a very good precision with the expected magnitude.

10.4. *Large Scale Structure Formation and the Early Universe*

Of course, the large scale structure formation and evolution as well as nucleosynthesis would need to be completely revisited in this new context where the game rules are drastically modified. We now have to consider:

- The interactions between conjugated density fluctuations favoring the gravitational collapse.
- The absence of gravitational horizon wich would account for the large scale homogeneity of the CMB.
- A slower expanding rate in the past thanks to the accelerated regime.
- A twice older universe ($2/H_0=28$ billion years) to be compared with the oldest galaxies ages ($z=5$) ≈ 17 billion years in quite a good agreement with the oldest stars ages while providing more time for galaxy formation.

Our hope is to be as successfull as the standard model in cosmology while avoiding ad-hoc hypothesis and adjustable parameters such as a cosmological constant, cold dark matter, inflation...

11. Conclusion

We could settle down here the foundations for a modified theory of gravitation. This theory is essentially general relativity enriched to take into account the fundamental discrete symmetries involved in the structure of the Lorentz group. Eventually, we find that this allows to solve many long lasting theoretical issues such as negative energies and stability, QFT vacuum divergences and the cosmological constant but also leads to very remarquable phenomenological predictions: Locally, the disagreement with GR only arises at the PPN level and black holes disappear. Globally (this is cosmology), a constantly accelerating necessarily flat universe in good agreement with the present data is a natural outcome of the model. At last, we could also show that the space/time exchange symmetry allows to derive a gravitational wave

solution leading to the observed decay of the binary pulsar orbital period and to clarify the status of tachyonic representations.

References

1. F. Henry-Couannier, gr-qc/0404110.
2. S. Chen, hep-th/0203230.
3. S. Weinberg, *Gravitation and Cosmology* (John Wiley and sons, New York, 1972).
4. A. D. Linde, *Rept. Prog. Phys.* **47**, 925 (1984).
5. R. R. Caldwell, *Phys. Rev. Lett.* **91**, 071301 (2003).
6. P. H. Frampton, *Mod. Phys. Lett.* **A19**, 801 (2004).
7. S. M. Carrol, M. Hoffman and M. Trodden *Phys. Rev.* **D68**, 023509 (2003).
8. A. D. Sakharov, *JETP Lett.* **5**, 24 (1967).
9. A. D. Linde, *Phys. Lett.* **B200**, 272 (1988).
10. J. D. Anderson, *Phys. Rev.* **D65**, 082004 (2002).
11. M. Tegmark, gr-qc/9702052
12. G. Feinberg, *Phys. Rev.* **D17**, No 6.
13. E. Recami, arXiv:physics/0101108.