Tracking Down The Standard Model With Gravity In Multi-Fold Universes

Stephane H. Maes[1]

August 20, 2020

Abstract:

In a multi-fold universe, gravity emerges from Entanglement through the multi-fold mechanisms. As a result, gravity-like effects appear in between entangled particles that they be real or virtual. Long range, massless gravity results from entanglement of massless virtual particles. Entanglement of massive virtual particles leads to massive gravity contributions at very smalls scales. Multi-folds mechanisms also result into a spacetime that is discrete, with a random walk fractal structure and non-commutative geometry that is Lorentz invariant and where spacetime nodes and particles can be modeled with microscopic black holes. All these recover General relativity at large scales and semi-classical model remain valid till smaller scale than usually expected. Gravity can therefore be added to the Standard Model. This can contribute to resolving several open issues with the Standard Model without new Physics other than gravity. These considerations hints at a even stronger relationship between gravity and the Standard Model.

Besides having multi-folds, and gravitons, living in AdS(5) tangent to the multi-fold universe spacetime, spacetime points and particles or field locally encounter additional 3D spatial dimensions due to the multi-folds used by paths of entangled particles. It provides an apparent local 7D manifold embedding the multi-fold universe spacetime.

Modern unconstrained 5+D Kaluza-Klein (KK) empty (flat) space models, i.e. without compactification constraints of the additional spatial dimensions in 7D, allow the recovery from the 7D vacuum of gravity and electromagnetism as well as Yang Mills and the symmetries needed for strong and weak interactions. They also provide geometrical sources for masses, charges, wave functions, equations, quantum behavior and quantum vacuum. Unfortunately, limitations in terms of lack of chirality and chiral fermions, as well as apparition 5^{th} or higher order forces, have tampered the enthusiasm just as what happened with earlier KK models.

Within a multi-fold universe, we can recover chiral fermion and chiral symmetry breaking, due to gravity, of Electroweak and Strong interactions, while avoiding 5^{th} (and more) forces, magnetic monopoles (because not relying on compactification), undue precessions, loss of conservation laws or supersymmetry. Such considerations do not work in conventional induced space-time-matter theories. In other words, the Standard Model seems to be induced purely from gravity and spacetime geometries in a multi-fold universe. Explanations for masses, charges and quantum behaviors (wave functions, equations QFT loops and of course entanglement and quantum gravity emerging from entanglement) can be hinted, albeit not (yet) quantified, in multi-fold universes. This is quite an achievement putting multi-fold mechanisms, themselves also physically clarified in terms of mapping, on par with, if not ahead of, other Quantum Gravity, GUTs and ToEs candidates of Unification of Physics. The analysis of 7D empty universes vs. AdS(5) both surrounding any spacetime points, in a multi-fold universe, also illustrates the implications of dualities and the differences between multi-fold universes with additional dimensions vs. the universe where superstrings, supersymmetry, supergravity and M-theory seem to live and matter.

Our analysis also discusses, for multi-fold universes, if General Relativity (GR) governs physics in AdS(5) (plus additional dimensions) and the resulting implications for the ADS/CFT correspondence and ER=EPR conjectures as well as for superstrings.

[1] shmaes.physics@gmail.com

Additional considerations in terms of what entanglement may mean for the associated microscopic black holes are also discussed.

———

1. Introduction

The new preprint [1] proposes contributions to several open problems in physics like the reconciliation of General Relativity (GR) with Quantum Physics, explaining the origin of gravity proposed as emerging from quantum (EPR-Einstein Podolsky Rosen) entanglement between particles, detailing contributions to dark matter and dark energy and explaining other Standard Model mysteries without requiring New Physics beyond the Standard Model other than the addition of gravity to the Standard Model Lagrangian. All this is achieved in a multi-fold universe that may well model our real universe, which remains to be validated.

With the proposed model of [1], spacetime and Physics are modeled from Planck scales to quantum and macroscopic scales and semi classical approaches appear valid till very small scales. In [1], it is argued that spacetime is discrete, with a random walk-based fractal structure, fractional and noncommutative at, and above Planck scales (with a 2-D behavior and Lorentz invariance preserved by random walks till the early moments of the universe). Spacetime results from past random walks of particles. Spacetime locations and particles can be modeled as microscopic black holes (Schwarzschild for photons and spacetime coordinates, and metrics between Reisner Nordstrom [2] and Kerr Newman [3] for massive and possibly charged particles – the latter being possibly extremal). Although surprising, [1] recovers results consistent with other like [4], while also being able to justify the initial assumptions of black holes from the gravity or entanglement model in a multi-fold universe. The resulting gravity model recovers General Relativity at larger scale, as a 4-D process, with massless gravity, but also with massive gravity components at very small scale that make gravity significant at these scales. Semi-classical models also turn out to work well till way smaller scales that usually expected.

The present paper presents how multi-fold mechanisms and uncertainties expose particles and spacetime points to an apparent 7D (empty) spacetime itself also subject to an Hilbert Einstein action and how as a result the Standard Model (equations, quantum behaviors, particles and fields with masses and charges) can be induced. Focus is on showing how specific properties of multi-fold universes enable success where past KK and induced unconstrained models failed to convince.

In this paper, we remain at a high level of discussion of the analysis and references are generic for the subjects. It makes the points accessible to a wider audience and keeps the door open to further papers or discussions devoted to details of interest. Yet, it requires the reader to review [1], as we do not revisit here all the details of the multi-fold mechanisms or reconstruction of spacetime. More targeted references for all the material discussed here are compiled in [1] and derived papers.

2. Conventional 5D Kaluza-Klein

Kaluza-Klein theory details and history can be found at [5, 6,7]. Its main claim to fame comes from the apparition of Maxwell equations in 4D out of the effect of the vacuum in 5D. Electromagnetism seems to originate from the fifth dimension with constraints like cylindrical behavior and compactification. It is known as the Kaluza miracle. Unfortunately, conventional 5D KK turned out to be unstable in the ground state due to vacuum tunneling [8]. 5D compactification also creates problems with the apparition of magnetic monopoles, in as much that they have never been observed and that we have argued that they probably do not exist in multi-fold universes [9]. Also odd dimensions like 5D cannot account for chiral fermions, which constitute matter (besides radiation) in the Standard Model [13,14,15]. Higher dimension conventional KK got stuck on these issues and drifted instead towards supersymmetry, super gravity and eventually superstrings as more dimensions were considered [6,10]. The

mechanisms behind the introduction of additional compact dimensions has certainly inspired the subsequent work in supersymmetry, super gravity and superstring as summarized for example in [10].

It is worth also noting the equivalence between KK and Yang Mills Lagrangians as reviewed and discussed in [16]; albeit without chiral fermions in 5D or higher odd dimensions (because no useful Lorentz invariant chirality matrix γ_5 can be defined in odd dimensions).

3. 5D unconstrained KK for empty space

On the fringes of mainstream physics, a small community has spent several decades revisiting and modernizing Kaluza-Klein [5,10,11,12] leading to what are known as theories of induced space-time-matter. In particular, their work focused on 5D unconstrained KK theories (i.e. KK in spacetime without compact dimensions) and showed how these derive most of the quantum behavior, electromagnetism (without necessarily magnetic monopoles), masses and charges (including their plausible quantization) or even equations of properties of QFT and vacuum [17]. Working in 5D (or any odd dimension) spacetimes, still results into no chiral Fermions: all Fermions solutions are limited to Dirac (and maybe Majorana) Fermions.

The issue with chirality remains the main block encountered by unconstrained KK approaches, which probably explains the limited interest in the work and limited communities involved, despite the interpellation naturally arising from such results! Indeed, otherwise simple extensions of the symmetries of *N*D spacetime, with $N > 4$, leads to Yang Mills Equation (we knew that per the works discussed, for example, in [16]) and the capability to support the Standard Model (SM) symmetries of Yang Mills in 7D. See [6] for models and references in the case of 5D compactified KK; the results are essentially the same when considering unconstrained from that the point of view of recovering physical Actions and field equations in 4D that model GR, Electromagnetism and Yang Mills (with SM symmetries)), i.e. the Standard Model (SM).

Of course, unconstrained KK models appear to also have a few other challenges:

- i) how to explain unobserved additional unconstrained and hence macroscopic or large extra dimensions? When the extra dimensions were compact (and microscopic), it was easier to make a case for us not to notice them. Of a same vein, we may lack of justifications for suggesting that spacetime is 5D (or higher dimensional); other than justifying that it motivates (via induction) the 4D physics that we observe. We would like at least some physical explanations to the why this would happen; not just that it happens mathematically.
- ii) This type of *N*D Physics, with $N > 4$, problems occur with conservation laws and precessions of spins / angular momentum as well as fifth (and higher order for $N > 5$) forces. Sure they may be small effects, so that no experiment has ever really ruled them out. But such results are a bit concerning. See [5,10,11,12] as well as [18] for some related issue lists. Satellites programs and Particle colliders programs like at CERN are running and planning experiments looking for any effects from extra dimensions (compactified, a leading interest because of superstrings and conventional KK theories, or not).

The Kaluza miracle, even if appearing as a gift that keeps on giving, now with the induced space-time-matter theories, does not seem to be sufficient yet to resolve i). It adds to clamors that, in terms of higher dimensional physics (that is a restriction we add to the statement, the clamors probably will typically often ignore such caveat), superstrings and M-theory would be the only game in town; something concerning, considering our analyses in the context of multi-fold theories [1,19,20,21], where we suggest that strings are unphysical. Note that competing constructive quantum gravity model [22] like Loop Quantum Gravity (LQG) are for the purpose of this discussion not considered to be higher dimensional models as they aim at recovering 4D spacetime (because of what we observe and of the work of [51]). Therefore, with the higher dimension caveat, our statement does not imply that superstring theories would be a better approach than LQG, its main competitor today. Refer to [22] for some analysis of LQG from a multi-fold universe perspective.

4. Unconstrained 7D KK for a Multi-fold universe

[1] describes the multi-fold mechanisms that appear when particles (systems) are entangled in a multi-fold universe: folds are activated outside spacetime and the mapping mechanisms ensure that particles crossing the support domains of these mappings have additional contributions to their Path Integrals due to paths on the multi-folds. It results into attractive gravity like effective potentials between the entangled particles or equivalently effective curvatures.

When energy or mass is located in spacetime, virtual particles are emitted around it resulting into massless and massive gravity contributions [1,23]. More discussions on the use of virtual particles instead of gravitons are covered in [1] and on the on-going discussions at [24]. At larger scales, this models recovers Einstein GR field equations and Hilbert Einstein Action in 4D.

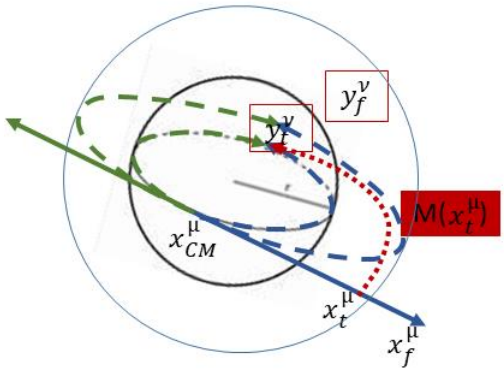

Figure 1: Aspects of the multi-fold and mapping mechanisms proposed in [1].

Figure 1 shows an example of activated fold and mapping (M) of the space time support between two EPR entangled particles. Many more folds are activated (axial symmetry) to form multi-folds. The set of folds (multi-folds) are in a space tangent to the multi-fold universe spacetime. [1] derived that the resulting space surrounding every particles or spacetime point is AdS(5), when we look at the evolution of the multi-folds involved in gravity.

Any particle is emitting entangled virtual particles and is surrounded by many multi-folds tangent to the multi-fold universe spacetime. From the point of view of any particle crossing the support domain of the mapping (essentially the region between entangled virtual particles), it sees many multi-folds to which some of its path are mapped. With uncertainties, the position of the particles (sources) and particle crossing the support domain are fluctuating. As a result, every particle (as emitter or as test) and every spacetime point (e.g. for the vacuum) "feel" three additional space dimensions (folds are 2D in 3D space and multi-folds virtual particles emitted at different time) create the 3D external / embedding additional dimensions (time is assumed shared for the this discussion).

Therefore, due to the multi-fold mechanisms and because of the uncertainty principle, spacetime appears as 7D (6 space and one time). The "feeling" is practically limited to moves (fluctuations) within uncertainty balls around every particle or spacetime point, as nothing really ventures further, even when fluctuations are actually expanding spacetime, à la dark energy, as discussed in [1,25]. Yet, because constrained only by uncertainties, the particles and spacetime points feel non-compact and unconstrained additional 3D space dimensions. This is reminiscent both of KK but rather as with induced space-time-matter induction models.

The approach of unconstrained KK, as in [10], can be repeated for 7D. Indeed, we can predict that 7D GR applies in 7D spacetime embedding a multi-fold universe: the uncertainty fluctuations amount to emitting entangled particles in the new 3D, and, if we repeat the multifold mechanism processes, as in [1], we end up recovering GR

(i.e. the Hilbert Einstein action) in 7D. Let's make a note that we also introduced therefore an additional 3D space dimensions for the new multi-folds: we have a 10D spacetime (assuming time is shared) and AdS(11) tangent surrounding every spacetime point (assuming the extra temporal dimension is shared as it amounts to scales). We will not make use of these 10D and 11D but it is interesting that we recover dimensions also encountered by superstrings, supergravity and M-theory.

For now, what is important is to understand that we can apply GR, in the 7D universe, without having to postulate it (as it is recovered from multi-fold mechanisms). From our point of view, nothing really lives in 7D (other than the path affected on the folds and the fluctuating presence). So the GR field equations become:

$$R^{AB} = 0 \qquad (1)$$

just as for unconstrained KK theories [10,11,12], and with A,B ranging over the 7D. In (1), R^{AB} is the 7D Ricci curvature tensor.

The approach and results from space-time-matter induction models, in 5D, can be fully reused in 7D, but now, the presence of a GR controlled 7D spacetime is physically justified; not just postulated. In a multi-fold universe, it is clear why we have embedding in a 7D spacetime following (1). Because the 7D spacetime is tangent to the multi-fold universe spacetime (à la dual (bundle) space), it is also explains why nothing happening beyond the 4D spacetime is observable by anything in the 4D multi-fold spacetime. Simply adding a dimension as in conventional or unconstrained KK does not typically have such a tangency concept, physically motivated.

On the other hand, as the effects are solely due to the uncertainty principle (fluctuations), and as multi-fold mechanisms do not leak energy or conserved values, none of the troubling effects of fifth (or higher order) forces, non-respect (leaks) of conservation laws dictated by 4D spacetime symmetries and no undue precession for 4D physics occur in the 4D multi-fold spacetime: the effects are not expected to take place and therefore to be observable, at the difference of unconstrained KK theories [10].

So again spacetime in a multi-fold universe is 4D. 7D vacuum spacetime following Hilbert Einstein action materializes through the uncertainty principle and multifold mechanisms.

Non vacuum models could also be investigated. However, Campbell's theorem [26,12] ensures that 7D (vacuum) flat solutions to GR, well justified by the above, can always embed a 4D manifolds like the spacetime of a multi-fold universe (and solution also to GR equations, at appropriate scales). We can in general restrict the discussion to such vacuum considerations.

5. Induced 7D Space-Time-Matter models in a Multi-fold Universe: SM_G

Repeating the search for solutions to (1) in 7D, as in [10,11,12], brings back the ability to explain:

- Mass and Charges as 7D geometrical (4D effects of solutions for suitable metric in 7D)
- The recovery of Klein Gordon or Dirac equations, as well as motivation of the uncertainty principle
- QFT behavior as well as quantum vacuum with its self-interaction loops [17]
- Field equations and actions with sources (matter, radiation, energy) for:
    - GR
    - Electromagnetism
    - Yang Mills [6] (not surprising we already stated the equivalence between Yang-Mills and KK – Yes these work are for conventional KK but [10] showed that from compactified to unconstrained dimensions, the Kaluza miracle is maintained and field equations are equivalently recovered in unconstrained situations if using the right metric / solution in *N*D)

Because 7D supports the symmetries of Weak and Strong interactions [6], we can recover the whole Standard Model with Gravity (by construction): SM_G, assuming, for now, that chiral fermions are not an issue (see next

section for resolution of that specific challenge). How multi-folds are related to the 7D objects or seeding them is for future work (*Note added on 11/29/20: Papers that we published after initial publication of the present paper provide further hints [52,53]*).

It is also important to remember that multi-folds (and gravitons) have their dynamics in AdS(5) sharing the spacetime extension portion with the 7D spacetime.

SM_G was introduced in papers detailing the implications of [1], one by one [24]. Appendix A (to avoid just simply self-referencing all or work) will provide a list with bibliography of our contributions so far. The conclusions of these works being that:

- Gravity with it massive contribution and multi-fold behaviors can be considered as well defined in semi classical mode and non-negligible at the Standard Model scales.
- When in a multi-fold universe, SM with gravity, i.e. SM_G, does not require New Physics (other than gravity) to contribute an explanation to many open issues with the Standard Model or Standard Cosmology.
- We therefore proposed in these works [1,24], that it is now time to consider SM_G, as a more complete Standard Model.

The spacetime reconstruction analysis, provided in [1], also derives a spacetime, for a multi-fold universe, that is discrete, fractal as a result of random walk process, Lorentz invariant and non-commutative. For the same reasons that every particle is surrounded by AdS(5), every particle and every spacetime point are surrounded by a microscopic black hole (*Note added on 11/29/20: relating spacetime location points in multi-fold universes and Higgs field are further detailed in[53]*). With the reasoning presented here, we now know that the mass and charges (electromagnetic, hypercharge or color) and mass are determined by the geometry of objects / metrics in 7D. They can be seen as microscopic hairs of the microscopic black holes. Spin can also be viewed as the result of the multi-fold mechanisms and virtual particles path making the particle wave function spin [1].

6. Chiral Fermions in a Multi-fold Universe with 7D induced Space-Time-Matter models

Because the space, tangent to the multi-fold spacetime, is 7D, we cannot encounter chiral fermions induced by the model in 4D. Therefore, fermions ready to interact with the fields induced from 7D geometry are Dirac fermions associated (or near) the microscopic black holes.

We already know that the parity symmetry is violated by gravity [1] in multi-fold universe and hence chirality. In fact it is a generic result that general gravity can be formulated entirely, and solely, relying on the left-handed spin connection, i.e. not using the right-handed part [27,28]. Physically, it can be understood as follows: because, in 4D and in a multi-fold universe, gravity flips fermion chirality / helicity [1,29-32], and gravity is always present, fermions and their corresponding fields or wave functions must be fully described by their left-handed only (or right-handed only) spinor (e.g. the right handed version is simply a left-handed version that has been or will be flipped). It explicitly shows that gravity breaks chirality symmetry.

As a result, the Dirac fermions properties induced by 7D physics are in fact fully modeled as say left-handed fermions that can be flipped to right-handed: Any fermion is a combination of operators acting on chiral fermions: they appear automatically in the 4D spacetime of the multi-fold universe.

Following the same reasoning, [33] argued that the symmetry breaking of chirality by gravity is exactly freeing the degrees of freedom to replace the right-handed symmetry representations with the electroweak representation post chirality symmetry breaking. So, gravity makes the chiral fermion reappear from 7D physics induction of non-chiral fermions and the effect allows for the electroweak chiral symmetry breaking. Above a certain level of energy (or below a certain scale), flips are so fast that fermion chirality is smeared and electroweak is no more chiral: this

correspond to a situation before chirality symmetry breaking by gravity. The maximal symmetry breaking explains why the weak interaction only interacts with left-handed fermions. Note that, per [29] which explains how the neutrino masses can be explained in SM_G with chirality flips, it is not the case for the Higgs mechanism and for the Higgs boson which interacts equally with both chirality. *Additional note added 11/29/20: Additional thoughts were provided in [53]. According to these conjectures, left-handed spacetime (gravity) is accompanied with missing right-handed representations stuck in 7D/multi-folds entry/mapping points.*

As a side note, the same reasoning could also explain the main chirality breaking of the strong interaction [14]: when a pair of (massive if the above already took place) quark/antiquark (reasoning can be repeated for more quarks) is considered, the helicity flips induced by gravity generate sequences of new pairs to conserve helicity; therefore resulting into spontaneous symmetry breaking of the QCD vacuum.

The important take away is that gravity restores chiral fermions in the 4D spacetime of a multi-fold universe even if only non-chiral Dirac fermions where from higher dimensional spacetime geometries. This completes the justification that, in a multi-fold universe, the standard model can be recovered from 7D vacuum objects and geometries. We can explain the origins of the properties of its elementary particles and fields and model them. However, we cannot (yet) predict coupling constants or values of the particle quantum numbers. *Note on 11/29/20: with more hints are presented in [52,53], where one can start to see how some of the quantum numbers could maybe also be encountered by this type of analysis.*

7. What about AdS and Superstrings?

[1] derived a AdS(5) spacetime surrounding every particles when considering the dynamics of the multi-folds. In fact, it is assumed that this is where multi-folds live and how gravitons are associated to them. They live in AdS(5) [1,34]; which is important to resolve some of the challenges with conventional quantization of GR that lead to divergences, non-renormalization etc.

Much ado has been made in [19,20,34] about the recovery of the AdS/CFT correspondence conjecture, as a factual property of multi-fold universe, along with its area laws and holographic principles. Were we wrong?

From this work, it seems that at least 7D (or higher) dimensions spacetime surround every spacetime point and particle in a multi-fold universe. 7D (6 spatial, one shared time) spacetime solutions (vacuum / flat solution of GR in 7D) induce space-time-matter behavior following SM_G, in multi-fold spacetime, which is where matter lives. Gravitons on the other hand live in AdS(5), i.e. in a 8D (sharing time), spacetime where multi-fold dynamics occur. As discussed in [1,19], multi-folds do not necessarily follow GR dynamics but the resulting AdS(5) can be a GR solution. Superstrings besides gravitons live in Ads(5)(plus extra dimensions). It may explains why, besides gravitons with dynamics in AdS(5), other superstrings are probably not physical [19]: they characterize physic in a spacetime (AdS(5), or AdS(8) when considering adding the scale (second time) dimension to the 7D spacetime), instead of the surrounding 7D spacetime of unconstrained KK models.

Analysis of these dimensions is also interesting. Indeed in a multi-fold universe,

- Space time is 4D (in fact discrete, fractal, non-commutative, Lorentz invariant and appearing 2D at very small scales)
- Multi-folds and gravitons live in AdS(5) surrounding every particle
- 7D flat spacetime solution of GR in 7D (vacuum solutions) surrounds every particle and spacetime point of the multi-fold universe.
- With gravitons and multi-fold dynamics, a AdS(8) (8D) is similarly surrounding every particle and spacetime point of the multi-fold universe.

- If multi-fold mechanisms exist also in 7D to explain 7D GR / Hilbert Einstein actions then it is actually a 10D spacetime that surrounds every particle and spacetime point of the multi-fold universe and induce space-time-matter and a AdS(11) for all the multi-fold dynamics and associated gravitons. Again this is reminiscent of supergravity, superstrings and M-theory.

None of these dimensions are compactified. AdS(5) matters the most to explain gravity and entanglements. It is not observable because tangent. This is why compactification is not required in multi-fold universes; at the difference of conventional higher dimensional Physics where the extra dimensions are postulated as directly dimensions of spacetime. In multi-fold universes, the other dimensions are similarly not observable because tangent and they are primarily used to induce quantum and field properties (and to support entanglement and gravity for AdS(5/8/11). While dimensions interestingly match results from Supersymmetry, supergravity, superstrings and M-theory, one can see where superstrings approaches bifurcate from ours (e.g. no compactification, no supersymmetry, positive curvature / cosmological constant, etc.). Yet it is intriguing that we successfully obtained the result of being able to explain SM_G from higher dimensional geometries, as had already been discovered but never completed physically motivated by conventional KK, and as actively investigated by superstring theories. Finding actual concrete objects inducing the quantum numbers / particles of SM_G or predicting those is for future work (*Note on 11/29/20: See additional details in [52,53]*). At least, it does not look like we would have to deal with the swampland [36] or a non-tractable zoology of Calabi-Yau manifolds [37] as met in superstring theories.

8. GR in AdS(5)?

We provided a simple argument to prove that the 7D flat spacetime surrounding and locally embedding the multi-fold universe spacetime is subject to GR equation (in 7D): fluctuation create multi-folds tangent to the 3D spacetime formed by the multi-folds from the multi-fold universe 4D spacetime. Space-time-matter models assume this 7D spacetime to be flat (and hence a vacuum universe).

However, the same reasoning cannot be extended to AdS(5) (or AdS(8)). As a result we do not know if the AdS(5) surrounding any particle or spacetime point in the multi-fold universe is governed by GR (in 5D). [1,19] go out of their way to also emphasize that the (multi-)folds dynamics in the model proposed in [1] are not a priori governed by GR: they might be or they might not be.

On a related topic, these aspects also relate to the ER=EPR conjecture [47]: in general (AdS) wormholes (and black holes) are not traversable within reasonable durations without the involvement of exotic matter (e.g. with negative energy or mass – see [1] for some references and discussion of the following considerations) and this may have prevented ER=EPR to complete the model into multi-fold mechanisms, by allowing the wormholes to offer additional paths to path integrals and resulting into the effective potentials or curvatures in spacetime. [48] also discusses some overview of the problem of wormhole traversability in AdS and offers a potential example where traversability is possible, but only with a suitable magnetic field; something not observed today as associated to entanglement (*Note on 11/29/20: find more discussions in [54]*). Not imposing GR on the folds avoids these problems. But as a result, it seems that in such a case we have less reasons to assume that Physics in AdS(5) would be governed by GR.

On the other hand, superstrings and the AdS/CFT correspondence conjecture as well as the associated ER=EPR conjecture assume that AdS(5) physics is modeled by GR in 5D. In fact, [49] proves that the AdS/CFT correspondence conjecture, as holographic principle linking to CFT with vacuum entanglement, behaving thermodynamically as expected, implies recovering GR in AdS(5), which justifies using GR to model black holes and worm holes in it. It was essential to accommodate superstrings that imply an Hilbert Einstein Action in a spacetime negatively curved / with negative cosmological constant.

In the case of AdS(5) surrounding the multi-fold universe, we can rely on a theorem that extends the Campbell Theorem beyond flat embeddings to Einstein spaces as embeddings [50]. Accordingly, AdS(5) can be an Einstein space embedding the 4D (3D space for the multi-folds) and 1D time shared with the multi-fold universe spacetime) manifold generated by the multi-folds. So indeed, GR(5) could govern the surrounding AdS(5). However other embeddings could be considered: we recover the principles stated in [1,19] and keep the freedom that the multi-fold dynamics does not follow GR thereby allowing any behavior driven by the behavior of the associated entangled particles in the multi-fold universe spacetime (something a priory hard to verify if possible to well model in AdS(5) with objects following GR) and avoiding problems of traversability. *The note added on 9/28/20, offer however a partial indication on how a GR governed AdS(5) could support traversable wormholes as multi-folds.*

On the other hand the same theorem extension applied to the unconstrained 7D KK model, implies that the 7D spacetime can also be an Einstein space (with positive cosmological constant considering the multi-fold mechanisms that motivates GR (in 7D) for that space); opening even more 7D physics. Yet because we do not believe that anything enters these addition dimensions other than negligible paths (recovered as disentanglement) and temporary fluctuation; that space is expected to be empty and so the vacuum / Ricci flat choices discussed earlier seem probably better justified (*Note on 11/29/20: However, the multi-fold Higgs considerations of [52] could provide new motivations. It is for future work*).

A lesson from this discussion is that: physical properties can come from geometries of the vacuum in 7D as induced model (KK unconstrained) and / or from geometries in AdS(5) + Additional dimensions (for superstrings) if GR applies. The latter is needed for superstrings / M-Theory models. Yet it still does not provide us with a mechanisms that would support ER=EPR as multi-fold implementation (e.g. traversability is a key issue) and as a result moving from CFT spacetime to the real universe (e.g. with QFT, gravity…) (*Note on 11/29/20: Comments in [54] may provide new ways to address the traversability challenge*). Induced unconstrained KK models do not have such problems. It is quite possible that this is the, or an, additional problem with supersymmetry, superstrings, supergravity or M-theories: they model AdS(5) (Plus additional dimensions) as governed by GR / Hilbert Einstein Action, but that may not be what happens with the real universe where it could be just an option (when not just for a CFT spacetime) imperiled with transversability and GR dynamics challenges that still would prevent explaining gravity effects in the real universe. If GR is not ruling in AdS(5), then all the superstrings particle predictions would be unphysical, as already discussed with other arguments in [1,19].

In a multi-fold universe, much of all this does not matter. Gravitons live in AdS(5) as multi-folds. They may not be governed by GR but their effects in the spacetime universe amounts to quasi particles in spacetime that produce effective attractive potentials and effective curvature and recover GR in that spacetime.

9. Conclusions

Trying to apply unconstrained KK to multi-fold universe resulted into the unexpected derivation of the standard model with gravity SM_G, while physically explaining the plausibility of the extra non compactified dimensions and their non observability. This is a result that certainly matches, if not exceeds, superstrings aspirations and most GUTs and TOEs. We cannot (yet) motivate quantum numbers or coupling constant. These are for future work, including {52,53]).

Having advocated (See Appendix A) for adding non-negligible gravity effects to the Standard Model as enabled in multi-fold mechanisms, it came as a surprise that revisiting Kaluza-Klein theories would produce SM_G. We are now really far from an original program aiming at explaining EPR entanglement between two particles and discovering gravity like interactions as a result [1,38]. The multi-fold mechanisms introduced as explanation of EPR were the missing link to resolving the problems of KK.

Of course, other models could lead to non-negligible gravity at the Standard Model scales and therefore physically justify therefore SM_G. If they also manage to overcome the problems of KK, and in particular explain chiral fermions, then they could provide other ways to derive SM_G. But New Physics, like supersymmetry and superstrings, have again been shown to not be the source of the Standard Model particles, as already suspected in [19].

We also shown that, while the AdS/CFT correspondence conjecture and the associate ER=EPR conjecture imply GR in AdS(5) (Plus additional dimensions) that leads to say superstrings, that conclusion may not apply to a multi-fold universe or the real universe. Therefore it could resolve the ambiguity in terms of which higher dimensional geometry can dictate the properties of SM_G: it comes from the 7D unconstrained KK model; not from AdS(5) (+plus additional dimensions) and its landscape with Calabi-Yau manifold geometries. Meanwhile, the AdS/CFT correspondence conjecture and the associate ER=EPR conjecture remain good models to inspire or deduct some related mathematical results. Superstrings particles may then be unphysical and even the graviton they model may not fully match what we have encountered in multi-fold universes.

It is interesting to note how the work of [1] has evolved [24]. We started from a proposal to explain the EPR paradox and entanglement by introducing multi-fold mechanisms. From it, we derived a proposal for gravity like interactions between entangled systems (albeit not hierarchical), and a model for massless and at small scale non negligible massive gravity. The former recovers GR at large enough scales and semiclassical models remain valid till very small scales. This, in turn, allows us to potentially address many of the open questions with the Standard Model by adding gravity (non-negligible at the SM scales) to it. Multi-fold mechanisms can contribute explanations to dark energy, while entanglement can contribute explanations to dark matter, in ways that also address some of the open challenges with these models. Entanglement between particles and their quantum fluctuations justify local feelings of embedding in 7D, with unconstrained KK models, that can recover the Standard Model (with gravity). These models are working only because the multi-fold mechanisms constrain everything to infinitesimal feelings (uncertainty fluctuations) and therefore avoid the issues of conventional unconstrained KK, especially with odd dimension embedding spacetimes (multi-fold spacetime is even for all Physics that matters). Multi-folds live in AdS(5) and this can hints at superstrings, and related models, while also explaining why they may not be physical. Entanglement of massive virtual particle opens a door to a different "ultimate Unification". On the way, we recovered the properties of a discrete, fractal (through random walks, i.e. a 2D apparent process – which was after all not a hint of strings but of random walks…), random, Lorentz invariant and non-commutative 4D spacetime at very small scales. We also encountered explanations at Quantum and Classic Physics behavior and (irreversible) thermodynamics behind all of them.

It is certainly a compelling journey that may merit further considerations in the quest to what's next in Physics.

Appendix A: Multi-fold mechanisms contribute to understanding several Standard Model and standard cosmology model open problems

In a multi-fold universe as defined in [1], at small scale, gravity is no more negligible and we recommend adding its effect to the Standard Model (SM) to obtain SM_G. Doing so resulted into providing solutions to several Standard Model open issues without New Physics other than this addition of gravity (SM_G) [1]:

- Why no proton decays [39]?
- Why no magnetic monopoles [9]?
- Why are there 3 and only 3 generations of fermions per family [40]?
- Why no strong CP violation [41]?
- Where can the neutrino masses come from and where did the right-handed neutrino go [29]?
- Why the Yang Mills Mass gap problem may not be already resolved [42]?
- Why is the Electroweak vacuum actually stable, despite the mass of the Higgs boson [43]?

It also explains cosmological problem again without adding New Physics to the Standard Model / Standard Cosmological Model other than gravity and our multi-fold mechanisms and SM_G [1]:

- Accelerated expansion, Dark Energy and small cosmological constant [25]
- Inflation with or without inflaton [25]
- Dark Matter [44]
- Why are there more matter than anti-matter and why do we exist [46]?

More results are being added to the list. Please refer to [24] to track the latest results and developments.

Eventually, our work resulted into revisiting the Weak Gravity Conjecture (WCG) [45] (no more valid as conventionally phrased at small scales in a multi-fold universe) and a new proposal for force unification: the Unified Unifications (UU) [21]. Based on the new analysis à la WCG [45], we see that all interactions equally contribute to gravity and their proper interactions at very small scales, resulting into a democracy of effects: a different twist on Grand Unification.

Because spacetime in [1] is discrete, fractal, noncommutative and Lorentz invariant, we can ensure good behavior of gravity at very large energy or very small scales (Asymptotic safety). In addition to discreteness, torsion and dark energy / random walk effects ensure the absence of gravity (and cosmological) singularities.

____

References: (most references come from popular science to make the discussion more approachable)

[1]: Stephane H. Maes, (2020), "Quantum Gravity Emergence from Entanglement in a Multi-Fold Universe", viXra:2006.0088v1, https://vixra.org/pdf/2006.0088v1.pdf (June 9, 2020).
[2]: https://en.wikipedia.org/wiki/Reissner%E2%80%93Nordstr%C3%B6m_metric
[3]: https://en.wikipedia.org/wiki/Kerr-Newman_metric
[4]: Burinskii, Alexander, (2008), "The Dirac-Kerr-Newman electron", arXiv:0507109v4
[5]: https://en.wikipedia.org/wiki/Kaluza%E2%80%93Klein_theory
[6]: David Bailint and Alex Love, (1987), "Kaluza-Klein theories", Rep. Prog. Phys. 50 (1987) 1087-1170.
[7]: Anze Zaloznik, (2012), "Kaluza-Klein Theory", http://mafija.fmf.uni-lj.si/seminar/files/2011_2012/KaluzaKlein_theory.pdf.
[8]: Edward Witten, (1982), "Instability of the Kaluza-Klein vacuum", Nuclear Physics B, Volume 195, Issue 3, 22 February 1982, Pages 481-492
[9]: Stephane H Maes, (2020), "Gravity or Magnetic Monopoles? You Cannot Have Both!", viXra:2006.0190v1, https://shmaesphysics.wordpress.com/2020/06/15/gravity-or-magnetic-monopoles-you-cannot-have-both/ , June 15, 2020.
[10]: Paul S Wesson, (1999), "Space - Time - Matter: Modern Kaluza-Klein Theory", World Scientific Pub Co.
[11]: Paul S Wesson, (2006), "Five-dimensional Physics: Classical And Quantum Consequences of Kaluza-klein Cosmology", World Scientific Pub Co.
[12]: Paul S. Wesson and James M. Overduin, (2018), "Principles of Space-Time-Matter: Cosmology, Particles and Waves in Five Dimensions", World Scientific Pub Co.
[13]: Schwartz, M.D., (2013), "Quantum Field Theory and the Standard Model", Cambridge University Press.
[14]: V. P. Nair, (2006), "Quantum Field Theory: A Modern Perspective", Springer
[15]: Palash B. Pal, (2010), "Dirac, Majorana and Weyl fermions", arXiv:1006.1718v2
[16]: Frank Reifler, Randall Morris, (2007), "Conditions for exact equivalence of Kaluza-Klein and Yang-Mills theories", arXiv:0707.3790v1
[17]: Timothy D. Andersen, (2019), "Quantization of fields by averaging classical evolution equations", Physical Review D 99, 016012
[18]: Richard L. Amoroso, (2015), "Yang-Mills Kaluza-Klein Equivalence: An Empirical Path Extending the Standard Model of Particle Physics", viXra:1511:0257.

[19]: Stephane H Maes, (2020), "Dualities or Analogies between Superstrings and Multi-fold Universe", viXra:2006.0178v1, https://shmaesphysics.wordpress.com/2020/06/14/dualities-or-analogies-between-superstrings-and-multi-fold-universes/, June 14, 2020.
[20]: Stephane H Maes, (2020), "Superstrings Encounter of the Second, Third or Fourth Types?", viXra:2010.0140v1, https://shmaesphysics.wordpress.com/2020/07/19/superstrings-encounter-of-the-second-third-or-fourth-types/, July 5, 2020.
[21]: Stephane H Maes, (2020), "Ultimate Unification: Gravity-led Democracy vs. Uber-Symmetries", viXra:2006.0211v1, https://shmaesphysics.wordpress.com/2020/06/16/ultimate-unification-gravity-led-democracy-vs-uber-symmetries/, June 16, 2020.
[22]: Stephane H Maes, (2020), "Alignments and Gaps Between Multi-fold Universes And Loop Quantum Gravity", viXra:2006.0229v1, https://shmaesphysics.wordpress.com/2020/06/19/multi-fold-universes-analysis-of-loop-quantum-gravity/, June 18, 2020.
[23]: Stephane H Maes, (2020), "Massless and Massive Multi-Gravity in a Multi-fold Universe", viXra:2010.0095v1, https://shmaesphysics.wordpress.com/2020/06/30/massless-and-massive-multi-gravity-in-a-multi-fold-universe/, June 19, 2020.
[24]: Stephane H. Maes, (2020), "Web Site Tracking all Publications around the Multi-fold universe" -Navigation page listing all papers. https://shmaesphysics.wordpress.com/shmaes-physics-site-navigation/
[25]: Stephane H Maes, (2020), "Explaining Dark Energy, Small Cosmological Constant and Inflation Without New Physics? ", viXra:2006.0261v1, https://shmaesphysics.wordpress.com/2020/06/19/explaining-dark-energy-small-cosmological-constant-and-inflation-without-new-physics/, June 19, 2020.
[26]: Campbell, J.E., (1926), "A Course of Differential Geometry", Clarendon, Oxford.
[27]: Ted Jacobson , Lee Smolin, (1988), "Nonperturbative quantum geometries", Nuclear Physics B, Volume 299, Issue 2, 4 April 1988, Pages 295-345
[28]: Ted Jacobson , Lee Smolin, (1988), "Covariant action for Ashtekar's form of canonical gravity", Class. Quantum Grav. 5 (1988) 583-594.
[29]: Stephane H Maes, (2020), "Right-handed neutrinos? Mass? Ask Gravity", viXra:2007.0018v1, https://shmaesphysics.wordpress.com/2020/06/21/right-handed-neutrinos-ask-gravity/, June 23, 2020.
[30]: Carlos Mergulhao Jr., (1995), "Neutrino Helicity Flip in a Curved Space-time", General Relativity and Gravitation, volume 27, pages 657–667.
[31]: R. Aldrovandi, G. E. A. Matsas, S. F. Novaes, D. Spehler, (1994), "Fermion Helicity Flip in Weak Gravitational Fields", arXiv:gr-qc/9404018v1
[32]: Soumitra SenGupta, Aninda Sinha, (2001), "Fermion helicity flip by parity violating torsion", arXiv:hep-th/0102073v2.
[33]: Stephon Alexander, Antonino Marciano, Lee Smolin, (2018), "Gravitational origin of the weak interaction's chirality", arXiv:1212.5246v2
[34]: Stephane H Maes, (2020), "Multi-fold Gravitons In-N-Out Spacetime", viXra:2010.0155v1, https://shmaesphysics.wordpress.com/2020/07/27/multi-fold-gravitons-in-n-out-spacetime/
[35]: Stephane H Maes, (2020), "Area Laws Between Multi-Fold Universes and AdS", viXra:2010.0207v1, https://shmaesphysics.wordpress.com/2020/08/10/area-laws-between-multi-fold-universes-and-ads/, August 10, 2020.
[36]: Cumrun Vafa, (2005), "The String Landscape and the Swampland", arXiv:hep-th/0509212v2
[37]: https://en.wikipedia.org/wiki/Calabi%E2%80%93Yau_manifold
[38]: Stephane H Maes, (2020), "Gravity-like Attractions and Fluctuations between Entangled Systems?", viXra:2010.0010v1, https://shmaesphysics.wordpress.com/2020/06/25/gravity-like-attractions-and-fluctuations-between-entangled-systems/, June 24, 2020.
[39]: Stephane H Maes, (2020), "Gravity Induced Anomalies Smearing in Standard Model so that Protons May Never Decay, Except in Black holes", viXra:2006.0128v1, https://shmaesphysics.wordpress.com/2020/06/12/protons-may-never-decay-except-in-black-holes/, June 13, 2020.
[40]: Stephane H Maes, (2020), "Gravity Dictates the Number of Fermion Generations: 3", viXra:2007.0068v1, https://shmaesphysics.wordpress.com/2020/06/24/gravity-dictates-the-number-of-fermion-generations-3/, June 24, 2020.

[41]: Stephane H Maes, (2020), ”Strong CP Violation Tamed in The Presence of Gravity”, viXra:2007.0025v1, https://shmaesphysics.wordpress.com/2020/06/23/strong-cp-violation-tamed-in-the-presence-of-gravity/ , June 21, 2020.
[42]: Stephane H Maes, (2020), ” Progress on Proving the Mass gap for Yang Mills and Gravity (maybe it’s already proved…)”, viXra:2006.0155v1, https://shmaesphysics.wordpress.com/2020/06/12/progresses-on-proving-the-mass-gap-for-yang-mills-and-gravity-maybe-its-already-proven/, June 12, 2020.
[43]: Stephane H Maes, (2020), “Gravity Stabilizes Electroweak Vacuum – No Bubble of Nothing to Worry About!”, viXra:2007.0173v1, https://shmaesphysics.wordpress.com/2020/06/24/gravity-stabilizes-electroweak-vacuum-no-bubble-of-nothing-to-worry-about/, June 24, 2020.
[44] Stephane H Maes, (2020), ”Explaining Dark Matter Without New Physics?”, viXra:2007.0006v1, https://shmaesphysics.wordpress.com/2020/06/19/explaining-dark-energy-small-cosmological-constant-and-inflation-without-new-physics/, June 21, 2020.
[45]: Nima Arkani-Hamed, Lubos Motl, Alberto Nicolis, Cumrun Vafa, (2006), “The String Landscape, Black Holes and Gravity as the Weakest Force”, arXiv:hep-th/0601001v2.
[46]: Stephane H Maes, (2020), ”More Matter Than Antimatter, All Falling Down”, viXra:2010.0121v1, https://shmaesphysics.wordpress.com/2020/07/05/more-matter-than-antimatter-all-falling-down/, July 5, 2020.
[47]: Maldacena, Juan and Susskind, Leonard (2013). "Cool horizons for entangled black holes", Fortsch. Phys. 61 (9): 781–811. arXiv:1306.0533
[48]: Juan Maldacena, Alexey Milekhin, (2020), "Humanly traversable wormholes", arXiv:2008.06618v1
[49]: Eunseok Oh, I.Y. Park, Sang-Jin Sin, (2017), "Complete Einstein equation from the generalized First Law of Entanglement", arXiv:1709.05752v5
[50]: F. Dahia, C. Romero, (2001), "The embedding of the spacetime in five dimensions: an extension of Campbell-Magaard theorem", arXiv:gr-qc/0109076v2
[51]: J. Ambjorn, J. Jurkiewicz, R. Loll, (2004), "Emergence of a 4D World from Causal Quantum Gravity", arXiv:hep-th/0404156v4
[52]: Stephane H. Maes, (2020) “Particles of The Standard Model In Multi-Fold Universes”, https://shmaesphysics.wordpress.com/2020/11/05/particles-of-the-standard-model-in-multi-fold-universes/, (November 4, 2020).
[53]: Stephane H Maes, (2020), “Multi-fold Higgs Fields and Bosons”, https://shmaesphysics.wordpress.com/2020/11/10/multi-fold-higgs-fields-and-bosons/, November 6, 2020.
[54]: Stephane H Maes, (2020), “Circular Arguments in String and Superstring Theory from a Multi-fold Universe Perspective”, https://shmaesphysics.wordpress.com/2020/10/11/circular-arguments-in-string-and-superstring-theory-from-a-multi-fold-universe-perspective/, October 5, 2020.
[55]: Ping Gao, Daniel Louis Jafferis, Aron C. Wall, (2016-2019), "Traversable Wormholes via a Double Trace Deformation", arXiv:1608.05687v3
[56]: Juan Maldacena, Douglas Stanford, Zhenbin Yang, (2017), "Diving into traversable wormholes", arXiv:1704.05333v1

9/28/20 notes:

The following papers [55,56] provide a possible way to ensure that traversability of wormholes, in GR governed AdS(5), can be achieved with couplings of their Left and Right boundaries, which may be what is entailed by entanglement. This could be a way to support multi-folds in AdS(5), governed by GR, although the dynamics of the black holes is dictated by the attachment that they have to the entangled EPR particles in the spacetime; something that still requires additional "explanations" but it is possibly not that different from hoping that the geometric objects in 7D adapt to follow the dynamics in 4D. So with this, we believe that we have proven: (i) we can have GR or not governing in AdS(5), and, when GR governs, it is compatible with multi-folds (ii) ER=EPR still misses using traversability to model effects on Path Integrals that creates the gravity like effect between entangled systems as discussed in [38]; but we are getting closer.

Note however that "coupling" is related to conventional AdS/CFT correspondence and hence CFT. As, neither multi-fold spacetime or its real universe equivalent are CFT... The analyses of these two papers above may just be another circular combination of redundant assumptions, i.e. the traversability with CFT coupled boundaries in a GR governed AdS(5) may not be traversable in AdS(5) with GR for non-CFT entanglement. So not imposing GR in AdS(5) is a safer and more generic approach that for multi-fold universes can encompass the cases where GR governs AdS(5).

The concept of entanglement amounting to coupling left and right boundaries of associated black holes is certainly warranting further analysis (*Note on 11/29/20: See [54] for related discussions*). As, in multi-fold universes, microscopic black holes are associated to any particles, or concretized spacetime point, this coupling could be a fundamental behavior of entanglement (with or without GR reigning in AdS(5)).

11/28/20: The original V0.1 available here:
https://drive.google.com/file/d/1Kv4I_ry_NpQUtWL_8H7tjBXNyU6sV14z/view?usp=sharing