# Justifying the Standard Model U(1) x SU(2) x SU(3) Symmetry in a Multi-fold Universe

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August 8, 2022

**Abstract**

*Group theory is a good way to study Particle Physics, when all the details are not known. U(1) x SU(2) x SU(3) is a good example as the symmetry group of the Standard Model (SM). It is well established, yet it is still a mystery why these symmetries, and why not a different or bigger group. It is what motivated efforts in the direction of Grand Unification Theories (GUTs).*

*The paper starts with an analysis of multi-fold aspects inspired from the Geometric Unity (GU). The first stages of the GU approach are contrasted with the multi-fold space time matter induction approach. It leads to different ways to characterize the symmetries of the 4D spacetime in the embedding space: Two unoriented 7D space time, tagged to cover a left and a right chirality, undefined in 7D, and therefore a Spin(7,7) symmetry. Spin (7,7) can be reduced by symmetry breaking to Sl(2,ℂ) x U(1) x SU(2) x SU(3), via a whole bunch of different paths and possible interim symmetries. The first term corresponds to General Relativity (GR) in 4D with Lorentz symmetries, while the rest are the SM symmetries associated to Quantum Physics. This 7D space, with chiral labels, is a local 7D ε neighborhood seen from the 4D spacetime, through multi-fold entry, exit or mapping points, locally embedding it, without Physics in it and implementing space time matter induction and scattering in the 4D multi-fold spacetime, ensuring U(1) x SU(2) x SU(3) for the SM, and induction of the SM particles. Indeed, the doubling of the spacetime sharing time as 7D embedding space explains the algebra doubling on non-commutative geometry in 4D that also predicts the SM particles.*

*Revisiting the multi-fold mechanisms, we explicitly detail why a multi-fold spacetime carries U(1) x SU(2) x SU(3) symmetries, in addition to Lorentz symmetry: U(1) is the symmetry of the paths on the multi-folds (as circles on the surface of 3D spheres), SU(2) is the axial symmetry of the multi-fold mechanisms, and SU(3) is the 3D symmetry for the multi-fold axis choices. These symmetries transfer to the embedding 7D space (ε neighborhood),generated by the multi-folds. Also, GR reigns in that space, Ricci flat or Einsteinian. This way, traversable wormholes, thanks to right-handed neutrinos, could implement multi-folds. Additional considerations on traversability of wormholes are also discussed, in particular introducing effects like Casimir without 7D Physics.*

*Explaining why SM has the symmetry that it has is quite unique. As far as we know, it has not been possible so far to derive a convincing explanation for why, larger symmetry breaking result into a remaining U(1) x SU(2) x SU(3) symmetry for the SM. Most papers either show compatibility with U(1) x SU(2) x SU(3) symmetries that are then assumed, or how larger symmetries could lead to U(1) x SU(2) x SU(3); but in general, not why this symmetry.*

*So far, the GUTs failures to provide such an explanation, made U(1) x SU(2) x SU(3) even more puzzling. Because of how tied the SM symmetries are to the multi-fold mechanisms, and the embedding ε space perception, it may be another hint that our universe could be well modeled with multi-folds. The absence of larger symmetries is also a*

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Cite as: Stephane H. Maes, (2022), "Justifying the Standard Model U(1) x SU(2) x SU(3) Symmetry in a Multi-fold Universe", https://doi.org/10.5281/zenodo.8422911, https://shmaesphysics.wordpress.com/2022/08/08/justifying-the-standard-model-u1-x-su2-x-su3-symmetry-in-a-multi-fold-universe/, August 8, 2022

*way to explain why no GUTs or supersymmetry exist, and to confirm our past prediction for a fundamental particle desert above the energy scale of the multi-fold gravity electroweak symmetry breaking.*

*The symmetries of the 4D spacetime, the SM and the 7D embedding space can also become first step towards more quantitative sketches of the multi-fold action, Lagrangian or Hamiltonian.*

*A consequence of this paper is that GR, or the Hilbert Einstein action contains fully the Standard Model and therefore the Standard Model (SM) (with gravity, i.e., the $SM_G$). And there is no need to invoke fine-tuning or multiverses to explain our universe.*

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# 1. Introduction

In a multi-fold universe [1,8-10], gravity emerges from Entanglement through the multi-fold mechanisms. As a result, gravity-like effects appear in between entangled particles, whether 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 (GR) at large scales, and semi-classical model remain valid till smaller scale than usually expected. Gravity can therefore be added to the Standard Model (SM) resulting into what we define as $SM_G$, the SM with gravity effect non-negligible at its scales. This can contribute to resolving several open issues with the SM and the Standard Cosmological model (ΛCDM) [125], without new Physics other than gravity (and multi-folds [1,8-10,148], which leaves most of conventional Physics as is) [1,4-32,34-40,44-47,54-56,59,60,63,64,68-110,112,117,*118-153*]. These considerations hint at an even stronger relationship between gravity and the Standard Model. *Note added on September 29, 2023: In this paper, references in italic were added on September 29, 2023*.

Among the multi-fold $SM_G$ discoveries, the apparition of an-always in-flight, and hence non-interacting, right-handed neutrinos, coupled to the Higgs boson is quite notable. It is supposedly always around right-handed neutrinos, due to chirality flips by gravity of the massless Weyl fermions, induced by 7D space time matter and scattering models, and hidden behind the Higgs boson or field at the entry points and exit points of the multi-folds. Massless Higgs bosons modeled as minimal microscopic black holes mark concretized spacetime location. They can condensate into Dirac Kerr-Newman soliton Qballs to produce massive and charged particles, thereby providing a microscopic explanation for a Higgs driven inflation, the electroweak symmetry breaking, the Higgs mechanism, the mass acquisition and the chirality of fermions and spacetime; all resulting from the multi-fold gravity electroweak symmetry breaking. The multi-fold theory has also concrete implications on New Physics like supersymmetry, superstrings, M-theory and Loop Quantum Gravity (LQG) [1,8-21].

The multi-fold paper [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-like Qballs of massless Higgs boson condensates (Schwarzschild for photons and concretized spacetime coordinates, and metrics between Reisner Nordstrom [2] and Kerr Newman [3] for massive, and possibly charged, particles – the latter being possibly extremal). Although possibly surprising, [1] recovers results consistent with others (see [4], and its references), while also being able to justify the initial assumptions of black holes from the gravity or entanglement model in a multi-fold universe. Above the energy of the multi-fold gravity electroweak symmetry breaking energy scales, massless particles are similarly induced by patterns of random walks.

The resulting gravity model recovers General Relativity at larger scale, as a 4D process, with massless gravity, but also with massive gravity components at very small scale that make gravity non-negligible at these scales. Semi-classical models also turn out to work well till way smaller scales that usually expected.

Multi-folds are encountered in GR at Planck scales [5,6] and in Quantum Mechanics[2] (QM) if different suitable quantum reference frames (QRFs) are to be equivalent relatively to entangled, coherent or correlated systems [7]. This shows that GR and QM are different facets of something that they cannot well model: multi-folds.

The present paper starts with concerns[3] about, and inspiration from, the Geometric Unity (GU) paper [22]. It contrasts the GU "observerse" with the embedding space encountered in multi-fold space time matter induction [27-29]: what is aligned and what isn't. The intent is not to pile on additional criticism of GU, there are many out there [23-26], but, instead, to compare the approaches[4], and add considerations, on why aspects of GU may not lead to the Theory of Everything (TOE) hoped for by its author.

On the other hand, among our congruent view with GU, we inspire ourselves of the GU "observerse" to position the space, responsible for the multi-fold space time matter induction and scattering [27,28], that embeds the multi-fold spacetime. Note that this is a 7D embedding spacetime felt by any multi-fold spacetime location as entry point, exit point or mapping point to the multi-fold. Only a ε region is felt, and it is generated by the multi-fold mechanisms from the 4D spacetime [1,27-29], which dictates these 7D spacetime symmetries felt in the ε regions. As proposed in [1,27-29], that space is 7D, and it has a spacetime that is GR flat or Einsteinian, and classical. However no Physics takes place in that space, a key difference with the GU "observerse", except for the multi-folds creating the 7D embedding, the massless Higgs boson random walks [1,77,80,*122*], and the kinematics and dynamics associated to the muti-fold [1,9,10,110,*148*].

If we wanted to imagine Physics in the embedding spacetime, to justify GR in 7D, we would need to add 3 dimensions for a space of multi-fold around a 7D point to also support multi-folds (and therefore explain GR). So there is a 10D locally involved (tangent around a point of the 4D spacetime), but it is a purely mathematical and unphysical concept [27-29]. In the spirit of dual vs. self-dual, we can add a 4D spacetime to the last 3D space which leads to 14D space time (still reduced to 10 if the original dimensions can be re-used or rather if we were to

[2] Standing in for Quantum Physics in general.

[3] Many concerns, and considerations, can be found in [23] and in the comments made on that page.

[4] Not trying to take part to the polemics involved, we note that we do not share the systematic criticism, or ostracism of the author of GU. Whatever are the flaws of his theory, or of his display of character, not considering the work, because of demands and expectations that shouldn't apply the same way to an independent researcher, does not seem appropriate. There are some interesting ideas in [22], worth considering, or inspiring from. Arguing no time to consider or the inability to evaluate the value of the paper, if not validated first by reviewers, might be construed to only denotes lack of scientific curiosity, inability to form one-selves opinion, or to read scientific paper while remaining appropriately skeptic. If this is really the opinion of most, it does not bode well of the abilities of the Physics community as a whole.

assume that we could reuse the same manifold (self-dual)). 14D matches the dimension of GU "observerse", which also has its own 4D spacetime mapped to the actual spacetime. It is again a pure mathematical and unphysical construct.

However we will preferably recover 14D in more physical way. We argue that as chirality is meaningless in 7D (and meaningful in 14D as it has even dimensions) [30], one can also see both 7D space as duals, essentially the same, but arbitrarily associated to a left and right chirality label. This is implied as a consequence of our handling of the fermion chirality problem with conventional space time matter induction [4,27,28,31]. The original uber symmetry group for that space is therefore Spin (7,7), which can be broken down into Sl(2,ℂ) x U(1) x SU(2) x SU(3) through respectively multi-fold space time matter induction and scattering [27-29] and multi-fold gravity electroweak symmetry breaking [31,32].

When it then comes to explaining why such a symmetry group remains standing (unbroken up to say chirality considerations), it directly results from the multi-fold spacetime and multi-fold mechanisms symmetries, reflected in the 7D (doubled) embedding space. There, we see that the symmetry must be[5] Sl(2,ℂ) x U(1) x SU(2) x SU(3), with the first term to support 7D (doubled) Lorentz symmetries [111]. Then, these imply the U(1) x SU(2) x SU(3) symmetries obtained by spacetime matter induction and scattering. We have to understand that we are not dealing with conventional symmetry breaking but rather sub-groups of symmetries resulting from the 7D local embedding constructed by the multi-folds. These are also not symmetries a priori from a generic 7D (x) embedding space [30], but due to the multi-fold mechanisms and degrees of freedom for the infinitesimal 7D (x2) ε region felt through at each 4D multi-fold spacetime location as entry, exit or mapping points to multi-folds. Such a construction from the multi-fold spacetime by the multi-fold mechanisms explains how the symmetries of the embedding space can be derived from multi-fold. Conventional physics, or GU has no such concept to link symmetries of Physics to Physical phenomena that dictate them.

The doubled 7D space sharing time constructed non-commutative [1], also explains via algebra doubling how the solitons of space time matter induction will lead to the SM particle and their quantum numbers.

With the understanding of the symmetries in the 7D embedding space, and for the multi-folds, we are making some steps towards being able to propose an action, Lagrangian or Hamiltonian, if those can be defined, which is still to be determined [1]. We believe this is also how we will eventually move from a qualitative framework, as in [1], to a quantitative one.

Finally, we need to keep in mind that a multi-fold spacetime is discrete, dominantly 2D at small scales and Lorentz invariant, as well as non-commutative [1,32], as may be our real universe per [6]. In this paper, we essentially assume that energies are still low enough to not be negatively affected by these aspects, although we know that effects and impact already exist at the scales of the standard model (SM) as in [1,36], where we have already shown that such a properties impacts the Yang Mills fields, aka Standard model QFTs, and guarantees a mass gap [36,102]. It is part of the arguments for a $SM_G$: Standard Model with gravity effect non-negligible at its scales [1,8-10,110,*148*]. Much of our work has shown that many open issues with the Standard model and the standard

[5] On the other hand, maybe one could consider that it is to some extent unfortunate that the symmetry in the doubled 7D embedding space is limited to Sl(2,ℂ) x U(1) x SU(2) x SU(3). If it had been based on Pati Salam [33], or SO(10), we would have been able to directly invoke the need for right-handed neutrinos out of it. Note that as we are speaking of the embedding spacetime, proton decay (not even present in Pati-Salam unless if derived from breaking a higher group like SO(10)), or magnetic monopoles, do not take place in 7D embedding space (no Physics hence no proton decay), or are anyway still suppressed by gravity once in the 4D multi-fold spacetime [1,34,38]. Supersymmetry is also not an option considering all our results so far, that indicate unphysicality and incompatibility with asymptotically de Sitter spacetimes or asymptotically safe gravity[1,6,11-18,20,35], which seem to be properties of our real universe. *Note added on September 29, 2023: See also [64] for a proposed alternate proof of that based on random walk considerations.*

cosmological model (ΛCDM) can be, at least partially and qualitatively, addressed with multi-folds and the $SM_G$ [1,4-32,34-40,44-47,54-56,59,60,63,64,68-110,112,117,*118-153*]. *Note added on September 29, 2023: We have also shown that the $SM_G$ seems to imply multi-folds [143,144].*

# 2. Some consideration on Geometric Unity

Apparently for no good reasons in our view, the Physics community does not seem to have spent a lot of efforts understanding the Geometric Unity theory [22]. Only one other author has publicly provided detailed analyses and pushes back [23-26], beyond the reportedly heavy animosity, or total lack of interest, from the Physics community. Unfortunately, it is not the first time that this seems to have happened. Consider the case of Lisi [112].

## 2.1 Concerns

We do not have issues with the comments presented in [23-26] that we will take as correct and align with.

Our first, and main, issue with GU is that the GU approach leads to defining quantum, not classical, Yang Mills in high dimensions (in the 14D observer). We know that above 4D, Yang Mills is not renormalizable and that above ~ 5.2D, it can't be asymptotically safe as discussed in [17,76,104,*138*] and references therein. In our view, which is a major obstacle to a viable, consistent, and physical theory, yet [22] claimed that Physics takes place in the GU "observerse", i.e. in these high dimensions.

To address this, the only way forward is to assume that the theory is supersymmetric in the conventional way, bringing in super partners, or at least the MSSM (Minimally Supersymmetric SM), and gravity asymptotic safety. Unfortunately, we know [13,14,16,17,*122*,*138*] that, at high dimensions, we have incompatibility of supersymmetry SM/MSSM with asymptotic safety of gravity. So, it does not work too well for Physics with metric in the GU "observerse", where asymptotic safety of gravity in 4D should be a minimum requirement to keep the solution consistent.

Furthermore, we know that supersymmetry is incompatible with a positive cosmological constant or asymptotic de Sitter spacetime [1,15], which should be the result for the metric in the GU "observerse". Superstrings, and variations, suffer of the same, and more, problems [1,6,11-18,20,17]. In any case, these challenges have are not addressed as a supported approach in GU, so far. *Note added on September 29, 2023: See also [64,138,152] for a proposed alternate proof of that based on random walk considerations.*

Supersymmetry, and higher level uber symmetries also often bring in problems with proton decay and magnetic monopoles [1,34,38]. Neither have ever been observed[6]. GU may partially go around the proton problem with its Pati-Salam symmetry proposal, yet that still may include proton decay, albeit with a longer proton lifetime in the case of GU[7], and magnetic monopoles. It is unclear, to us, how, or if, the proposed pull-back would suppress those. It most probably does not. These effects are not observed in the real universe (post GU pull-back) in inertial

[6] Note however that an accelerated proton can decay as discussed in [37].

[7] The Pati-Salam model has no lower order proton decay, if not coming from higher symmetries [33,41,42]. As it seems that GU would involve symmetry breaking of such larger symmetries, there is (slower) proton decay due to higher order operators. In any case, even experimentally, we are experimentally slowly drifting to reach the limit of invalidation across most proton decay options [43]. We submit that it simply does not happen as discussed in [1,34,37].

frames. We suspect that therefore they probably also can't occur in the GU "observers", to the best of our limited understanding of GU at this stage.

Finally, we are uncertain about insights like Yang Mills as the square of gravity [22,43]. We understand that the discussion is related to the order of the equations (i.e., the order of highest derivatives involved), and that similar arguments led to the Dirac equation, and the introduction of spinors key to characterize fermions. But, based on the Yang Mills double copy duality, see [44,45] and references therein, we see, Feynman diagram-wise, gravity as the square of Yang Mills[8], just the opposite. We have challenge reconciling the pictures, even if they involve different formalisms, considerations and definitions. We may revisit in the future if we can clarify our confusion.

As far as we know, the idea of a topological spinor, i.e., spinors without metric, as defined in [22], is also new and unproven in Mathematics and Physics. What is proposed may make sense, but probably requires much more investigation.

### 2.2. Inspiration

Despite these concerns, we were captivated by a few aspects of the GU, which have inspired some of the next steps described in the rest of the paper:

- The ability to mix/define physics as observable in 4D spacetime, via the pull-back, while (some) Physics runs in the GU "observerse".
- The proposal, for topological spinors on a spacetime without (a priori) defined metric, and its definition in 14D on GU "observerse", from where we have a pull-back to the 4D spacetime.
- The derivation of Spin (7,7) as the symmetry for group the GU "observerse", granted that it is not the only path to end up with Spin (7,7) or SO(10) [48,49]. There is a whole GUT line of research related to that. See for example [50,51] [9].

We will especially focus on s multi-fold analysis expanding on the last bullet.

## 3. Multi-fold and $SM_G$ symmetries from Induction

Following [27-29], we know that the multi-fold spacetime can be locally minimally[10] embedded in a 7D space. As discussed in [27,30], no chirality is defined in 7D. [4,27,31] proposed a physical solution: during spacetime matter induction (and scattering) into the 4D multi-fold spacetime, gravity orients globally (below gravity electroweak symmetry breaking [31]), or locally (above it) the 4D spacetime and it becomes possible to distinguish left and right chirality.

There are probably better ways to explain the above in terms of groups and symmetries, as in some references in [31]. These statements has a more direct and rigorous mathematical interpretation [30]. One can model the two

[8] Which we interpreted in [45], as the Yang Mills action actually containing the GR action and the mechanisms behind the multi-fold gravity of entanglement of pairs of particles [1,46,47]. We already met that in [14], and we will encounter it again later in this paper.

[9] See chapter 94, "Grand Unified Theories", in [50]

[10] i.e., not covering the 10D or larger dimension options discussed in [29], or global embedding options starting at 8D.

chiralities in the 7D embedding space, by considering two spaces each separately associated a left and right-handed labels: $S_L(7) \oplus S_R(7)$, each with chiral objects characterized with Spin(7) symmetry.

The resulting symmetry is: (in the spirit of this paper, we refer to these results also reported in GU [22], and for now look at them in the (doubled) 7D local embedding space)

Spin (7) x Spin (7) x $G \simeq$ Spin(7,7) x $G$ (1)

$\simeq$ Sl(2,$\mathbb{C}$) x SO(10) x $G$ (2)

$\rightarrow$ Sl(2,$\mathbb{C}$) x SU(4) x (SU(2) x SU(2)) x $G$ (3)

$\rightarrow$ Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3) x $G$ (4)

$G$ denotes possible additional symmetries of the system, not accounted by the analysis. It is added for completeness, but $G$ can be considered as the identity $\mathbb{1}_G$ for now. When in 4D multi-fold spacetime, it should be read as $G$', when we will see it later.

In (3) the last three terms before $G$ correspond to the Pati-Salam GUT/model [33].

The SM symmetries itself can also be on its own embedded in SU(5) (e.g., as for Georgi Glashow GUT [52]), and other sub-groups, e.g.,

Sl(2,$\mathbb{C}$) x SO(10) x $G \supset$ Sl(2,$\mathbb{C}$) x SU(5) x $G$ (5)

(5) however is not an option for the multi-fold theory, before reaching the embedded 4D spacetime: in the 5D embedding space that would represent the dominant 5D effects of the multi-folds, we must keep the ability to have left and right chirality. So it must be rather do (6):

Sl(2,$\mathbb{C}$) x SO(10) $\simeq$ Sl(2,$\mathbb{C}$) x SU(5) x SU(5) x $G$ (6)

(6) could lead to Georgi Glashow GUT in 4D.

While partially addressed (higher order operators in the case of (2) and (3) or flipped SU(5) vs. Georgi Glashow), all these have magnetic monopoles and proton decays, already ruled out by experiments, or about to be [51,53]. If these were the symmetries of the embedding space, the flat (doubled) 7D GR space used for space time matter induction would not be able to suppress these effects, and at least at high energy we would encounter a GUT in the multi-fold 4D spacetime. It is something we have essentially already rejected in multi-fold theory [13-39]. This path is just not working.

So the only acceptable path for a symmetry breaking in the double 7D locally embedded space seems to be:

(1) $\rightarrow$ (4) (7)

Obtaining (4) explicitly shows that the multi-fold space time matter induction and scattering as in [27-29], contains, and therefore can recover, the SM symmetries, as argued in [27] and differently in [29]. Section 5, will provide a microscopic interpretation and justification.

If we assume that (1) is broken, into (4), in the doubled 7D spacetime, then we explicitly have the need for right-handed neutrinos in $S_L(7) \oplus S_R(7)$, as we have concluded through our derivation of the multi-fold theory [1,8-10,54-56,110,*148*]. It is needed by the symmetry.

(4) is the symmetry of the embedding space felt through the ε region.

In (4) we recover as first term the Lorentz symmetries of spacetime and GR, and the next three terms are the symmetries of the standard model and $SM_G$.

Above multi-fold (gravity) electroweak symmetry breaking [31], we can keep the same labels but all induced particles are now massless. It is a modification of the induction and mass generation due to the multi-fold (gravity) electroweak symmetry breaking, not a real change[11] in the doubled 7D locally embedding space that maintains the same symmetries (4). As discussed in [4,31,*122*], in the massless case, the induction is implemented by patterns of the 2D random walks instead of multi-fold microscopic black holes -like Qballs of Higgs condensates.

# 4. Physics in the embedding space

Note that, so far, we have not discussed, or argued, that quantum physics reigns in the 7D locally embedding space. Our multi-fold reasoning is aligned somehow to the view on particle physics attributed to Witten in [30] and repeated as key foundation in GU [22].

GR (7D), and not GR (14D) as it is for each chirality, has suitable solitons following (4) symmetries, and will induce the SM interactions. In [27-29], we showed that space time matter induction and scattering can give the (fermions and scalar) particles of the SM. In [1,10,29,32,64,92,*122,123,148*] and references therein, we see that algebra doubling on non-commutative geometry in 4D also predicts the SM particles including neutrino mixing. The embedding space is non-commutative at small scales, per the properties of the multi-folds [1,32].

For the rest, we also know that no physics takes place in multi-folds, and embedding space per the principle of multi-tenancy [1,9,10,110,*122,148*]. Accordingly, particles do not see other particles (It makes sense, it's their own local ε 7D (x2) region) in multi-folds other than Higgs, encountered at entry, exit or mapping points, which result from the fact that multi-folds are also built by the random walks of the massless Higgs bosons [1,77,80,*122*], also playing the role of dilatons (associated to the kinematics/dynamics of the multi-folds [4,17,36,45,*122*,*132*,*138*]), and the particles at the entry and exit points, that includes the entangled particles associated to the multi-folds [1], and right-handed neutrinos behind the (massive) Higgs boson, forming the isospin doublet spacetime spinor companion to the Higgs [1,31,54-56]. As shown by Witten the presence of fermions then also stabilize the Kaluza Klein effects behind the multi-fold space time matter induction [113,*135,138*]. All this is consistent with 7D (dominantly 5D) multi-fold space time matter induction with a classical flat/Einsteinian embedding space where no Physics takes place.

## 4.1 GR kingdoms

Remember that the 7D embedding space, as felt as an ε neighborhood, is also expected to be discrete [1], at least if generated by spacetime reconstruction (i.e. generated by the 4D spacetime reconstruction with multi-folds) which is all what matters for the ε regions perceived at 4D spacetime locations.

[11] Anticipating section 5, because all particles are massless, the discrete random walks create maximally separated concretized points in 7D (they move at *c*), but they remain random/Poisson. So, remembering that the 7D space is actually also discrete, we will see that it also encounters a phase change. It matters only if we were to model discrete effects. It also probably only appears coming from the big bang. Any other situation would still mix lower and higher energy particles and probably just the distribution of the discrete steps size not completely going to its maximum associated to *c*. On the other hand, the disappearance of spacetime orientation, implies that Right-handed or Left-handed objects in 7D spacetime do not model differently anymore, and, of course, that we have a right-handed neutrino and its anti-particle.

When considering a 7D embedding space, we do not know for sure, if the 7D embedding space (Ricci flat) [27-29], or the tangent dual (AdS(5)) are governed by GR [1,14,56], or just sharing its symmetries. After all, we can't observe anything of these spaces, just their effects. But when the 7D space is limited to the ε neighborhood felt by the 4D spacetime at entry, exit and mapping point, and within the associated multi-folds, with no Physics per [1,9,10,110,*148*], we can at least say that GR reign as Ricci flat, or rather Einsteinian, as we discuss below in that localized embedding 7D space.

Indeed, with the multi-fold mechanisms detailed in [1,6], where we derived the contribution of the multi-folds as an attractive effective potential, the effects are consistent with QFT in curved spacetime. It is reasonable to expect that it means that GR reigns in the embedding space felt through the ε neighborhood.

For AdS(5), as discussed in [1,14,18,56], we can live without GR, as AdS(5) is built from the gravity and spacetime curvature effects. In [14] and references therein, it is shown that assuming GR in AdS(5) would imply superstrings in AdS(5) (+…), e.g., AdS(5) x $S^5$, with the notation used in [1,*138*].

Multi-folds mechanisms are described in [1]. They do not require GR. However, if GR governs them, something plausible per our discussion earlier, then, it is possible to see them modeled, or implemented, by GR wormholes [1,6,14,18,56]. In order to achieve stability and traversability of wormholes, without requiring crazy exotic matter or negative energy, we can reuse the right-handed and left-handed neutrinos near entry and exit of the wormholes / multi-folds [14,56].

We can add the following considerations:

- If of concern to the reader, the wormhole charge invoked in [57,62] may be a polarization of the vacuum, or a Casimir effect [58].
    - It offers a compelling explanation for a non-interacting right-handed neutrino and its left-handed anti-particle that can explain the mass of neutrinos and its non-observability (non-interacting other than via Higgs) by being behind Higgs in multi-folds at the edge of spacetime, aligned with multi-fold gravity electroweak symmetry breaking results, aligned with some proposals of multi-fold space time matter induction and able to explain the matter anti matter asymmetry [1,31,54,55,59].
- It is granted that stability may not matter either, as the multi-folds evolve to follow entangled particles and therefore, if implemented by wormhole, would involve always changing ones. But following the right-handed neutrinos approach [56] may be a way to achieve the required dynamics and kinematic effects [1]. This changing "radius" is what can be seen as associated to a dilaton in conventional Kaluza Klein theories [4,17,36,45,*122*,*138*], and the theory is stabilized by the presence of fermions [a45,*132,135,138*].
- Above multi-fold gravity electroweak symmetry breaking, we do not have massive neutrinos any more[12], and all particles become massless, and able to traverse, even non-traversable wormholes, like photons.

[12] Note also [57,61,62] are enumerating how massless fermions could also fulfill the same requirements, but leading to other challenges (unstable or metastable for a long time, which can also be a problem as already mentioned, only in AdS or stitched together AdS, or non-renormalizable because the spinors do not vanish at infinity (*)). But, again, at these energy scales, it's not really needed when we just need to support massless particles to traverse the wormholes.
By the way, (*) may actually have a physical explanation: massless fermions pairs are expelled from the wormhole and therefore they may not be able to support stability and traversability for much time, at the difference of [57] with massive fermions. So assuming that massive neutrino, as in [56], keeps the wormhole traversable is feasible, massless fermion can't do it the same way. Repeating the next argument then, while it may at first appear to be a problem when the neutrinos are massless at energies above the multi-fold gravity electroweak symmetry breaking energy scales, it isn't because then all particles are massless and can traverse.

Therefore, [56] does not fall apart above the multi-fold gravity electroweak symmetry breaking. The mechanisms is a credible way to implement multi-folds, albeit not mandated.

- [58] alone[13], offers another option to ensure wormhole traversability by massless particle relying on Casimir effect at the throat that ensure slow collapse. We do not favor this explanation, but leave it as an option, especially above multi-fold gravity electroweak symmetry breaking, as it is not really needed (following Occam's razor principle), and its slow decay could otherwise maybe prevent it to support the multi-fold kinematics and dynamics proposed in [1], like multi-fold deactivation, and mentioned above. Also these effects may appear, and we know that it should not be the case, to indicate quantum Physics in 7D; something that we do not want to consider beyond our previous comments.
  - Note that in a model where multi-folds are implemented with wormhole, it would be fair to consider that physics take place in the 7D spacetime (GR and other), but that the kinematic and dynamic making the wormhole typically grow and stretch, prevents interactions (other than at exit points) and amounts to the same as no Physics: the 7D ε neighborhood appears without Physics in it.
  - This kinematics and dynamics of the multi-folds described in [1,9,10,110,*148*] can be seen as analogous to exercising pressure analogous to the effects above, not requiring Physics in 7D embedding space. while ensuring the same results due to dynamics of the wormholes

The locally embedding 7D spacetime (ε neighborhood) is built by the multi-folds always popping in and out of existence due to entanglement [1,8-10,110,*148*], or non-zero wavefunctions or quantum fields. The latter case is due to the multi-fold W-type hypothesis [60]. For the study of the symmetries seen in the 4D multi-fold spacetime, only the ε regions matter.

The (multi-fold) space time matter induction assumes that the embedding space is Ricci flat (or Einsteinian) [27,28,29] (and references in [27]), which means essentially a space without matter or energy (zero energy momentum tensor per GR. *Note added on September 29, 2023: See also [143]*). It makes sense in our model: nothing, or just a particle, per the tenancy model [1], is in a multi-fold, and it is assumed to not deform it, i.e. no gravity is involved. Again it makes sense that the embedded space is therefore flat, consistent with the multi-fold space time matter induction and scattering as in [27-29], or Einsteinian, if we want to add cosmological constant effects. Einsteinian space are also similarly supported by the multi-fold space time matter induction and scattering [27-29], and embedding theorems.

It plausible that stitching[14] together all the multi-folds provides an essentially flat spacetime in 7D (and remember it is essentially 5D per [27]). Paths passing in the multi-folds have negligible ε impact on curvature everywhere outside the 4D spacetime (as infinitesimal contribution, and because the multi-fold mechanisms, kinematics and dynamics as postulated in [1] do not deform the multi-fold therefore implying Ricci flatness in that space, or Einsteinian properties). Most paths pass in 4D spacetime instead anyway. Discrete 7D space locations would have same properties (e.g., Lorentz symmetry) as the multi-fold spacetime (but now in 7D and for how concretized discrete locations are open, see after), and so expecting GR in 7D makes sense, with a Ricci flat space. After all, it just amount to preserved Lorentz volumes and surfaces through the action. More will be discussed in section 5, where we will positively answer to this.

Note that we actually rather have an Einsteinian 7D embedding space with GR because of the universe expansion, due to dark energy effects [1,77,80,*122*], that must be matched (not because of dark energy but because one must

[13] i.e., not combined with [56].

[14] Being able to stitch together multi-fold may open the door to macroscopic traversability, as needed by the more exotic and science fiction-like applications envisaged in [1].

follow the expanding separation between entangled particles) in the multi-folds (per construction, as in [1], and because the same microscopic interpretation, with (quantum) random walks of massless particles, supports such an expansion at same rate as the underlying 4D multi-fold spacetime (This later comment is useful when entangled systems remain bound, and therefore do not behave the same way. *Note added on September 29, 2023: See also [126]*).

In conclusion, a Ricci flat / Einsteinian space with GR for the 7D ε neighborhood is a legitimate assumption.

## 4.2 Quantum Physics kingdoms

Also, our model does not assume quantum Physics (or much Physics in general other than flat 7D GR) in the extra dimensions of the 7D embedding space. As we discussed, the multi-fold tenancy model [1,9], implies no interaction (beyond with Higgs in the multi-folds entry and exit point, hence always available as the multi-fold keep the path ending near the exit points [1], to keep the same masses of the particles when on a path in the multi-folds) within the multi-folds. It's good because otherwise, quantum Physics in the 7D spacetime would probably imply vacuum fluctuation, field interactions, curved space particle creations, and more effects that might force us to add more restricting assumptions on the multi-folds, or that might introduce new phenomena, or predictions, that we have not yet accounted for in our theory, and as far as we know there are no related effects observed in the real world that we would want to explain this way. The discussion in the previous section of traversable wormhole kinematics and dynamics, justified that there appear therefore to also be no Physics in that case in the wormholes, due to their typical stretching as we already explained.

Considerations like the absence of chiral Fermions in odd dimensions above 4D, the non-renormalizability or asymptotic safety of Yang Mills fields respectively above 4D and ~5.2D ([17] and references therein), add to the concerns of proposing Quantum Physics in the 7D spacetime.

- The alternative to define Supersymmetric Physics would be the anathema of our results so far, as we deemed it unphysical in asymptotic de Sitter spacetime [11-20]. *Note added on September 29, 2023: See [64,138,152] for additional considerations, and proof, of why we have no supersymmetry in an expanding 4D universe*.
- Kaluza Klein (KK) and multi-fold space time matter induction and scattering approaches generate Yang Mills and particles in 4D spacetime, not the 7D embedding space. To justify Yang Mills in 7D would require a new satisfactory explanation for them to appear: i.e. recurrent KK from bigger spaces or superstrings. Not an appealing model in either case, especially for non-observable space outside our physical spacetime, and with the Yang Mills challenges at large dimensions [17,76,104,*138*].

Therefore it seems that it is only if we want to also explain GR in 7D, that we would revert to multi-fold mechanisms and evolve towards a 10D or 11D spaces [14,29], which is relevant only when we try to compare to superstrings and M-theory, which we have already established as unphysical, and purely mathematical, at least with respect to a multi-fold universe [11-20,17].

So, for now, we assume that the 7D embedding space, generated in ε neighborhoods, and used for multi-fold space time matter induction and scattering, does not contain quantum Physics, outside what happens within the multi-folds in terms of pat propagation and in truth massless Higgs boson random walks: we have no contradiction.

# 5. Physical, or microscopic, justifications of the multi-fold and $SM_G$ symmetries

After all these considerations, can we justify the symmetry breaking to (4) and provide physical interpretations of the symmetries? So far we have shown how we could encounter the SM symmetries not that they must be encountered, and why. We are still falling short of our goals.

Section 3 justifies starting from Spin(7,7) for the embedding space (spin(7) squared, or doubled) to be associated to spinning solutions in 7D, where we distinguished with a label those that result into left-handed vs right-handed solitons in 4D, i.e. spinning one way or another; hence squaring the symmetry, which, we have and will see, is also key as a consideration as in [1,10,29,32,64,92,*122,123,148*] and references therein.

We now have to show what symmetries exist in that space, why and why not other symmetries.

## 5.1 Symmetries in the 4D multi-fold spacetime impacting the 7D embedding ε space

Let us see if we can do better bottom-up: starting from the 4D spacetime.

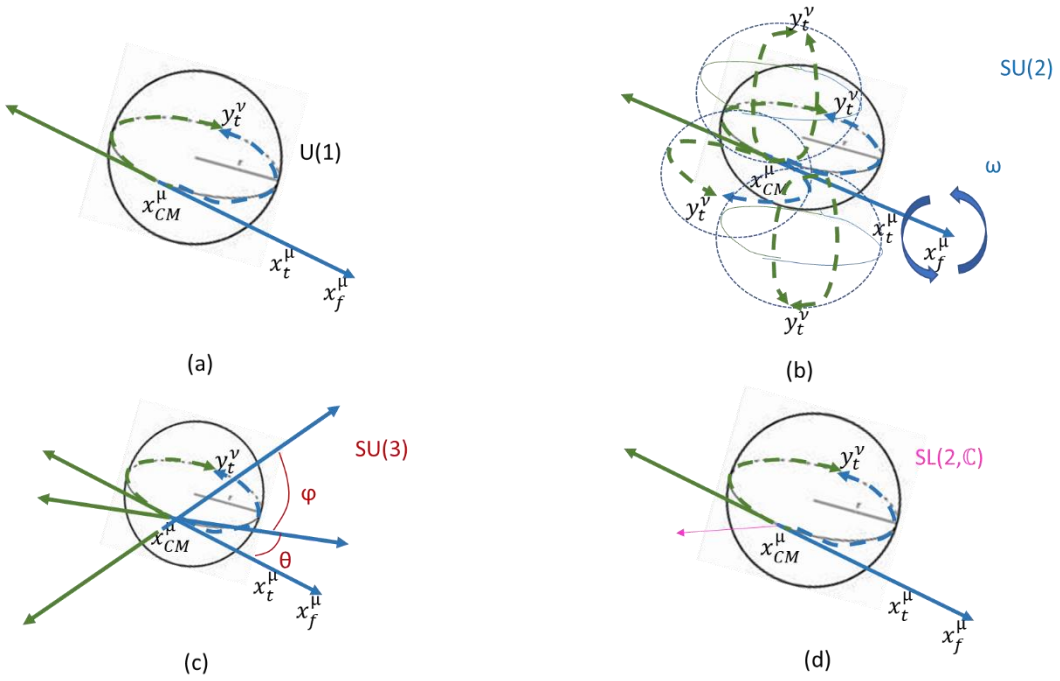


*Figure 1: Multi-fold mechanisms as described in [1], where x is in 4D spacetime. We also indicate the sources of the symmetries discussed in the text: (a) shows the U(1) symmetry coming from folds and their mechanisms as spheres, just like electromagnetism comes from a compactified KK. (b) shows the SU(2) axial symmetry of the multi-folds. (c) show SU(3) symmetry of the multi-fold mechanisms for gravity in selecting the axis direction. (d) then shows spacetime evolution of the spacetime location tangent to the multi-folds brings in Lorentz symmetries.*

We argue that, in the 4D spacetime, the symmetry from the embedding spacetime can break down (from Spin(7,7) x $G$), and must result into a Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3) x $G$', ultimately associated to gravity/spacetime, weak

hypercharge, weak isospin, and color [114], itself evolving with the multi-fold gravity electroweak symmetry breaking [31].

Conveniently, in the 4D multi-fold spacetime, we can explain these symmetries as follows and as also shown in figure 1:

- Sl(2,$\mathbb{C}$) is the 4D Lorentz symmetry, that also plays a key role in the multi-fold gravity electroweak symmetry breaking [31,111].
- U(1) results from the topology of each fold (as a growth of spacetime outside 4D spacetime) that is equivalent to the constrained KK model, except not attempting compactification, yet evolving in radius, which result into the massless Higgs boson as dilaton [4,17,36,45,*122*,*138*]. It evolves with the multi-fold gravity electroweak symmetry breaking [31], from weak hypercharge to electromagnetic charge. See figure 1.
- SU(2) is the axial symmetry of the multi-fold mechanisms (also referred as spin symmetry in [1]) that also evolves with the multi-fold gravity electroweak symmetry breaking [31]. See figure 1.
- SU(3) is the 3D rotation symmetry associated to the radiation of virtual particles in all directions (See [1]).
- $G$' defines additional symmetries or group operations possibly not included in the analysis so far. For now we consider it as the identity $\mathbb{1}_{G'}$. $G$' may differ from, be a sub-group of, or be $G$. At small enough scales, discreteness of the spacetime will also affects the symmetries.

As we know, other symmetry breaking can take place, think of chirality [1,36,88], internal symmetry also exist. T, C, P symmetries are discussed in [1].

And so, earlier, we have argued that, when going from the 7D embedding space and entering the 4D multi-fold spacetime, the symmetry breaking (1) → (4) must be what happens, because of what we know of the 4D multi-fold spacetime, adding the considerations of section 3 on why some of the other candidates are not that suitable in multi-fold 4D spacetime. Remember that the multi-fold spacetime matter induction and scattering is from the 7D ε region felt in the 4D spacetime and created by the multi-folds mechanisms from the 4D spacetime. The symmetries in that space must be of the form (4).

These are symmetries affecting anything involving spacetime (and therefore at the core of GR and Quantum gravity), and entanglement (and therefore at the core of a key aspect of Quantum Physics), but also every quantum effect if we assume that the multi-fold W-type hypothesis implies attracting between every points linked by multi-fold, i.e., on average as a result towards the center of probability of the wavefunction (or local quantum field) [60].

It is convincing that therefore SM or $SM_G$ must bear these, or a subset of these symmetries.

We believe that this is actually a convincing proof. Indeed, multi-folds explain gravity in terms of quantum entanglement effects [1,46,47], GR seems to encounter multi-folds towards Planck scales [6], and GR / Yang Mills, aka SM, contain (dualities of) each other in their actions [1,14,44-47]. *Note added on September 29, 2023: And we then also have the hints that stable QFT implies multi-folds [144].*

Yet some readers would probably still object that it would automatically imply some specific symmetry for the particle fields (fermions) in SM or $SM_G$. In our approach, it is derived from the actual multi-fold space time matter induction and scattering, not two different symmetries in an embedding and embedded space, even if one is a subset of the other. We have proven that the embedding 7D space symmetry is (4).

Because no other symmetries are involved in generating the 7D embedding space, from the 4D multi-fold spacetime, as felt by the 4D spacetime as a 7D ε neighborhood, it implies that the 4D multi-fold spacetime symmetries couldn't be a larger symmetry, at least until and unless additional mechanisms and symmetries are

encountered that would contribute to their generation of the 7D embedding ε space from the 4D multi-fold spacetime. There are no such consideration at this stage in the theory.

We are still short of our goals. But we are not done yet.

## 5.2 Reconstructed 7D spacetime

We need to re-emphasize something important that we have mentioned several time so far: 4D multi-fold spacetime is obtained by space time reconstruction [1,6]. In that context, we have always explained the AdS(5) is a dual tangent space that is built from the multi-folds (curved as seen from the outside of the multi-folds – outside in) [1]. Similarly we have argued that the 7D locally embedding space is a local embedding space built by the multi-folds (inside out) and seen from the inside of the 4D multi-fold spacetime, like for example the ε neighborhood in 7D, and entry and exit, mapping point inside the multi-folds [1], or in the multi-fold dark energy effects [1,63]. It is also how we justified a non-commutative spacetime, or a discrete spacetime also in the multi-folds [1,32].

In other words, 7D is not a physical absolutely pre-existing space. Instead, it is the result of the multi-folds and their kinematics and dynamics, which generate it as something seen from the 4D multi-fold spacetime as a set of discrete locations (corresponding to each of the shared time clicks give or take relativistic effects not important for this argument here, as we can take agree on a reference frame as the center of mass of entanglement or a particle source of gravity [1]).

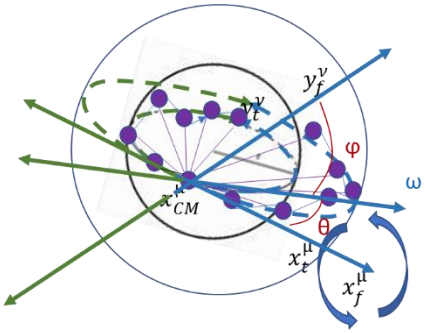


*Figure 2: Random walks on evolving multi-folds generate concretized locations of the 7D spacetime. They are random sprinkled Poisson distributions. They are shown in 3D extensions (+ sharing time dimension). With the 4D spacetime discrete location we have a 7D sprinkling.*

As a result, we can argue that the 7D symmetries contains:

- U(1) because the 7D space time constructed by each fold has a U(1) symmetry. See figure 2.
- SU(2) because of the multi-fold axial symmetry around the point where we have tangency for a multi-fold. See figure 3.

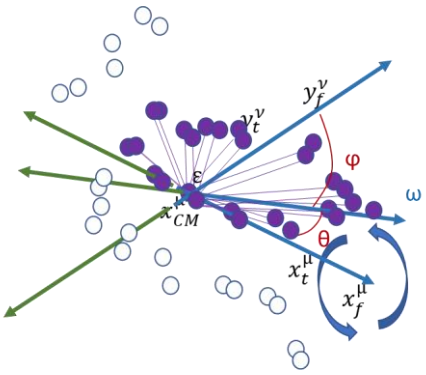


*Figure 3: Axial rotations implies 7D symmetry of the random Poisson distribution.*

- SU(3) because of the symmetry for selecting axis direction when generating gravity.
- Sl(2,ℂ) because of sharing time with the 4D multi-fold spacetime: we can encounter 4D Lorentz transformation in the 7D embedding space due to move of the tangency point in the 4D multi-fold spacetime, and moves in the embedding space due to the kinematics and dynamics of the multi-folds as time passes. When combined with the Lorentz symmetries in the 4D multi-fold spacetime, sharing time, we obtain 7D Lorentz symmetries (at least a sub-group). Another way to see that is that just as random walk in the 4D multi-fold spacetime leads to Lorentz invariance in 4D, the equivalent in the multi-folds (and for multi-fold attached to different4D multi-fold spacetime), implies 7D Lorentz symmetry thanks to the same symmetry (as transformation of Poisson distribution).
    - Note that if time weren't shared we would have the problem of 2 times Physics which while considered by some is rather problematic in terms of what results from it, especially in terms of causality, ghosts and unitarity [115,116,*135,138*].

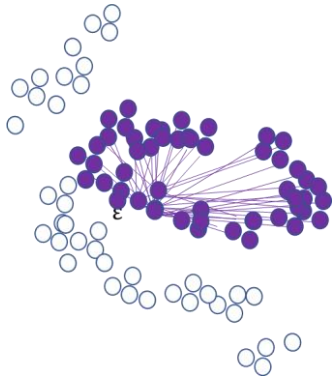


*Figure 4: Lorentz moves in 4D spacetime or fluctuations towards a fold further add to the distribution of discrete points. They are transformation of Poisson distributions, i.e. still compatible with Lorentz invariance.*

The last bullet implies that the 7D embedding space can indeed be Ricci flat 7D GR, without requiring multi-folds mechanisms within the 7D space to motivate GR[15]. It is also Ricci flat because of the absence of Physics in multi-folds and the infinitesimal paths crossing them that do not deform the multi-fold implying flatness [1]. In truth,

[15] Even if multi-folds can be grafted behind them in a 10D (locally) or 11D (Globally – see [29], it does not exist, it is a mathematical construct only). It's just not needed other than to feel good. This is physical (just as superstrings and M-theory are not physical [1,11-20]).

because a multi-fold expands with a positive cosmological constant, the space is Einsteinian, but everything in terms of multi-fold space time matter induction and scattering works the same way [1,27-29].

All the bullets above imply that with spacetime reconstruction, the 4D multi-fold spacetime transfers

Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3) x $G'$ → Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3) x $G$ (8)

|__4D_Multi-fold_Spacetime__|→ |___(7D_local_embedding) x 2_|

when it constructs the local 7D embedding space (with chirality labels).

Remember that chirality is captured by labels and product of the symmetries in a double 7D embedding space.

We already know that $G$ may encompass Lorentz symmetries from dimensions larger than 4.

But for the rest, we have proven that if the 7D (14D with chirality labels) local embedded spacetime is constructed by the multi-fold mechanisms, then it supports symmetry (4), not (1) or another subgroup of spin(7,7) as (2),(3),(5) or (6). From a group theory perspective, the symmetry breaking takes place in the 7D embedding spacetime (duplicated with chirality labels) not in the multi-fold 4D spacetime, as a result of the generation of the local 7D ε embedding neighborhood as 7D embedding space It is that generation that forces the symmetry (7). As a result, the result of the multi-fold space time matter induction and scattering must reflect, i.e., be, or be a subset, of Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3) x $G'$. In other word, $SM_G$, is Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3), and, therefore, SM, is U(1) x SU(2) x SU(3), or a subset / broken symmetry of it. In saying so, we assumed that $G'$ and $G$ are the identity, or more explicitly focused respectively on 4D spacetime aspects and GR(7D).

This is a unique way to demonstrate, and explain, the symmetry group behind the standard model. We now know why this is the subgroup that was selected by nature, and why not another one. It also explains differently, i.e. not as a negative “because it can’t be”, as we did so far.

The construction does not imply any quantum models, and in fact the multi-fold tenancy model implies no interactions or fields (other than Higgs at entry and exit point and in theory within the multi-folds, and the particle on its path). We can reasonably assume that the 7D local embedding space obtained from the multi-fold is 7D GR (Ricci flat/Einsteinian without Physics), discrete and non-quantum[16].

Conversely, without (quantum) Physics in the multi-folds we can now explains the multi-fold tenancy model that we proposed [1,8,9]. We discussed that no such Physics is indeed the expected case for a multi-fold universe.

## 5.3 Additional consequences

The reasonings so far, and the construct provided here, a priori do not allow for larger symmetries. The consequences are immediate: No GUTs (based on larger symmetries), no Supersymmetry, no superstrings. We already knew that [1,11-20,64,*138,152*]. But this proves it for a multi-fold universe. Indeed, the only other symmetries that are allowed, and relevant would be “internal symmetries”, and C, P, T as well as Chirality. They can’t affect the construction of the (double) 7D locally embedding space, other than its orientation [20,36] already

[16] At least and until we find a reason why not. Concretization of the visited discrete location in 7D, as in 4D spacetime [1], with massless Higgs is not an issue as already discussed. Oh, and the 7D embedding space is Ricci flat or rather Einsteinian.

captured by the embedding space doubling, and therefore can't induce a larger symmetry back on the 4D multi-fold metric.

Another consequence is that this constitutes another great hint that we have a new-fundamental-particle desert above the gravity electroweak symmetry breaking energy scale as predicted in [64]: there is no super or uber symmetry to occur in 4D spacetime [1,39], or be broken in it, and therefore in SM or $SM_G$.

## 6. Input towards a Multi-fold Lagrangian or Hamiltonian

Unfortunately, [1] and subsequent works, tracked at [8-10,110,*148*], have been so far only qualitative. It is, in part, because, we have not been able to discover the Action, Lagrangian or Hamiltonian of the multi-fold theory, yet, assuming that it can be formulated[17]. Fortunately, the work at [1, 8-10,110,*148*], shows that it isn't needed to already get good value from the approach. But, yes, our ambition is to evolve towards a quantitative model.

Yet, the results here allow us to argue that any candidate Lagrangian or Action must respect:

$Sl(2,\mathbb{C})$ x U(1) x SU(2) x SU(3) x $G'$ (9)

in the multi-fold 4D spacetime (e.g. with $V_{eff}$ effective potentials as in [1]), or

$Sl(2,\mathbb{C})$ x U(1) x SU(2) x SU(3) x $G$ (10)

, when looked at from the outside in of the multi-fold 4D spacetime.

It could be an opportunity for future work and collaborations [117], to try to construct the most generic action that would match the multi-fold mechanisms. Of course $G'$, still leaves the problem open ended and we are not sure if the theory can have a clean, consistent and useful QFT type of formulation, even if just effective. After all, [1] also advocates considerations moving a bit away from QFT, and back towards Quantum mechanics. So we may need to also evolve a bit the formalism.

For now we assume

$G' = \mathbb{1}_G$ (11)

, and $G$ as only adding Lorentz symmetries in 7D (at least in a ε neighborhood).

This latter result allows us to assume that GR reigns in the 7D embedding spacetime, which increases the plausibility that multi-fold could be implemented with traversable wormholes and right-handed neutrinos [1,56]. It doesn't have to be though.

The same argument can be repeated for AdS(5), where GR can reign, implying superstrings and branes in the space tangent to the multi-fold spacetime, i.e. in AdS(5) x $S^5$, and related variations, as already discussed and proven by references in [14]. Yet they are non-physical, just mathematical curiosities [1,11-20].

For an interested, or confused, reader, not familiar with the group zoology (the question came while the paper was quickly first reviewed…), note that [65] speaks of Spin(3,1), as symmetries of spacetime, instead of $Sl(2,\mathbb{C})$. We have (See [66,67,111], if still confusing):

$Sl(2,\mathbb{C}) \simeq \mathrm{Spin}\,(1,3) \simeq \mathrm{Spin}\,(3,1)$ (12)

[17] As argued in [1,*128*] and references therein, it can't always be guaranteed to exist.

Note also that in the big picture, the analysis provided so far also explains why Kaluza Klein seems to work so well [27-29], including to recover the SM interactions [30], with of course the stability problem, a big reason for its demise [113], nicely resolved with the neutrinos as fermions [113,*135,132,138*], at the entrance and exit of the multi-folds as In the multi-fold theory.

## 7. The Standard Model had to be what it is

Eventually, it is worth pointing out that a consequence of this paper is that GR, or the Hilbert Einstein action contains fully the Standard Model. Indeed, multi-fold explain and imply GR [1], and GR contains multi-folds [6]. Furthermore, the Hilbert Einstein action implies Yang Mills, conformal behavior, superstrings [14], while Yang Mills theory implies gravity [14,45], and the multi-fold mechanisms [45]. Therefore, the multi-fold theory applies to our 4D ([9] and reference [93] therein) real universe and the SM is a combination of Yang Mills fields that conforms to all this. Then, chiral aspects and symmetry breaking result from the properties of gravity and gravity electroweak symmetry breaking [31], as well as (QCD) confinement [36].

The doubling of the spacetime, sharing time, into the 7D embedding space explains the algebra doubling on non-commutative geometry in a 4D spacetime that leads to the SM particles, including neutrino mixing. See [1,10,29,32,64,92,*122,123,148,154*] and references therein. It also guarantees that the solitons induced and scattered on the 4D spacetime via multi-fold space time matter induction and scattering will induce the SM particles, and a priori nothing else (Skyrmions for examples are rather the result of QCD / Chirality effects, as stable solitons, see [36] and references therein. Note that the algebra doubling can also be seen as the result of the embedding space doubling for each chirality then reduced to 7D considerations. We also invoked it in past papers ([10,92]). That is mathematically equivalent to also justify the correct solitons, but it is not how physically the multi-fold space time matter induction and scattering was unfolded in our papers [27-29], where the space time matter induction and scattering is repeated for left and right chirality, i.e. each Spin(7), not Spin(7,7), nor the best way to paraphrase say [154]. For the future we will stick only to the original explanation as in [1,32].

In the presence of gravity, the SM had to be as it is. And yes that means $SM_G$. There are no issue of fine-tuning, multi-verse, or God to invoke [*135,153*].

## 8. Conclusions

The paper provides a unique justification for the symmetries (U(1) x SU(2) x SU(3)) of the SM, or (Sl(2,$\mathbb{C}$) x U(1) x SU(2) x SU(3)) for the $SM_G$ , i.e., the SM with gravity effects non-negligible at the scales of SM. It is derived in a multi-fold universe. Because GR encounters multi-folds at Planck scales [6], we propose that this result probably holds for our real universe.

This result is different from all what we saw so far in the literature where the focus was how the SM symmetries may be obtained from uber symmetries, by some hypothetical symmetry breaking or from supersymmetry. These do not explain why the SM symmetries, just how they may result from bigger ones, and how, or why, these bigger ones are plausible.

We have also provided additional details on the symmetries in the 7D locally embedding ε space, generated by multi-folds, and the multi-fold mechanisms, and that is responsible for the multi-fold space time matter induction and scattering that recovers the SM interactions / particles and fields.

A consequence is that no GUT or supersymmetry exists, shown a different way this time, and we reinforce our conjecture for a new-fundamental-particle desert above the multi-fold gravity electroweak symmetry breaking.

We have proven that one could consider that GR can reign in AdS(5), and that it seems to reign in the embedding 7D ε space, albeit all discrete. The latter increases the plausibility, it is not necessarily the case, nor needed by the multi-fold theory, that multi-folds be implemented via wormholes rendered traversable below multi-fold gravity electroweak symmetry breaking by massive non-interacting right-handed neutrinos and left-handed anti-neutrinos. Above the energy scales of the multi-fold gravity electroweak symmetry breaking, wormholes would be traversable by all particles as they are all massless. The former also recovers that superstrings and branes can be seen mathematically as living in a mainly tangent ADS(5) (+…) space governed by GR. But they are still unphysical.

We also added a few consideration on traversability and possibly charged wormholes seen as vacuum polarization and / or Casimir effects, including how effects like Casimir force could result from the way that the multi-fold kinematic and dynamics are felt and/or the subsequent wormhole stretching. It is important so that no interactions is assumed to take place in the multi-folds, and charges are no more a requirement.

Related to that, we argued for no Physics, quantum and classical other than basic random walks of massless Higgs bosons in multi-folds and the 7D embedding ε space, that therefore appears Ricci-flat (or rather Einsteinian flat in an expanding universe with a positive cosmological constant as are multi-fold universes) with GR.

The doubling of the 7D embedding space explains the algebra doubling on non-commutative geometry in 4D that also predicts the SM particles.

Finally, with more details in terms of the symmetries, we open the door to starting to study the Action, Lagrangian and / or Hamiltonian that apply in a multi-fold universe. It may lead to a more quantitative multi-fold theory. It is for future work, and a topic on which we would like to invite collaboration.

Overall, a reader interested in GU, should have found some of our key concerns with GU, and differences with the GU "Observerse", built locally , and seen through multi-folds from the multi-fold spacetime. No physics takes place there other than flat / Einsteinian GR. The equivalent to the Pull-back is probably the multi-fold space time matter induction (i.e. ~ Kaluza Klein) and scattering. This way issues of viable Yang Mills in GU, "Observerse" or "Shiab" operators are not encountered. It might guide alternative ways to proceed with GU, or not. In any case, the paper show how we could rationalize it best. We left open the discussion of Yang Mills being the square or the square root of gravity. I is for future studies.

Last but not least, the paper, as in previous work, implies that the SM is contained in the Hilbert Einstein action. This is a groundbreaking, which is probably too often lost in the concerns of physicist about naturalness or ability to predict all the parameters of the SM (or $SM_G$): Qualitatively at least, fine-tuning, and non-naturalness is settled here, in the presence of gravity. We expect that quantitative progress on the parameter values can progress when the multi-fold theory becomes more quantitative. Being more quantitative, and connected to experiments, is for future work and starting to obsess us.

At the end, we are ready to conclude that a multi-fold universe, well modeling our real universe, it may be a good model of it, is the only possible universe. In the presence of gravity, the SM had to be as it is. And yes that means $SM_G$. There are no issue of fine-tuning, multi-verse, or God to invoke. That's it!

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