


# Pointers to Nowhere with Geometric Unity Theory, or Some Ways Forward in Multi-fold Universes?

Stephane H. Maes<sup>1</sup> 

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## Abstract

*The theory of Geometric Unity is an incomplete, often misunderstood, and controversial new candidate as Theory of everything, that has been proposed by Eric Weinstein.*

*This paper starts with some pointers to conventional reviews of the Geometric Unity theory.*

*Then, we add our own considerations, that indicate that some of the main inconsistencies like anomalous fiber bundle, and complexification of the group used for the bundle and connections, may be addressable with approaches, and arguments, encountered in the multi-fold theory, including anomaly smearing by gravity, via chirality flips, and spacetime orientation flips, fractal discrete spacetime, and multi-fold space time matter induction and scattering.*

*Yet the assumptions of supersymmetry, and high dimensions present in Geometric Unity probably doom the physicality of the Geometric Unity model, just as we have shown it to be the case for most supersymmetry-based GUTs and TOEs.*

*The arguments can apply to GU over our real universe, especially if it was multi-fold, but to be multi-fold is not necessarily a requirement.*

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## 1. Introduction

The theory of Geometric Unity (GU) is described in [1,2]. Many controversies, and confusion, surround this theory. It seems to many, that it may just be a cabal, because of all the mysteries and absence of a clear description. We do not share that view.

In fact it seems like the push back seems primarily motivated by the fact that the theory was developed outside the main Physics community and bypassed expected publication steps. So what? That may not be an appropriate justification for tossing it aside, without much consideration as seems to be the case so far.

[1] sketches the theory, as finally published by its author. It is in our view the best and most detailed mathematical formulation of the theory publicly available to date. [2] remained for a long time the only way that the proposal was known through this video of the controversial 2013 Cambridge lecture.

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<sup>1</sup> [shmaes.physics@gmail.com](mailto:shmaes.physics@gmail.com)

A review and criticism of GU can be found in [3]. With a few follow-up from the same author, it is the only published analysis and review of GU.

*Note added on 10/26/22: [27], and references therein, list additional issues with, and discussions of GU [1,2].*

## 2. Analysis of Existing Reviews of GU

In our views, there are a few things that are worth noting.

There has been way too much drama around this matter. As a consequence, everything makes the GU proposal too mysterious, and suspicious. See for example the comments in [4] (e.g. comment [5]), that can also be widely found by Googling the history of the Oxford talk, the Guardian article [17], and the Scientific American follow-up [6]. As a result, it seems that to some extent the theory has been dismissed by many, without having even considered, reviewed and proven wrong or falsified.

It is sad. Indeed we believe that the idea behind GU and merit and it is certainly attractive, from a modeling point of view, with its position of General Relativity (GR) / spacetime, fields and matter, and quest for a common first order equation where gravity/GR, Dirac and Yang Mills can be different aspects of a same equation. *Note added on 10/16/22: It is a bit like when we argue in [14,33,34] that GR (the Hilbert Einstein Action) is contained in Yang Mills and Yang Mills is contained in gravity/GR.*

Unfortunately, there seems to be many challenges with the proposal [1,2] that is incomplete, argued inconsistent, etc. The current GU paper [1], is certainly under-documented and poorly explained, and therefore often not verifiable, or at time even not understandable. For example, even intuitively, the hope in self-dual Yang Mills equation as square root of Yang Mills equations (we are speaking of the order of the equations), built on the analogy of what needs to be done, inspired by Dirac vs. Klein Gordon equations/operator with Dirac and squared root of Klein Gordon, itself based on the fact that Feynman diagrams seem to hint that matter (seen as fermions here) like electrons and positrons would be the square root of bosons like the photon, seem farfetched and somehow hard to reconcile with dualities like the gravity as double copy of Yang Mills (*Note added on 11/16/22: See [34] and reference therein*).

However, we are not sure that the main issues raised so far in [3] mean necessarily the end for the geometric Unity Theory (GU). Indeed, there may be ways around these key issues, based on what we did or encountered in the multi-fold theory [7,16]. Unfortunately, doing so, additional challenges with GU are encountered.

## 3. Anomaly inconsistencies, Yeah or Nay?

The anomaly challenges, discussed in [3], may not be what they seem, and it can possibly be solved with the mechanisms that we proposed to address the anomalies of the symmetries forbidding proton

decays, quantum gravitational anomalies, and chiral anomalies [7-10,18]. In particular, in [7,9], we have seen that the anomalies could be smeared out by the chiral flips induced by gravity, keeping the symmetry valid, and canceling the non-conserved axial chiral current (averaged over the chirality flips for particles, or orientation changes of space time at higher energies) [7,18,26]. Indeed,  $U(128)$ , the group in question, plays its role only at energies way above (the series of) different symmetry breakings ultimately into the GR (General Relativity) and SM (Standard Model) symmetries.

On that basis, we argue that, at energies well above the electroweak symmetry breaking energy scales, the spacetime is not yet oriented. It will not happen until way lower in energy scales. It means that notions of orientations, and hence chirality, are red herrings, at the energy levels where  $U(128)$  plays a role: chirality is undefined and therefore so is the axial chiral current, except for local spurious notions, based on the local rotation of temporary local massive particle. As the notion of chirality does not exist, its symmetry cannot be broken. That can only happen when or after chirality symmetry appears. No anomaly is observable or relevant at the scales where GU proposes that  $U(128)$  plays a role. More details on chirality and orientation flips are provided in [7,18].

*Note added on 11/16/22: A fuller discussion, and interpretation of the effects, has since been further discussed in [28,29].*

These two arguments (chirality/orientation flips due to gravity, and the absence of global/stable orientation at energies where  $U(128)$  would matter) show that [3] is possibly incorrect in assuming that it would be impossible to think of a mechanism that could consistently remove the Gauge (chiral) anomaly associated to  $U(128)$ . Indeed, QFT, SM, and GR can be seen as effective, and valid at larger spacetime scales, than the ones relevant to  $U(128)$ . Therefore, smearing of the UV effects is exactly what is expected: anomalies disappear in that process. GU can be modeled using  $U(128)$ , no need to go to  $Spin(14)$ , and encounter the dimension and isomorphism incompatibilities mentioned in [3].

Such considerations would allow GU, as is, to maintain unitarity of the theory, despite the anomalies, and apparent subsequent loss of unitarity.

Of course, it also implies that, even if it were to lead to unification, GU would not be a true TOE, but, at best, still be an effective theory approximating the UV / Planck scale Physics. It would be progress, but not to the full extent hoped for, and claimed, by Weinstein.

## 4. Complexification of the (bundle) group, an issue?

[3] argues that GU misses a complexification step, as it proceeds to defining (a) Shiab (Ship in a Bottle) operator(s). Firstly, we are not so sure that it is the case: [3] may have missed on the reading [1], as it is our understanding that it was composed mostly based on [2], before [1] was made available. It seems that [1] is working with  $Gl(128, \mathbb{C})$  (See equations 3.30, 3.34 to 3.36, 3.37 and 8.4 in [1]). But we admit that so many groups are thrown around in [1] that it may not be what is ultimately used at the critical step.

Secondly, and, in any case, and as already mentioned, GU applies at very high energies, above all the potential symmetry breakings leading to the final GR and SM symmetries, and above typical GUTs

energy scales, with their symmetries listed in [1]. At such GU scales, and above, it is unclear if one can still consider that spacetime is continuous, instead of discrete, non-commutative, fractal like, generated via random walks and still Lorentz invariant [7] (*Note added on 10/16/22: See also [30]*), or if the dominant processes are 4D, 3D or 2D [7]. We need to know more details about GU to understand the actual scales involved. However, if the process, followed by GU, is aware of spacetime discreteness, and its fractal nature, as we do expect, then we know that it is typically described with QM (/QFTs) on fractional spacetime and that involves complex/imaginary potentials [7,19], hence particles with complex or imaginary masses, just as for the Higgs above the electroweak symmetry breaking scale [20]. Therefore, it could be possible to interpret complexification as an approximation, and a sign, of what exactly happens at these high energies. At such energies, high enough, the complex gauge connection could very well reflect the discreteness, and fractal nature, of spacetime, that we met in the multi-fold theory [7].

When spacetime become discrete, the notion of gauge symmetry is itself an approximation. Also, it may just not correctly handle unitarity considerations under these conditions.

*Note added on 11/16/22: More details about the 2D processes, random walk, discrete spacetime, and how these properties can be addressed by the Higgs field and approximately modeled in QFT can also be found in [7, 12,15,21,22,28,30].*

On this basis, we argue that the GU approach may reflect being able to approximate, and hint, what is physically happening, and that the complexification, with complex connections, may rather be an advantage, instead of a doomsday con, as argued in [3].

Also, the analysis of [3], and paper 15 in [3], focus on aspects of complex connections that may not be what complexification implies in GU; just as imaginary masses are not really about Tachyonic Higgs, but rather instability and (global) electroweak symmetry breaking by the Higgs mechanisms [20].

## 5. 14D, U(128), Spin(14) and more

In GU, a 14D space corresponds to the GU "observeverse", proposed by Weinstein [1], with reduction to 4D, via pull back via  $\gamma^*$ , that probably requires more thoughts.

The multi-fold theory encounters also 14D, through the different paths described in the next two paragraphs. Therefore, it is a priori a reasonable model for the GU "observeverse", as target for a super in-and-out mapping/modeling of spacetime.

For example, we note that extending the multi-fold mechanisms to explain, with multi-folds, gravity in the Ricci flat 7D embedding spacetime [15,21], associated to multi-fold universe version of 7D space time matter induction, (i.e. adding 3D and sharing time) [This amount to what the 4D multi-fold spacetime feels in the presence of multi-folds, i.e. the inside-out view], and considering AdS(5) sharing time (i.e. adding 4D, the 3D to again explain gravity in AdS(5) via multi-fold can be shared with the 3D already added to the 7D spacetime) [This amounts to the space where multi-fold live, i.e. the outside-in view] leads to a 14D spacetime.

Alternatively, space time matter induction (see [15,21] and reference therein) requires 14D to account for left and right chirality, that it can't model on its own in a 7D space [9,18,26]. This would imply symmetries  $\text{Spin}(7,7) \simeq \text{Spin}(14)$ , in that 14D space.

And yes, one could also argue that 14D are enough dimensions to support all relevant flavors of supersymmetry, super strings, super gravity and M-theory [14], even if a key outcome of the multi-fold theory seems to be that supersymmetry and superstrings/M-theory are no physical, but rather a mathematical duality [7,11,12,14,23-25]. Follow [16], to get the latest papers and comments on this.

*Note added on 10/16/22: However, in a paper later published [27], we further analyzed GU and got inspired by to progress the multi-fold theory, thereby proving wrong those in the Physics community who simply rejected GU, and decided to not pay attention to it because of its challenges and its allegedly controversial promotion: even problematic studies may have good ideas! In particular, we derived the symmetries of SM and GR. A key implications of the derivation [27], and the Ultimate Unification [7,13,29] is however that we probably have a desert of new fundamental particles above the gravity electroweak symmetry breaking energy scales and that no grand unification symmetry breaking takes place [7,29,31]. In other words, no  $U(128)$  or  $\text{Spin}(14)$ , or even lower level symmetry breaking are expected to be encountered, at high energy scales. That may be a new even more problematic problem for the GU program: there may be no room for  $U(128)$  symmetry breaking, just as there is no room for GUTs.*

*Also, [35] will provide on all these multi-fold dimensions thrown around, albeit there we did not try to focus on interpreting possible 14D spaces.*

## 6. More Multi-fold Considerations: more dead-ends, or ways forward for Geometric Unity?

More importantly, based on the work we have done so far, we know that supersymmetry, and 14D spacetime are not compatible with the Standard Model along with Asymptotic Safety of gravity [11,12]. This seems to doom, for now at least, the GU proposal just as for other GUTs and TOEs [7, 11-13], as well as superstrings. Again, addressing this, or looking at a reformulation that would not require supersymmetry, may be a good way forward, if at all plausible and consistent.

To be fair the notion of proposed supersymmetric in GU is vague in [1]. It may imply something different, albeit not likely.

In a multi-fold universe, these 5D, 7D, 14D extra dimensions relate to multi-folds, but they are not encountered as the spacetime, where the particles live, and where Physics takes place, and therefore not affected by the large dimension incompatibility issues. Therefore, there may still be ways forward compatible with Multi-fold theories, or not... This is also for future work, but worth some collaboration.

*Note added in 10/16/22: [27] discusses follow-ups to [3], and discusses a new problem for GU, if we were to follow this train of thought. There are no stable and renormalizable (asymptotically safe) Yang Mills in more than 4 (5)D, unless of supersymmetric. This is another challenge with GU approach as it seems to*

*imply the need to introduce supersymmetries to ensure such renormalizability or asymptotic safety, but then hit our stated incompatibility with asymptotically safe gravity (and SM), which we have confirmed in [7,11,12,32], even for the real universe. Also it is unclear that high dimensional self-dual Yang Mills equation can help with these issues. The problem is that when quantization of GU is introduced, all the work may fall apart if asymptotic safety can't be ensured. A theory that relies on high dimensional Yang Mills, can't be quantized and asymptotically safe, unless if super symmetric. But that would then be incompatible with the standard model in 4D.*

## 7. Conclusions

Besides the objections to Geometric Unity raised within conventional Physics, we identified additional considerations arguing against it, related to supersymmetry and high dimensionality, which has been established as incompatible with the Standard Model plus asymptotic safety of gravity, *and supersymmetric Yang Mills (Note added on 11/16/22) and to the lack of asymptotic safety of high dimension Yang Mills that is not supersymmetric).*

These issues remain problematic, especially as asymptotic safety of gravity seems to apply to the real universe, even if that is not (yet) accepted by many. Note added 11/16/22: See [11,12,32]

On the other hand, we have shown that some of the (conventional) concerns raised against GU (in [3], the only paper / preprint that the community bothered to produce, yet got refused publication even just on arXiv), may have answers based on approaches, and results, encountered in the multi-fold theory, which can be applied to GU to address these concerns. Not being experts in GU, we can't be sure if they will ultimately help, or if the effort is any way futile, considering the new issues that we identified.

Also, there are also discrepancies and gaps between GU and the multi-fold approach, so that we are also not sure if GU can apply to multi-fold universes, or the Physics in multi-fold spacetime.

It is also unclear if some, or all, of our proposals to address some of the GU challenges, are valid in the real universe. We have growing reasons to believe it might, but for more details, the reader should check upcoming papers tracked that at [16]. Yet, our arguments could also be repeated for non-multi-fold universes if we are willing to accept the ability of gravity to flip chirality, or spacetime orientation, or that spacetime would be discrete and fractal. *Note added on 10/16/22: then again, [33] seems to indicate that our universe is indeed multi-fold.*

It is also worth mentioning that the dimensions of the GU "obverse" can be confirmed as sensible in the multi-fold theory, in multiple ways. Different reasonings also lead to Spin (14), and therefore glimpses of U(128), with complexification. We see it as a mutual consistency check between GU and the Multi-fold theory.

*Note added on 10/16/22: More issues have since been raised in [27], inspired by GU. Unfortunately, [27] encounters, and predicts, the absence of group symmetry larger than SM and gravity above the energy scales of multi-fold gravity electroweak symmetry breaking.*

In conclusions, while we may have proposed some useful input to GU, we do not believe that we have been able to progress the quest motivating GU, or even catch a glimpse of hint that it would be the right approach, or that the desired Shiab operator(s) would exist. We are left not too optimistic for GU, even if grateful for the proposal.

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