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Research Article

From Dark Gravity to LENR

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Abstract

Dark Gravity (DG) theories are extensions of General Relativity having a stable anti-gravitational sector. From the beginning, the motivation for such an extended framework was not only phenomenological, trying to address several well-known enigmatic cosmological discoveries in an alternative way: missing mass effects, universe acceleration, ... but also theoretical, and the main achievement is that indeed, it is possible to avoid most if not all generic instability issues which are well known to prevent the introduction of negative masses in General Relativity. Moreover it was also shown that such constructions are not arbitrary but can be entirely derived following the alternative mathematical choice for understanding the Time Reversal Symmetry, that of a Unitary T operator in QFT, needing a complete rehabilitation of negative energies in theoretical physics. All versions of DG theories studied so far unsurprisingly share many phenomenological outcomes, but here we shall focus on one which, for the first time, very naturally leads us to investigate the likely existence of genuine field discontinuities. The resulting phenomenology started to be explored. The first part of the article is a reminder of the main steps that led us to Dark Gravity. The second part focuses on discontinuities to show that these are all we need to explain in an unifying and very simple way many if not all of the well known so called "LENR miracles": Large eXcess Power (XP) not possibly of chemical origin with extremely low levels of nuclear radiations (alpha, beta, gamma, neutrons) as compared to what would be expected from nuclear processes producing the same amount of energy, Transmutations and isotopic anomalies in cold conditions, Incredible properties such as huge inertia anomalies and temperature discontinuities of a new category of objects produced in association with LENR and behaving as extremely magnetic micro ball lightnings.

Keywords: Anti-gravity, Field discontinuities, Janus field, LENR, Negative energies, Time reversal

1. Introduction

So far, most popular attempts to explain the cold fusion "miracles" have been based on a bet which also corresponds to a widely accepted view among LENR leader theorists: standard physics alone must be able to explain them. Those scientists generally agree that it is only the extreme complexity of how the accepted fundamental laws apply to a variety of condensed matter non trivial structures subjected to unusual treatments that had prevented for decades the identification of those peculiar configurations and involved combinations of processes allowing these unexpected phenomena to occur.

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Given how challenging indeed is a priori the identification of processes based on standard physics alone that would allow to overcome the Coulomb barrier in usual temperature and pressure conditions (this is the first LENR miracle), what appeared to me so paradoxical was this extremely conservative principled stand among the same adventurers who often had sacrificed their own careers relentlessly continuing their efforts down this direction of research. The more and more absurd this sounded to me when after studying some of the more popular candidates, I realised that the more involved were the models and complicated the equations, the more incredibly unphysical the hypothesis these too often tried to hide or minimize. The miracle that needed to be explained was just repeatedly, more or less explicitly, translated into another hidden miracle which was sooner or later identified by the other LENR theorists and skeptics. Eventually each such new cross in the cemetery of LENR theories apparently added ever growing confirmation to the common skeptical view that the effort was doomed to failure. Even worse, many models focusing on the first “miracle”, were neglecting the growing accumulation of new evidence showing even more challenging other related “miracles”. These are for instance the transmutations always favouring final stable nuclei in the absence of high energy particles radiation that were considered to be the unavoidable nuclear products underscoring the occurrence of any kind of nuclear processes according to the laws of nuclear physics. Last but not least, even the models meeting the challenge of the first two miracles almost always completely missed another category of observations, pointing the “miracles” of the third kind that I will try to address in more details in the second part of this article: the existence of extremely enigmatic objects, genuine micro ball lightnings produced in association with the LENR type of transmutations thus undoubtedly linked to the first two “miracles”. This convinced me that for a theory to have any chance of successfully addressing the two other so called LENR miracles, the theory should first take seriously and address in detail not just some selected properties of these objects but all of them, starting from the most incredible and challenging ones: temperature discontinuities, huge inertia anomalies, ability to propagate through matter and so on.

This surely would not have been possible if a theoretical framework did not already exist providing the right cards in hand, my own version [1,2,7] of a Dark Gravity [1–5] theory which I had initially (knowing nothing about LENR) developed to deal with well known theoretical instability issues of General Relativity in the presence of negative energy objects. One of the right cards was the new physics of field discontinuities which occurrence is made natural by the new dynamical status of discrete symmetries in this version of Dark Gravity theory the genesis of which I will outline the main steps in the first part of the article. As I will try to convince the reader in the second part, these are so perfectly suited to describe the very peculiar properties of the micro ball lightnings, that these properties can even certainly be considered to be as many signatures of the physics of field discontinuities.

2. Negative Energies, the Forgotten Solutions; a Scandal at the Root of All Modern Quantum Field Theories

Just because of the famous formula

$$E = \pm\sqrt{p^2 + m^2} \tag{1}$$

negative energy field solutions were expected in any relativistic classical field theory for both massive and massless ($m = 0$) particles. For instance the free scalar negative energy field just requires negative kinetic energy terms in its action and maximization of this action to get its free motion equations and a negative Hamiltonian through the Noether Theorem [6].

There is however a very widespread belief that eventually, thanks to second quantization, the negative energy states were completely understood and re-interpreted in terms of antiparticles. In many modern QFT academic courses the reader is actually faced with an incredible zoo of wrong demonstrations and arguments starting from the Dirac sea saturated with negative energy states, which holes would have been interpreted as antiparticles (an interpretation given up a long time ago by theorists because the picture does not work for bosons, not affected by the Pauli exclusion principle, and yet also having their antiparticles, see [8] pages 12,13), up to the more stubborn view that in the plane wave

Fourier expansion of a field, terms such as $e^{i(Et-px)}$ and $e^{-i(Et-px)}$ respectively initially stood for the negative and positive energy solutions of (1). Then, given that after second quantization the plane wave $e^{i(Et-px)}$ cannot anymore be interpreted as a negative energy wave but, now being associated with an annihilation operator in $a(p,E)e^{i(Et-px)}$ rather represents the operation of removing E,p from a given state, provided E is positive, we avoid the creation of negative energy particles by annihilating instead positive energy particles. Of course in this case the mistake was to consider that $e^{i(Et-px)}$ a priori had to stand for the negative energy solution in (1). Yet it is well known that in any real signal Fourier decomposition one can always artificially generate such negative frequency terms by simply rewriting $\cos x = (e^{ix} + e^{-ix})/2$, a purely mathematical trick which does not at all imply that the negative frequencies or energies that would appear in this way are physically relevant.

It is only after second quantization that one understands the genuine physical meaning now acquired by such terms when, being associated with creation and annihilation operators makes clear that the $\pm i$ alternative has nothing to do with the sign of the particle energies involved but rather with the operation of removing or adding quanta to a given state. Indeed, if a plane wave term is associated to a creator the complex conjugate one must be to an annihilator and vice versa, see [8] formulas 5.1.15 and 5.1.16. Then because a field is required to mix the creation and annihilation operators as in formula 5.1.31 of [8], it will involve the creation and annihilation of particles of only one sign of the energy. Therefore if the positive energy scalar field solution of the Klein–Gordon equation is:

$$\phi(x,t) = \int \frac{d^3p}{(2\pi)^{3/2}(2E)^{1/2}} \left[a(p,E)\, e^{i(Et-px)} + a^\dagger(p,E)\, e^{-i(Et-px)}\right] \tag{2}$$

with $E = \sqrt{p^2+m^2}$, we have no reason at all to discard the negative energy scalar field solution of the same Klein–Gordon equation:

$$\tilde{\phi}(x,t) = \int \frac{d^3p}{(2\pi)^{3/2}(2E)^{1/2}} \left[\tilde{a}^\dagger(-p,-E)\, e^{i(Et-px)} + \tilde{a}(-p,-E)\, e^{-i(Et-px)}\right], \tag{3}$$

where we just required the field here to create and annihilate negative energy quanta, this field having its own negative action and Hamiltonian [6]. In other words there are still two possible ways to add (resp remove) a positive energy *E* from a given state: either one creates (resp annihilates) a particle of energy *E*, or one annihilates (resp creates) a particle of energy $-E$, the second option being mathematically as valid as the first. Neglecting the second possibility just amounts to miss half of the solutions of all our equations! Thus, it is certainly correct to argue that QFT convincingly demonstrated that positive and negative energy states cannot be mixed in a Field, but not to claim that we eventually understood the negative energy sector.

As for the anti-particles their existence is required for a charged field to have definite charge, i.e., we cannot have in the same superposition the creator of a charge *Q* and the annihilator of this charge, rather we need to introduce in place of a the annihilator usually called a_c of the opposite charge. It is this argument, not related at all to the negative energies issue, that actually implies the existence of anti-particles, see [8] page 199.

At last we also all remember the famous Feynman interpretation of these anti-particles as negative energies propagating backward in time. But this still has nothing to do with the badly discarded negative energy solutions of all our fundamental field equations which of course should be propagating forward in time.

It is a pity that so many QFT academic courses use kind of magical tricks to try to convince their reader that we were well in our right to discard the negative energy states from the landscape. Fortunately this is not the case in more serious courses such as the Weinberg QFT where the author admits honestly that the only reason to put aside these solutions is that the corresponding particles were never detected in any experiment and also because of the catastrophic instabilities which are apparently unavoidable whenever we shall let them interact with the positive energy states.

At this stage of our reflexion it remains that, as admitted also by [9,10], one could perfectly imagine a mirror standard model of negative energy particles, perfectly stable and with the same phenomenology as in the positive energy standard model, provided interactions are strictly forbidden between the two standard models; this is of no physical interest and, as we shall see, this is not the picture required from a deeper investigation.

3. Unitary Time Reversal

Not only are negative energy fields solutions of all our field theory equations but there is a symmetry, time reversal, believed to be a very fundamental one, that applied to any positive energy state is expected to regenerate the corresponding negative energy state. Indeed, according to special relativity alone, E should flip to $-E$ as t flips to $-t$ just because these are the fourth component of their respective four vectors. Fortunately for QF theorists this can be avoided if i also flips to $-i$ at the same time thanks to the mathematical choice of an anti-unitary time reversal operator in QFT. Let us cite [8] pages 75,76: "If *P* were anti Unitary . . . for any state Ψ of energy *E* there would be another state $P^{-1}\Psi$ of energy $-E$. There are no states of negative energy . . . so we are forced to choose the other alternative: *P* Unitary. On the other hand if we supposed that *T* is unitary we could simply cancel the is in $TiHT^{-1} = -iH$ (where *i* is nothing but the familiar complex number satisfying $i^2 = -1$) and find $THT^{-1} = -H$ with the again disastrous conclusion that for any state Ψ of energy *E* there would be another state $T^{-1}\Psi$ of energy $-E$. To avoid this we are forced to conclude that *T* is anti-unitary."

Recalling the story of Dirac equation solutions that were considered unphysical for many years until the discovery of anti-particles, extreme caution should be the rule before discarding solutions of so fundamental equations. Even more, we believe that such attitude was a genuine collective fault given that even after second quantization there is still no convincing theoretical argument to discard them as we explained. Instead, based on the non observation of negative energy states and the related instability issues, a significant effort was required to better understand how the consistent rehabilitation of such states could be carried on assuming Unitary time reversal linking naturally positive to negative energy states is the correct option. The first impediment we encountered on this way and that turned out to be very instructive is that even though

$$T\phi(x,t)T^{-1} = \tilde{\phi}(x,-t) \tag{4}$$

and

$$Ta^{\dagger}(p,E)T^{-1} = \tilde{a}^{\dagger}(p,-E). \tag{5}$$

It seems impossible to transform the "positive" Hamiltonian for our free neutral scalar positive energy field:

$$H = +\frac{1}{2}\int \mathrm{d}^3x \left[\left(\frac{\partial\phi(x,t)}{\partial t}\right)^2 + \left(\frac{\partial\phi(x,t)}{\partial x}\right)^2 + m^2\phi^2(x,t) \right] \tag{6}$$

into the "negative" Hamiltonian for the corresponding negative energy field:

$$\tilde{H} = -\frac{1}{2}\int \mathrm{d}^3x \left[\left(\frac{\partial\tilde{\phi}(x,t)}{\partial t}\right)^2 + \left(\frac{\partial\tilde{\phi}(x,t)}{\partial x}\right)^2 + m^2\tilde{\phi}^2(x,t) \right] \tag{7}$$

through Unitary Time Reversal (see [6]).

The only way out of this dead end was to reconsider the problem in a gravitational context, i.e., after introducing everywhere as they should be, in the actions and Hamiltonians the order two tensor field of GR provided it should also transform in a non trivial way under time reversal, i.e., in another order two tensor field, different in the sense that such a transformation would not merely be a general coordinate transformation but would also involve a non trivial jump from the initial inertial coordinate system to another inertial coordinate system. Only such an approach would still respect and allow it to remain meaningful, even in a gravitational framework, the discrete character of time reversal, a symmetry linking as we know otherwise disconnected representations of the Lorentz group [2] pages 4,5.

This approach was from the beginning very promising as it would obviously isolate the positive and negative energy sectors from each other, given that propagating on different sets of geodesics these would never meet (interact through EM, weak or strong interactions) each other. This would explain why the negative energy particles escaped observation and at the same time avoid the instability issues at least for all non gravitational interactions.

Before setting out the concrete solution that eventually has emerged, it is worth recalling two other interesting results collected from our investigation of negative energies in a non gravitational framework [6].

- If we actually allow both positive and negative energy boson propagators to propagate an interaction what we actually discovered is that the interaction vanishes. This might be interesting to cancel QFT UV loop divergences by allowing the reconnection between positive and negative energy worlds beyond a given energy threshold.
- Vacuum divergences for positive and negative energy fields being unsurprisingly found to be exactly opposite, it is hoped a cancellation of their gravitational effects, solving thereby a very long lasting issue.

It is also worth recalling that any new ingredient manifesting anti gravitational properties is irresistibly attractive for cosmologists given that the LCDM model of course passes many tests with flying colours but still relies on many enigmatic components: Dark Energy, Dark Matter, Inflation, still badly understood and introducing very serious issues such as fine tuning and coincidence problems. This was actually the motivation for the first Dark Gravity theory ever published by [3] which has been followed by his many other publications detailing the very rich expected new phenomenology and showing for instance how efficiently the negative masses of our twin universe can help our galaxies rotate as observed, see [12,11] and references therein. One can convince oneself of the extreme motivation for anti-gravity among theorists by typing "phantom fields" or "ghost fields" on arXiv: thousand of articles, a huge theoretical effort all over the world to try nevertheless to introduce negative energy fields in such a way that Hawking positive energy conditions would not be violated too seriously. All this waste of time and energies could have been avoided by recognizing the correct way to reintroduce negative energies in GR while avoiding all instability issues as S. Hossenfelder states on her famous blog [13], mentioning her Phys Rev D publication [5], strongly convergent to my previously published works [1,2] (read the next section then look at the Janus relation (47) in her Annex).

It was a pleasant surprise when I learned recently that Milgrom himself, who is very famous for being the father of MOND theories, has refined his modified gravity theories in such a way that this effort eventually has resulted in a genuine Dark Gravity theory [4].

4. The Janus Gravitational Field

The previous section led us to the conclusion that we certainly need to introduce another gravitational field which geodesics the negative energy fields will have to follow. However, this mere idea is strongly conflicting with an almost religious belief shared by almost all gravity experts: a good theory should be background independent. Before studying gravity, we thought that we had the right to build theories with as many fields we wanted and of any kind: scalar, vector, higher order tensors, and Dirac fields upon a flat non dynamical space-time described by the Minkowski metric η. But according GR experts, the order two tensor field of GR has a very special and privileged status: it is the metric that describes the geometry of space-time itself! Of course this belief has been supported by the fact that the tensor of gravity, as any order two tensor field, has the required properties to be a metric and since η is now completely absent from the fundamental general covariant equations of gravity, g could replace completely η in the role of being the genuine metric of space-time itself. Anyway, as a consequence of this a priori, one could not consider anymore the possibility of having two different gravitational fields defining two different incompatible geometries in a theory, given that we have only one space-time. By the way, another far reaching consequence is that for both string theorists and loop quantum gravity theorists, quantizing gravity means quantizing space-time itself.

For us, who need to introduce two different gravitational fields on a single manifold (x, y, z, ct) such fields obviously cannot describe the geometry of space-time itself. These just describe the two different geometries felt by the matter and radiation fields propagating along their respective geodesics. Eventually just as light is deflected from air to water, in the same way light can be deflected by interacting with a gravitational field even though in this latter case it has been possible to interpret this interaction as mere propagation along deformed geodesics of space-time itself, a view that we have to give up completely.

However, now the Minkowskian background η describing the still flat and non dynamical background geometry of space-time itself certainly cannot be neglected as we did in GR: we are not anymore background independent. More specifically η is now the object we need to rise and lower tensor indices. But then in a theory where we have a priori both η and the usual gravitational field g we also unavoidably have the other tensor field $\tilde{g}$ obtained by lowering the indices of the contravariant g^{-1} with η. This is

$$\tilde{g}_{\mu\nu} = \eta_{\mu\rho}\eta_{\nu\sigma}\left[g^{-1}\right]^{\rho\sigma} = \left[\eta^{\mu\rho}\eta^{\nu\sigma}g_{\rho\sigma}\right]^{-1}. \tag{8}$$

Thus the Janus gravitational field, like the Janus God, has two faces, $g_{\mu\nu}$ and $\tilde{g}_{\mu\nu}$ linked by the above manifestly covariant and background dependent relation. The two forms play perfectly equivalent roles relative to the background metric $\eta_{\mu\nu}$ so should be treated on the same footing in our actions if we do not want to artificially destroy the basic symmetry of the picture under their permutation. Symmetrizing the roles of $g_{\mu\nu}$ and $\tilde{g}_{\mu\nu}$ is performed by simply adding to the usual GR action, the similar action built from $\tilde{g}_{\mu\nu}$ and its inverse.

$$\int \mathrm{d}^4x(\sqrt{g}R + \sqrt{\tilde{g}}\tilde{R}) + \int \mathrm{d}^4x(\sqrt{g}L + \sqrt{\tilde{g}}\tilde{L}), \tag{9}$$

where *R* and $\tilde{R}$ are the familiar Ricci scalars built from g or $\tilde{g}$ as usual and L and $\tilde{L}$ the Lagrangians for respectively SM F type fields propagating along $g_{\mu\nu}$ geodesics and $\tilde{F}$ fields propagating along $\tilde{g}_{\mu\nu}$ geodesics. The theory that follows from just symmetrizing the roles of $g_{\mu\nu}$ and $\tilde{g}_{\mu\nu}$ is DG which turns out to be essentially the other option of a binary choice that must be done at the level of the conceptual foundations of a covariant theory of a symmetric order two tensor field: either the space-time is curved with metric $g_{\mu\nu}$ and we get GR, or it is flat with background metric $\eta_{\mu\nu}$ and we get DG!

Now remember our initial purpose, which was to identify another field which geodesics would welcome the forgotten negative energy standard model of QFT. We shall show that the "inverse form" $\tilde{g}_{\mu\nu}$ is this field (this is not truly speaking of another field because it is not independent from g) that we get for free from Eq. (8), i.e., just from our understanding that we should not be in a background independent theory anymore. The two faces of the Janus Field will turn out to be conjugate under the time reversal symmetry, and all energies of field propagating on one face will be seen opposite from the point of view of the fields living on the other face and feeling their anti-gravitational effect. So the choice between DG and GR becomes an easy one. The usual extreme action principle must be used by eliminating the $\tilde{g}_{\mu\nu}$ degrees of freedom thanks to the Janus relation Eq. (8) to eventually get a single field equation in place of Einstein equation satisfied by $g_{\mu\nu}$. The solution also allows to get immediately $\tilde{g}_{\mu\nu}$.

5. The Static Isotropic Elementary Solution

In [2], we were led to explore many non standard theoretical possibilities because we did not want to miss any prediction that could allow us to decide between GR and DG, one "problem" being that DG, without any free additional parameter, mimics so perfectly GR. Here we shall take instead the most standard path until we introduce the new phenomenology relevant for LENR.

We found a couple of static isotropic conjugate solutions in vacuum of the form $g_{\mu\nu} = (B, A, A, A)$ and $\tilde{g}_{\mu\nu} = (1/B, 1/A, 1/A, 1/A)$

$$A = \mathrm{e}^{\frac{2MG}{r}} \approx 1 + 2\frac{MG}{r} + 2\frac{M^2G^2}{r^2}, \tag{10}$$

$$B = -\frac{1}{A} = -\mathrm{e}^{\frac{-2MG}{r}} \approx -1 + 2\frac{MG}{r} - 2\frac{M^2G^2}{r^2} + \frac{4}{3}\frac{M^3G^3}{r^3} \tag{11}$$

perfectly suited to represent the field generated outside an elementary source mass *M* (understood to include all contributions to the total gravific mass including the energy of the gravitational field). This is different from the GR one, though in good agreement up to post-Newtonian order. It is straightforward to check that this Schwarzschild new solution involves no horizon: no more black hole! Only future precision experiments able to probe the PPN order terms or strong gravity tests near the Schwarzschild radius will be able to decide between GR and DG.

The solution also confirms that a positive mass *M* in the conjugate metric is seen as negative mass $-M$ from its gravitational effect felt on our side. Masses on the same side attract each other, masses on different sides repel each other. There is no longer the runaway instability that was unavoidable when one naively introduced negative energies on the same side as positive energies. Neither do we find any instability in the gravitational sector.

Indeed, the requirement that the conjugate metrics should satisfy the same isometries is very constraining. This is easily seen by adding an arbitrary Spherical Harmonic perturbation $f(r)Y_{l,m}(\theta, \phi)$ to any element of an isotropic $g_{\mu\nu}$. Then the inverse form $\tilde{g}_{\mu\nu}$ elements will develop an infinite number of other Spherical Harmonics, meaning that obviously the two forms do not share the same isometries anymore. So the only acceptable metrics are a priori in the isotropic form $g_{\mu\nu} = (B, A, A, A)$, and $\tilde{g}_{\mu\nu} = (1/B, 1/A, 1/A, 1/A)$. We also introduced new exchange symmetries constraining the fields even more to either $B = -1/A$ or $B = -A$! As a consequence of these fundamental requirements, our new $B = -1/A$ Schwarzschild solution cannot accept any kind of the non isotropic Spherical Harmonics perturbations as the ones introduced by [14] to test the stability of the Schwarzschild solution. But then, the only isotropic non static perturbation solution in vacuum must be in the sector $B = -A$ which stability is granted (see Section 6).

Moreover the impossibility of any $B = -1/A$ perturbation that would satisfy a wave equation means that there is no wave at all allowed in this sector of the theory and that our gravitostatic field is un-propagated. It is instantaneous but may be no more than the electrostatic field according recent impressive experimental results [15] that seriously call into question the traditional understanding that the static fields in our theories actually result from the exchange of waves at the speed of light. Alternatively it might soon become common knowledge that a non propagated sector have always co-existed with a propagated sector in all our most familiar theories. This will probably require that the EM differential equations no longer be considered valid from $t = -\infty$ to $t = +\infty$ and everywhere but only piecewise over finite time and space intervals where it will be possible to replace them by timeless differential equations in case of a static elementary source.

The most natural interpretation of our isotropic $B = -1/A$ field, is that, as we explained above, this is the elementary field sourced by an elementary mass. Fortunately, it is easy, thanks to the exponential form of the metric [2] Eq. (14) to combine any elementary metrics of this kind for source points even moving with respect to each other, after exporting them to a common coordinate system. From this you can get the total gravitational field produced by any extended distribution of energy and momentum, pressure (from massive relativistic particles only), any potential energies either gravitational (energy of the gravitational field) or non-gravitational being taken into account in the same way as in GR up to post-Newtonian order with the same quantitative predictions. Then we can later require matter and radiation fields to follow, as in GR, the geodesics of the $B = -A$ dynamical field combined with this total $B = -1/A$ field which is not dynamical anymore (the various elementary fields already played their dynamics in their own individual actions where their point mass source was not dynamical). One of course can derive in this way as usual the covariant conservation equation $T^{\mu\nu}_{;\mu} = 0$ describing energy exchange between matter and gravitation, keeping in mind that as far as the $B = -1/A$ total field is concerned this exchange is not the radiation of gravitational waves. This is just the familiar exchange between kinetic energy and potential energy of a mass throughout its trajectory, the latter being nothing else but the energy of the total non dynamical $B = -1/A$ gravitational field.

6. $B = -A$ Field: The Global Homogeneous Solution + Perturbations

6.1. The $B = -A$ field and perturbations

The theory at this stage will remain globally static. To get both background expansion and gravitational radiation we need the $B = -A$ field but with drastically reduced number of degrees of freedom, a metric defined from a scalar field Φ that we can write $g_{\mu\nu} = (-A, A, A, A) = \Phi\eta_{\mu\nu}$ and $\tilde{g}_{\mu\nu} = (-1/A, 1/A, 1/A, 1/A) = \frac{1}{\Phi}\eta_{\mu\nu}$. Recall that the forms taken both by the elementary static isotropic field of the previous section and by this new global homogeneous field were justified based on discrete space-time symmetry arguments, [2] Section VI.

Reducing the number of degrees of freedom to a single scalar is mandatory to have an energy–momentum tensor for gravity that does not vanish to second order in perturbation to get binary pulsars decays as observed. As for the stability in the $B = -A$ sector, it is granted because a mass always couples to the side of the Janus Field which waves carry the same sign of the energy as itself.

6.2. Cosmology

We immediately noticed that the two conjugate metrics cannot be both homogeneous and isotropic unless the spatial curvature is zero. Thus the conjugate universe solutions are necessarily flat in DG without needing inflation! Perturbations about Minkowski can account for the radiative decay of pulsars as in GR, yet the "gravitational waves" in this case have spin zero rather than spin 2 though the coupling to matter is still spin 2 like (minimal coupling to an order two tensor field) and the exchange of such waves between two masses is not expected to generate any additional gravitostatic interaction after quantization (additional to the one described in Section 6.1).

After requiring the action to be extremum we get a single equation for our background single degree of freedom:

$$3A\left(-\frac{\ddot{A}}{A} + \frac{1}{2}\left(\frac{\dot{A}}{A}\right)^2\right) - \frac{3}{A}\left(\frac{\ddot{A}}{A} - \frac{3}{2}\left(\frac{\dot{A}}{A}\right)^2\right) = n\pi G(A^2(\rho - 3p) - \frac{1}{A^2}(\tilde{\rho} - 3\tilde{p})). \tag{12}$$

The scale factor $a(t)$ definition is as usual $A(t) = a^2(t)$. When $a(t) = 1$, the conjugate metrics identify to each other and to Minkowski allowing to reconnect the content of the two sides. It is thus natural to assume an almost exact compensation, i.e., the same initial global density of energy and pressure on our and conjugate side, an easy way to explain the origin of the matter-antimatter asymmetry, a small initial excess of baryons on our side resulting in the same relative small excess of anti-baryons on the conjugate side just after their separation.

The initial solution is

$$A \approx 1 \Rightarrow \ddot{A} = \frac{\dot{A}^2}{A} \Rightarrow a = \mathrm{e}^{\frac{t-t_0}{T_{\mathrm{ini}}}}. \tag{13}$$

We notice that $a(t) \approx 1$ implies $t \approx t_0$, the origin of times.

As long as both sides remain hot, the source terms both vanish and the conjugate worlds have simple evolution laws in the particular ranges $a(t) \ll 1, a(t) \gg 1$. Indeed, the scale factor evolution is then driven by the following

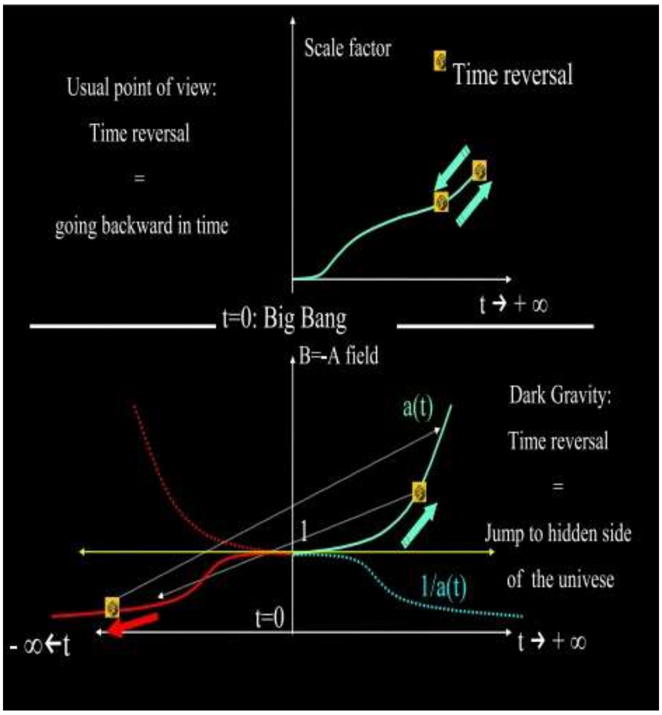

Figure 1. Time reversal in DG vs RG, plotted curves are not realistic.

differential equations:

$$a \ll 1 \Rightarrow (\ddot{1/a}) = 0 \Rightarrow a(t) = \frac{T_{\text{hot}}}{t_0 - t}, \quad \text{where } t < t_0, \tag{14}$$

$$a \gg 1 \Rightarrow \ddot{a} = 0 \Rightarrow a(t) = \frac{t - t_0}{T_{\text{hot}}}, \quad \text{where } t > t_0. \tag{15}$$

If one or both are evolving in a cold era, there is a dominant source term determined by the content of the side with greater scale factor. The differential equations read:

$$a \ll 1 \Rightarrow (\ddot{1/a}) = \frac{-n\pi G\rho_0}{6} = \frac{2}{T_{\text{cold}}} \Rightarrow a = \frac{1}{\left(\frac{t-t_0}{T_{\text{cold}}}\right)^2 + K}, \quad \text{where } t < t_0, \tag{16}$$

$$a \gg 1 \Rightarrow \ddot{a} = \frac{-n\pi G\rho_0}{6} \Rightarrow a = \left(\frac{t - t_0}{T_{\text{cold}}}\right)^2 + K, \quad \text{where } t\ > t_0, \tag{17}$$

where ρ_0 is the unknown density at t_0. Of course the integration constants t_0, T_{ini}, T_{hot}, T_{cold} and K of the approximate solutions in the different ranges are a priori not the same but must be non trivially related to each others and to ρ_0.

The harvest is already impressively successful! The first good news is that we can check in a straightforward way that $t - t_0 \to -(t - t_0)$ implies $A \to 1/A$ i.e. remarkably, we have $A^{-1}(-t) = A(t)$ setting $t_0 = 0$. The conjugate universes are really linked by time reversal, one of our initial goals! One is expanding and the other contracting. But here time reversal does not mean going backward in time anymore. As shown in Fig. 1, reversing time means jumping to the time $-t$ of the conjugate universe where one can remain for sometime before jumping back which can never make you reappear in the past there.

From now on we shall assume that K is negligible in the formula for the scale factor cold evolution. Then the coordinate transformations to the more familiar standard cosmological time t' is much simpler. We also set the arbitrary t_0 to 0 and for the sake of simplicity "forget" the other integration constants. We discover that not only our universe can be accelerated thanks to a t'^2 evolution (equivalent to $\frac{1}{t^2}$ after the coordinate transformation from t to $t' = -1/t$) for the scale factor without any need for a cosmological constant or dark energy component, not only can it also decelerate thanks to a $t'^{2/3}$ solution (equivalent to t^2 after the coordinate transformation from t to $t' = t^3$) as in standard cosmology in the matter dominated era but we also have a standard $t'^{1/2}$ evolution (equivalent to t after the coordinate transformation from t to $t' = t^2$) again as in standard cosmology for the radiative era. However, the transition between the decelerated expansion to the recent accelerated expansion regime at the so called turnaround red shift where the universe was between 4 and 7 billion years younger than now requires that coming back to the conformal time we had a sudden (discontinuous) transition from $t^2 \ll 1$ to $1/t^2 \ll 1$, which implies that time reversal occurred and the two conjugate metrics exchanged their roles. But t'^2 is known to be still expanding so t' increases

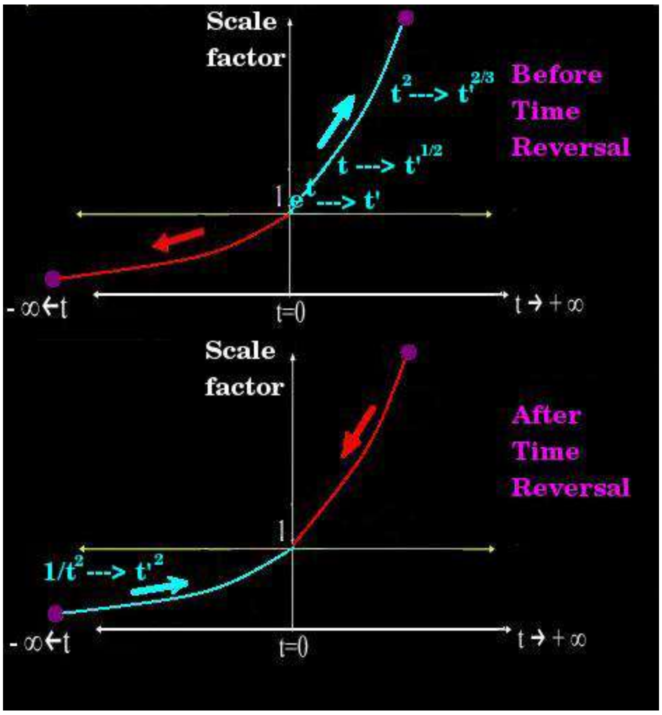

Figure 2. Evolution laws and time reversal of the conjugate universes, our side in blue.

and consequently $-t$ decreases and returns to zero so $1/t^2$ must still be expanding (as did t^2). All this is summarized in Fig. 2.

Now one needs to understand why the huge discontinuous transition from $t^2 \gg 1$ to $1/t^2 \ll 1$ did not have any observational effect. Indeed the same kind of transition if it had been continuous would have produced huge red shift anomalies. This is where the new rules describing the effect of genuine gravitational field discontinuities on various fields minimally coupled to them must be understood. The usual differential equations based on the hypothesis that all fields are C∞ clearly cannot help us to understand the transition. But the evidence is there that only the red shift derived as usual from the continuous variation of the cosmological field before and after the discontinuous transition did have observational effects, not the transition itself. This is as if the effect of the discontinuity was a mere renormalization of the field rather than a time variation and we know that indeed the renormalization of a gravitational field has no observational effect. Also notice that the Hubble expansion rate is the same just before, $H(t) = 2/t$, and just after, $\tilde{H}(t) = -H(-t) = \frac{-2}{-t}$ (since (a(t),dt) $\Rightarrow$ (a(-t)=1/a(t),-dt)), the transition.

Now, coming back to the standard cosmological time we can require that the total age of the universe must be $1/H_0$ as in the standard model (beware that we now change our notations: subscript zero refers to the present time, and t to the standard time). This total age is the sum of the duration Δt_2 of the decelerating regime from the decoupling red shift $\gg 1$ to the transition redshift $z_{\rm tr}$, given by $\Delta t_2 = (2/3)\frac{1}{H_{\rm tr}}$, and the duration Δt_1 of the subsequent accelerated t^α regime given by

$$\frac{\alpha}{H_0}\left(1 - \frac{1}{(1+z_{\rm tr})^{1/\alpha}}\right).$$

Knowing that $H_{\rm tr}$ is related to H_0 by $H_{\rm tr} = H_0(1+z)^{1/\alpha}$ it is straightforward to simplify $\Delta t_1 + \Delta t_2 = 1/H_0$ to get:

$$z_{\rm tr} = \left(\frac{2/3 - \alpha}{1-\alpha}\right)^{\alpha} - 1. \tag{18}$$

One checks that our predicted $\alpha = 2$ gives $z_{\rm tr} = 0.78$ in perfect agreement with the best current estimation $z_{\rm tr} = 0.77 \pm 0.18$ [17]. This confirms that DG cosmology can perfectly mimic GR cosmology without inflation nor a cosmological constant as regards the scale factor evolution. The transition redshift is expected not to be everywhere exactly the same due to local perturbations so that integrated over large regions, the resulting transition is likely to be observed significantly smoothed by this dispersion of $z_{\rm tr}$.

Perhaps we can go a little further considering that we have actually obtained a large family of cosmological solutions corresponding to different initial ρ_0 and integration constants. All these universes have a cyclic evolution as in Fig. 2, but some of them will remain in the regime $a(t) \ll 1$ where $a(t)$ is exponential and $a(t') \propto t'$ throughout the cycle. For each such universe, at any time t' its age is given by exactly $1/H(t')$. This is the same formula as the one satisfied by our universe at the present time only by chance! We are therefore tempted to postulate that all universes are constrained to satisfy exactly the same formula giving their age as $1/H_0$ at the end of their completed cycle when returning to and all crossing each others at $t = 0$. Then the coincidence that the total age of our universe is exactly $1/H_0$ at the present time would just be the translation of another amazing coincidence: we are presently almost exactly at the end of a cosmological cycle! This coincidence might be correlated with another extreme coincidence: the present time is also the first time in the history of the universe when human kind has reached a degree of development allowing to understand and may be to take advantage of this! Indeed, being near $t = 0$ also means that various regions of the universe are in a kind of metastable state. These have to choose between $a(t)$ and $1/a(t)$ for the next cosmological cycle and the discrete jump at the frontier between two such regions can be relatively very small because we are very close to $a(t) = 1$. May be this speculation will make more sense later when discussing LENR.

What remains to be investigated is whether the anti-gravitational effects of the matter from the conjugate side can do a better job than Dark Matter at all scales and any epoch of the history of our universe. The situation is very promising from both galaxy simulation studies by JP Petit and my analysis of well known anomalies of Dark Matter models at the galactic scales see [2] Section XX.e. At larger scales it seems difficult to decide between DM and conjugate matter given that they tend to perfectly mimic each other in the linear domain.

Of great importance is the fact that the background metric in DG applies to all scales and not only to the largest scales. For instance the solar system is also expanding (this is not the case in GR [16]) and to avoid conflicts with precision tests probing effects equivalent to a variation of the gravitational constant *G*, an extension of DG is required and was postulated that would result in the electromagnetic field being also affected by the scale factor. A bridge between gravity and electromagnetism takes shape, this being already favoured by the mere fact that our theory is now also a theory having a flat space-time background so that $g_{\mu\nu}$ does not have anymore the exceptional status it acquired in GR and that made it very different from usual other fields such as A_μ.

7. Discontinuities of the Background Field

According to Eq. (12), our side of the universe could have evolved in two possible ways, expanding or contracting in this coordinate system starting from $t = t_0$ where the total source term vanished and the conjugate metrics were equal. But local initial density fluctuations (net source term slightly positive or negative) might have determined how the background decided to evolve in different regions of the universe. This is just similar to the situation we encounter when there is a spontaneous symmetry breaking, a phase transition resulting in different vacuum expectation values for a field in various regions. In other words, one single solution $a(t)$ for the scale factor might not be at work everywhere in our side of the universe. Some regions might instead be evolving according to the other solution $1/a(t)$ implying that the conjugate background metric exchange their roles from one to the neighbour region but then also a genuine discontinuity of this background field at their common frontier. Remember that indeed, it is rather the spontaneous symmetry breaking of a discrete time reversal symmetry that we have to deal with in this case. The background field is a two valued field that can only jump from one value to the other T-conjugate one.

What kind of new phenomenology could we expect from such discontinuities? This was the subject of our article [6] where we focused on three main effects. First, if highly relativistic particles take advantage of these discontinuities which are at the same time metric points and switches to transit from one universe to the conjugate one, these particles would appear to propagate in the conjugate metric faster than our local speed of light. The second effect appears if we compare ticks of two identical clocks separated by a discontinuity: in one region times accelerates as $a(t)$ and in the other region times decelerates as $1/a(t)$ so from the point of view of one clock the other will be seen to accelerate or decelerate at a rate equal to twice H_0. This is exactly (quantitatively) the so called Pioneer effect! The third kind of effect is the one we want to investigate in more details now. Discontinuities of our conformal background metric imply potential barriers able to accelerate massive particles crossing them (the energy gained or lost is proportional to their mass) so these could be new sources of energy for LENR phenomena. However these should be totally transparent to light or other massless particles.

8. Summary Statement

Serious experimentalists in Cold Fusion, when they are quite fed up because of the plethora of ad hoc theories flooding the market, tend to say that to make good physics one should not be imaginative. What one needs is to respect all the experimental data, which are indeed already very much constraining in the field of LENR given how many variants of the initial experiments and effects we have to explain at the same time. Of course this is true, but what these experimentalists do not suspect or tend to neglect is that almost all these models are already born dead by very simple purely theoretical arguments. Even in theoretical physics there is actually almost no place for imagination. First the game is not to reinvent everything but instead we have to stick to the accepted physics until we can point to a hidden hypothesis that deserves to be put in question or a forgotten solution. Our starting point was that the negative energies were not understood properly but discarded out of hand. To understand them we need to rehabilitate Unitary Time reversal in QFT and a complete revolution of our understanding of time reversal in a gravitational framework but a revolution that unsurprisingly turned out to be so constrained that a single solution were dictated to us by the structure of the problem. Down the road we find that there is another strong assumption of all field theories that we should also put in question: the continuity of all fields (even assumed C infinite in Lagrangian theories). But if we allow ourselves to relax the everywhere continuous hypothesis, it is only because we are strongly justified to do so by the new symmetry of our DG theory, a time reversal that we are now able to really treat as a discrete fundamental symmetry even in a gravitational framework. The plan is especially not to brush off all the physics which has proven itself, of continuous fields that relied on infinitesimal calculus! These laws will still apply almost everywhere i.e. in the bulk of spatial regions at the frontier of which new complementary supplemented rules will apply for discontinuities (see Fig. 3).

Anyway, because this new step is an extraordinary one, it needs extraordinary justifications. This is why we think it is useful to take some time here to explain why we believe discontinuities are one of the missing keys for a better understanding of our Universe.

9. Theoretical Motivations for Discontinuities

9.1. Classical relativistic field theories in a nutshell: encounter of the fourth kind

Classical Relativistic Field Theories were the triumph of four ideas: first it was possible to reach a mathematical quantitative and accurate description of almost all known phenomena. Second the whole theoretical construction can be derived from a very small number of principles: it is extremely economic which also ensures its predictive character. Third, both the principles and the theoretical construction that follows do not conflict much with common sense, our familiar conceptions about the real world (it is much easier to learn how to live with SR than with QM). Fourth,

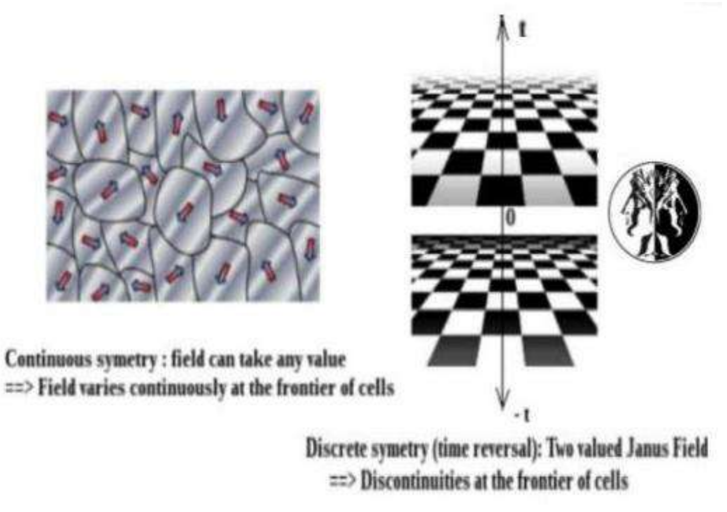

Figure 3. Discrete symmetry domains vs continuous symmetry breaking domains.

the principles themselves do not appear arbitrary but would seem to be implied by a meta-principle which could be summarized in the mere sentence: "science must be possible".

The advent of QM reinforced the two first ideas by extending our understanding to the micro-world with very few new principles, disproved once and for all the third and left the fourth in a worrying status.

To clarify the last point, let us outrageously summarize our understanding of how classical relativistic field theories could have been obtained. To describe the container of everything we give ourselves three space coordinates and one time coordinate. Everything in the content will be described in terms of fields, i.e., just one or several numbers at each point of space and time. Nothing is more refined than the idea that at the roots of everything you do not have water (as would have argued Thales), nor fire (à la Heraclitus) nor even atoms (à la Democritus) but just . . . numbers.

But probably because this was not simple (unified) enough we require that the Transformation between two Galilean frames should be rather of Lorentzian than Galilean type (no other choice according modern axiomatizations of SR) because this is the only choice that really allows to unify the four space-time coordinates in a single multi-component object (x, y, z, ct) but this requires the introduction of an invariant universal finite speed c. From this follows the whole theory of SR. In particular the structure of the container, our now unified space-time, requires the content, the fields, to belong to well defined representations of the Lorentz group, i.e. our numbers must be arranged into single or multi-component objects, our now familiar scalar, four-vector and higher order tensors, Dirac fields and so on. The next step is to ask what are the laws of physics that these fields should obey. Of course such question presupposes that we believe in a kind of meta-principle: that science is possible. This in turn implies that there must be universal laws valid everywhere and at any time. Obviously if we had to reestablish the laws at each new location or each new morning, science would not be possible. The requirement needs to be generalized to any kind of space-time transformation that should leave the fundamental equations invariant. Science is possible also implies that we are not in a trivial world: things must occur, fields must be allowed to vary, derivatives are needed. But science is possible also implies that the laws should not be over-complicated if we want to be given some chance to discover them so let's ask no more than two derivatives in all terms of our fundamental equations. Now just knock the door of your favourite mathematician and ask the generally covariant laws with no more than two derivatives and he will give you all our familiar laws for a massless or massive four-vector Field, the GR laws for the order two tensor field of gravity and, he might also give you a very powerful recipe to get the laws, the extreme action principle. Without exaggerating too much, that is the very impressive feeling that you might be left with after studying Classical Field theories: the mere requirement that science must be possible could have led pure thought to discover the laws without even performing a single experiment!

9.2. Two parallel paths: from DG to QM, from DG to LENR

Given how unexpected and weird were the new rules introduced by QM, the Planck Einstein quantization relations and the non local and non deterministic collapse of the wave function, it was clear from the beginning that considering these new rules as principles would irremediably and severely maul our fourth idea that the principles of our fundamental theories should not be completely arbitrary. Yet when theoreticians progressively realized that they will have to give up forever the idea of a local theory behind QM after many experiments confirmed the reality of the "spooky action at a distance" in the words of Einstein, they threw the baby out with the bath water, they gave up the fourth idea together with the third.

Indeed, almost no effort was engaged to explore a deeper world with new discontinuous and non local laws and to discover less arbitrary principles (themselves almost necessary starting from the meta-principle that science must be possible) from which the QM rules could have been hopefully derived. Instead the effort was focused on unifying the interactions and trying to apply quantization as we (do not) understand it to gravity which resisted up to now.

In DG the context is the best one could imagine to start such exploration:

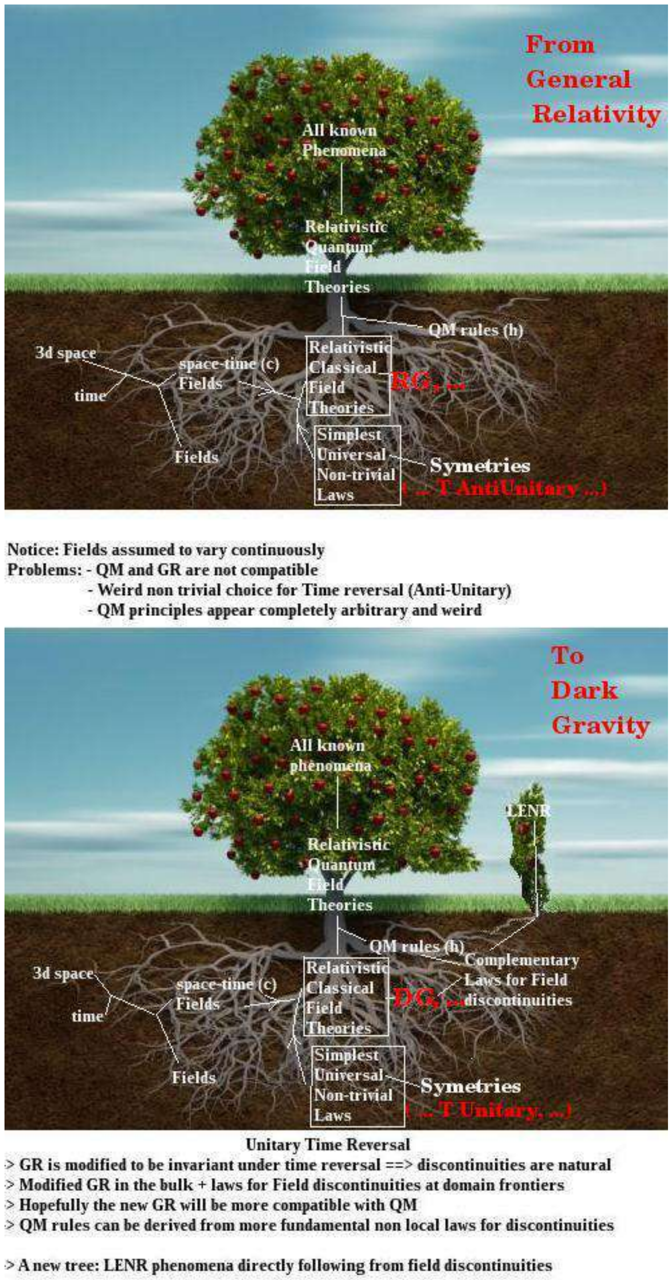

Figure 4. Synopsis.

- Discontinuities and our non propagated gravity have all to be the missing keys to understand where discontinuous and non local rules of QM come from and to hopefully predict the value of the Planck constant, in other words, compute the fine structure constant α.
- Rehabilitation of negative masses allows us for the first time to imagine a stable structured vacuum based on alternating positive and negative masses, a new actor hopefully responsible for the non local QM collapse, and standing for the creation and annihilation operators of QFT.
- LENR phenomena could be the direct consequences of the physics of discontinuities allowing to probe a deeper level of reality without conflicting with the accepted physics that results from the quantization of our classical field theories, QM being the other indirect parallel consequence of the physics of discontinuities.

Moreover let us stress again that being a theory with a flat space-time background and with a not so exceptional field (apart its Janus Character), DG gravity might be much better positioned than GR gravity to be quantized if necessary or unified with other interactions. Figure 4 is a synopsis of the ideas developed in the previous sections.

10. LENR, the Whole Experimental Evidence

None of the following LENR main signatures, the so called miracles, should be ignored or neglected.

(A) Large excess Power (XP) not possibly of chemical origin with very low levels of nuclear radiations (alpha, beta, gamma, neutrons) as compared to what would be expected from nuclear processes producing the same amount of energy.
(B) Transmutations and isotopic anomalies in cold conditions.
(C) Observation of a new category of incredible objects which behaviour seems almost impossible to understand without postulating new physics (for instance caterpillar traces left by micron sized magnetic and radiating objects able to fly meters away from their source, to go through dense materials, to explode and release much energy in them, and so on) objects which were discovered by many scientists independently (Matsumoto, Dash et al., Shoulders, Lewis, Savvatimova, Urutskoev et al. , Ivoilov and other groups) in many kind of experiments involving macro or micro electric discharges and independently named Evos, EVs, Ectons, Plasmoids, Ufos, Leptonic Monopoles, Charged Clusters, Nucleon Clusters, Micro Ball Lightning, . . . [18] and all references therein.

Any idea proposed to explain (A) or (B) but neglecting (C) is almost certainly wrong because it is unlikely that two kinds of very different new theoretical ingredients are needed, one to explain (C) and another to explain (A) and (B), while the detections of the two kind of effects are clearly related. Indeed, typical transmutations of LENR (without high energy radiation and leading to stable nuclei only) have often been reported in association with the observation of strange tracks, and often in the tracks themselves. There is even an annual conference called Russian Conference on Cold Nuclear Transmutation and Ball-Lightning (RCCNT and BL) and regularly there also have been presentations on Ball Lightning and strange tracks at the ICCFs. The properties of these objects are so unimaginable that even if we could produce a theory to address (A) or (A) and (B) pushing standard physics to its limits to get unusual screening effects or energy concentrations in condensed matter, it seems extremely unlikely that it will explain at the same time observations of the third kind (C). On the other hand if you are able to provide an explanation for (C), you might be more lucky to elucidate (A) and (B) at the same time. Clear sightedness thus recommends that we should first gather the detailed evidence about the strange objects that we shall call micro ball lightnings (mbl) following the interpretation of [18], that though much smaller than their sisters produced in lightning storms, these are probably of the same nature given that in both cases we have to explain the long term stability of an object concentrating electromagnetic energy, luminous and charged appearing as the result of a more or less powerful electrical discharge. Apparently the more powerful the discharge, the greater and longer lived the ball lightnings. We include micro-discharges near metal surfaces in simple electrolysis experiments or inside metal cracks (Ni, Pd) in experiments where these discharges can result from either the metal surface being submitted to mechanical, thermal or EM pulse shocks or the cracks to successive loading and de-loading of H or D or to a current flow that these cracks block, triggering micro-discharges. We also leave open the possibility that the universal trigger might just be a concentration of charges implying a local increase of the electrostatic energy since such conditions can both lead to discharges or be created by them.

11. From Field to Temperature Discontinuities

The challenge is thus the same as it is for macroscopic ball lightning; it is to find a mechanism able to confine a significant amount of energy in the form of heat (the temperature inside is at least of 1000°) and resist the pressure during the whole lifetime of for instance a 6 μm sized mbl (between 10 and 0.01 μs, [21]) and to explain how such

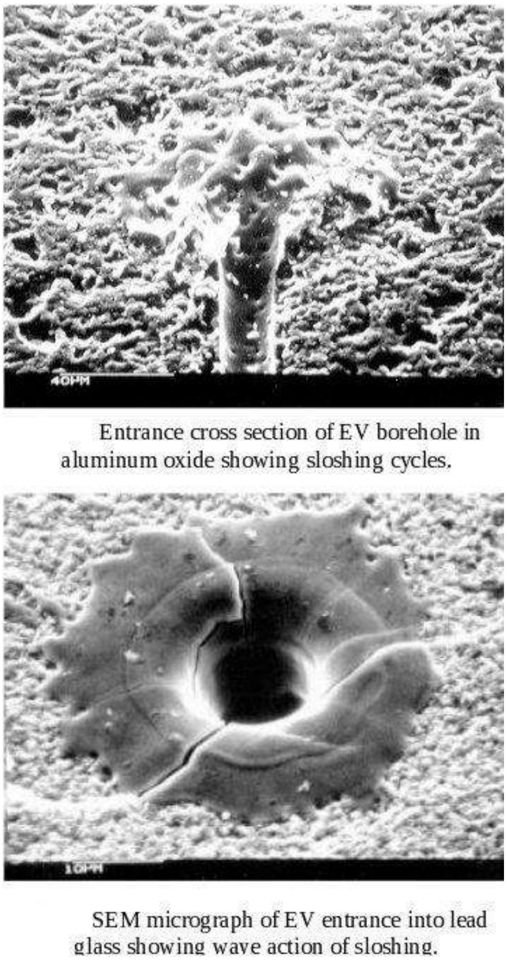

Figure 5. Boreholes left by mbls.

a macroscopic collection of a huge number of particles can behave as a single object leaving a well defined track in nuclear emulsions or boreholes in matter. The stability problem is even worse if you take seriously the results from various researchers [20,21] strongly suggesting that the mbls also carry a huge electric charge, because you then have to explain how these can resist the corresponding electrostatic repulsion between an incredible concentration of charges of the same sign.

Let us cite the ground breaking result obtained by Shoulders after analysing boreholes left by mbls: "The borehole is fairly clean for a process that is capable of fluidizing a material with a melting point of 2600°C and projecting it to an unholy velocity. In fact, when a special test is set up to determine the thermal gradient at the edge of the borehole, one comes to an astounding conclusion: either a gradient of over 26,000°C/μm exists here, or this is a non-thermal process!". Can we imagine a better signature for a field discontinuity than this evidence for a temperature discontinuity (Fig. 5)?

We are led to understand the mbl as a macroscopic object, i.e. a huge collection of particles with an initial density determined by the medium where it formed (gas, liquid, and solid) surrounded by a discontinuous gravitational potential which can accelerate in a centripetal way all massive particles encountered up to an energy proportional to their mass and then trap them inside, resisting both pressure and electrostatic repulsion between particles of the same charge trapped in the volume delimited by the discontinuity. The discontinuity is of course one possible source of the particles kinetic energies and hence temperature inside the mbl. But how could the energy escape out of the mbl and be measured as heat (XP) outside if the energetic particles are all trapped inside? Again the answer is simple. The kind of gravitational potential barrier implied by a discontinuity of the background field has no effect on massless particles (conformal metric), so any photon can cross it and escape (hence the name Ball Lightning). Thus the radiative cooling of the mbls can take place efficiently, implying that these are able to heat their environment but only radiatively.

The mbl is also charged and it is actually the electrostatic density of energy implied by this charge that reached the threshold that triggered the apparition of the discontinuity. For instance, an electrical discharge impact might generate a very short-lived concentration of charges of the same sign which is of course electrically very unstable and should disperse very fast if a discontinuous potential suddenly appearing did not trap them, stabilizing the object for a much longer time. The mbl would therefore be stabilized as long as it is able to keep the charge that gave birth to it.

Let us specify our understanding of the most likely origin of this electrostatic energy threshold. The source term in Eq. (12) determines whether the background will choose the $a(t)$ evolution or the $1/a(t)$ evolution. It just depends on which contribution is the greater, our side positive or the conjugate side negative. If we are in a vast region dominated by the conjugate side source term then a local concentration of energy on our side, an energy that fills the available space as is the energy of the electromagnetic field rather than concentrated in points (as is the energy of massive particles), as soon as this new contribution locally exceeds the conjugate side one, the background will flip in this region to the other regime, producing a discontinuity with amplitude $a(t) - 1/a(t)$ sitting exactly at the surface frontier between the external area where the conjugate side still dominates and the internal one which is enclosed by the discontinuity. Of course this surface is defined by the vanishing of the total source due to the exactly compensating terms from our and conjugate side. As we explained earlier the dynamical background components $a(t)$ and $1/a(t)$ are expected to be rather close to each other in our cosmological epoch. If the difference is of the order of 10^{-9} the potential barrier implied is 20 eVs for nucleons and of the order of 10 meVs for electrons.

Since the probability of reaching the crucial threshold is determined by the local density of energy on the conjugate side on which we have no control and no knowledge, but also on potential gravitational energies implied by the position of massive local objects (planets, sun), and since these are expected to fluctuate in time, it is not surprising that eventually, cold fusion COPs are so erratic and unpredictable.

12. Fate of mbls: the Fast Case

Because the discontinuous potential barrier is two thousand times more effective for the more massive nucleons than it is for electrons, it turns out that it is much easier to keep alive positively charged mbl than negative ones. Indeed inside the mbl any interaction between the cold electrons (accelerated to 10 meV) and much hotter nuclei (accelerated to 20 eV) will likely boost the electrons to an energy much above the 10 meV mbl barrier for them. Thus eventually the electrons tend to be ejected out of the mbl while the nucleons are trapped much more efficiently because the potential barrier is much higher for them. This would result in a very unstable initially negatively charged mbl (remember an mbl must keep its charge to stay alive) unless the radiative cooling of the nucleons is much faster than the rate at which the hot nucleons interact with the cold electrons (the crucial physical parameter here is probably the plasma density). On the other hand stability should be granted for the positively charged mbls in vacuum. Indeed, in this case, the electrostatic attraction by the protons prevents the electrons to escape too far from the mbl even if they have sufficient energy to overcome their discontinuous potential barrier.

But of course, in real life conditions, mbls can only rarely be considered isolated from surrounding matter of their environment, as if they were in vacuum. As a consequence of their charge the mbls will be attracted and will attract any opposite available charges around and absorbing them will tend to recover neutrality. Losing its net charge in this way any mbl is expected to soon collapse and "evaporate" as it recovers neutrality. Eventually, any mbl, either positively or negatively charged is unstable if it is not strictly isolated.

Two fate scenarios are possible, a fast and slow one. Let us list the steps involved in the most common fast collapse:

- As the mbl neutralizes, at any place where the density of electrostatic energy has decreased below the threshold defined by the conjugate density of energy the background has returned to its exterior value which therefore gains ground on the volume of the mbl. In other words, the mbl collapses.
- For a fast input of opposite charges and hence fast neutralization, because of the mechanical work that the discontinuity gives to the mbl interior plasma during the collapse, the heat accumulates too fast in the mbl to allow it to radiatively dissipate this heat.
- The kinetic energies of the particles inside the mbl increase up to the point where these can overcome the discontinuous barrier and escape. The lost of its charge as it seems to "evaporate" in this way also accelerates the collapse of the mbl up to total disappearance.
- In such process it is still only the radiative losses that are responsible for heating the environment and the XP because the particles escaping the barrier are instantaneously cooled to the exterior temperature. The very origin of this excess energy is neither directly chemical nor nuclear so far. It is rather the potential energy implied by the discontinuity, and the mechanical compressional work performed by this discontinuity both turned into radiation (light). Because the Noether theorem does not apply any more for discontinuous fields, the energy is a priori not locally conserved in such process but still might be globally conserved.

13. Fate of mbls: the Slow Case

13.1. The slow collapse

The slow collapse is probably exceptional but much more energetic as it triggers nuclear reactions. If the collapse is sufficiently slow, such a small object as is the mbl can radiatively dissipate its heat faster than it is produced so that the mbl can remain cold during the collapse. The particles kinetic energies now remain insufficient to escape the potential well. Thus the mbl keeps its content and compresses it up to huge densities. For this to be possible a first necessary condition is probably that the positively charged mbl is magnetically trapped in a metal crack or trapped in an insulating material or any area where it is slowly fed with electrons and recovers neutrality extremely progressively. A magnetic trap may rely on the extremely magnetic properties of the mbl that we shall investigate in the next section. What also makes it possible to reach huge densities is that the effect on a given test nucleus of even a small amplitude discontinuity always overcomes the repelling potential of another neighbour nuclei whatever its amplitude which indeed becomes huge when the other nucleus gets closer and closer [22]. Actually it is only by reaching enough kinetic energy that a nucleus can overcome a discontinuous barrier, but for this to be possible, this nucleus needs its huge repelling potential energy implied by the compression, to be converted into enough kinetic energy. This is not the case because the nuclei do not have enough place to move and their thermal vibrations are efficiently dissipated by the mbl as we already explained in this slow scenario.

As the nuclei get closer and closer the electron wave packets tend to more and more overlap each others and must shrink to respect Pauli exclusion principle so we are approaching the picture of the black dwarf: nuclei very close to each other in a cloud of electrons with much higher “Heisenberg kinetic energies”. In this case an electronic screening effect can take place because the electronic density of the sea of electrons also increases in between any two nuclei as these approach each other. At this level the degeneracy pressure of the electrons is not yet beaten by the discontinuity but the proximity of the nuclei and the electronic screening makes possible a variety of nuclear multi-body reactions between all the trapped nuclei that will eventually lead to the more stable reachable states. As in a white dwarf everything might eventually be turned into Ni^{62}. Reaching higher mass nuclei thanks to an mbl increased density is not insured because again if the release of energy is too sudden the mbl will heat too fast and lose its content as in the fast collapse scenario which anyway is expected to occur sooner or later.

13.2. Clean nuclear energy

Mbls are actually very common objects expected in any kind of electrical discharges or any phenomena producing local concentrations of charges having the same sign, such as for instance capacitors, point effects, biological membranes, the impact of a target by a narrow beam if the charges are not cleared out efficiently. It is the very revolutionary nature of these objects that escaped the attention of mainstream physicists for decades mainly because it is so unexpected. One of the most impressive kind of observations are those revealing many types of transmutation or nuclear fusion products clearly associated with these objects and their various traces and pitches these left in the materials met on their path. We explained in the previous section that the mbl understood as a kind of micro black dwarf, the fate of a slowly collapsing gravitational discontinuity, is the ideal candidate to trigger the chain of multi-body reactions that will lead to the most stable and more easily reachable nuclei: He^4, Ni^{62} and so on. Stable means that we already understand why eventually the residuals of CF reactions are not radioactive. What would seem to be a priori more challenging is to explain why the nuclear reactions inside the mbl themselves do not produce large fluxes of high energy particles: α, β, γ, neutrons in the MeV range for which the discontinuity potential barrier is negligible. We already discussed this problem in [6] and concluded that most highly energetic particles produced in the mbl, included neutrons, should be thermalized well before they are able to reach the surface of the object. For instance a 10-micron mbl with the density $d = 1$ of condensed matter at birth, once compressed to a nanometer size, will have a density d over 10^{12} and neutron mean free path of the order of 10 fm, hence so much smaller than the mbl, that only very exceptional neutrons produced near the surface of the mbl can be radiated at high energies. The conclusion a fortiori also applies to all other nuclear radiations with even smaller mean free paths. Eventually most of the energy produced in the mbl should be radiated electromagnetically by at most soft X-rays (10 eV) except there may ultimately be more or less explosive fast dispersion of the mbl if a chain of nuclear reactions is triggered.

14. Other Extreme Properties of mbls

Traces of mbls have been reported revealing objects of various sizes [19] as they propagate through various materials. This, along with the specific properties of these traces confirms that we are seeing a macroscopic object, not any kind of elementary particle, and yet an extremely penetrating one able for instance to pass through two meters of atmospheric air and two layers of black paper. This would be very hard to explain if we did not understand that a mbl is not merely a micropiece of hot matter which would be arrested immediately by any dense obstacle. Of course its surface discontinuity can fuse, evaporate or even turn all the material encountered into a plasma which might help penetrating a solid for instance. But this is not enough! The question is how is an mbl able to propagate such a long distance in a dense medium and interacting so much with it without apparently slowing down, as if its motion was not resisted at all. We already have the answer. The whole material content of the mbl is actually enclosed by the discontinuity, which itself is completely driven by its minority of charged particles in excess that defines the distribution of the electrostatic energy that gave birth to the mbl. If some of these charges during a small time interval interact and are deviated or slowed down, the majority of the other charged particles do not interact (being elementary particles these are much less likely to interact than a macroscopic object) still carrying the discontinuity at almost uniform speed, discontinuity that is able to permanently refocus, gather and re accelerate the latecomers and dispersing ones. Moreover these charged particles being elementary are individually extremely sensitive to any external electromagnetic field because of their huge charge over mass ratio q/m and so is the cluster of these charged particles, thus the mbl as a whole even though it has a much smaller Q/M being essentially neutral as any macroscopic quantity of matter.

We are indeed faced with an extraordinary macroscopic object able to react to external EM fields or propagate through matter almost the way elementary particles do. Many searchers reported those incredible tracks left by mbls showing sharp angle turns manifesting huge accelerations as if the mbl as a whole did not have any inertia and could be accelerated as efficiently as each single electron in the electrical field (inside a mbl plasma the much greater mobility of the electrons relative to the ions suggests that the electrons are the main drivers of the mbl)! Phenomenal accelerations of a macroscopic object is made possible by mbls but these can also describe circles at high cyclotron frequencies in a

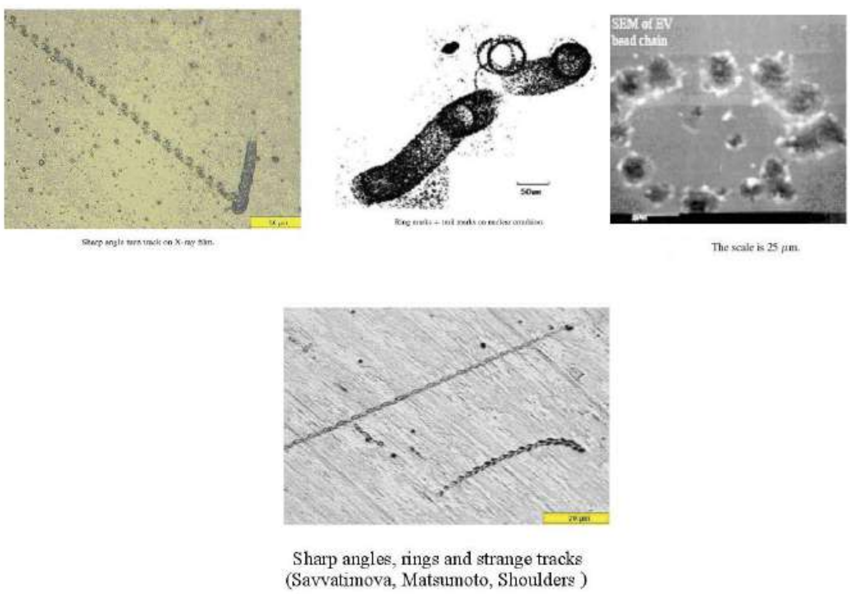

Figure 6. Inertia anomalies and strange traces.

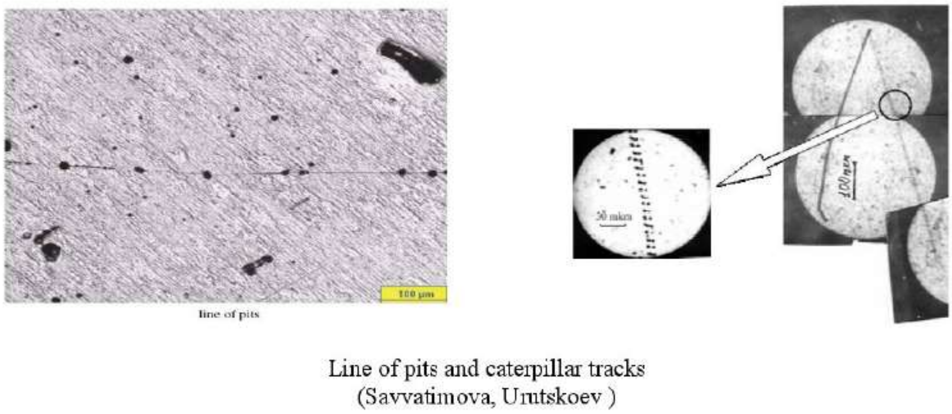

Figure 7. Caterpillar and dotted line traces.

magnetic field as was also observed [18]. Various strange traces can be seen in Fig. 6.

Such kind of observations might have created the illusion that the mbls manifesting so huge Q/M ratios were clusters of an incredible number of electrons, though this interpretation is hardly tenable.

For all the previous reasons, the mbls are obviously extremely effective charge carriers in a wire submitted to a voltage and therefore able to produce dramatic falls in wire resistivity as is also regularly reported in cold fusion experiments even up to the destruction of the wire.

At last, the mbls being very charged and, due to the conservation of angular momentum during their collapse, also rotating at high angular velocity, these are expected to be extremely magnetic. So it is not so surprising that such objects can be trapped in ferromagnetic materials [19].

Eventually let us not forget that discontinuities in DG are connecting the two sides of the universe. This is why the material content of the mbl might oscillate between our side of the universe and the conjugate side (the antimatter universe) via the peripheral surface discontinuity of the mbl so that the mbl may have an alternating luminosity from one side (the observer side, i.e. our side) point of view, hence leave those strange caterpillar or dotted line traces in emulsions as described in [19] for instance (see Fig. 7).

15. Conclusion

The review on Dark Gravity given in the first part of the article was necessary to clarify and present in the most intuitive way, avoiding the mathematical formalism already developed elsewhere, the main steps toward an anti-gravitationally stable extension of General Relativity with Time Reversal treated as a fundamental discrete symmetry even in a gravitational context, and its naturally expected associated field discontinuities. Having established this stable extension of General Relativity, we can then list many key observations of LENR and show that each one is an almost perfect signature of the physics of these discontinuities. By the way we were also able to derive a correct transition red shift from deceleration to acceleration of our Universe, showing thereby that our DG cosmology can perfectly mimic the LCDM one as for the scale factor evolution without the free parameters associated to DM, DE, Inflation.

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