Emergence Theory
Conceptual Overview

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ABSTRACT: Emergence theory is a code-theoretic first-principles based discretized quantum field theoretic approach to quantum gravity and particle physics. This overview covers the primary set of ideas being assembled by Quantum Gravity Research.

MOTIVATION

Modern unification models relate experimental observables via gauge symmetry modeling. The observables themselves are generally not explained within the models. We believe nature is code theoretic. Codes are finite sets of object types with syntactical ordering rules and degrees of freedom. Discovering and simulating with nature's actual code would generate precise first principles-based analytical values for the fundamental dimensionless constants, c, h and G, along with the dimensional constants and derivatives. Gauge symmetry unification equations would be a natural outcome of discovering the first-principles rigor of the universe's mathematical code.

AXIOMS

We adopt Euclid's first postulate as an axiom. A straight line exists between two points, i.e., a flat 1D space. This leads to higher dimensional spaces (composited from 1D spaces) being flat. We are interested in the power of Euclidean space objects, such as Lie lattices and their physically important Lie algebraic analogues. We interpret the physical realism of Lie algebraic gauge symmetry unification physics to be a clue that nature uses flat spaces in the form of Lie lattice theory. An equivalent non-geometric view is to correlate the algebras associated with Lie lattices to be equal to certain graph theoretic algebras, wherein the magnitudes of near neighbor graph connections are of equal magnitude. For example, if we take the complete graph of three objects and assume the magnitudes of the three connections to be equal, we can correlate this to the equidistant set of three points in a flat space – a 3-simplex. Such a graph theoretic approach can be extended to a complete Lie lattice, from which the corresponding Lie algebra may be derived.

Our second axiom is the assumption that the *code theoretic axiom* is true.

DISCRETIZING SPACETIME INTO A CODE

Loop quantum gravity (LQG) is elegant because it starts with graph theory and discretizes spacetime in a quantum mechanical framework. Our thinking is similar. But it is dissimilar with respect to the code theoretic axiom. A code is a finite set of objects (symbol types) with rules and syntactical degrees of freedom – allowed ways to relate the objects. With LQG, the infinite set of object types – the infinite or “smooth” set of deficit angle values associated with the spacetime quanta of a spin foam – prohibits the evolution from being code theoretic.

We take a different approach. In order to recover standard model gauge symmetry physics while creating a spacetime code, we start with a slice of the Lie lattice analogue of the largest exceptional Lie group, E_8. It contains the necessary algebraic structure to recover standard model gauge symmetry equations. Using a projection angle derived directly from the 4D subspaces of the E_8 lattice, we transform it into a 4+1 dimensional geometric code, wherein quasiparticles, called *phasons*, propagate and interact according to the code syntax degrees of freedom. See here for more. Although many codes, such as C++ and English are arbitrary and not based on first principles, other codes, such as a division algebra or a quasicrystalline phason code (based on a shift vector algebra) are based on first principles. Nature would use a first principles code.

Instead of using an infinite set of smooth curvature values in the deficit angles of a spin foam formalism, we use a highly restricted set of deficit angles corresponding to standard Euclidian space trigonometry. See here for details.

The behavior of this code is represented as a 3+1D phason code on a 3D graph space called the *quasicrystalline spin network* (QSN). As with any code, its expression is never a deterministic algorithm playing itself out. While it is true that codes can be used to write deterministic algorithms, syntax decisions must always be made when using codes. This can be done with a a random number generator, a human syntax chooser or some other way of exercising the non-deterministic nature of syntactically free choices.

It is not controversial to admit that freewill can emerge within the laws of physics, since most physicists presume they have freewill. The term *freewill* can be defined as: *A non-random choice not strictly determined by other events*. Assuming the code theoretic axiom to be true, freewill syntax choosers can emerge from a physical spacetime code and loop back to act upon the code’s syntactical freedom. By way of example, consider a woman at the bottom of an energy well. We assume her freewill has emerged according to the rules of some fundamental spacetime code. In emergent systems much simpler than the woman, the statistics of the code should reproduce a form of quantum thermodynamics. Let us imagine the energy well is very deep. Accordingly, quantum thermodynamic statistics alone would not allow the wavefunction of her body or its individual particles to climb out of the energy well with real-world probability. And yet, due to her freewill, she chooses to spend energy to climb out of the well each time she is placed in it. The example illustrates that her emergent freewill exponentially modifies the probability amplitudes of the particles that composite to form her. The modification of the statistics is extreme and far from the thermal equilibrium based statistics of classic or quantum thermodynamics. She overrules the statistics of quantum thermodynamics because her emergent freewill is concerned not with energetic efficiency but instead with her theory that getting out of the energy well comports with her abstract information theoretic strategies, such as picking up her kids from school. See here for more.

Any quantum gravity based spacetime code is, by definition, a *hidden variables* theory. In order not to violate Bell's theorem, such a theory must be both non-deterministic (a code is non-deterministic by definition) and non-local. Quasicrystalline phason codes can be fundamentally described by non-commutative geometry. They are inherently non-local via the first principles of projective geometry. Structures called *empires* in quasicrystals allow patterns to be non-locally connected over spacetime. See here for details.

ENERGY PART I - THE AB = P SOLUTION SPACE

We must wait for further advances in computational power in order to use our spacetime code to simulate emergent complex systems capable of exponential probabilistic deviations from the ordinary equilibrium statistics of quantum thermodynamics, as exemplified in the case of the woman in the energy well. For now, our program focuses instead on simple systems, where thermodynamic statistics dominate. Codes are vast possibility spaces for expressing information. If there is no emergent complex system guide for the code expression of a simple system, such as the woman's free will and abstract preference for climbing out of energy wells, how will we attach a syntactical choosing mechanism in our fundamental particle simulations?

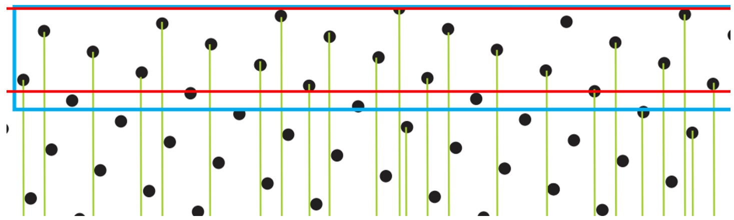
Before explaining this, we must define energy via first principles. *Energy* in physical models is an abstract observational plug with no rigorous first principles explanation for what exactly it is. In minimally complex systems, such as an electron interacting with its own field, our *principle of efficient action* takes the form of a principle of least computational action to economically describe particle internal clock cycles and forward propagation steps. Details are here. Code expression requires resources, where the resources are generally "energy". However, we require a first principles definition of energy as a computational least action principle, similar to how Numrich presents it here.

Above, we discussed a projection transformer of E_8 lattice slices that generates phason quasiparticle interactions in a 4+1D (Elser-Sloan quasicrystal) and the derivative 3+1D quasicrystal code called the QSN. To understand our form of the principle of least computational action, let us begin with a possibility space called the *AB = P solution space*. There are at least two bijections of this object. Let us discuss two.

First, let us elucidate the geometric form, which animates the QSN – the physical space. Let A = an irrational projection vector derived from the ArcCos ¼ based relationship between an adjacent pair of bivectors in the E_8 lattice. Let B = the rational angular relationships as multiples of ArcCos ½ between pairs of unit root vectors in the E_8 lattice. Let P = the irrational product of the AB coefficient pair – a projection to an H_3 or H_4 symmetric quasicrystal.

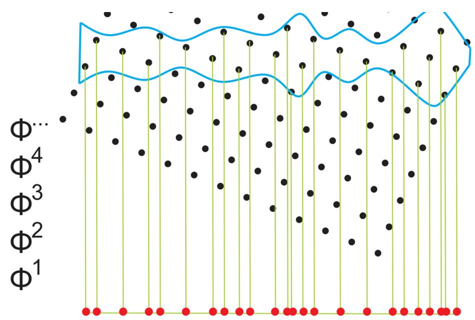
Using the above reference explaining *empires*, recall that we have two objects in a projective transform that generate an action step or new *graph state selection* in a quasicrystalline phason code. The first object can be called a *boundary window*, W_B

(blue), placed on the Lie lattice slice which is being transformed. The second can be called the projection window, W_P (red), which lives inside W_B.



For a finite boundary window, W_B, there is a finite set of $W_B\,W_P$ relationships derived by shift-vector actions of W_P within W_B. These are the syntactically free relationships that the smaller embedded projection window, W_P, may be shifted to within the larger boundary window, W_B, to generate ordered sets of projections or graph state selections in the Elser-Sloan QC (ESQC) and the QSN possibility spaces – the discrete action steps of the phason quasiparticle code. The superposition of all $W_B\,W_P$ relations is the possibility space or solution space of all AB products, P, i.e., the possibility space of P solutions defining quasiparticle walks.

The projection window is likely not uniform and instead possesses a dynamic "vibrating" hypersurface corresponding to the non-uniform energetic physical quantum energy landscape.

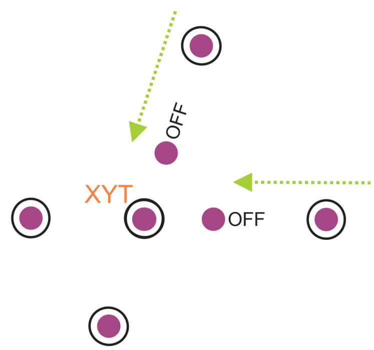


One purely numerical non-geometric bijection of this formalism is a tensor network algebra. To conceptualize the logic of this view, consider that both the dynamic ESQC and QSN (ordered sets of AB = P solutions forming quasiparticles) can be reduced to the interactions of 1D quasiparticles on the 1D quasicrystals, called *Fibonacci chains*, two-letter codes made of the Dirichlet integers 1 and 1/Φ, which composite to form the 3D and 4D dynamic quasicrystals. The Fibonacci chains are isomorphic to binary strings of 0s and 1s, called *Fibonacci words*, where each state of the changing string non-arbitrarily corresponds to a unique integer, called a *Lucas number*.

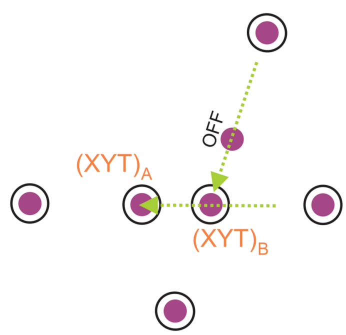
The propagation of these 1D quasiparticles is the result of eigen value probabilities in an ordered set of matrix solutions. However, when the ordered sets of matrix solutions are composited into a tensor network of interactive matrices, which maps to the interactive network of dynamic Fibonacci chains in the 3D and 4D QCs, the eigen value probabilities of each 1D set of matrix solutions is modified. For example, one might recognize that the probabilities for the various shift vector actions that can change a 1D quasiparticle on a stand-alone dynamic quasicrystal are relatively homogenous. However, applying the principle of least computational action, which will be described next, the Bragg peaks of the probability amplitudes for shift vector actions in the abstract higher dimensional AB = P solution space become non-homogenous and accentuated. This corresponds to equal changes to the various eigen value probabilities on the ordered sets of matrix solutions in the tensor network bijection.

ENERGY PART II - COMPUTATIONAL SAVINGS

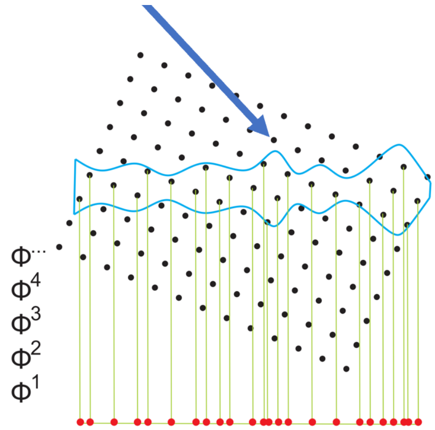
Let us say we have two 1D quasiparticles propagating in two directions shown by the green arrows. Let us say their random walk worldlines are such that they each need an object, such as a 20-group, a tetrahedron or a point at coordinate XYT, where "T" is AB = P solution N, within an order set of AB = P solutions describing the particle's evolution.



The local *inflation* value stays the same because they share the pattern advancement need at XYT.

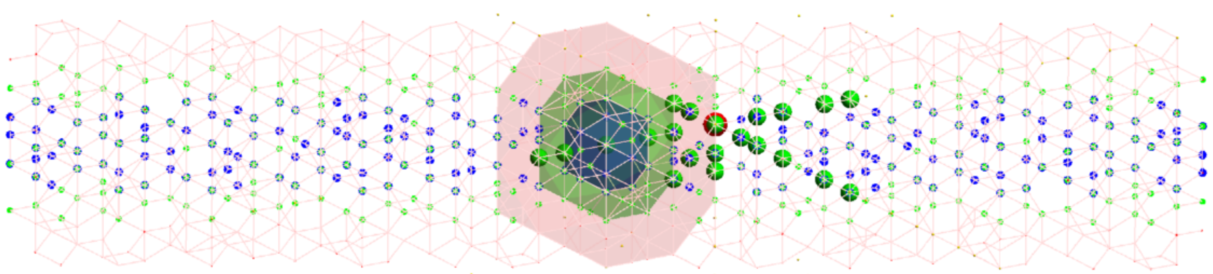


Above, we have a case where the two 1D quasiparticles do not share the need for a coincident XYT.



Accordingly, the amplitude of the corresponding region of the projection window surface must be greater in this region. In other words, the local deflation introduced a 3rd distance letter here, such that now we have three lengths, L, M, S, instead of in the first case, where we had only two lengths. This local deflation has occurred due to a lack of computational savings. Here we are recognizing that more computation is required to project a region of the projection window that is larger, such as in the case of the three-letter region, versus the smaller window needed in the two-letter region.

We extend this idea to the previously explained idea of a quantum clock, wherein we have a Hamiltonian circuit or some other circuit on the QC graph, which describes an internal clock cycle of a preon-based fermionic clock. Because empires extend outwards from the emperor object in a QC in a given step, the empire waves share this same quality, where the density of empire objects drops with distance from the fermion. Interactions of these particles do not occur at the region of the clocks themselves but via the empire wave-based discretized quantum field around clocks.



FIBONACCI ANYONS

Emergence theory posits that the spacetime code of reality is a topological quantum superfluid. Put differently, it is a topological quantum net that expresses on a spin network to exhibit various mixed phases of a topological quantum superfluid. Some expressions of this topological code simulate classic-type systems while other expressions of the same topological code simulate topological phases of matter. Is the universe a topological quantum computer? Yes, in some sense. Is the neural net architecture of your brain a computer? Yes and no. Yes, because it computes. No, because the 20th century term for computers generally means a system that performs a deterministic solution as an output to that depends on some input. Our minds compute, but they are not computers in the ordinary sense of the word. A topological neural net code is interesting because it has syntactical degrees of freedom. And, where an emergent mind-like pattern can emerge (in principle) on such a neural net, it can essentially *hijack* the syntactical freedom within the code and guide it for its own creative and strategic purposes.

The underlying quantum statistical quasiparticle in topological quantum nets is the non-abelien anyon, reduceable to the Fibonacci anyon. Quasicrystals are known to be topological phases of matter. See here, here and here background. The last link says, "The surprising result suggests quasicrystals could be used to create systems with dimensionality higher than 3D – something that could be useful both in studying fundamental physics and creating materials with new and useful properties." Clearly, QGR agrees.

To deeply understand where we are going with Fibonacci anyons, I must start with the motivation of the QSN. Why do we project the E_8 lattice slice to 4D and then make the compound QC representation in 3D – the QSN and its subset, the CQC? If we want a 3D spin network based on E_8, why not simply create phason quasiparticles by projecting directly to 3D? There are two reasons. The first is that we must preserve the group theory of the $A_3 = D_3$ root system via its vector polytope, which is a building bock of the fundamental 20-groups in the QSN. This will allow us to use the 7+1 values of the Cartesian coordinates of the cuboctahedron 5-compound to exploit the physical power of octonions, as opposed to the E_8 to 3D projection which is more deeply based on icosians with their 4+1 fundamental values. Furthermore, the cuboctahedron encodes the Lie algebras associated with the groups SU(3), SU(2) and U(1). These extra physical power or complexity is deeply based on the quantity of parallel vector classes in a lattice or quasilattice transformation of a Lie lattice. For example, the E_N algebras and lattices are more powerful than the Z_N series. Trivially, this is because these vector algebras generate solution spaces for algebraic patterns on the relevant root lattice. The greater quantity of parallel vector classes, the richer the root vector polytope and algebra itself. Are vector algebras associated with quasilattice transformations of Lie lattices more powerful if they contain a greater quantity of parallel vector classes? Of course. The quantity of parallel vector classes in a quasicrystal resulting from the projection of a Lie root lattice is always equal to the quantity of parallel vector classes of the Lie lattice itself. We have 120 parallel vector classes in E_8. However, if we project to 3D via an irrational angle, we will generally get a projection which does not correspond to a vector algebra. We may project E_8 slices to lower dimensional crystallographic Lie lattices corresponding to Lie algebras. Or we may project them via arbitrary irrational angles to produce lower dimensional shadows that are not algebras. The special case are the angles of projection that maximize the quantity of parallel vector classes in the projective space while at the same time revealing vector algebras. When we project E_8 to 3D, we collapse the 120 parallel vector classes in E_8 to 15 parallel vector classes in the projection. We may use the icosian calculous, forms of non-commutative geometry and other algebraic isomorphisms and bijections. But not octonion based algebras. As long as the projection corresponds to a crystallographic or non-crystallographic algebra, we can recognize that the quantity of parallel vector classes corresponds to the complexity of the root vector polytope of the resulting vector algebra. When we project E_8 to 4D, we get 60 parallel line classes. When we project E_8 to 4D and then represent that projection in 3D via the compounding method, we get 60 parallel vector classes. We must soon discover an analogue of icosian calculous in the QSN. One can understand icosian calculous via the Cartesian coordinates of the icosahedron and its dual, the dodecahedron. With 15 parallel edge classes, these objects are significantly less complicated than the 20-group, which shares the same convex hull as the cuboctahedron 5-compound. The values of the Cartesians of the 20-group are 7+1, which may make the 7+1 integral octonians ideally powerful for exploitation. Of course, the E_8 vector algebra is deeply based on the octonians. But, just as the root vector lattice is transformed into the QSN, so too are each of the integral octonions transformed under the AB = P transform action. The octonian based analogue of icosian calculous we might need could be called C5C calculous for “cuboctahedron 5-compound calculous”. Anyone looking for deep mathematical insights into this calculous must come to learn how to exploit the fact that 2J +P = ArcCos½. The basis of this exploration is [here] and [here]. J is the angle by which you rotate a tetrahedron in an evenly spaced 5-group of tetrahedra sharing a common edge on an axis running from the outer edge through the centroid and to the center of the opposing perpendicular edge. This is one of the two classes of axes of symmetry of the tetrahedron. This angle is (ArcCos ¼ - ArcCos -½)/2. This reduces the number of parallel plane classes to 10 and closes all gaps. It generates the angel P, as ArcCos ¼ - ArcCos ½. Or we can take two tetrahedra with kissing and coincident faces and rotate via P along the remaining class of symmetry axes, which is the axis running through a vertex through the centroid and to the opposing face center. This generates J along the other axes. Although the two angles are irrational, the sum of J+J+P = 60˚. Think of the C5C calculous as allowing various vector algebraic circuits to dance between the sets of five $A_3 = D_3$ root vector polytope to form various Hamiltonian and Eulerian circuits.

The second reason we don’t project E_8 directly to 3D is because we desire the additional sign value that results, a chiral sign value as right or left. This will reveal itself to be crucial soon.

And how does the QSN relate to anyons versus an ordinary E_8 to 3D projection? My intuition on this is based on the hexagonal relationship of the cuboctahedral 5ths of each 20-group, which composite in groups of five to form the pentagonal association of the 20-group as a whole. [Here], Paredes comments, “For an anyon model to exist its fusion and braiding rules cannot be arbitrary. They have to fulfill a collection of consistency conditions which can be written as a set of equations, known as the Pentagon and Hexagon equations. An anyon model is therefore a solution of these equations.” As opposed to a textbook, that overview article and [this] one are highly recommended as an introduction to the motivation and basics of anyon quasiparticles.

A modern father of knot and braid theory is Louis Kauffman. He said of Fibonacci anyons, “Remarkably, this primitive Fibonacci particle takes part in a braided tensor category that generates a unitary representation of the Artin braid group that is dense in the unitary groups. This representation can be used for universal topological quantum computation and for studying quantum algorithms that compute Jones polynomials."

With respect to the topology of the unitary group, the set of all $n \times n$ complex matrices is homeomorphic to a $2n^2$-dimensional Euclidean space. Where n = 2, we may consider the 8 vectors of R_8 and attempt to relate this to the 8 + 240 dimensional E_8 Lie algebra. The Wikipedia article on the unitary group says something interesting, "… the splitting of U(n) as a semidirect product of SU(n) and U(1) induces a topological product structure on U(n), so that…

$$\pi_1(\mathrm{U}(n)) \cong \pi_1(\mathrm{SU}(n)) \times \pi_1(\mathrm{U}(1))$$

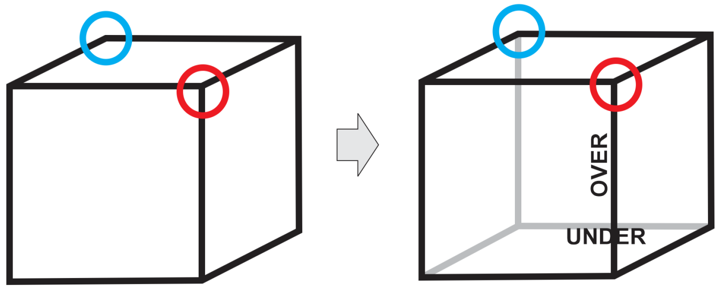
…

So far in this anyon section, I'm giving you my intuitions. Consider them as puzzle pieces for you to figure out how to assemble and make more sense of them. However, I will provide something more than an intuition. Anyons are abstract quasiparticles playing out in 2D. However, there are 3D anyons. This document is a good thing to study. And there are 3D anyon-based quasiparticles as composites of quantum correlated interacting planes of 2D anyons.

Paredes, in the above link, said, "…an anyon can be identified with an irreducible representation of the group of braids… …its non-Abelian character is a natural consequence of the composition of braids being non-commutative." 3D is special because it's the only dimension knots can exist in. Knot and braid theory are both deeply associated with anyon formalism.

Pretend the AB = P solution space is physically realistic. If it is, then the first principles physical explanation for the mathematical predictive power of the anyon formalism is based deeply on the 8D projection window to boundary window relationships and their transformations to the P solution space. I want to know this geometric isomorphism explanation for anyons before the tensor network isomorphism. The geometric version is less computation friendly for our simulation purposes on computers. But it provides the deep first principles foundation necessary for articulating the proper algebraic restrictions of the tensor network form of the AB = P solution space. One can implement the fusion rules in 2D with a very abstract notion of "over" and "under" and helicity. However, if these quantum statistical particles have their origins in the hyper-Euclidean vector algebra E_8, is there a less abstract geometric notion of over, under and handedness?

Here's part of my intuition on this. Consider a cube in 3D on the left. Don't imagine it yet as a projection. The red circle is closer to you than the blue. From your perspective, you might say, the red is over or on top of the plane where the blue circle is. On the right, we show the other sides of the cube. But now let us allow the representation to be a projection transform on the plane. Even though we have a 2D object, we can make a labeling scheme that correspond the edge cross point near the "over" and "under" words to be labeled abstractly with the notion of "over" and "under" in order to give diagrammatic information about the actual absolute relationship of the pre-transformed edges relative to the projective plane.



I presume the projective geometric approach of QGR to be sharply on the right track. And it is clear that anyon theory, with its abstract over/under braid theoretic fusion rules, is the irreducible way to understand quantum topological net quasiparticles. Therefore, the absolute pre-transformed over/under values of our edges and vertices in the hyper-lattice relative to the perpendicular space must deeply make contact with the anyon formalism. Someone open to my intuition on this subject and able to think deeply, creatively and rigorously must try to work it out.

THE EMPIRE WAVE

The last important puzzle piece of our spacetime code discrete quantum field theory program is the empire wave. We can derive the algebraic possibility space of sequences of AB = P solutions, each forming various patterns, some physically realistic and others not. However, there is probably no way our program can proceed without a clear understanding and, to start, a toy simulation of the empire wave. This is a statistical evolution of a topological quasiparticle in the QSN, where probability amplitude or statistical weightings are based strictly on the principle of least computational action. To more deeply decompose my explanation for our quantum clocks, it is highly recommended to carefully study the presentation *Quantum Clocks – Let's Get Physical* and to secure one-on-one time with me to satisfy all ambiguities that you will inevitably have from the review.