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Perspective on This Week's Announcement in High Energy Particle Physics and the Mechanism of Gauge Symmetry Breaking

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Abstract:

This week, the Large Hadron Collider at CERN announced the discovery of a new boson with mass of ~125 GeV. Many have interpreted these results as evidence in favor of the Higgs boson believed to provide a mechanism for subatomic particle mass generation. However, CERN stated in their announcement that the true identity of the new boson, if confirmed, has yet to be determined. In this article, I argue the proposed Higgs boson mass (~125 GeV) is too large to directly explain any effect as common as particle mass generation. An alternative is introduced in which subatomic particle masses are generated by cross-dimensional projections. These cross-dimensional projections are a natural consequence of inherent uncertainty in the connectivity dimensionality field of physical space due to its non-uniform discrete-continuous dual structure. Like the Higgs mechanism, these cross-dimensional projections break electroweak symmetry. These cross-dimensional projections also break the strong nuclear interaction gauge symmetry, and this causes matter to anti-matter asymmetry. I propose that Space Mixing Theory is useful for studying these types of symmetry breaking, the mechanisms for subatomic particle mass generation, inflation, dark matter, and the unification of physical interactions.

keywords: subatomic particle mass generation, Higgs boson, Higgs field, space mixing theory, Standard Model of particle physics, string theory, Heim theory, gauge symmetry breaking, matter to anti-matter symmetry breaking, dark matter, latent scalar field, connectivity dimensionality field, quark and gluon confinement, cross-dimensional projections, temporal channel averaging, Large Hadron Collider, CERN, Einstein-Cartan theory, unification of physical interactions, electrogravity, fuons, multi-story space-time model, theory of everything (TOE), inflation, strong nuclear interaction, quarks, weak nuclear interaction.

This week, the Large Hadron Collider at CERN announced the discovery of a new boson with mass of ~125 GeV.[1,2] Earlier this week, researchers at Fermilab's Tevatron announced they had seen hints of the particle, but did not have strong enough data to declare discovery.[3] Many scientists interpret these results as evidence supporting a theory (called the Higgs mechanism) for how subatomic particles acquire mass as proposed by six physicists in 1964.[4-8] In layman's terms, the proposed Higgs mechanism involves the motion of subatomic particles through a background of molasses (the Higgs field), which imparts mass to the particles by slowing them down. A particle called the Higgs boson can theoretically be formed by exciting the Higgs field. The experiments did not observe the Higgs particle directly, but instead looked for debris it is expected to leave behind as it decays. When trillions of high energy particle collisions were analyzed, researchers at the LHC and Tevatron observed collision events consistent with decay pathways predicted for a Higgs-like boson. If the Higgs mechanism is true, space contains a scalar field (called the Higgs field) with an associated particle called the Higgs boson that interacts with subatomic particles to create mass. Additional experiments are needed to uncover the exact identity of the new particle. If confirmed, the Higgs boson would complete the experimental discovery of all the elementary particles predicted by the Standard Model of particle physics.

In this article, I argue the proposed Higgs boson mass (~125 GeV) is too large to directly explain any effect as common as particle mass generation. The current average mass density of the observable universe has been estimated to be about 0.2 to 0.7 times the critical density separating a closed universe from an open one[9, 10] This corresponds to a density of $\sim 10^{-27}$ kg/m^3 or ~1 GeV per cubic meter.[10] If the universe's mass was generated by the Higgs mechanism with a Higgs boson of ~125 GeV mass, this would correspond to an average of approximately one Higgs boson per 100 cubic meters of space. At 25° C and a pressure of one bar, there are $\sim 10^{28}$ molecules per cubic meter of liquid water. It seems preposterous to me that one Higgs boson could simultaneously generate the mass for each of $\sim 10^{30}$ molecules in 100 cubic meters of liquid water. This rules out mass density generation via a ~125 GeV Higgs particle *uniformly distributed throughout space*.

If we postulate that Higgs particles are not present in "empty" space but rather are generated dynamically by interactions with massive particles, then the Higgs boson might exist only when scattering a massive particle. According to this postulate, the electron's mass is due to an intermittent and fleeting interaction with a ~125 GeV Higgs boson that briefly pops into existence and then disappears again. Because the electron's mass is tiny (~0.0005 GeV) compared to that of the proposed Higgs boson (~125 GeV), nearly all of the energy required to temporarily form the Higgs boson would have be borrowed from surrounding space. The vacuum simply doesn't loan out virtual particles with a mass of ~125 GeV frequently enough to explain any common property. This is why very heavy subatomic particles are primarily observed in high energy particle colliders and high energy cosmic rays. Due to its heavy mass, the Higgs boson is projected to be extremely unstable and decay very rapidly. In summary, I believe the proposed Higgs boson is not a valid explanation for subatomic particle mass generation, because such a heavy particle (~125 GeV) would not exist often enough to explain common properties.

The above argument does not rule out a relationship between a Higgs-like field and subatomic particle mass generation as proposed in the Higgs mechanism.[4-6] ***To reiterate, a subatomic particle's mass might be generated by interactions involving a Higgs-like field*, *but the electron's mass cannot arise from interactions with a heavy Higgs-like boson.*** Irrespective of whether or not the Higgs boson exists, the Higgs boson does not generate subatomic particle masses, even if a Higgs-like field plays a key role in subatomic particle mass generation. The statement "Subatomic particles like the electron acquire their masses by interacting with the Higgs boson." is definitely false *even if the Higgs boson exists*. On the other hand, the statement "Subatomic particles like the electron acquire their masses by interacting with a Higgs-like scalar field." may be true.

I now explain my current understanding of mass generation from the perspective of Space Mixing Theory (SMT). According to SMT, physical space is a discrete-continuous dual space described by a self-scalar field called the Latent Scalar Field and its associated connectivity dimensionality field.[11-13] The term "self-scalar" field means this is not a scalar field defined over a background space, but rather a scalar field whose distance-related (i.e., "metric") properties and connectivity dimensionality field are generated dynamically and self-consistently. I previously showed these distance-related properties and the connectivity dimensionality field have inherent uncertainty, because physical space is a non-uniform discrete-continuous dual space.[12, 13] This uncertainty makes subatomic particles like the electron follow a wavefunction instead of a classical trajectory.[13]

For convenience, elementary oscillations of the Latent Scalar Field are hereafter called *fuons*. Fuon is an acronym for fundamental unit of nature. According to SMT, fuons are the little "bits" of space-time that give rise to all of Nature's fundamental interactions. Waves on the ocean's surface are a good analogy for fuons, where the height of the ocean's surface is analogous to the latent scalar value. Some waves travel over a long distance on the ocean's surface with almost constant shape, while other waves change shape rapidly. On the ocean's surface there are tiny ripples and there are huge waves. So it is with the latent scalar field. Some fuons travel with an almost constant shape while others deform rapidly, and some fuons have much longer wavelengths than others. Fuons are not particles, but they exhibit some characteristics of wave-particle duality. I now show fuons have almost zero masses that are many orders of magnitude smaller than the electron's proper mass. There is one independent value of the Latent Scalar Field for each independent location in physical space.[11] Because each elementary oscillation of the Latent Scalar Field represents a few degrees of freedom, the number of fuons is of the same order of magnitude as the number of independent locations in physical space. Consequently, the average mass per fuon can be naively estimated by dividing the estimated average mass density of the universe by the estimated number of independent locations per unit volume. Although we do not know the precise number of independent locations per cubic meter of physical space, this number is $\gtrsim 10^{66}$, because the electron's core radius appears to be $\lesssim 10^{-22}$ meters.[14] Using the average density of ~1 GeV/m^3, this would correspond to an average mass of $\lesssim 10^{-66}$ GeV per fuon. Because the estimated mass of a fuon is so small, I believe subatomic particle masses are due to collectivized scattering events involving numerous fuons not isolated scattering events of one or two fuons.

Each fuon represents a small nearly-constant number of independent Latent Scalar Field values. Consequently, the nodal hypervolume[12] of a region of physical space is proportional to the number of fuons enclosed within that region. The number of fuons and their amplitudes can be altered by natural dynamic processes. It is possible to inflate (deflate) a region of space by increasing (decreasing) the number or amplitudes of fuons contained within it. In this way, SMT provides a mechanism for studying inflation (or deflation) of the universe. Astronomical evidence indicates inflation of the universe.[15, 16]

Other interactions involving fuons include their scattering by cross-dimensional projections and changes in their trajectories by gradients in the space-time metric (or affine connection). The space-time metric (or affine connection) is a recipe for measuring distances between points (or along paths) in space-time. At the elementary level, an invariant distance parameter is directly related to fluctuations in the Latent Scalar Field, with longer paths having a higher integral of $d\beta = \sqrt{\left(dL\right)^2}$.[11] Fuons interact with each other indirectly via changes they induce in the space-time metric (or affine connection) and connectivity dimensionality field. Fuons with longer wavelengths see the connectivity dimensionality field averaged over a larger region. Because the inherent uncertainty in the connectivity dimensionality field is smaller for a larger region,[12] fuons with longer wavelengths are scattered less by background uncertainty in the connectivity dimensionality field. This leads to longer lifetimes for longer wavelength fuons traveling through vacuum space. These long-lived fuons may account for a significant fraction of the "dark matter" believed to permeate the universe and concentrate near galaxies, or such "dark matter" may turn out to be an illusion. Many other ideas have been proposed to explain "dark matter".[17]

I believe particle mass is generated by cross-dimensional projections. This could explain why all subatomic particles have non-zero proper masses, except photons traveling through the vacuum. Specifically, photons traveling through the vacuum (but not through a dense material) are eigenstates of the electromagnetic field. According to SMT, electromagnetic fields are gradients in the local average connectivity dimensionality field. Thus, photons are eigenstates of the local average connectivity dimensionality field. Because over long distances through the vacuum the average median value of the connectivity dimensionality field is approximately constant, these eigenstates remain orthogonal to each other and thus non-interacting. Accordingly, photons are not subject to cross-dimensional projection by background fluctuations in the connectivity dimensionality field as long as the long-range average properties of the vacuum they are traveling through remain sufficiently constant. Because all other types of matter are not explicit eigenstates of the electromagnetic field, they are scattered by background cross-dimensional projections, thereby acquiring mass. This scattering by cross-dimensional projections causes a massive subatomic particle to follow a wavefunction rather than a classical trajectory.[13] This effect is quantified by wavefunction equations (e.g., Schrodinger, Dirac, Klein-Gordon) in which the propensity of the particle's wavefunction to localize is proportional to the particle's mass. (In this article, a particle's mass always refers to its proper mass.)

According to the Higgs mechanism, subatomic particle mass generation is closely related to electroweak symmetry breaking.[4-8] As I showed previously, cross-dimensional projections break gauge symmetries.[13] Thus, my proposed mass generation mechanism also causes electroweak symmetry breaking. This gives rise to the following question: "How can experiments be designed to tell whether symmetry breaking and mass generation occur by the Higgs mechanism or by cross-dimensional projections?" This question is more subtle than it first appears. *Let me be clear:* If electroweak symmetry breaking occurs by cross-dimensional projections at the observation scale where the connectivity dimensionality of physical space fluctuates appreciably, this will manifest itself as some type of interaction field when examined over larger distances by mathematical models that treat the space-time dimensionality as constant. In such a manner, gauge symmetry breaking by a Higgs-like field can emerge as an approximate description of gauge symmetry breaking by cross-dimensional projections. Nevertheless, gauge symmetry breaking by a Higgs-like field is not completely equivalent to gauge symmetry breaking by cross-dimensional projections. The distinction arises because cross-dimensional projections will break the symmetries of all gauge fields (e.g., electroweak, strong nuclear, and electromagnetic interactions), while a Higgs-like field may selectively act on a subset of gauge fields. The breaking of gauge symmetries by cross-dimensional projection can thus be falsifiably tested by experiments that determine whether the symmetries of all gauge fields are broken or whether the symmetry of one gauge field is broken while others remain intact. According to SMT, electromagnetic fields arise from gradients in the connectivity dimensionality field. Thus, a positively charged particle carries a dimensionality deviation opposite in sign to that of a negatively charged particle. Therefore, a positively charged particle lives in a space whose connectivity dimensionality is not exactly the same as its negatively charged anti-particle. This breaks the symmetry of both the strong nuclear (because quarks are charged) and electromagnetic interactions, leading to different measureable properties for particles and their anti-particles. (Of course, this does not apply to particles like the photon that are their own anti-particles.) This matter to anti-matter asymmetry creates the predominance of matter over anti-matter in our universe. Further theoretical and experimental research is required to understand how experimental tests could be performed to tell whether gauge symmetry breaking occurs by cross-dimensional projections or some other mechanism.

Until this point, we have discussed the concept of particle mass extensively with almost no mention of the gravitational interaction. According to Einstein's General Relativity (GR) theory, gravitational interactions are due to gradients in the space-time metric.[18] I now describe a research strategy for uncovering relationships between gravity and the other fundamental interactions of Nature. Suppose there is some principle of least action that governs the motion of a particle in the spirit of Feynman's path integral approach to quantum mechanics. This principle of least action tells us what a system will do, but it does not assign "cause" or "effect". Accordingly, if a change in the space-time metric affects the trajectory of a massive particle, then we can infer that this interaction will also work in reverse such that a trajectory of a massive particle will also affect the space-time metric. This principle of reciprocity means that if A interacts with B then B also interacts with A. Now we are in a position to make a startling discovery. Because metric (e.g., "gravitational") changes act on all particles, metric changes appear in the path action as modifiers of the path length. Because all physical interactions are presumably expressible in terms of a generalized path action, this means a modification of the path length affects all of the fundamental interactions of Nature. Hence, metric ("gravitational") interactions must be coupled to all of Nature's other fundamental interactions. Because changes in the path length do not change the constants of motion (proper mass, particle charge, particle spin, etc.), I infer that constants of motion for all of Nature's *other* fundamental interactions are the causes for metric ("gravitational") changes. In other words, gravity "borrows" its causes from all of Nature's other fundamental interactions. This leads to the prediction that a particle's mass, charge, spin, magnetic moment, and quark color all cause changes in the space-time metric (or more generally its affine connection). The affine connection is an extension of the space-time metric concept that includes torsion.[19] This further means fundamental interactions are unified together through physical space's affine connection. In SMT, the affine connection will be directly derived from the Latent Scalar Field. In summary, the Latent Scalar Field (and its associated connectivity dimensionality field) will generate the affine connection and path action. Minimizing this path action will produce fundamental interactions and relationships between them. Recent experiments indicate capacitors charged to high voltages appear to lose mass.[20] The apparent mass loss was proportional to a constant of motion (the capacitor's energy, perhaps with a dielectric constant correction).[20] Brown reported another electrogravity effect when a capacitor is charging.[21] Additional research is needed to determine whether these effects are reproducible.

A more rigorous mathematical treatment incorporating a multi-story space-time model will be required to advance these concepts further. The first story (aka ground floor) of this space-time model is the Latent Scalar Field which lives in a discrete-continuous dual space of variable connectivity dimensionality field. To get from the first story to the second story, one takes the stairway of cross-dimensional projections. As will be explained in a future article, SMT predicts that three complex short-range dimensions forming an SU(3)-like symmetry is the only stable result of such a cross-dimensional projection. This second story of three complex dimensions having SU(3)-like symmetry describes the strong nuclear interaction and its associated affine connection in a curved space-time. (The Standard Model describes the strong nuclear interaction in a flat space-time.) According to SMT, the three real dimensions represent microscopic spatial channels and the three imaginary dimensions represent temporal channels for a total of six motion channels. According to SMT, quarks of ±1/3 (±2/3) charge have quantization of the connectivity dimensionality field along one (two) spatial channels. To be isolatable, a charged particle must have quantization of the connectivity dimensionality field equally along all three channels. Consequently, balanced combinations of quarks (e.g., neutron or proton) are isolatable, but quarks themselves are not isolatable. According to SMT, gluons mediate the strong interaction by scrambling the six motion channels. Elementary leptons like the electron have equal charge quantization along all three spatial channels and thus are blind to the strong nuclear interaction. According to SMT, the weak nuclear interaction is probably caused by a form of space-time torsion which scrambles the spatial channels amongst themselves and the temporal channels amongst themselves. For three complex dimensions, this type of rotation corresponds to two SU(2)-like symmetries. The spatial channel scrambling (torsion) is associated with particle spin, and the temporal channel scrambling is associated with particle generation. According to SMT, neutrinos are the associated quanta of space-time torsion that perform this scrambling. I believe the first, second, and third subatomic particle generations correspond to simultaneous vibrational/torsional quantization along one, two, and three rotational degrees of freedom of the temporal channel scrambling, respectively. According to SMT, the colors “red”, “green”, and “blue” denote quantization along each of the three microscopic temporal channels. One takes the stairway of time channel compaction to get to the third story. For reasons that will be explained in a future article, over sufficiently large distances the three microscopic temporal channels average out to form one macroscopic time-like dimension. In SMT, quarks and gluons are confined by this temporal channel averaging that compactifies two of the temporal channels. This is why quarks and gluons come in three colors at pre-compaction length scales but occur in essentially colorless combinations at post-compaction length scales. (This process is called “color confinement”.) Thus, the third floor consists of three macroscopic space-like dimensions and one macroscopic time-like dimension. I believe this story will be described by something similar to an Einstein-Cartan spacetime[19] that has been extended to include interactions between electromagnetism and gravity and the nuclear interactions. Finally, it is possible to add simpler models on higher stories of the building. The fourth floor is split into two different halves. Neglecting spacetime torsion and the nuclear interactions leads to the fourth floor half consisting of a General Relativity like theory in which space-time is described by a (curved) four-dimensional pseudo-Riemannian space-time with an associated metric tensor of signature (-,+,+,+). On the other hand, flattening the spacetime (which neglects gravitational interactions) and projecting the nuclear interactions onto matrix operators leads to the Standard Model of particle physics, which occupies the other half of the fourth floor. Neglecting the space-time curvature, metric gradients, and nuclear interactions, we ascend to the fifth floor of Special Relativity in which the metric is flat and constant. The fifth floor can be reached from either half of the fourth floor. If we neglect relativistic effects, we ascend to the simplest possible space-time model consisting of three Euclidean spatial dimensions plus one time dimension. This multi-story building also has something like a partially built basement comprised of a hypothetical edge-vertex graph. Strictly speaking, this edge-vertex graph does not have a pre-defined form that is locally averaged to determine the Latent Scalar Field. Instead, the Latent Scalar Field evolves according to rules that may be interpreted as approximately (but not necessarily strictly) consistent with locally averaged properties of a hypothetical edge-vertex graph. In other words, the rules governing space-time dynamics are embodied in the Latent Scalar Field rather than in the hypothetical edge-vertex graph. This multi-story space-time model is just a concept now, and further research is needed to fully develop it.

To understand the spectrum of subatomic particles, it may be useful to borrow and extend some ideas from existing theories. In recent decades, the Standard Model of particle physics has been the most successful theory for explaining the properties of subatomic particles.[22] SMT is a successor to the Standard Model and as such will incorporate and extend many ideas present in the Standard Model. Many terms and concepts (e.g., quarks, neutrinos, color confinement, gluons, strong nuclear interaction, weak nuclear interaction) occur in both the Standard Model and SMT. I believe the relationship between the Standard Model and Space Mixing Theory is analogous to the relationship between classical and quantum mechanics. Just as classical mechanics emerges in some limit as an approximation to the more rigorous quantum mechanics, I expect the Standard Model will emerge in some limit as an approximation of the more rigorous Space Mixing Theory. The Standard Model uses quantum field theory to describe subatomic particle interactions in a classical Minkowski space-time. In SMT, all aspects of the space-time structure are treated quantum mechanically. The Higgs mechanism allows the Standard Model to incorporate particle masses,[4-6] but to the best of my knowledge it does not provide a way to calculate accurate subatomic particle masses from first principles. I believe the Higgs mechanism is an approximately true but incomplete theory of subatomic particle masses, and a theory going beyond the Standard Model and Higgs mechanism will be required to understand the ultimate origins of subatomic particle masses.

String theory is one approach to predicting the spectrum of subatomic particles.[23, 24] However, progress in string theory has been slow despite intense efforts by many researchers for decades.[25] String theories come in so many different variations that it is difficult to make predictions that could be experimentally tested.[25] Many string theories have been formulated using supersymmetry, but the elementary superpartners predicted by such theories have not yet been observed. A ten-dimensional string theory can be constructed in which six dimensions are compact to form a microscopic manifold with SU(3)-like symmetry.[23, 24] I believe this string theory lacks an appropriate correspondence between the microscopic (i.e., compactified) and macroscopic (i.e., long-range) dimensions. According to SMT, the three complex dimensions that form the microscopic dimensions should be treated as generators (through the process of temporal channel averaging that compactifies two of the three time channels) of the four macroscopic dimensions. I believe string theory will need to incorporate this correspondence between microscopic and macroscopic dimensions to make further progress. According to SMT, the study of string theories with anything other than three microscopic complex dimensions and four macroscopic (three spatial and one temporal) dimensions has no significance as a model for the elementary space-time structure in our or any other universe that may physically exist. Other dimensional structures may be of interest for purely mathematical reasons or to study other physical applications, but they are completely wrong for modeling the elementary structure of physical space.

Six-dimensional Heim theory is the most successful theory to date for explaining and predicting subatomic particle masses.[26] Unfortunately, much of Heim's work was written in German using a specialized jargon that is nearly impossible to decipher.[27, 28] The spectrum of subatomic particles predicted by six-dimensional Heim theory is similar to but not the same as that experimentally observed. For example, it predicts some extra neutrinos and a few other particles that have not been observed, as well as too many excited states for known particles.[26] Nevertheless, it predicts astonishingly precise values for the masses of many known particles. To the best of my knowledge, Heim theory projects the metric of a six-dimensional space (with three space-like and three time-like dimensions) onto the metric of a four dimensional space (with three space-like and one time-like dimension), where the 36 independent metric components for the six-dimensional space are mapped onto curvature-related quantities of the four-dimensional space-time. Using various field equations and a finite-difference calculus (to account for the discrete-continuous duality of physical space), Heim solved for the eigenstates of this polymetric to compute the spectrum of subatomic particle masses.[26] Because many of its predictions are in line with experimentally measured values, some ideas in Heim theory must be correct. However, some features of Heim theory are not entirely correct in their present form. Heim theory gets the number of microscopic dimensions (six) correct as well as their signatures (three space-like and three temporal) plus it gets the number (four) and signature (three spatial and one temporal) of the macroscopic dimensions correct. I believe Heim theory does not correctly capture the SU(3)-like symmetry of the six microscopic motion channels, and this causes it to predict some spurious particles. SMT will capture this SU(3)-like symmetry, so it would be interesting to see if some of Heim's ideas can be applied to SMT to predict the spectrum of subatomic particles and their masses.

In summary, Space Mixing Theory is an attractive approach for studying a variety of complicated phenomena that go beyond established physics. Among other things, SMT provides a conceptual framework for studying the unification of fundamental interactions, mechanisms for mass generation, inflation, dark matter, electroweak symmetry breaking, and matter to anti-matter symmetry breaking. SMT is still in the early development phase and needs significant further research.

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Daniel Manz (my brother) suggested the acronym fuon (fundamental units of nature) to denote some type of primitive particle-like entity comprising space-time at the most elementary level.

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