Multi-fold Embeddings, Spacetime Matter Induction or Gravity Asymptotically Safe and The AdS/CFT Correspondence Conjecture, they all can recover the Standard Model

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December 20, 2021

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, 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 small scales. Multi-folds mechanisms also result in a spacetime that is discrete, with a random walk fractal structure, and a 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 models remain valid till smaller scale than usually expected. Gravity can therefore be added to the Standard Model resulting in what we defined as the SM_G. This can contribute to resolving several open issues with the Standard Model without New Physics other than gravity, i.e. no new particles or forces. These considerations hint at an even stronger relationship between gravity and the Standard Model.

In the past we showed that space time matter induction and scattering in 7D (dominated as a 5D effect) can recover the Standard Model (with gravity: SM_G). It is an embedding space that illustrates what any particle "feels" due to the multi-fold mechanisms where paths enter such an extra 3D space, with a dominant 1D effect. The 7D (/5D) flatness and embedding allows to recover the SM_G particles as effects of geometric objects in 7D (/5D) on 4D spacetime, and scattering effects at the boundary. These define the properties of the solitons of Higgs condensates that model SM_G particles as (possibly extremal) microscopic black holes, consistent also with the multi-fold gravity electroweak symmetry breaking. Some clarifications of the different dimensions, which should be considered, are discussed in the paper.

One also identified an AdS(5) space dual tangent to every point of the multi-fold spacetime, and where multi-folds can live (characterizing also that 1D dominant effect as a scale). It gives the multi-fold version of the AdS/CFT correspondence conjecture. We relate AdS(5) as an outside-in view versus the inside out view of the 7D embedding space.

The different dimensions, which are considered for space time matter induction, are consistent with Kaluza Klein theories (constrained and unconstrained, i.e. without imposed compact dimensions), and superstrings or M-theory dimensions. In fact, the paper offers a unique clarification of the differences in the required dimensions for KK theories versus unconstrained KK theories used for space time matter induction, and the different embedding theorems behind these approaches. It also hints on why gravity renormalization differs from Yang Mills.

A recently published result showed, while rather focusing on the bulk and cosmological results, that renormalizing gravity on the 4D boundary of a AdS(5) spacetime amounts to imposing "flatness" of the corresponding Einsteinian space with negative cosmological constant. The boundary is then characterized by a positive, small cosmological constant, and the model can match the ΛCDM cosmology model.

We take this as a demonstration that asymptotic safety of gravity in a de Sitter universe implies the ability to support the Standard Model (SM), and conversely explains why supersymmetry or superstrings are not compatible

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Cite as: Stephane H Maes, (2021), "Multi-fold Embeddings, Space Time Matter Induction or Gravity Asymptotically Safe and The AdS/CFT Correspondence Conjecture, they all can recover the Standard Model", https://shmaesphysics.wordpress.com/2021/12/20/multi-fold-embeddings-space-time-matter-induction-or-gravity-asymptotically-safe-and-the-ads-cft-correspondence-conjecture-they-all-can-recover-the-standard-model-or-smg/, December 20, 2021.

with SM along with asymptotically safe gravity. Such results should get the attention of those who challenge the asymptotic safety of gravity. Then, the possibility to derive, by induction, the SM particles and fields from the new dS(4) Boundary of AdS(5), stands on its own, especially, as it does not require multi-fold mechanisms, or the SM_G for that matter.

With this, the paper provides a way to add gravity to the CFT side of the AdS/CFT correspondence (conjecture or factual), as we had all along for a multi-fold universe: it is a new AdS(5)/dS(4) [CFT+Asymp. Safe Gravity] correspondence duality, where dS(4) contains CFTs and asymptotically safe gravity.

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1. Introduction

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 [1,49,50], detailing contributions to dark matter and dark energy [1,32,51-54,73-77], and explaining other Standard Model (SM) mysteries without requiring New Physics beyond the SM other than the addition of gravity to the SM Lagrangian [1,6,7,9,26,27,40,41,48,55-67,70,78-84]. All this is achieved in a multi-fold universe that may well model our real universe, which remains to be validated. *Note added on December 10, 2022: [69] goes a long way in suggesting that our real universe is multi-fold.*

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 concretized spacetime coordinates, and metrics between Reissner Nordström [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. The resulting gravity model recovers General Relativity (GR) 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 than usually expected.

The paper starts with a recap of the AdS/CFT correspondence conjecture and the multi-fold points of view on the AdS/CFT correspondence conjecture with AdS(5), tangent and dual of the multi-fold spacetime [1,5]. Then, we review how we encountered the standard model particles as geometrical objects and associated scatterings in a flat spacetime embedding the multi-fold universe [6,7], relying on unconstrained[2] Kaluza Klein (KK) approaches with multi-fold space time matter induction, a small-scale quantum gravity to plasma physics duality, and chirality recovery [4,6,9]. Particles can then be modeled as microscopic black holes, shaped from solitons of superconducting Higgs condensates, with properties derived from the flat embedding space geometrical objects.

[2] In our terminology, unconstrained KK is at the difference of constrained KK where the extra dimensions are compactified. The spacetime is embedded in the larger unconstrained KK universe. Multi-folds provides “feelings” of higher dimensions without the problem of having to make them unobservable via compactification. They only see a ε region. In the multi-fold case, this region correspond to entry, exit or mapping points for a multi-fold.

Starting from the relationships between these spaces, we discuss how their dimensions relate to other typical constrained KK approaches, and generic embedding theorems; thereby reconciling many different mathematical results and assumptions in the Mathematics and Physics communities, and clarifying the multi-fold use cases.

The next section reviews the state of asymptotic safety of gravity in multi-fold universe, and considerations to the real universe [10,11].

The next main contribution of the paper is then based on [12]. We review the results and recast them in terms of a multi-fold universe, showing the interesting consequences of the gravity renormalization proposed in [12], including deriving how asymptotic safety of gravity, enables the recovery of the standard model particles now from an induction analysis. This time the induction is initially motivated by superstrings, and the AdS/CFT correspondence conjecture, seen by many as non-perturbative hints or parts of the M-theory [14]. The outcome is a new duality: the AdS(5)/dS(4)[CFT+Asymp. Safe Gravity] correspondence and new insight on why supersymmetry and superstrings are incompatible with SM and asymptotic safety of gravity.

2. The AdS/CFT Correspondence Conjecture

Section 5 of [13], provides an extensive analysis of the AdS/CFT correspondence conjecture, with an analysis inspired from the multi-fold theory.

Often labelled as the biggest discovery in the field of the last 25 years, the AdS/CFT conjecture establishes a concrete duality between supersymmetric gauge CFT in D-1 dimensions and gravity in D dimensions [15,17]. It implements the holographic principle [20-22] assumed from the Bekenstein-Hawking area/entropy formulas for black hole entropy [19,16]. Reasoning-based derivation can be found in [20,18].

Note added on December 10, 2022: more details about the holographic principle can be found in [1,68] and references therein.

3. AdS(5) as dual tangent to a Multi-fold universe

[1] derives that every concretized spacetime location has a tangential AdS(5) space related to microscopic black holes surrounding them and in particular any particles [4,5]. The 5D results from the 3D multi-folds, time and scale of the multi-folds. Alternatively, one can see that AdS(5) is generated by the multi-folds that live in AdS(5) [1,513,46,47]

More analyses relating superstrings in AdS(5) and the spacetime of multi-fold universes are provided in [1,5,10,13,46,], suggesting non physicality of superstring and supersymmetry [5,13], or even related relationship like the Ryu–Takayanagi conjecture [23].

The multi-fold theory however does not impose that GR governs AdS(5), even if it could [1,13]. Note added on December 10, 2022: See more consideration on GR and multi-folds [28,69]

The important message is that AdS(5) is the space tangent dual to spacetime and created by the multi-folds that live in it. It is an outside-in view of the multi-fold spacetime plus the dynamic multi-folds.

Note that we have subsequently encountered more multi-fold related AdS/CFT dualities as discussed in [85].

4. Multi-fold space time matter induction in Ricci-flat embedding 7D space

[6,7] exploits 5D space time matter induction to derive SM physics and particles from geometrical objects[3] in a 5D Ricci flat universe that embeds the 4D multi-fold spacetime. The embedding space is actually 7D, but dominated by 5D effects, due to the spin-2 symmetry of entanglement, multi-fold effects and gravity. 7D is the minimum dimensions required to support the Standard Model (SM) symmetries. *(Note added on December 10, 2022: See [67] for a different proof of the suitability of 7D to support the symmetries of the SM, and the symmetries of the embedding 7D spacetime, such that we can justify the SM, or SM_G symmetries, from the multi-fold mechanisms in 4D spacetime.)* Except for chirality, as we are in odd dimensions, which could be handled by adding a second 7D space matching the first, where each would be labelled with left or right chirality. We may discuss that in future work. *Note added on December 10, 2022: [67] could be seen as the promised paper that explores doubling the embedding space. For the rest, discussions on how spacetime gets oriented, and chirality handled, are provided in [4,6-9,48,70].*

The space time matter induction and scattering [6,7] approach is what we call a non-constrained KK theory (or unconstrained) that can also support a cosmological constant in 4D [24]. It is our own terminology.

Above the gravity electroweak symmetry breaking energy scales, the induction results into massless solitons in 4D multi-fold spacetime that are realized as pattern of the massless bosons [4,8,9,27]. Below that energy scale, Higgs bosons condensate into the solitons, resulting into massive particles [4,8,9,27]. This way, massless then massive particles can share quantum number, e.g., charges, colors etc., while existing as massless then massive particles. It is the physical interpretation of the Higgs mechanism described by the electroweak QFT, as part of the SM.

[6] overcomes the chirality issue in odd dimensional universes by asserting that non-chiral objects in 5D, or 7D, can become chiral in 4D spacetimes via the multi-fold gravity electroweak symmetry breaking [4,6,9]. As multi-fold spacetime are discrete, it is also important to understand that the support for right-handed neutrinos always in flight [1,13,26-28], within the multi-folds is critical to overcome no-go Nielsen Ninomiya theorem that otherwise would predict incompatibility of the conventional Standard Model with 4D discrete [25]. [4,9] address issues with beyond extremality of the microscopic black holes behind the model, using the solutions from 7D (~5D) solutions of Ricci flat GR. Any problem of singularity, horizon and evaporation are addressed by the Higgs Qball and its skin, which behaves like a superconducting surface that regularizes these issues [4].

[28] also make multi-fold theory compatible with a GR-governed wormholes that can be traversable and support the multi-fold mechanisms, which makes assuming that GR reigns in AdS(5) much more plausible and implies superstrings in AdS(5)+… as discussed in [13]. *Note added on December 10, 2022: See also [69].*

To avoid any confusion, it is probably good to emphasize and detail the difference between this embedding space, and the AdS(5) dual tangent of section 3. The embedding space is to be understood as a ε region, 7D, seen from the 4D spacetime, at the entry and exit (and at the mapped spacetime locations, which are on the multi-fold mappings support in the multi-fold spacetime) of the multi-folds. It is an inside-out view. This is quite different from the AdS(5) present around each particle, or each concretized spacetime location, and where multi-fold dynamics and kinematics takes place. AdS(5) is where the multi-fold live or could be seen as generated by them. It exists on its own. The 7D embedding on the other hand is defined by the properties and symmetries of the multi-

[3] Scatterings with such objects then account for the Higgs and Neutrinos [7,28]. It further illustrates the link between multi-fold and quantum theory as well as SM_G. This is due to being able to feel the 5D or 7D universe at the entrance to the multi-folds, not more.

fold 4D spacetime, and in turn it induces, by induction and scattering. the SM particles in the multi-fold 4D spacetime.

Note on December 10, 2022: This should also explain the symmetry derivation of SM / SM_G obtained in [67].

5. Some considerations on dimensions and embeddings

This section provides an extensive analysis of the dimensions required to support derivation of the SM Yang Mills field and gravity from KK with compactified dimensions, vs. from unconstrained KK. It also discusses how the embedding used for space time matter induction relates to the different manifold embedding theorems out there. In our opinion, this analysis stands on its own as a contribution on a topic that, to our knowledge, has never been clarified in previous KK and 5D space time matter induction contributions found in the literature.

Note added on December 10, 2022: The main result that 7D embedding space can support the SM symmetries is also discussed and derived in [67], which corroborate the suitability of 7D embedding space argued here and in [6,7].

5.1 Counting Dimensions

The work of Richard Kerner [29,30] seems to indicate some discrepancies in terms of compatibilities between KK theories, compactified, and KK theories unconstrained, with the 7D approach (for symmetries but essentially 5D in effects) that we propose in [6,7]. Indeed, according to [29.30], KK must add to the 4 dimensions (3 dimensions for space and 1 dimension for time): 1 dimension for Electromagnetism, 2 for the weak force and 4 for the strong interaction (Yang-mills)[4]. This would mean that we need at a minimum 11-dimension universe, as encountered by the M-theory [14]. How does it relate to our 7D embedding universe, which is also positioned as the minimum dimension required to support the SM symmetries [31].

First of all, we need to distinguish global dimensions, from local embedding, and manyfold embedding in another manyfold. They are not the same. Constrained KK, works with global dimensions. Unconstrained KK, or conventional space time matter induction [34] is rather locally focused, as illustrated by the inside out aspect of induction, mentioned in section 4. Multi-fold space time matter induction, or multi-fold unconstrained KK [6,7], only sees, and care about, local embedding, and its local dimension seen in a ε neighborhood around entry (or exit) points (and mapped points) to the multi-folds.

In [6], we stated that compactification did not change the suitability of a 7D flat/vacuum GR governed space to generate SM from its geometry. But, in reality, it does change things: because the dimensions are not compactified, in unconstrained KK, the 4D spacetime can locally be part of the required dimensions, i.e., can be used for the GR universe, while when the additional dimensions must be compact, one then needs 7 such extra dimensions without the possibility of reuse. Our space time matter induction is for the embedding space to locally embed manifolds, not for the product of manifolds… It is the key difference that needs to be understood. So,

[4] For Yang Mills, the basic idea to obtain these numbers of dimensions is that you take the dimension of the associated gauge group, then you can quotient out by a maximal subgroup. Note the dimension of G=SU(3) is 8 not 3 (it has 8 generators). But then it has a maximal subgroup H=SU(2) x U(1) which has dimension 3+1=4. So the quotient G/H has dimension 8-4=4, hence the result of 4 as in [30].

locally dimensions can now be reused: the 4D for gravity, on the embedded manifold and 4D for QCD in the embedding space.

So [29] is correct. Globally, we need 7 compactified dimensions for extensions, and so a 11D spacetime for gravity + SM, which, very interestingly, is the dimension of M-theory (and possible for supergravity). But [6] is also correct, as for a multi-fold universe without compactified dimensions, locally, we have a 4D multi-fold spacetime as a locally embedded manifold within the 7D embedding space, and the 7D dimensions of the locally embedding space can support SM symmetries for the particles and fields[5].

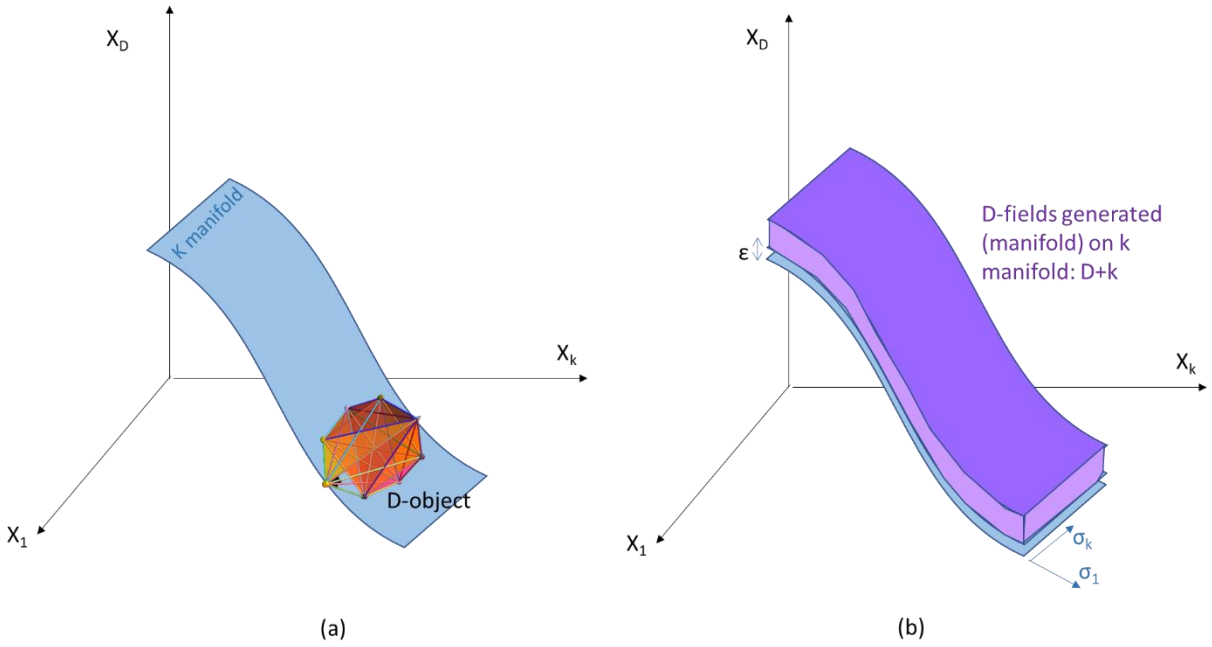

Figure 1: *(a) Shows how D dimensional geometrical objects[6] will locally impact the embedded k dimensional manifold via the Ricci-flat (or Einsteinian flat) equations. This provides the degrees of freedom for the SM particles as well as how scattering can take place on the k dimensional manifold. (b) Shows how fields can be developed on a k dimensional manifold with D dimensional degrees of freedom and therefore per [31] all the degrees of freedom of the SM Yang Mills fields. Neighborhood fields can also be seen to impact on the k dimensional manifold as [33][7] was used in [13]. Computation à la constrained KK, with k + D compactified dimensions have the same degrees of freedom. It also illustrates how embedding in D dimension and local induction reduces the number of dimensions required versus constrained KK with compactified dimensions. In our example, k = 4 and D = 7. It globally amounts to a 11 dimensional constrained KK, as expected from [29,30]. The multi-fold mechanisms that provides the feelings of D dimensions in a ε neighborhood, also add gravity within the k dimensional manifold.*

The analysis and its detailed explanation are illustrated in Figure 1.

Accordingly, a 7D embedding space is sufficient to locally embed the 4D multi-fold spacetime, and locally generate the SM, or SM_G, with the multi-fold mechanisms to generate gravity, up to chirality. In multi-fold theory, no

[5] Chirality is not handled by (unconstrained) KK models. To address those, one needs a reasoning as presented in [9], and based on the references recalled in footnote [22]. As also mentioned, one could go with 7 + 7 spacetime to handle left and right chirality as a label. *Note added on December 10, 2022: See also [67] for this.*

[6] These dictate the superconducting skins of the solitons of [4] that envelope the multi-fold Higgs condensates.

[7] As described in [13,33], it results into conformant fields on the manifold, i.e. renormalizable. This is not expected to be problematic as Yang Mills, and therefore the SM, are renormalizable QFTs.

compactification is required yet higher-dimensionality play a role because of i) the multi-folds mechanisms that add gravity to the multi-fold spacetime[8] ii) how quantum fluctuation make spacetime content feel (and only feel) the higher dimensions within ε surrounding regions (and this is also the origin of dark energy effects [32]) when they enter / emit particles / have path in their multi-folds) iii) the space time matter induction and scattering mechanisms.

Figure 1 also implies that Yang Mills or SM are almost CFT, i.e. renormalizable, as a consequence of being recoverable by unconstrained KK: [33] (that can be extended to a 4D brane) implies action equivalence between Yang Mills and superstrings (up to a term that does not change the outcome), and therefore quasi conformance of Yang Mills. Gravity renormalizability is not implied the same way, because it is not recovered the same way on the k-manifold. An interesting way to look at the Hilbert Einstein action vs. Yang Mills action, and maybe why quantum gravity is so hard to tame[9]. *Note added on December 10, 2022: However, gravity can then still be shown as asymptotically safe, through the double copy duality [71,84].*

Note that following the references in [13,33], without the multi-fold universe, i.e. for conventional Physics, one wouldn't be able to have gravity in the k=4D dimensional manifold of figure 1, only CFTs, and unfortunately, everything is supersymmetric, which is not compatible with asymptotic de Sitter spacetime [13,38]. This is consistent with conventional AdS/CFT correspondence conjecture, and as well as *k Dimensional-brane* in a D space for dimensions and space compatible with superstrings / M-Theory (See also [12,44]). Again, in our view, it is a new conclusion that explains why the AdS/CFT correspondence conjecture is what it is, and why the differences in multi-fold universes [1,5,13,45,46].

In retrospect, it is also interesting to see how the focus on fixing the chirality problem[10] via supersymmetry, and dealing with explanations for the non-observation of these extra dimensions[11], led to KK theories with higher dimensional requirements, and compactified dimensions that missed a key result (i.e. required dimension reduction when using unconstrained KK) obtained here[12] (see section 8), with or without superstrings[13].

5.2 Embedding Theorems: local versus global

[8] In a non-multi-fold universe, gravity would be missing. As discussed after the strings equivalent/associated to the Yang Mills fields are defined by the Yang Mills, no room for gravity. However, in the multi-fold theory, gravity can be captured on a same background spacetime with the effective attractive potentials. It is another reason why we can actually share 4 dimensions for SM and for gravity without possible conflict in the degrees of freedom.
[9] In our view, it is an insight that goes beyond the typical "non-linear GR field equations" hand waving.
[10] No chirality in odd dimensions above 4D, see footnote [16].
[11] Coming from the original Kaluza Klein theories, with the compactified fifth dimension, and probably exacerbated by the fact that ADS/CFT correspondence conjecture and the holographic principle had not yet been encountered to justify a tangent dual, and hence no visible, extra dimensions. Of course missing the multi-fold mechanism also meant missing its invisibility in 4D spacetime, except for the ε region from the multi-folds. What the tangent dual misses is the justification for a visible region ε. Multi-fold provide that immediately via entry/exit/mappings to the multi-folds.
[12] Result obtained independently of our multi-fold theory, i.e. not requiring it, even if inspired by its multi-fold matching derivation.
[13] Ironically, these higher dimensions are key to understanding why superstrings are not physical [10], at least as soon as considered at scales where gravity and Physics are no more fundamentally 2D [11].

The Campbell theorem [34,35] is behind the local embeddings used for space time matter induction. Locality is sufficient as for our purposes of [6,7] only local feelings of the 5D/7D embedding space matter[14]. Note that this works for Ricci flat and Einsteinian spaces [34,35,37].

There are other embedding theorems like the Whitney theorem [36]. This theorem implies that we need 8D to globally embed the 4D spacetime in a (flat) spacetime. Also, if the spacetime is closed, compact and orientable then N=4 (pseudo) manifolds globally embed in 7D; recovering our local result as a global embedding spacetime, as in figure 1. It happens for multi-fold universes as the cosmological constant is positive [1], and therefore a multi-fold universe is finite. For 4D, it is orientable with chiral models. Another reason why 7D is essential[15].

Then we have 10D if we then want to recover GR locally via multi-folds (and sharing time); i.e. justify GR in 7D by adding again multi-fold mechanism for the extra 3D.

If spacetime is not compact, closed or orientable etc., then one requires 8D globally which is (5 (AdS(5) + 3 spacetime spatial with time sharing with AdS(5) for GR to exist in AdS(5) via multi-folds) or 11D (i.e., 8D + 3D for GR to also exist in the space locally embedding AdS(8) space via multi-folds, with time sharing) leading to 11D. Because superstrings are only compatible with negative cosmological constant (~AdS) [38,39], they need a global 11D embedding as is needed by M-theory.

Because multi-folds are ~ spheres (at least as in [1]), and spacetime is expected to be with positive cosmological constant, the 7D global observation is more relevant. Furthermore, because spacetime (4D) only feel local multi-fold (entry/exit points), only local embedding matters to the physics in 4D: the 7D global embedding is well approximated with 5D (because of the spin-2 symmetry for each multi-fold).

So the real relationship between AdS(5) and embeddings in 7D are: 5D for local tangent dual, 7D: local and global embedding with multi-folds. 8D: global embedding for any 4D manifold. 11D for superstrings or supergravity is related to the need to explain GR in 7D or 8D by adding multi-folds (10D) or global embeddings (11D). Then you have the inside out versus outside in perspectives.

AdS(5) is a dual tangent reality at every point that we arrive to it from a multi-fold point of view [1,13], or superstrings as Maldacena did [15-18]. Global embedding is what matters to superstrings as they model bulk gravity (even if unphysical) with closed and open strings. It relates to the outside in perspective. This is why they can't just relate to local embeddings. It is also why asymptotic de Sitter vacuum is in the superstring swampland [38]: the most compact embedding with 7D is not sufficient. Adding multi-folds to 7D and 8D to justify GR leads respectively to 10D (Superstrings ad supergravity) and 11D (M-theory and supergravity)…

It is for sure another interesting way to look at the difference between the multi-fold theory and superstrings, and quite an interesting set of deductions.

While the 7D induction is not essential (e.g. 5D is a good enough approximation if one keeps it in mind when dealing with QCD), its derivation simply from the multi-fold mechanism is extremely satisfactory as a top-down derivation of SM from classic GR solutions in 7D (along with 10D when modeling the 7D GR also with multi-folds), or 11D globally, or when giving it also a scale extra dimension, again recovering 10D for superstrings/supergravity and 11D for M-theory and supergravity through a completely different reasoning from these theories, and without the chiral fermion challenges that led Witten to these theories.

[14] Nor is it a dual local tangent space as AdS(5), where we are playing loosely on the dual tangent at every point as one common space.

[15] Global embedding can be 5D if we are using N-spheres, which happens to be what multi-folds consist of. It is another reason why 5D embedding is a good enough approximation.

Of course induction can be considered from all these larger embedding manifolds; but it is not needed. Also, as already established, these 10D and 11D universes are problematic as supersymmetric (with a supersymmetric base manifold) as envisaged by Witten (to address the chiral Fermion problems[16]), leading to new particles or fields that are not observed, and not compatible with SM and asymptotic safety [10,11,38*]. Note added on December 10, 2022: See [71] for proof of asymptotic safety of gravity, and, therefore, of the challenges with supersymmetric models, or superstrings, beyond being mathematical tools.*

Interestingly, the base manifold can also be non-commutative as are multi-fold spacetime. Non-commutativity allows a bottom-up derivation of SM (e.g., See NCSG theory of Connes, for example as references in [1,8]) and discrete spacetime justifies derivation of its dynamics from the dynamics of the Higgs field [8,9,27,39]. As hinted in [8], we conjecture that the algebra doubling involved in the derivation of SM, comes from the 3D spatial dimensions added by the multi-fold local embedding, or 4 additional spacetime dimensions for Global embedding. Detailing this will be for future work.

6. Asymptotic safety of Gravity

[10,11] review the asymptotic safety of gravity, and the point of view of its detractors. The papers motivate why multi-fold theory implies asymptotic safety of gravity as a result of the ε behavior at very small scale, something recognized and also compatible with superstrings and other models [86].

Conversely, [10] also discusses results from other researches that point out that asymptotic safety of gravity is not compatible with SM, or SM_G, with large dimensions (e.g., above 6D). It threatens the physicality of superstrings, supergravity, of the most popular GUTs and TOEs, as well as of the M-theory, in multi-fold universe. Our analysis in [10,11] hints at asymptotic safety also in non-multi-fold universes, and therefore similarly challenges all the physicality of all these theories, something already challenged in for a variety of reasons, [1,5,13,38,40,41].

Note added on December 10, 2022: Find a non-perturbative proof that gravity is asymptotically safe in [71].

7. Renormalizing gravity in embedded k dimensional manyfold and SM in the real universe

[12] proposes a new cosmology model where the universe spacetime, as a AdS brane, would be 4D de Sitter (dS) universe and the boundary of an AdS(5) bulk space; not just a duality or correspondence mapping concepts with a pre-defined dictionary. The proposed new model seems to still match the standard cosmology model ΛCDM.

Furthermore it proposes to model gravity in the dS universe, and to renormalize with an holographic renormalization that avoids divergence of the energy momentum tensor in the bulk, when it reaches its boundary (which is why in other models, the boundary is assumed without gravity, as the only way to tame that behavior), and relates to why in [33] no gravity is considered as discussed in section 5.1. After renormalization, the effective cosmological constant is confirmed negative in AdS(5) and positive (but small) in dS(4).

The results of [12] are non-trivial: it would not be possible to explicitly have the gravity in AdS(5) well behaved on the dS(4) boundary where it would diverge without suitable renormalization. The proposal of [12] works, is

[16] See footnotes [5] and [22].

physically understandable, and is aligned / consistent with ΛCDM. This makes it a key achievement: it is the first model that we are aware of where AdS/CFT correspondence conjecture actually amounts to a viable geometrical model of our real universe, not just a mathematical duality just based on holography.

Keep in mind that our multi-fold model derived AdS/CFT correspondence from the physical model of the multi-folds [1], not the other way around as done here: we encounter AdS(5) as tangent dual to every spacetime location, and particle, rather than encountering spacetime as the boundary of a AdS(5) initial model, as done here.

That being said, the physical and geometrical model of [12] is overall similar to how AdS(5) is recovered in the multi-fold theory.

Doing so, [12] recovers a renormalized AdS space time that is an 5D Einsteinian manifold (after transformation), i.e. Ricci flat in 5D when correcting the cosmological constant. Such Einstein manifold can also satisfy the embedding (Campbell embedding theorems) and 5D space time matter induction. In fact, equation (10) in [12] is the Ricci flat equation used in [34] (as an Einsteinian space). Non compactified dimensions is justified by AdS(5) being tangent dual to dS(4) and so arguably not visible, albeit with the challenge on how to introduce feelings of it in a ε region, other than invoking quantum fluctuations, putting particles or locations at time in AdS(5) as we did for multi-fold black hole horizons [1,*68,87,88]. (Note added on December 10, 2022: Italic references indicated that they were added on December 10, 2022)*.The whole analysis performed earlier could be repeated[17], including encountering SM particles and fields this time in a manifold with gravity that is asymptotically safe, proving that, in a conventional or superstrings universe, where a dS(4) real universe is the boundary of an AdS(5) bulk, where gravity is renormalized in the dS(4) universe (and where we have an holographic correspondence between bulk and boundary[18]), asymptotic safety can recover SM in dS(4). Gravity does not have to be null anymore in dS(4).

If superstrings existed in in AdS(5)[19] + …[20], SM is not derived from them but by induction from the space. Again, not from the Physics of the superstrings, and Physics does not occur in AdS(5), beyond classical GR. Indeed, if SM particles existed in AdS(5) +…, from the superstrings, then, we would have too many particles and dimensions and therefore we would encounter a contradiction: asymptotic safety would not be possible per the results discussed in [10,11]. We already knew that supersymmetry is also incompatible with a positive cosmological constant [38]. And we saw that gravity is null in dS(4) unless id asymptotically safe.

It is another hint that superstrings, supergravity, GUTs, TOEs, M-Theory or supersymmetry with more than 6D are not physical [5,13]. At best, they motivate/construct the tangent dual AdS(5) or the AdS/CFT correspondence conjecture[21], e.g. think of AdS(5) built by the multi-fold dynamics and kinematics. AdS(5) would remain compatible with SM only if without any of the additional dimensions needed by these supersymmetric theories *(Note added on December 10, 2022: Also, AdS(5), pure in in the string swampland [72])*. Asymptotic safety in such dS(4) derives

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[17] With one correction. Just as [6] needed 7D, repeating the analysis with unconstrained KK, requires 7D to have the right symmetries and degrees of freedom. So it should rather be AdS(7) or AdS(5) + at least 2 dimensions (compactified or not). In a multi-fold universe, we know that building the dual AdS(5) is actually by reducing AdS(7) associated to the direction perpendicular to the spin-2 (180^o) symmetry in the multi-fold mechanisms that we can consider as not affecting the analysis (a bit like, in [6,7], we could use 5D instead of 7D because the other two dimensions are not really relevant other than when counting degrees of freedom). It is a bit harder to fully justify these extra two dimensions in the non-multi-fold case, but, of course, nothing prevents it. And, in fact, because/if only a ε neighborhood matters, curvature is not exactly visible and extracting the results from [6,7], or AdS(5) (or AdS(7)) does not make much difference: the induction effects are similar in all these cases.

[18] This is consistent with gravity as it is what is encountered in black holes.

[19] Bulk gravity is also renormalized in AdS(5), by the process and we know that in conventional superstrings, GR reigns in AdS(5) (+…).

[20] … denotes additional dimensions like S^5.

[21] And the jury is out on branes as a result.

SM, but prevents superstrings from having physicality attributed to them. A real universe dS(4) with asymptotic safe gravity is consistent with SM, and AdS(5) (+…) isn't.

Alternatively, dS(4) has no gravity, as in the conventional AdS/CFT correspondence conjecture. We still can't evolve the conjecture beyond a useful mathematical tool for computation, but not a physical model.

Finally, we can consider non renormalizable gravity (in AdS(5)). It would seriously weaken the promises and motivations for superstrings.

If we believe in Occam's razor principle, the approach of [12] is the most attractive and would further converge the real universe towards multi-fold results.

8. SM tracking in the New dS(4) Boundary of AdS(5)

This separate section aims at explicitly calling out the result obtained expanding on [12].

Independently from the multi-fold theory, we repeat a specific result in the context of [12]: the new model proposed by [12] relying on the AdS/CFT correspondence conjecture, holographic renormalization of the quasi local stress-energy tensor of Brown and York, that characterizes the entire system including contribution from both the gravitational field and matter fields (,and branes), provides dS(4) boundary with renormalized fields (~ CFTs) and gravity, where space time matter induction from AdS(5) (~AdS(7)) can recover the SM particles and fields. The chirality problem can also be handled as in [6][22]. The ε region argument in AdS is provided by quantum fluctuations in spacetime.

In other words, we have encountered a glimpse of a conventional AdS/dS correspondence conjecture:

- dS(4) is populated by CFT and asymptotically safe gravity
- AdS(5) is populated by non-supersymmetric gravity bulk (classical) physics derived from GR (but not superstrings, or supergravity). Only AdS(5) is considered, not AdS(5) + …
    - It is reminiscent of gravitons from GR, in AdS(5), instead of dS(4).

It matches directly the multi-fold spacetime / AdS(5) factual duality/geometry, and recovers SM as described in section 7.

The fact that gravity asymptotically safe leads to recovering an AdS(5)/dS(4) [CFT+Asymp. Safe Gravity] correspondence with gravity and SM in dS(4), is another way to look at the incompatibility of SM and asymptotically stable gravity with supersymmetry and superstrings (in AdS(5)+….).

9. Conclusions

This paper has reviewed the use of unconstrained KK for space time matter induction in multi-fold theories vs. constrained KK in conventional physics, and clarified the dimensionality aspects associated to both cases, as well as other key differences between gravity and Yang Mills / SM. We also positioned the analysis with respect to different embedding theorems of which we are aware. Embedding was positioned versus AdS duality, the

[22] Without the multi-fold spacetime reconstruction [1], the handling of the chirality challenges in 5D or 7D may only rely on the arguments of [42,43] used in [6] (section 6), instead of [6,7,9]. Fortunately, also, the spacetime orientation arguments of [9], derived from [42,43], were first made for non-multi-fold theories.

holographic principle, and the AdS/CFT correspondence conjecture. We reviewed how embedding leads to the recovery of the SM in multi-fold theory (particles, fields, symmetry and chirality).

Then, we reviewed asymptotically safe gravity and its implications in terms of the SM on many theories with large dimensions, and, or supersymmetry, as well as past arguments on why, especially within multi-fold universes, gravity seems to indeed be asymptotically safe once correctly modeled at scales where it is dominantly a 2D process.

Using a recent proposal for a new dS(4) spacetime, or brane, with gravity in an AdS(5) space, we showed that renormalized fields and gravity (i.e., asymptotically safe gravity) in dS(4) (and in AdS(5), can support recovering the SM in dS(4), as we did in a multi-fold universe, and support a suitable cosmological constant in both. Doing so we also challenged superstring / supersymmetry aficionados and opponents to asymptotic safety of gravity, to tackle the observation that their own models lead to recovery the SM by induction, if and only if gravity is asymptotically safe. This is something that does not seems to happen directly with superstrings, and that we, and others before us, have argued not to be compatible with that same asymptotic safety. Conversely, it hints differently at why supersymmetry or superstrings are not compatible with SM along with asymptotically safe gravity. Such results should get the attention of those who challenge the asymptotic safety of gravity.

The possibility to derive, by induction, the SM particles and fields from the new dS(4) Boundary of AdS(5), stands on its own, especially, as it does not require multi-fold mechanisms, or the SM_G for that matter. With this, the paper provides a way to add gravity to the CFT side of the AdS/CFT correspondence (conjecture or factual), as we had all along for a multi-fold universe: it is a new AdS(5)/dS(4)[CFT+Asymp. Safe Gravity] correspondence duality, where dS(4) contains CFTs and asymptotically safe gravity.

Another outcome of the paper is therefore that when gravity is asymptotically safe we can recover SM, and a AdS/dS correspondence. When it isn't, gravity must be null on the AdS boundary, and so no gravity can exist. If strings are introduced then supersymmetry ensures that no gravity can ever be safely present [10].

Throughout the paper we also shed light on the difference between gravity and Yang Mills theories, why one (gravity) does not renormalize as obviously as the others (Yang Mills), because on how they appear in figure 1. We also emphasized that the new results that we relied on, e.g., [12], also provide ways to add gravity to the CFT side of the AdS/CFT correspondence (conjecture or factual).

Our extensive analysis of the dimensions required to support derivation of the SM Yang Mills field and gravity from KK with compactified dimensions, vs. from unconstrained KK, and our discussion of how the local embedding used for space time matter induction relates to the different manifold embedding theorems out there, is, in our opinion, a unique contribution that has never been fully clarified, in previous KK and 5D space time matter induction contributions, at least as found in the literature.

Finally we want to call out the clear positioning between the inside out view offered for the 7D embedding space versus the outside in view of the dual tangent AdS(5).

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