No Conventional Sterile Neutrinos In a Multi-fold Universe: just SM_G business as usual

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Abstract:

In a multi-fold universe, gravity emerges from Entanglement through the multi-fold mechanisms. As a result, gravity-like effects appear in between entangled particles, that they be real or virtual. Long range, massless gravity results from entanglement of massless virtual particles. Entanglement of massive virtual particles leads to massive gravity contributions at very smalls scales. Multi-fold mechanisms also result into a spacetime that is discrete, with a random walk fractal structure and non-commutative geometry that is Lorentz invariant and where spacetime nodes and particles can be modeled with microscopic black holes. All these recover General relativity at large scales and semi-classical model remain valid till smaller scale than usually expected. Gravity can therefore be added to the Standard Model. This can contribute to resolving several open issues with the Standard Model.

Different recent experiments have argued against, or in favor of a sterile neutrinos. In a multi-fold universe, or whenever we can add a non-negligible gravity contribution at the scales of the Standard Model, we showed how to explain the mass of the neutrino without New Physics and predict the number of generations for each fermions family, including the number of neutrinos flavors, to be exactly 3. Therefore, in a multi-fold universe, there should not be conventional sterile neutrinos: right-handed flavored neutrinos no ability to interact with $W^{\pm}$ and Z^0 (they only interact only with the Higgs and though gravity) suffice to explain the neutrino oscillation anomalies encountered so far.

The results extend to SM_G.

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1. Introduction

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

With the proposed model of [1], spacetime and Physics are modeled from Planck scales to quantum and macroscopic scales, and semi classical approaches appear valid till very small scales. In [1], it is argued that spacetime is discrete, with a random walk-based fractal structure, fractional and noncommutative at, and above Planck scales (with a 2-D behavior and Lorentz invariance preserved by random walks till the early moments of the universe). Spacetime results from past random walks of particles. Spacetime locations and particles can be modeled as microscopic black holes (Schwarzschild for photons and spacetime coordinates, and metrics between

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Reisner Nordstrom [2] and Kerr Newman [3] for massive and possibly charged particles – the latter being possibly extremal). Although surprising, [1] recovers results consistent with others like [4], while also being able to justify the initial assumptions of black holes from the gravity or entanglement model. The resulting gravity model recovers General Relativity at larger scale, as a 4-D process, with massless gravity, but also with massive gravity components at very small scale that make gravity significant at these scales. Semi-classical models also work well till way smaller scales than usually expected.

In this paper, we remain at a high level of discussion of the analysis and references are generic for the subjects. It makes the points accessible to a wider audience and keeps the door open to further papers or discussions devoted to details of interest. Yet, it requires the reader to review [1], as we do not revisit here all the details of the multi-fold mechanisms or reconstruction of spacetime, nor the derivations of implications for the Standard Model. More targeted references for all the material discussed here are compiled in [1].

2. Reminder of past results in Multi-fold Universes

2.1 Neutrino Masses and Right-handed Neutrinos

[1,5] observed that gravity induces chirality/ helicity flips for fermions, including the neutrinos. As no right-handed neutrino has ever been observed, it is assumed that right-handed neutrinos do not interact other than with the Higgs (and gravity) and so they appear only in flight as part of the neutrino oscillations. Doing so, interactions with the Higgs also flipping helicity can account for the mass of the neutrinos.

2.2 No place for an extra Neutrinos (flavor) in SM

[1,6] expand the Standard model's Lagrangian with gravity (SM_G) in order to predict exactly three regimes for the mass contributions of each fermion family to the Lagrangian; therefore justifying the ability to only distinguish three flavors. A same mass generation applies to all fermions including neutrinos. There is therefore no room for a sterile neutrino, unless if by this we mean right-handed neutrino, which is sometimes the definition encountered in the literature, but not our choice.

Note that we consider that this is a consistent with , but a different result from the experimental estimations based on the Standard Model that the Z^0 spectrum also implies only 3 light neutrino species based on the analysis of the decay of Z^0 into neutrino / anti-neutrino pairs [14,8]. Our results is rather derived from the analysis of multi-fold gravity impact on the SM Lagrangian.

Therefore, We believe that in a multi-fold universe, we would not encounter most of the cases envisaged in [8].

3. Sterile Neutrinos?

See [7,8] for some overviews of sterile neutrinos.

There is ample confusion with the terminologies and different definitions in different domains or papers [7,8]. For example, in the literature, the notion of sterile neutrino is sometimes associated to a right-handed neutrino [7] or a 4^{th} (or more) neutrino with no hypercharge or weak nuclear charge [8,15] (models allow Majorana models or inclusion (as we propose in section 2.1; but without the justification of the role of gravity in SM_G), or not of right-handed flavored neutrino corresponding to the electron, muon and tau flavors of the left-handed neutrinos).

These sterile neutrinos are allowed to participate to neutrino oscillations [16]. Because the sterile neutrino is decoupled from the strong nuclear scale or the electroweak symmetry breaking scale, its mass can be large or small. Accounting for the neutrino anomalies reported below would require a mass larger than the conventional neutrinos (to account for the anomalies and to not violate the Z^0 (and $W^{\pm}$) decay widths) [8,14].

4. Sterile Neutrinos Experimentation Results

4.1 Con Sterile Neutrinos Results

The IceCube Collaboration [9,10] has repeatedly and consistently found no discrepancies between predicted amounts of detected muon neutrinos that traversed the earth versus what they observed. If sterile neutrinos existed, one would expect less muon neutrinos, especially at certain frequencies due to mass resonance effects like the Mikheyev–Smirnov–Wolfenstein effect (MSW)[17] plus additional effects [24]. This is the most recent experiment at the time of write-up of this paper.

Many other experiments seem to indicate the same (even if without disproving completely Sterile neutrino) [11].

4.2 Pro Sterile Neutrinos Results

On the other hand. the MinibooNE [12] and LSND [13] collaborations have detected discrepancies for muon neutrinos traveling over relatively short distance, in the form of detection of too many electron neutrinos: the neutrinos oscillations are not expected to have had time to take place, since production of the muon neutrinos to justify such observations. Other cases (always with the same paradigm of short distances between source and detection) have been observed [17]. [8] also discusses examples of disappearing electron neutrino anomalies.

The proposed explanation (see for example [18]) is that the introduction of one (or in fact 2 or more (3 being in fact probably more probable but experimentally not distinguishable from 2)) sterile neutrino(s) (with one of the conventional definitions of section 3), allows for shorter oscillation wavelengths (with more massive sterile neutrinos) and therefore resolves the issue. It is seen as a strong indication of the existence of such sterile neutrinos.

5. A multi-fold Explanation: flavored right-handed neutrinos only

We believe that our results, from section 2.2, forbid sterile neutrinos, with the conventional definitions of section 3 (especially as in [18]): to be oscillating, they should be a flavor. To be a flavor, they violate 2.2, period. The Z^0 decay width may be compatible with heavier sterile neutrinos (as are the $W^{\pm}$). The results of section 2.2 however again does not encourage such a model.

One could consider that the right-handed in-flight only right-handed neutrinos are the sterile neutrinos: they have a flavor, but no ability to interact with $W^{\pm}$ and Z^0 (they only interact with the Higgs and though gravity). This is consistent with the SM, where the neutrinos only couple left-handedly to the Z and W-bosons.

Per section 2.1, we believe that it is what happens in a multi-fold universe and SM_G (Standard Model with non-negligible gravity effects at the SM scales).

Indeed, results as in section 4.1 are explained by the fact that matter does not modify the helicity/chirality flips of neutrinos and so no differences of rates should be measured by the IceCube collaboration (and yes it is also affected by gravity per [23]). It matches their observation. Regarding section 4.2, although our proposal is sometimes considered as a case of sterile neutrino, it would not provide a justification for the pro Sterile neutrino results. Instead, we propose a new explanation based on [19]: gravity effects on neutrino oscillations. According to [19], they can be ascribed to three effects: propagation decoherence, Penrose decoherence and quantum decoherence due to gravitation scattering. The first is shown (e.g. [20,21]) to mostly amount to lensing effects and changes of the coherence length of the oscillations. The second is not really an effect per [22]. The latter on is exactly what we observe: mass eigenvalue mixes decohere into single mass values: right-handed neutrinos disappear for interactions (they remain in flight) and when they reappear (as a mix of mass states) they may be in any flavor state; which explains the unexplained neutrino flavor apparitions. The effects are not affected by distances shorter than the coherence length of the oscillations. The results of section 4.2 are therefore explained.

Note added on 3/30/21: See [25,26] for a more detailed justification on how and why this in-flight/hiding mode can be achieved in a multi-fold universe by being at the edge of spacetime/living within the multi-folds, behind the Higgs boson.

Therefore, in a multi-fold universe, right-handed flavored neutrinos without ability to interact with $W^{\pm}$ and Z^0 (they only interact only with the Higgs and though gravity) suffice to explain the neutrino oscillation anomalies encountered so far. It is another confirmation of the value of SM_G and a proposal that argues against New Physics, which we consider to not include the case of a sterile neutrino being just as right-handed neutrinos (and left-handed anti-neutrinos) that does not interact because of the chirality discrimination by the electroweak massive bosons.

As already discussed, the model may also works beyond multi-fold universe whenever gravity is non-negligible at the SM scales (and semi-classical effects remain correct), including the in-flight mode.

So it is not that there are no Sterile neutrinos, it is rather than with SM_G, sterile neutrinos are just the missing right-handed neutrinos and left-handed anti-neutrinos. They are always in-flight not interacting.
Note added on 3/30/21: See [25-27] for more details on the in-flight mode.

5. Conclusions

We believe that [1] makes a compelling case for the consistency of its multi-fold proposal. The present paper shows how the mechanisms of multi-fold universes can explain neutrino oscillation anomalies without a conventional sterile neutrino (or at least with a new definition of sterile neutrino).

The proposal is extensible to any situation where gravity is non-negligible at SM scales (SM_G).

It again motivates our call for taking SM_G seriously, considering how many open issues with SM can be (partially) explained with SM_G [24].

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