The Structure of Beethoven’s Grosse Fugue (Opus 133 and 134) corresponds to Cl(16) - E8 Physics (viXra 1810.0365) and the evolution of our Universe and Human civilization. Since Beethoven wrote the Grosse Fugue in 1825, two years before his death in 1827, and the E8 Lie Algebra and the Cl(16) Real Clifford Algebra were not known until the work of Lie, Killing, and Clifford in the 1870s-1880s, it was not possible for Beethoven to have used the math knowledge of his day in writing the Grosse Fugue. A possible explanation could be that (Appendix on Quantum Consciousness - page 24) our conscious brains have structure similar to the structure of Cl(16) - E8 so that when Beethoven was composing, looking deep inside his conscious brain to “hear” music mentally that he could not hear normally because of his deafness, he was “seeing” Cl(16) - E8. Human quantum consciousness is based on microtubules containing maximally about 65,536 Tubulin Dimers. E8 lives in the 65,536-dimensional Real Clifford Algebra Cl(16). Cl(16) is the basic structure of our Universe so Beethoven could have been “seeing” in his mind that the E8 inside Cl(16) looks like part of the structure of microtubules of his consciousness and then writing that structure into the Grosse Fugue.

The Grosse Fugue correspondences with Cl(16) - E8 are shown in this paper using visualizations by Stephen Malinowski. The Timetable of evolution of Human civilization is based on viXra 1810.0365 and this chart derived from it:
The Timetable of evolution of our Universe is based on this chart derived from a Fermilab chart:

The correspondences seem to me to be too extensive to be mere coincidence, although it is possible that I am just seeing what I want to see in the Grosse Fugue. Even so, the structural correspondence are useful to me (the music reinforces the math / physics and vice versa).

A similar line of reasoning might explain correspondences between Cl(16) - E8 Physics and the Archetype images of Jung’s Red Book (Appendix on Red Book Physics - page 38).
Beethoven wrote String Quartet Opus 135 in 1826, the year after writing the Grosse Fugue and the year before his death. Its last movement is headed “Der schwer gefasste Entschluss” (“The Difficult Decision”). In it Beethoven wrote in the manuscript “Muss es sein?” (Must it be?) to which he responds “Es muss sein!” (It must be?). (Wikipedia)

![Der schwer gefasste Entschluss.](image)

(My view is that Beethoven sees that the Grosse Fugue has the deep theoretical / historical correlations that I describe in this paper and that he is asking himself to make the Difficult Decision of whether or not those correspondences made it inevitable that he write the Grosse Fugue as he did write it and continue to support it despite the fierce dislike of it expressed by his audience and his publisher. His answer “Es muss sein!” is a declaration that the Grosse Fugue is as important and accurate as to theory and history as I think it is.

There are 3 Appendices to this paper:
Appendix I - Some details about Grosse Fugue Overture .... page 16
Appendix II - Quantum Consciousness ... page 24
Appendix III - Red Book Physics ... page 38
**Grosse Fugue** - Structural Correspondence with Cl(16) - E8 and History

0:04 4 Generators from M4 of Parent Universe - Clifford Iteration of M4 = Cl(16)
16-dim Cl(16) Vectors = Lie Sphere Bounded Domain with 8-dim Spacetime Lie Sphere Shilov Boundary

0:08 Overture - Quantum Fluctuation Vacuum Organizes Itself as Cl(16) containing E8
248-dim E8 = 120-dim Cl(16) BiVectors + 128-dim Cl(8) half-Spinors

Beethoven's Grosse Fugue Opus 133 Overture is an Outline of E8 Lie Algebra
560-dim Cl(16) Trivectors = 10 copies of 56-dim Fr3(O)
Fr3(O) = complexification of 27-dim J3(O) with traceless part = J3(O)o of 26D String=World-Line Theory
26D Clifford Algebra Cl(1,25) = Cl(0,26) = M(2,Cl(0,24)) = 2x2 Matrices of Cl(0,24)
Cl(0,24) = Cl(0,16) x Cl(0,8) by Real Clifford 8-Periodicity
Non-Unitary Octonionic Inflation and Creation of \(2^{256} = 10^{77}\) Particles

Everything is in Coherent Superposition
3:14 End of Inflation $10^{-34}$ sec $10^{14}$ GeV

Quantum Decoherence selects Initial Low Entropy Universe

No Reheating was needed because the Inflationary Universe was filled by Particles created by Non-Unitary Octonionic Processes.

4:43 Quaternionic Radiation Expansion Begins $10^{-33}$ sec $10^{13}$ GeV
5:00 Electroweak Symmetry Breaking $10^{-12}$ sec 250 GeV

5:34 Quark-Hadron Transition $10^{-6}$ sec 1 GeV
6:15 Nucleosynthesis 1 sec 10 MeV  Neutrino fog ends

7:22 Quaternionic Matter Expansion Begins  $10^{11}$ sec 1 KeV
Recombination Atoms Form at age $10^{13}$ sec 100,000 years 1 eV
Photon fog ends, Cosmic Microwave Background radiation at 3000 K then (2.75 K now)
Dark Age begins
10:00 First Stars burn H and He for heavy elements and photons to end Dark Age by Reionization at age \(400 \times 10^6\) years

10:37 Globular Clusters, then Galaxies, form \(10^9\) years
11:48 Dark Energy Accelerated Expansion begins at about $6 \times 10^9$ years = $7.5 \times 10^9$ years ago

12:22 Solar System $4.5 \times 10^9$ years ago
12:48 Earth 4.5 x 10^9 years ago

Moon by Collision 4.4 x 10^9 years ago

13:02 Bacteria Life 4 x 10^9 years ago
The big event around 2 x 10^9 years ago was the start of biological production of atmospheric Oxygen.

13:12 Cambrian explosion of Life 500 x 10^6 years ago
13:42 Dolphin Life 20 x 10^6 years ago

13:49 Humans Evolve in Africa 100,000 years ago

14:12 Hyperborean Spirit Consciousness Connects with Human Consciousness 50,000 years ago

Hyperborean / Human Connection is initially Harmonious but begins to degrade
14:57 African IFA - Lemurian Angkor Rig Veda - Atlantean Giza Britain America 40,000 years ago

15:09 Humans Disconnect from Hyperboreans after Flood 12,000 years ago Humans use Technological Consciousness

The Grosse Fugue History ends in 2012, as do the Mayan Calendar and the Timewave of Terence McKenna derived from the I Ching.

There are 3 Appendices to this paper:
Appendix I - Some details about Grosse Fugue Overture .... page 16
Appendix II - Quantum Consciousness ... page 24
Appendix III - Red Book Physics ... page 38
Visualizations of Beethoven’s Grosse Fugue (Opus 133) (about 16 minutes long) have been done by Stephen Malinowski
Its Primary Subject has 8 notes that can be seen as basis elements of 8-dimensional Euclidean Space

According to Wikipedia, it is played in every possible variation: fortissimo and pianissimo, different rhythms, upside down and backwards.

The E8 Lie Algebra is constructed from the largest possible consistent group of reflections in 8-dim Euclidean space, analogous to the variations of the Grosse Fugue Primary Subject.

The Overture to the Grosse Fugue (24 bars, about 40 seconds)"... presents ... the material that will make up the entire piece ...” (quote from Wikipedia)

Here is how those segments of the Overture correspond to E8 Lie Algebra structures:
The initial segment introduces the instruments of the String Quartet:

first violin; second violin; viola; cello

Statement of the 8 elements of the Main Fugal Subject

corresponds to the 8 dimensions of an Octonionic Vector Space.

E8 has a D8 subalgebra that acts as rotations / reflections in a 16-dimensional Space that is an 8-complex-dimensional Complex Domain known as a Lie Ball. The Shilov Boundary of the Lie Ball is an 8-real-dimensional Lie Sphere RP1 x S7 with symmetry Spin(10) / Spin(8) x U(1) corresponding to 8-dim Octonionic Spacetime and to the 8 elements of the First Fugue.
At low energies (relative to the Planck Energy) the Octonionic Symmetry of Spacetime breaks to Quaternionic Symmetry of (4+4)-dim Kaluza-Klein M4 x CP2

The M4 Physical Spacetime with Lie Sphere structure RP1 x S3 corresponds to 1 long note (time) and 3 medium notes (space).

The CP2 Internal Symmetry Space of CP2 = SU(3) / SU(2)xU(1) corresponds to 1 medium note, 2 short notes, and one complicated medium note.

The whole thing is repeated in 3 instruments (second violin, first violin, cello) to correspond to the 24-dim Leech Lattice and to the 3 Octonions of the 56-dimensional Fr3(O) Freudenthal Algebra (10 copies of which are Cl(16) TriVectors) Fr3(O) is the complexification of the 27-dimensional Jordan Algebra J3(O) whose traceless part J3(O)o is the basic structure of 26D String=World-Line Theory
Repetition of Main Fugal Subject twice, in diminution corresponds to the two D4 subalgebras in the D8 subalgebra of E8.

As to what effects the Grosse Fugue Overture music and animation have on my feelings compared to effects of the D4 subalgebras of E8 Physics,

When I hear the Grosse Fugue Overture two-part sample of music and see the animation of it I get feelings that are specific to that experience. It is reproducible: the same hearing / seeing gives the same feeling.

I also work on the physics of the Cl(16) Clifford Algebra which contains E8 Lie Algebra which contains two D4 subalgebras - one D4 for Gravity+Dark Energy and another D4 for Standard Model with Color Force. When I think of the Gravity D4 and the Color Force D4 I get exactly the same feeling as from the two-part sample of the Grosse Fuge Overture.

The feeling for the first of the two parts (the 12 notes in the cyan boxes - 8 blue of Gravity and 4 red of Dark Energy) is the same as the feeling for Gravity D4.

The feeling for the second of the two parts (the 6 notes (blue) in the magenta boxes) is the same as the feeling for Color Force D4.

I hypothesize that the same patterns of Tubulin excitations in my brain Microtubules are activated by the Grosse Fugue experiences and by the Gravity - Color Force D4 subalgebras of E8 in Cl(16).
The Main Fugal Subject again (first violin) corresponding to 8 Fermion Particles of the First Generation.

Its three recapitulations (second violin, viola, cello) correspond to the 3 Generations of Fermions.
Statement of the Other Fugal Subject with 12 + 16 elements corresponding to the 12-element Standard Model SU(3) x SU(2) x U(1) and to the 16-element Conformal Gravity+Dark Energy U(2,2) of the two 28-dimensional D4 subalgebras of the D8 subalgebra of E8.

Statement of the First Subject in the cello corresponding to 8 Fermion AntiParticles of the First Generation.

On the following page is a summary diagram of the Grosse Fugue Overture and E8.
Beethoven's Grosse Fuge Opus 133 Overture

E8 Lattice 8-dim Spacetime
E8 x E8 x E8 = 24-dim Leech Lattice of 260 Strings=World-Line Theory

Gravity D4
12 Standard Model Ghosts
4 Gravity Ghosts are sterile

M4
M4 x CP2 Kaluza-Klein Quaternionic Spacetime

CP2 = SU(3)/U(2)

12 SU(2,2) Root Vectors

8 Standard Model Root Vectors

8 Fermion Particles

3 Generations of Fermions

12 SU(3)xSU(2)xU(1)

16 U(2,2)

8 Fermion Antiparticles

Beethoven's Grosse Fuge Opus 133 Overture is an Outline of E8 Lie Algebra
The Algebraic Quantum Field Theory (AQFT) structure of the Bohm Quantum Potential of 26D String Theory is given by the Cl(16) Physics Local Lagrangian

\[ \int \text{Gauge Gravity} + \text{Standard Model} + \text{Fermion Particle-AntiParticle} \]

8-dim SpaceTime

and by 8-Periodicity of Real Clifford Algebras, as the Completion of the Union of all Tensor Products of the form

\[ \text{Cl}(1,25) \times \ldots (N \text{ times tensor product}) \ldots \times \text{Cl}(1,25) \]

which is analogous to Fock Space Hyperfinite II1 von Neumann factor algebra that is based on 2-Periodicity of Complex Clifford Algebras.

For \( N = 2^8 = 256 \) the copies of Cl(1,25) are on the 256 vertices of the 8-dim HyperCube

For \( N = 2^{16} = 65,536 = 4^8 \) the copies of Cl(1,25) fill in the 8-dim HyperCube as described by William Gilbert’s web page: “... The n-bit reflected binary Gray code will describe a path on the edges of an n-dimensional cube that can be used as the initial stage of a Hilbert curve that will fill an n-dimensional cube. ...”.

The vertices of the Hilbert curve are at the centers of the \( 2^8 \) sub-8-HyperCubes whose edge lengths are 1/2 of the edge lengths of the original 8-dim HyperCube.

As \( N \) grows, the copies of Cl(1,25) continue to fill the 8-dim HyperCube of E8 Space Time using higher Hilbert curve stages from the 8-bit reflected binary Gray code subdividing the initial 8-dim HyperCube into more and more sub-HyperCubes.

If edges of sub-HyperCubes, equal to the distance between adjacent copies of Cl(1,25), remain constantly at the Planck Length, then the full 8-dim HyperCube of our Universe expands as \( N \) grows to \( 2^{16} \) and beyond similarly to the way shown by this 3-HyperCube example for \( N = 2^3, 4^3, 8^3 \) from William Gilbert’s web page:
The Union of all Cl(1,25) tensor products is the Union of all subdivided 8-HyperCubes and their Completion is a huge superposition of 8-HyperCube Continuous Volumes which Completion belongs to the Third Grothendieck Universe.

26D String Theory Structure is

Green, Schwartz, and Witten, in "Superstring Theory" vol. 1, describe 26D String Theory saying ".... The first excited level ... consists of ... the ground state ... tachyon ... and ... a scalar ... 'dilaton' ... and ... SO(24) ... little group of a ...[26-dim]... massless particle ... and ... a ... massless ... spin two state ...".
Tachyons localized at orbifolds of fermions produce virtual clouds of particles / antiparticles that dress fermions by filling their Schwinger Source regions.

Dilatons are Goldstone bosons of spontaneously broken scale invariance that (analogous to Higgs) go from mediating a long-range scalar gravity-type force to the nonlocality of the Bohm-Sarfatti Quantum Potential.

The SO(24) little group is related to the Monster automorphism group that is the symmetry of each cell of Planck-scale local lattice structure.

\[
\text{The massless spin 2 state} = \text{Bohmion} = \text{Carrier of the Bohm Force of the Bohm Quantum Potential.}
\]

Similarity of the spin 2 Bohmion to the spin 2 Graviton accounts for the Bohmion’s ability to support Penrose Consciousness with Superposition Separation Energy Difference \( G \frac{m^2}{a} \) where, for a Human Brain, \( m = \) mass of electron and \( a = 1 \) nanometer in Tubulin Dimer

“... Bohm’s Quantum Potential can be viewed as an internal energy of a quantum system ...”

according to Dennis, de Gosson, and Hiley (arXiv 1412.5133) and

Bohm Quantum Potential inherits Sarfatti Back-Reaction from its spin-2 structure similar to General Relativity

Peter R. Holland says in "The Quantum Theory of Motion" (Cambridge 1993):
"... the total force ... from the quantum potential ... does not ... fall off with distance ... because ... the quantum potential ... depends on the form of ...[the quantum state]... rather than ... its ... magnitude ...".

Penrose-Hameroff-type Quantum Consciousness is due to Resonant Quantum Potential Connections among Quantum State Forms.

The Quantum State Form of a Conscious Brain is determined by the configuration of a subset of its \( 10^{18} \) to \( 10^{19} \) Tubulin Dimers described by a large Real Clifford Algebra. Paola Zizzi in gr-qc/0007006 describes the Octonionic Inflation Era of Our Universe as a Quantum Consciousness Superposition of States ending with Self-Decoherence after 64 doublings of Octonionic Inflation, at which time Our Universe is “... a superposed state of quantum ... [ qubits ].

the self-reduction of the superposed quantum state is ... reached at the end of inflation ...[at]... the decoherence time ... [ Tdecoh = 10^9 Tplanck = 10^8(34) sec ] ...

and corresponds to a superposed state of ... [ \( 10^{19} = 2^{64} \) qubits ]. ...".

64 doublings to \( 2^{64} \) qubits corresponds to the Clifford algebra

\[
\text{Cl}(64) = \text{Cl}(8x8) = \text{Cl}(8) \times \text{Cl}(8) \times \text{Cl}(8) \times \text{Cl}(8) \times \text{Cl}(8) \times \text{Cl}(8) \times \text{Cl}(8) \times \text{Cl}(8) = \text{Cl}(8) \times \text{Cl}(8)
\]

By the periodicity-8 theorem of Real Clifford algebras, \( \text{Cl}(64) \) is the smallest Real Clifford algebra for which we can reflexively identify each component \( \text{Cl}(8) \) with a basis vector in the \( \text{Cl}(8) \) vector space.

This reflexive identification causes our universe to decohere at \( N = 2^{64} = 10^{19} \).
Octonionic Quantum Processes are Not Unitary and so can produce Fermions. (see Stephen Adler's book "Quaternionic Quantum Mechanics..." at pages 50-52 and 561).

At the end of 64 Unfoldings, Non-Unitary Octonionic Inflation ended having produced about \((1/2) \cdot 16^{64} = (1/2) \cdot (2^4)^{64} = 2^{255} = 6 \times 10^{76}\) Fermions.

At the End of Inflation Our Universe had Temperature / Energy \(10^{27} \text{ K} = 10^{14} \text{ GeV}\) so each of the \(10^{77}\) Fermions had energy of \(10^{14} \text{ GeV}\) and collisions among them would for each of the \(10^{77}\) Fermions produce jets containing about \(10^{12}\) particles of energy 100 GeV or so that the total number created by Inflation was about \(10^{89}\).

The End of Inflation time was at about \(10^{(-34)} \text{ sec} = 2^{64} \text{ Tplanck}\)

and the size of our Universe was then about \(10^{(24)} \text{ cm}\)

which is about the size of a Fermion Schwinger Source Kerr-Newman Cloud.

The \(2^{64}\) qubits created by Inflation is roughly \(10^{19}\) which is roughly the number of Quantum Consciousness Tubulins in the Human Brain.

Therefore

the Human Brain Quantum Consciousness has evolved in Our Universe to be roughly equivalent to the Maximum Consciousness of Our Inflationary Era Universe.

Further, each cell of E8 Lagrangian Spacetime corresponds to \(65,536\)-dim Cl(16)

which contains \(248\)-dim E8 = \(120\)-dim D8 bivectors +\(128\)-dim D8 half-spinors

Human Brain Microtubules 40 microns long have \(65,536\) Tubulin Dimers

![Image](image adapted from 12biophys.blogspot.com Lecture 11)

and so can have Bohm Quantum Resonance with Cl(16) Spacetime cells so that at any and all Times the State of Consciousness of a Human is in exact resonant correspondence with a subset of the cells of E8 Classical Lagrangian Spacetime.

Therefore

E8 Lagrangian Spacetime (as a Nambu-Jona-Lasinio Condensate) is effectively the Spirit World in which the Human States of Consciousness = Souls exist.

After the death of the Human Physical Body the Spirit World interactions with its Soul are no longer constrained by Physical World interactions with its Body so that the Spirit World can harmonize the individual Soul with the collective Universal Soul.
A Single Cell of E8 26-dimensional Bosonic String Theory, in which Strings are physically interpreted as World-Lines, can be described by taking the quotient of its 24-dimensional O+, O-, Ov subspace modulo the 24-dimensional Leech lattice. Its automorphism group is the largest finite sporadic group, the Monster Group, whose order is:

\[ 8080, 17424, 79451, 28758, 86459, 90496, 17107, 57005, 75436, 80000, 00000 = 2^{46} \cdot 3^{20} \cdot 5^{9} \cdot 7^{6} \cdot 11^{2} \cdot 13^{3} \cdot 17 \cdot 19 \cdot 23 \cdot 29 \cdot 31 \cdot 41 \cdot 47 \cdot 59 \cdot 71 \]
or about \( 8 \times 10^{53} \).

"... Bohm’s Quantum Potential can be viewed as an internal energy of a quantum system ..." according to Dennis, de Gosson, and Hiley (arXiv 1412.5133) and Peter R. Holland says in "The Quantum Theory of Motion" (Cambridge 1993): "... the total force ... from the quantum potential ... does not ... fall off with distance ... because ... the quantum potential ... depends on the form of ...[the quantum state]... rather than ... its ... magnitude ...".

Penrose-Hameroff-type Quantum Consciousness is due to Resonant Quantum Potential Connections among Quantum State Forms. The Quantum State Form of a Conscious Brain is determined by the configuration of a subset of its \( 10^{18} \) to \( 10^{19} \) Tubulin Dimers with math description in terms of a large Real Clifford Algebra:

Resonance is discussed by Carver Mead in “Collective Electrodynamics" (MIT 2000):

"... we can build ... a resonator from ... electric dipole ... configuration[s] ...

[ such as Tubulin Dimers ]

Because there are charges at the two ends of the dipole, we can have a contribution to the electric coupling from the scalar potential ... as well [as] from the magnetic coupling ... from the vector potential ... electric dipole coupling is stronger than magnetic dipole coupling ... the coupling of ... two ... configurations ... is the same, whether retarded or advanced potentials are used. Any ... configuration ... couples to any other on its light cone, whether past or future. ... The total phase accumulation in a ... configuration ... is the sum of that due to its own current, and that due to currents in other ... configurations ... far away ...
The energy in a single resonator alternates between the kinetic energy of the electrons (inductance), and the potential energy of the electrons (capacitance). With the two resonators coupled, the energy shifts back and forth between the two resonators in such a way that the total energy is constant ... The conservation of energy holds despite an arbitrary separation between the resonators ... Instead of scaling linearly with the number of charges that take part in the motion, the momentum of a collective system scales as the square of the number of charges! ... The inertia of a collective system, however, is a manifestation of the interaction, and cannot be assigned to the elements separately. ... Thus, it is clear that collective quantum systems do not have a classical correspondence limit. ...".
For the $10^{18}$ Tubulin Dimers of the human brain, the resonant frequencies are the same and exchanges of energy among them act to keep them locked in a Quantum Protectorate collective coherent state.

Philip W. Anderson in cond-mat/0007287 and cond-mat/007185 said: "... Laughlin and Pines have introduced the term "Quantum protectorate" as a general descriptor of the fact that certain states of quantum many-body systems exhibit properties which are unaffected by imperfections, impurities and thermal fluctuations. They instance ... flux quantization in superconductors, equivalent to the Josephson frequency relation which again has mensuration accuracy and is independent of imperfections and scattering. ...

... the source of quantum protection is a collective state of the quantum field involved such that the individual particles are sufficiently tightly coupled that elementary excitations no longer involve a few particles but are collective excitations of the whole system, and therefore, macroscopic behavior is mostly determined by overall conservation laws ... a "quantum protectorate" ...[ is ]... a state in which the manybody correlations are so strong that the dynamics can no longer be described in terms of individual particles, and therefore perturbations which scatter individual particles are not effective ...

Mershin, Sanabria, Miller, Nawarathna, Skoulakis, Mavromatos, Kolomenskii, Scheussler, Ludena, and Nanopoulos in physics/0505080 “Towards Experimental Tests of Quantum Effects in Cytoskeletal Proteins” said:

Classically, the various dimers can only be in the ...[ ... ]... conformations. Each dimer is influenced by the neighboring dimers resulting in the possibility of a transition. This is the basis for classical information processing, which constitutes the picture of a (classical) cellular automaton.

If we assume ... that each dimer can find itself in a QM superposition of ...[ those ]... states, a quantum nature results. Tubulin can then be viewed as a typical two-state quantum mechanical system, where the dimers couple to conformational changes with $10^{-9} - 10^{-11}$ sec transitions, corresponding to an angular frequency $\sim 10^{10} - 10^{12}$ Hz. In this approximation, the upper bound of this frequency range is assumed to represent (in order of magnitude) the characteristic frequency of the dimers, viewed as a two-state quantum-mechanical system ...

The Energy Gap of our Universe as superconductor condensate spacetime is from $3 \times 10^{(-18)}$ Hz (radius of universe) to $3 \times 10^{43}$ Hz (Planck length). Its RMS amplitude is $10^{13}$ Hz = 10 THz = energy of neutrino masses = critical temperature $T_c$ of BSCCO superconducting crystal Josephson Junctions]...

large-scale quantum coherence ...[ has been observed ]... at temperatures within a factor of three of biological temperatures. MRI magnets contain hundreds of miles of superconducting wire and routinely carry a persistent current. There is no distance limit - the macroscopic wave function of the superfluid condensate of electron pairs, or Cooper pairs, in a sufficiently long cable could maintain its quantum phase coherence for many thousands of miles ... there is no limit to the total mass of the electrons participating in the superfluid state. The condensate is “protected” from thermal fluctuations by the BCS energy gap at the Fermi surface ... The term “quantum protectorate” ... describe[s] this and related many-body systems ...".
The Human Brain has about $10^{11}$ Neuron cells, each about 1,000 nm in size. The cytoskeleton of cells, including neurons of the brain, is made up of Microtubules.

Each Neuron contains about $10^9$ Tubulin Dimers, organized into Microtubules some of which are organized by a Centrosome. Centrosomes contain a pair of Centrioles.

A Centriole is about 200 nm wide and 400 nm long. Its wall is made up of 9 groups of 3 Microtubules, reflecting the symmetry of 27-dim $J(3,0)$.
Each Microtubule is a hollow cylindrical tube with about 25 nm outside diameter and 14 nm inside diameter, made up of 13 columns of Tubulin Dimers

Each Tubulin Dimer is about 8 nm x 4 nm x 4 nm, consists of two parts, alpha-tubulin and beta-tubulin (each made up of about 450 Amino Acids, each containing roughly 20 Atoms) A Microtubule 40 microns = 40,000 nm long contains 13 x 40,000 / 8 = 65,000 Dimers

The black dots indicate the position of the Conformation Electrons.

There are two energetically distinct configurations for the Tubulin Dimers:
- Conformation Electrons Similarly Aligned (left image) - State 0
- Conformation Electrons Maximally Separated (right image) - State 1

The two structures - State 0 ground state and State 1 higher energy state - make Tubulin Dimers the basis for a Microtubule binary math / code system.
Microtubule binary math / code system corresponds to Clifford Algebras $\text{Cl}(8)$ and $\text{Cl}(8) \times \text{Cl}(8) = \text{Cl}(16)$ containing 16-dim $V_{16}$ (magenta) and 120 (inside purple outline) + 128-dim (yellow green red) = 248-dim E8 and 560 (inside black outline) 10 copies of 56-dim Fr3(O):

That leaves 1 (orange) + and 127 (blue) = 128-dim Mirror Fermion half-spinors and 65,536 - 256 - 560 - 120 - 16 = 64,584 elements of $\text{Cl}(16)$ available to carry information in the processes of Quantum Consciousness.

According to 12biophys.blogspot.com Lecture 11 Microtubule structure is dynamic: “... One end of the microtubule is composed of stable (GTP) monomers while the rest of the tubule is made up of unstable (GDP) monomers. The GTP end comprises a cap of stable monomers. Random fluctuations either increase or decrease the size of the cap.
This results in 2 different dynamic states for the microtubule. 
Growing: cap is present 
Shrinking: cap is gone ...

Microtubules spend most of their lives between 10 microns and 40 microns, sizes that can represent E8 as half of the Even Part (half) of Cl(16) (10 microns) or as the Even Part (half) of Cl(16) (20 microns) or as full Cl(16) (40 microns).

In a given Microtubule
the 128 Cl(8) Half-Spinor part is represented by a line of 128 Dimers in its stable GTP region and
the 120 Cl(16) BiVector part by a 12 x 10 block of Dimers in its stable GTP region
The 560 Cl(16) TriVector part is represented similarly.

(image adapted from 12biophys.blogspot.com Lecture 11)
How do the Microtubules communicate with each other?

Consider the Superposition of States State 0 and State 1 involving one Tubulin Dimer with Conformation Electron mass m and State1 / State 0 position separation a.

The Superposition Separation Energy Difference is the internal energy

\[ E_{ssediff} = G \frac{m^2}{a} \]

that can be seen as either the energy of 26D String Theory spin two gravitons or the Bohm Quantum Potential internal energy, equivalently.
Communication between two Microtubules is by the Bohm Quantum Potential between their respective corresponding Dimers with the correspondence being based on connection between respective E8 and Fr3(O) subsets.

How is information encoded in the Microtubules?

Each Microtubule contains E8 and Fr3(O), allowing Microtubules to be correlated with each other. The parts of the Microtubule beyond E8 and Fr3(O) are in Cl(16) for 40 micron Microtubules, or the Even Subalgebra of Cl(16) for 20 micron Microtubules, or half of the Even Subalgebra of Cl(16) for 10 micron Microtubules so since by 8-Periodicity of Real Clifford Algebras Cl(16) = Cl(8) x Cl(8) and since Cl(8) information is described by the Quantum Reed-Muller code [[256, 0, 24]] the information content of Cl(16) and its Subalgebras is described by the Tensor Product Quantum Reed-Muller code [[256, 0, 24]] x [[256, 0, 24]].

What about information in the Many Microtubules of Human Consciousness?

The information in one Microtubule is based on Cl(16) which is contained in the Cl(1,25) of 26D String Theory E8 Physics.

How does this give rise to Penrose-Hameroff Quantum Consciousness?

Consider the Superposition of States State 0 and State 1 involving one Tubulin Dimer with Conformation Electron mass m and State1 / State 0 position separation a.
The Superposition Separation Energy Difference is the internal energy

\[ E_{ssediff} = G \frac{m^2}{a} \]

that can be seen as the energy of 26D String Theory spin two gravitons which physically represent the Bohm Quantum Potential internal energy. For a given Tubulin Dimer a = 1 nanometer = 10^(-7) cm so that

\[ T = \frac{\hbar}{E_{electron}} = \left( \frac{\text{Compton}}{\text{Schwarzschild}} \right) \left( \frac{a}{c} \right) = 10^{26} \text{ sec} = 10^{19} \text{ years} \]
Now consider the case of $N$ Tubulin Dimers in Coherent Superposition connected by the Bohm Quantum Potential Force that does not fall off with distance. Jack Sarfatti defines coherence length $L$ by $L^3 = N a^3$ so that the Superposition Energy $E_N$ of $N$ superposed Conformation Electrons is

$$E_N = \frac{G M^2}{L} = N^{(5/3)} E_{ssediff}$$

The decoherence time for the system of $N$ Tubulin Electrons is

$$T_N = \frac{h}{E_N} = \frac{h}{N^{(5/3)} E_{ssediff}} = N^{-5/3} 10^{26} \text{ sec}$$

so we have the following rough approximate Decoherence Times $T_N$

<table>
<thead>
<tr>
<th>Number of Involved Tubulin Dimers</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{(11+9)} = 10^{20}$</td>
<td>$10^{(-33 + 26)} = 10^{(-7)} \text{ sec}$</td>
</tr>
<tr>
<td>$10^{20}$ Tubulin Dimers in Human Brain</td>
<td></td>
</tr>
<tr>
<td>$10^{16}$</td>
<td>$10^{(-27 + 26)} = 10^{(-1)} \text{ sec}$</td>
</tr>
<tr>
<td>Human Alpha EEG is 8 to 13 Hz</td>
<td></td>
</tr>
<tr>
<td>Fundamental Schumann Resonance is 7.8 Hz</td>
<td></td>
</tr>
<tr>
<td>Time of Traverse by a String World-Line Quantum Bohmion of a Quantum Consciousness Hamiltonian Circuit of $10^{16}$ TD separated from nearest neighbors by 10 nm is $10^{16} x 10 \text{ nm} / c = (10^{16} x 10^{(-6)}) \text{ cm} / c = 10^{10} \text{ cm} / c = 0.3 \text{ sec}$</td>
<td></td>
</tr>
</tbody>
</table>
Each cell of E8 Classical Lagrangian Spacetime corresponds to 65,536-dim Cl(16) which contains 248-dim E8 = 120-dim D8 bivectors +128-dim D8 half-spinors

In E8 Physics (viXra 1602.0319)

**Spacetime is the 8-dimensional Shilov Boundary RP1 x S7**

of the **Type IV8 Bounded Complex Domain Bulk Space**

of the Symmetric Space Spin(10) / Spin(8)xU(1)

which **Bulk Space** has 16 Real dimensions

and is the Vector Space of the Real Clifford Algebra Cl(16).

By 8-Periodicity,

Cl(16) = tensor product Cl(8) x Cl(8) = Real 256x256 Matrix Algebra M(R,256)

and so has 256x256 = 65,536 elements.

Cl(8) has 8 Vectors, 28 BiVectors, and 16 Spinors with 8+28+16 = 52 = F4 Lie Algebra.

Cl(16) has 120 BiVectors and 128 Half-Spinors for 120+128 = 248 = E8 Lie Algebra giving a Lagrangian for the Standard Model and for Gravity - Dark Energy.

Cl(16) has 560 TriVectors for 10 copies of Fr3(O) and Cl(1,25) AQFT

so 65,536 - 248 - 560 = 64,728 elements of Cl(16) are for Consciousness Information.

The Complex Bulk Space Cl(16) contains the Maximal Contraction of E8 which is H92 + A7 a generalized Heisenberg Algebra of Quantum Creation-Annihilation Operators with graded structure

\[ 28 + 64 + ((\text{SL}(8,R)+1) + 64 + 28 \]
Human Brain Microtubules 40 microns long have 65,536 Tubulin Dimers and so can have Bohm Quantum Resonance with Cl(16) Spacetime cells.

Therefore, E8 Classical Lagrangian Spacetime NJL Condensate is effectively the Spirit World in which the Human States of Consciousness = Souls exist. After the death of the Human Physical Body the Spirit World interactions with its Soul are no longer constrained by Physical World interactions with its Body so that the Spirit World can harmonize the individual Soul with the collective Universal Soul. William Kingdon Clifford, who invented Real Clifford Algebras, called them “mind-stuff”, saying: “…When matter takes the complex form of a living human brain, the corresponding mind-stuff takes the form of a human consciousness …”.

So that at any and all Times
the State of Consciousness of a Human
is in exact resonant correspondence with
a subset of the cells of E8 Classical Lagrangian Spacetime

Void \rightarrow Cl(16) \rightarrow Cl(4) \rightarrow Cl(1) \rightarrow Cl(2) \rightarrow Cl(4) \rightarrow Cl(16)
How Jung’s Red Book Archetypes connect with E8 - Cl(16) Physics

Frank Dodd (Tony) Smith, Jr. - 2018

The first five pages after the cover summarize the rest of this paper.
CLIFFORD ALGEBRAS to E8

CLIFFORD EVOLUTION of OUR UNIVERSE

CREATION - OCTONIONIC NON-UNITARY INFLATION

28+64+28 = 120 D8 = 4X32 = 128 D8 HALF-SPINOR

E8 - PARTICLES and FORCES - 8D LAGRANGIAN - TRIALITY
E8 HEISENBERG CREATION-ANNIHILATION - 28+64+(63+1)+64=28

AFTER INFLATION - QUATERNIONIC UNITARY EXPANSION now - DE : DM : OM = 0.75 : 0.21 : 0.04

E8 = H4 STANDARD MODEL CP2 + H4 GRAVITY+DARK ENERGY M4 STRINGS = WORLD LINES 26D STRING THEORY - SPIN-2 BOHMIONS QUANTUM BLOCKCHAINS OF SCHWINGER SOURCES
HIGGS = NAMBU-JONA-LASINIO TRUTH QUARK COMPOSITE
FERMILAB TRUTH QUARK MASSES 130 GeV - 174 GeV - 220 GeV
CMS HIGGS MASSES 125 GeV - 195 GeV - 260 GeV

M4xCP2 KALUZA-KLEIN - MAYER HIGGS - 3 FERMION GENERATIONS

FERMION OCTONIONIC BRAIDS - FERMION MASSES
D4 STANDARD MODEL and GRAVITY+DE GHOSTS
D4 GRAVITY+DE and STANDARD MODEL GHOSTS

FORCE STRENGTHS - 4D LAGRANGIAN - CALCULATION RESULTS

E8 - H4 - F4 - D4 - D3=A3 - H3 - H2=PENROSE STAR
William Kingdon Clifford (1845 - 1879) described Geometry in terms of his invention: Real Clifford Algebras, which he called “mind-stuff”, saying:

“... That element of which ... even the simplest feeling is a complex, I shall call Mind-stuff.

A moving molecule of inorganic matter does not possess mind or consciousness; but it possesses a small piece of mind-stuff. ...

When molecules are ... combined together ... the elements of mind-stuff which go along with them ... combine ... to form the ... beginnings of Sentience. When the molecules are so combined as to form the brain and nervous system ... the corresponding elements of mind-stuff are so combined as to form some kind of consciousness ... changes in the complex which take place at the same time get so linked together that the repetition of one implies the repetition of the other. When matter takes the complex form of a living human brain, the corresponding mind-stuff takes the form of a human consciousness ...”.

Clifford Algebra = Algebra of Spaces = = Fundamental Human Understanding

For our 3-dim Space with coordinates x y z

Cl(3) describes
1 - all of 3-space itself

3 - three types of planes in space:
xy yz zx

3 - three types of lines / directions in space:
x y z

1 - one type of 0-dim point

so
Cl(3) of 3-dim space has total dimension
1+3+3+1 = 2^3 = 8
Generally, Cl(N) of N-dim space has dimension $2^N$ so the process of forming Clifford Algebra creates $2^N$-dim spaces from N-dim spaces.

This is how our universe grew from nothing:

| Cl(VOID) | 0 | $2^0=1$ | Cl(0) | $2^1=2$ | Cl(1) | $2^2=4$ | Cl(2) | $2^4=16$ | Cl(4) | $2^8=256$ | Cl(8) | $2^{16}=65536$ | Cl(16) | $256 \times 256$ | Cl(8) $\times$ Cl(8) |
Cl(16) = $2^{16} = 65,536$ dimensions with graded structure

The 120 grade-2 BiVectors form the D8 Lie Algebra that is related to rotations in 16-dim space

The Real Clifford Algebra Cl(16) = 256 x 256 Real Matrix Algebra

The 256 first-column-vectors are the Spinors of D8 that are related to entanglement of connections to 16-dim space

The 256 D8 Spinors break down into two half-Spinors:

$256 = 128 + 128$

The 128 and 128 half-spinors are mirror images of each other so 128 can describe all useful physics by itself.

120 D8 BiVectors + 128 D8 half-Spinors = 248-dim E8
248-dim E8 lives in Cl(16) containing 120-dim D8 biVectors of Cl(16)

E8 / D8 = 64 + 64 Fermions = 128-dim D8 half-Spinors of Cl(16)

D8 / D4 x D4 = 64 Spacetime

D4 = 28 Standard Model (12) with 16 Gravity + Dark Energy Ghosts

D4 = 28 Gravity + Dark Energy (16) with 12 Standard Model Ghosts
The completion of the union of all tensor products of \( \text{Cl}(8) = \text{Cl}(8) \times \text{Cl}(8) \) produces a generalized hyperfinite III von Neumann factor that gives the \( \text{Cl}(16) \)-E8 model a natural Algebraic Quantum Field Theory.

The \( \text{Cl}(16) \)-E8 AQFT inherits structure from the \( \text{Cl}(16) \)-E8 Local Lagrangian.

The Creation-Anihilation Operator structure of \( \text{Cl}(16) \)-E8 AQFT is given by the Maximal Contraction of E8 = semidirect product \( A7 \times U(2) \) where \( U(2) = U(1) \oplus U(1) = 105 \)-dim Heisenberg algebra and \( A7 = 63 \)-dim SU(8).

240 E8 Root Vectors

```
1/2 = 56 + 56 = (24+32) + (24+32)
1/2 = 1 + 126 + 56
```

Timelike AntiNeutrino + 1 + +

SU(2)

126

E7

56

1

Timelike Neutrino
When Our Planck Scale Universe emerged from its Parent Universe by Quantum Fluctuation it was described by SO(16) symmetry of Compact E8(-248). E8 Compact Form E8(-248) with Symmetric Space E8 / Spin(16) represents Our Planck Scale Universe when it emerged from its Parent Universe by Quantum Fluctuation.
E8 Split Form EVIII E8(8) with Symmetric Space E8 / SO(8,8) represents Our Universe during Octonionic Inflation with Non-Unitary Quantum Processes.
D4

8x8 = 64

D4
Lagrangian

D8 / D4x4

D4_{sm}

D4_{gde}

E8 / D8

CP2

8 x 8 position x momentum

A7+1

M4

the Octonionic Inflation Unfolding Process creates Fermion Particles with no Antiparticles
Creation-Annihilation Operators for 8 components of 8+8 Fermions are odd-grade+/-1 part of E8 Maximal Contraction generalized Heisenberg Algebra

\[ h^{92} \times A7 = 28 + 64 + (\text{SL}(8,\mathbb{R})+1) + 64 + 28 \]

At the end of Non-Unitary Octonionic Inflation Our Universe had about \(\frac{1}{2} \times 16^{64} = \frac{1}{2} \times (2^4)^{64} = 2^{255} = 6 \times 10^{76}\) Fermion Particles.

The size of our Universe was then about \(10^{24}\) cm, which is about the size of a Fermion Schwinger Source Kerr-Newman Cloud.

The End of Inflation time was at about \(10^{34}\) sec = \(2^{64}\) Tplanck.

The Zizzi Inflation phase of our universe ends with decoherence "collapse" of the \(2^{64}\) Superposition Inflated Universe into Many Worlds of Quantum Theory.

Paola Zizzi in gr-qc/0007006:

"... The self-reduction of the superposed quantum state ... corresponds to a superposed state of... \([10^{19} = 2^{64}\) qubits]\)... also the number of superposed tubulins-qubits in our brain... leading to a conscious event. ..."
Inflation ends when a preferred Quaternionic Subspacetime freezes out, converting 8 dim Spacetime into 4+4 dim M4 x CP2 Spacetime where M4 = Physical Minkowski Spacetime and CP2 = SU(3) / U(2) Internal Symmetry Space. Octonionic Integral becomes two Quaternionic Integrals.

8-dim Octonionic Spacetime was broken into (4+4)-dim Unitary Quaternionic M4 x CP2 Kaluza-Klein Spacetime with SO*(16) symmetry of EIX E8(-24). That transition was a Weyl Unitary Trick within E8(8) from SO(8,8) to SO*(16) followed by a shifting of SO*(16) symmetry from E8(8) to E8(-24). E8 form EIX E8(-24) with Symmetric Space E8 / SO*(16) represents Our Universe after End of Inflation.
The Cl(16)-E8 AQFT inherits structure from the C(16)-E8 Local Lagrangian

\[
\int \text{Standard Model Gauge Gravity} + \text{Fermion Particle-AntiParticle}
\]

8-dim SpaceTime

the Cl(16)-E8 model at the Planck Scale has spacetime condensing out of Clifford structures forming a Leech lattice underlying 26-dim String Theory of World-Lines with \(8 + 8 + 8 = 24\) dim of fermion particles and antiparticles and of spacetime.

Slices of \(8v\) SpaceTime are represented as D8 branes. Each D8 brane has Planck-Scale Lattice Structure superpositions of 8 types of E8 Lattice denoted by 1E8, iE8, jE8, kE8, EE8, iE8, jE8, kE8

Stack D8 branes to get SpaceTime with Strings = World-Lines

Let Oct16 = discrete multiplicative group \(\{+/-1, +/-i, +/-j, +/-k, +/-e, +/-l, +/-j, +/-k\}\).

Orbifold by Oct16 the \(8s+\) to get 8 Fermion Particle Types

Orbifold by Oct16 the \(8s-\) to get 8 Fermion AntiParticle Types

Gauge Bosons from 1E8 and EE8 parts of a D8 give U(2) Electroweak Force

Gauge Bosons from 1E8, jE8, kE8, and EE8 parts of a D8 give SU(3) Color Force

Gauge Bosons from 1E8, iE8, jE8, and kE8 parts of a D8 give U(2,2) Conformal Gravity

The 8x8 matrices for collective coordinates linking one D8 to the next D8 give Position x Momentum

The automorphism group of a single 26-dim String Theory cell modulo the Leech lattice is the Monster Group of order about \(8 \times 10^{53}\).

When a fermion particle/antiparticle appears Tachyons create a cloud of particles/antiparticles. The cloud is one Planck-scale Fundamental Fermion Valence Particle plus an effectively neutral cloud of particle/antiparticle pairs forming a Kerr-Newman black hole. That cloud constitutes the Schwinger Source.

The Schwinger Sources are finite regions in a Complex Domain spacetime corresponding to Green's functions of particle creation / annihilation.

Its structure comes from the 24-dim Leech lattice part of the Monster Group which is \(2^{4}(1+24)\) times the double cover of Co1, for a total order of about \(10^{26}\).

(Since a Leech lattice is based on copies of an E8 lattice and since there are 7 distinct E8 integral domain lattices there are 7 (or 8 if you include a non-integration E8 lattice) distinct Leech lattices.

The physical Leech lattice is a superposition of them, effectively adding a factor of 8 to the order.)

The volume of the Kerr-Newman Cloud is on the order of \(10^{27} \times \text{Planck scale,} \approx \text{roughly} \, 10^{37-27} \text{ cm.} \)
Julian Schwinger describes Elementary Particles as volumes of space - Sources - whose properties are determined by Green’s Functions characteristic of the volumes.

In E8 Physics any Elementary Particle is immediately surrounded by a cloud of virtual particle-antiparticle pairs similar to a Kerr-Newman Black Hole with Symmetric Space - Bounded Complex Domain - Shilov Boundary structure corresponding to its Gauge Group properties.

The Poisson Kernel - Bergman Kernel defines the Green’s Function.

The initial Valence Particle is Planck scale. The number of Virtual Particles is determined by the Planck scale geometry of spacetime. The E8 model at the Planck Scale has spacetime condensing out of Clifford structures forming a Lorentz Leech lattice underlying 26-dim String Theory of World-Lines with $8 + 8 + 8 = 24$-dim of fermion particles and antiparticles and of spacetime.

The automorphism group of one 26-dim String Theory cell modulo the Leech lattice is the Monster Group of order about $8 \times 10^{53}$. The Cloud structure comes from the 24-dim Leech lattice part of the Monster Group which is $2^{4}(1+24)$ times the double cover of Co1, for an order of about $10^{26}$. Due to superpositions of algebraically independent E8 Lattices the total number of Virtual particle/antiparticle pairs is about $10^{27}$ so the volume of the Kerr-Newman Cloud is on the order of $10^{27}$ x Planck scale, and its size should be about $10^{5(27/3)} \times 1.6 \times 10^{5(-33)}$ cm = roughly $10^{4(-24)}$ cm.

Each Schwinger Source particle-antiparticle pair should see (with Bohm Quantum Potential and Serafatti Back-Reflection) the rest of our Universe in the perspective of $8 \times 10^{53}$ Monster Symmetry so a Schwinger Source acting as a Jewel of Indra’s Net of Schwinger Source Bohm Quantum Blockchain Physics can see $10^{27} \times 8 \times 10^{53} = 8 \times 10^{80}$ Other Sources of an Indra’s Net.

To fit inside the initial Schwinger Source the Information Elements of all the Other Schwinger Sources of Our Universe ($10^{477}$ or so) should be distributed as a Fractal Julia Set. There are $2^n$ stage-$n$ cells in a Binary Decomposition of Julia Sets, so a stage-256 Julia level set based on Binary Decomposition has $2^{256} = about 10^{477}$ cells so Full Indra Net information can be seen/ reflected by each Schwinger Source Indra Jewel.

Each Schwinger Source contains $10^{27}$ Virtual pairs of particles each of which can see along a connecting Line an Other Indra’s Net Source which Line sees Other Sources through Monster Group Lens elements so that the Other Source appears to the Original Source to be a Julia Set.

Each Schwinger Source has a Mandelbrot Set that tells its Source what each of the many Indra’s Net Sources Julia set looks like by correlating Monster Group Lens Elements with Types of Julia Set. Self-Perception is always the $c = 0$ Circle Julia Set.
Critical Point
250 H, 220 Tq

Non-Perturbativity 4+4 K-K
Composite H as Tq-Tantiq Condensate
195 H, 174 Tq

Normal Stable Ground State
125 H, 130 Tq

Non-Perturbativity

260 H, 220 Tq

195 H, 174 Tq

125 H, 130 Tq

Normal Stable

Instability
Quatemionic $E_7 \times SU(2)$ structure breaks 8-dim Spacetime Octonionic Symmetry to Quaternionic (4+4)-dim Associative $\times$ CoAssociative Kaluza-Klein Spacetime
(see Reese Harvey "Spinors and Calibrations" (Academic 1990))
where $M_4 = 4$-dim Minkowski Physical Spacetime is Associative
and $CP^2 = SU(3) / SU(2) \times U(1)$ Internal Symmetry Space is CoAssociative

Meinhard Mayer said (Hadronic Journal 4 (1981) 108-152): "... each point of ... the ... fibre bundle ... $E$ ...

... consists of
a four-dimensional spacetime point $x$ [ in $M_4$ ]
to which is attached the homogeneous space $G / H$ [$SU(3) / U(2) = CP^2$ ]

... the components of the curvature lying in the homogeneous space $G / H$ could be reinterpreted as Higgs scalars (with respect to spacetime [ $M_4$ ])

... the Yang-Mills action reduces to a Yang-Mills action for the $h$-components [$U(2)$ components] of the curvature over $M$ [$M_4$] and a quartic functional for the "Higgs scalars", which not only reproduces the Ginzburg-Landau potential, but also gives the correct relative sign of the constants, required for the BEHK ... Brout-Englert-Higgs-Kibble ... mechanism to work. ...

(see Appendix - Details of Mayer - Higgs)
3 Generations of Fermions

In Kaluza-Klein M4 x CP2 there are 3 possibilities for a fermion represented by an Octonion O basis element to go from point A to point B:

1 - A and B are both in M4: First Generation Fermion whose path can be represented by the single O basis element so that First Generation Fermions are represented by Octonions O.

2 - Either A or B, but not both, is in CP2: Second Generation Fermion whose path must be augmented by one projection from CP2 to M4, which projection can be represented by a second O basis element so that Second Generation Fermions are represented by Octonion Pairs OxO.

3 - Both A and B are in CP2: Third Generation Fermion whose path must be augmented by two projections from CP2 to M4, which projections can be represented by a second O and a third O, so that Third Generation Fermions are represented by Octonion Triples OxOxO.
3 Generation Fermion Combinatorics

First Generation (8)

(geometric representation of Octonions is from arXiv 1010.2979)

electron          red        green         blue               red          green        blue         neutrino
up           up             up               down        down        down
quark       quark        quark            quark        quark       quark
E               I               J               K                    i                j              k                 1

Second Generation (64)

Mu Neutrino (1)
Rule: a Pair belongs to the Mu Neutrino if:
All elements are Colorless (black)
and all elements are Associative
(that is, is 1 which is the only Colorless Associative element).
Muon (3)
Rule: a Pair belongs to the Muon if:
   All elements are Colorless (black)
   and at least one element is NonAssociative
   (that is, is E which is the only Colorless NonAssociative element).

Blue Strange Quark (3)
Rule: a Pair belongs to the Blue Strange Quark if:
   There is at least one Blue element and the other element is Blue or Colorless (black)
   and all elements are Associative (that is, is either 1 or i or j or k).

Blue Charm Quark (17)
Rules: a Pair belongs to the Blue Charm Quark if:
1 - There is at least one Blue element and the other element is Blue or Colorless (black)
   and at least one element is NonAssociative (that is, is either E or I or J or K)
2 - There is one Red element and one Green element (Red x Green = Blue).

( Red and Green Strange and Charm Quarks follow similar rules )
Third Generation (512)

Tau Neutrino (1)
Rule: a Triple belongs to the Tau Neutrino if:
All elements are Colorless (black)
and all elements are Associative
(that is, is 1 which is the only Colorless Associative element)

Tauon (7)
Rule: a Triple belongs to the Tauon if:
All elements are Colorless (black)
and at least one element is NonAssociative (that is, is E which is the only Colorless NonAssociative element)
Blue Beauty Quark (7)
Rule: a Triple belongs to the Blue Beauty Quark if:
There is at least one Blue element and all other elements are Blue or Colorless (black)
and all elements are Associative (that is, is either 1 or i or j or k).

Blue Truth Quark (161)
Rules: a Triple belongs to the Blue Truth Quark if:
1 - There is at least one Blue element and all other elements are Blue or Colorless (black)
and at least one element is NonAssociative (that is, is either E or I or J or K)
2 - There is one Red element and one Green element and the other element is Colorless (Red x Green = Blue)
3 - The Triple has one element each that is Red, Green, or Blue,
in which case the color of the Third element (for Third Generation) is determinative
and must be Blue.

( Red and Green Beauty and Truth Quarks follow similar rules )
Fermion masses are calculated as a product of four factors:
\[ V(Q\text{fermion}) \times N(\text{Graviton}) \times N(\text{octonion}) \times \text{Sym} \]
The ratio of the down quark spinor manifold volume factor to the electron spinor manifold volume factor is
\[ \frac{V(Q\text{down quark})}{V(Q\text{electron})} = \frac{V(S^7 \times \text{RP}^1)}{1} = \pi^5 / 3. \]

The third generation fermion particles correspond to triples of octonions. There are \(8^3 = 512\) such triples.
The triple \{1,1,1\} corresponds to the tau-neutrino.
The other 7 triples involving only 1 and E correspond to the tauon:
\{E, E, E\} \{E, E, 1\} \{E, 1, E\} \{1, E, E\} \{1, 1, E\} \{1, E, 1\} \{E, 1, 1\}
The symmetry of the 7 tauon triples is the same as the symmetry of the first generation tree-level-massive fermions, 3 down, quarks, the 3 up quarks, and the electron, so by the Sym factor the tauon mass should be the same as the sum of the masses of the first generation massive fermion particles. Therefore the **tauon mass is calculated at tree level as 1.877 GeV**.

The beauty quark corresponds to 21 triples.
They are triples of the same form as the 7 tauon triples involving 1 and E, but for 1 and I, 1 and J, and 1 and K = red, green, and blue beauty quarks.
The seven red beauty quark triples correspond to the seven tauon triples, except that the beauty quark interacts with 6 \text{Spin(0,5)} gravitons while the tauon interacts with only two.
The red beauty quark constituent mass should be the **red beauty quark mass is mb = 5.63111 GeV**.

Triples of the type \{1, I, J\}, \{I, J, K\}, etc., do not correspond to the beauty quark, but to the truth quark.
The truth quark corresponds to those 512 - 1 - 7 - 21 = 483 triples, so the constituent mass of the red truth quark is 161 / 7 = 23 times the red beauty quark mass, and the **red T-quark mass is mt = 129.5155 GeV**.
248-dim E8 contains 120-dim D8

\[ \text{E8} / \text{D8} = 64 + 64 \text{ Fermions} \]

\[ \text{D8} / \text{D4} \times \text{D4} = 64 \text{ Spacetime} \]

\[ \text{D4} = 28 \text{ Standard Model (12)} \]
with 16 Gravity + Dark Energy Ghosts

\[ \text{D4} = 28 \text{ Gravity + Dark Energy (16)} \]
with 12 Standard Model Ghosts
The 24 Orange Root Vectors of the D4 of E8 Standard Model + Gravity Ghosts are on the Horizontal X-axis.

8 of them in the Orange Box represent the 8 Root Vectors of the Standard Model Gauge Groups SU(3) SU(2) U(1).
Their 4 Cartan Subalgebra elements correspond to the 4 Cartan Subalgebra elements of D4 of E8 Standard Model + Gravity Ghosts and to half of the 8 Cartan Subalgebra elements of E8.

The other 24-8 = 16 Orange Root Vectors represent Ghosts of 16D U(2,2) which contains the Conformal Group SU(2,2) = Spin(2,4) that produces Gravity + Dark Energy by the MacDowell-Mansouri mechanism.

Standard Model Gauge groups come from CP2 = SU(3) / SU(2) x U(1)
(as described by Bäckke in Class. Quantum Grav. 3 (1986) L99-L106)

Electroweak SU(2) x U(1) is gauge group as Isotropy group of CP2.

SU(3) is global symmetry group of CP2 but due to Kaluza-Klein M4 x CP2 structure of compact CP2 at every M4 spacetime point, it acts as Color gauge group with respect to M4.
The 24 Yellow Root Vectors of the D4 of E8 Gravity + Standard Model Ghosts are on the Vertical Y-axis.
12 of them in the Yellow Box represent the 12 Root Vectors of the Conformal Gauge Group SU(2,2) = Spin(2,4) of Conformal Gravity + Dark Energy.
The 4 Cartan Subalgebra elements of SU(2,2)xU(1) = U(2,2) correspond to the 4 Cartan Subalgebra elements of D4 of E8 Gravity + Standard Model Ghosts and to the other half of the 8 Cartan Subalgebra elements of E8.

The other 24-12 = 12 Yellow Root Vectors represent Ghosts of 12D Standard Model whose Gauge Groups are SU(3) SU(2) U(1).

Gravity and Dark Energy come from its Conformal Subgroup SU(2,2) = Spin(2,4)
(see Appendix - Details of Conformal Gravity and ratio DE : DM : OM)

SU(2,2) = Spin(2,4) has 15 generators:

1 Dilation representing Higgs Ordinary Matter

4 Translations representing Primordial Black Hole Dark Matter

10 = 4 Special Conformal + 6 Lorentz representing Dark Energy
(see Irving Ezra Segal, "Mathematical Cosmology and Extragalactic Astronomy" (Academic 1976))

The basic ratio Dark Energy : Dark Matter : Ordinary Matter = 10:4:1 = 0.67 : 0.27 : 0.06
When the dynamics of our expanding universe are taken into account, the ratio is calculated to be 0.76 : 0.21 : 0.04
The force strength of a given force is

\[
\frac{1}{M_{\text{force}}^2} \cdot \frac{\text{Vol}(\text{MIS}_{\text{force}})}{\text{Vol}(\text{Q}_{\text{force}})} \cdot \frac{\text{Vol}(\text{D}_{\text{force}})}{\text{Vol}(\text{D}_{\text{force}})^{\frac{1}{m_{\text{force}}}}}
\]

where:

- \(M_{\text{force}}\) represents the effective mass;
- \(\text{MIS}_{\text{force}}\) represents the relevant part of the target Internal Symmetry Space;
- \(\text{Vol}(\text{MIS}_{\text{force}})\) stands for volume of \(\text{MIS}_{\text{force}}\) and is sometimes also denoted by \(\text{Vol}(M)\);
- \(\text{Q}_{\text{force}}\) represents the link from the origin to the relevant target for the gauge boson;
- \(\text{Vol}(\text{Q}_{\text{force}})\) stands for volume of \(\text{Q}_{\text{force}}\);
- \(\text{D}_{\text{force}}\) represents the complex bounded homogeneous domain of which \(\text{Q}_{\text{force}}\) is the Shilov boundary;
- \(m_{\text{force}}\) is the dimensionality of \(\text{Q}_{\text{force}}\), which is \(\text{Vol}(\text{D}_{\text{force}})^{\frac{1}{m_{\text{force}}}}\), stands for a dimensional normalization factor (to reconcile the dimensionality of the Internal Symmetry Space of the target vertex with the dimensionality of the link from the origin to the target vertex).

\(\text{Q}_{\text{force}}\), Hermitian symmetric space, \(\text{D}_{\text{force}}\), \(m_{\text{force}}\), and \(\text{Vol}(\text{D}_{\text{force}})\) for four forces are:

<table>
<thead>
<tr>
<th>Force</th>
<th>(M)</th>
<th>(\text{Vol}(M))</th>
<th>(Q)</th>
<th>(\text{Vol}(Q))</th>
<th>(D)</th>
<th>(\text{Vol}(D))</th>
</tr>
</thead>
<tbody>
<tr>
<td>gravity</td>
<td>S^4</td>
<td>8pi^2/3</td>
<td>RP^1xS^4</td>
<td>8pi^3/3</td>
<td>IV5</td>
<td>\pi^5/2^4 5!</td>
</tr>
<tr>
<td>SU(3)</td>
<td>CP^2</td>
<td>8pi^2/3</td>
<td>squashed S^5</td>
<td>4pi^3</td>
<td>B^6(ball)</td>
<td>pi^3/6</td>
</tr>
<tr>
<td>SU(2)</td>
<td>S^2xS^2</td>
<td>2x4pi</td>
<td>RP^1xS^2</td>
<td>4pi^2</td>
<td>IV3</td>
<td>pi^3/24</td>
</tr>
<tr>
<td>U(1)</td>
<td>T^4</td>
<td>4x2pi</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

squashed S5 = Shilov boundary of complex domain of symmetric space SU(4) / SU(3) x U(1)

The relative force strengths at the characteristic energy level of each force are:

- **Spin(5) gravity** at \(10^{19} \text{ GeV} = 1\); \(\text{GG}_{\text{proton}}^2\) \approx 5 \times 10^{-39}

- **SU(3) color** at 245 MeV = 0.6286
  - at 5.3 GeV = 0.166
  - at 34 GeV = 0.121
  - at 91 GeV = 0.106; with nonperturbative effects = 0.125

- **SU(2) weak** at 100 GeV = 0.2535; \(\text{GW}_{\text{proton}}^2\) \approx 1.05 \times 10^{-5}

- **U(1) e-mag** at 4 KeV = 1/137.03608
Fermion masses are calculated as a product of four factors:

\[ V(Q_{\text{fermion}}) \times N(\text{Graviton}) \times N(\text{octonion}) \times \text{Sym} \]

The ratio of the down quark spinor manifold volume factor to the electron spinor manifold volume factor is

\[ \frac{V(\text{Qdown quark})}{V(\text{Qelectron})} = \frac{V(S^7 \times RP^1)}{1} = \pi^5 / 3. \]

The third generation fermion particles correspond to triples of octonions. There are \( 8^3 = 512 \) such triples.

The triple \( \{1, 1, 1\} \) corresponds to the tau-neutrino.

The other 7 triples involving only 1 and E correspond to the tau-meson.

The beauty quark corresponds to 21 triples.

They are triples of the same form as the 7 tauon triples involving 1 and E, but for 1 and I, 1 and J, and 1 and K, which correspond to the red, green, and blue beauty quarks, triples of the type \( \{1, I, J\}, \{I, J, K\}, \text{ etc.,} \)

do not correspond to the beauty quark, but to the Truth quark.

The Truth quark corresponds to those \( 512 - 1 - 7 - 21 = 483 \) triples, so the constituent mass of the red truth quark is \( 161 / 7 = 23 \) times red beauty quark

red Truth quark mass is \( m_t = 129.5155 \text{ GeV} \)
Here is a summary of E8 Physics model calculation results. Since ratios are calculated, values for one particle mass and one force strength are assumed. Quark masses are constituent masses. Most of the calculations are tree-level, so more detailed calculations might be even closer to observations.

Dark Energy : Dark Matter : Ordinary Matter = 0.75 : 0.21 : 0.04

Fermions as Schwinger Sources have geometry of Complex Bounded Domains with Kerr-Newman Black Hole structure size about 10^(-24) cm.

<table>
<thead>
<tr>
<th>Particle/Force</th>
<th>Tree-Level</th>
<th>Higher-Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>e-neutrino</td>
<td>0</td>
<td>0 for nu_1</td>
</tr>
<tr>
<td>mu-neutrino</td>
<td>0</td>
<td>9 x 10^(-3) eV for nu_2</td>
</tr>
<tr>
<td>tau-neutrino</td>
<td>0</td>
<td>5.4 x 10^(-2) eV for nu_3</td>
</tr>
<tr>
<td>electron</td>
<td>0.5110 MeV</td>
<td></td>
</tr>
<tr>
<td>down quark</td>
<td>312.8 MeV</td>
<td>charged pion = 139 MeV</td>
</tr>
<tr>
<td>up quark</td>
<td>312.8 MeV</td>
<td>proton = 938.25 MeV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>neutron - proton = 1.1 MeV</td>
</tr>
<tr>
<td>muon</td>
<td>104.8 MeV</td>
<td>106.2 MeV</td>
</tr>
<tr>
<td>strange quark</td>
<td>625 MeV</td>
<td></td>
</tr>
<tr>
<td>charm quark</td>
<td>2090 MeV</td>
<td></td>
</tr>
<tr>
<td>tauon</td>
<td>1.88 GeV</td>
<td></td>
</tr>
<tr>
<td>beauty quark</td>
<td>5.63 GeV</td>
<td></td>
</tr>
<tr>
<td>truth quark (low state)</td>
<td>130 GeV</td>
<td>(middle state) 174 GeV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(high state) 218 GeV</td>
</tr>
</tbody>
</table>

W+ 80.326 GeV  
W- 80.326 GeV  
W0 98.379 GeV  

M_{Planck} 1.217x10^19 GeV

Higgs VEV (assumed) 252.5 GeV  
Higgs (low state) 126 GeV  

(Gravity Gg (assumed) 
(Gg)(M_{proton}^2 / M_{Planck}^2) 5 x 10^(-39) 
EM fine structure 1/137.03608  
Weak Gw 0.2535  
Gw(M_{proton}^2 / (M_{W+}^2 + M_{W-}^2 + M_{Z^0}^2)) 1.05 x 10^(-5)  
Color Force at 0.245 GeV 0.6286  
0.106 at 91 GeV

Kobayashi-Maskawa parameters for W+ and W- processes are:

d u 0.975 0.222 0.00249 -0.00388i  
c -0.222 -0.000161i 0.974 -0.0000365i 0.0423  
t 0.00698 -0.00378i -0.0418 -0.00086i 0.999  
The phase angle d_13 is taken to be 1 radian.
E8 = H4 + H4 = 120 + 120 = 240-vertex Witting polytope tiling of 8-dim space

E8 = 120 BiVectors + 128 half-Spinors of Cl(16) Clifford Algebra with graded structure
   1 16 120 560 1820 4368 8008 11440 12870 11440 8008 4368 1820 560 120 16 1
By 8-Periodicity of Real Clifford Algebras: Cl(16) = tensor product Cl(8) x Cl(8)
so with that product E8 = F4 x F4

H4 = 24 (vertices) + 96 (edges) = 120-vertex 600-cell tiling of 4-dim space with Coxeter Group determined by E8
**F4 = 24 cell + dual 24-cell tiling of 4-dim space**

F4 = 8 Vectors + 28 BiVectors + 16 Spinors of Cl(8) Clifford Algebra with graded structure 1 8 28 56 70 56 28 8 1
tile 4-dim space by 24-cells and their dual 24-cells

**D4 = 24-cell tiling of 4-dim space**

D4 = 28 BiVectors of Cl(8) Clifford Algebra with 24 root vectors with graded structure 1 8 28 56 70 56 28 8 1
tile 4-dim space by 24-cells

**A3 = D3 = cuboctahedral tiling of 3-dim space**

A3=D3 = 15 BiVectors of Cl(6) Clifford Algebra with 12 root vectors and with graded structure 1 6 15 20 15 6 1
tile 3-dim space by cuboctahedra which can be seen as a central part of a 24-cell (green vertices above)

**H3 = 12-Vertex Icosahedron as Jitterbug Transform of 12-Vertex Cuboctahedron**

with Coxeter Group determined by D6
H2 Penrose STAR tilings of 2-dim space

H2 = $I^5_2$ = Penrose STAR tiling of 2-dim space

with Coxeter group determined by A4 which contains A2
and field extension $\mathbb{Q}(\sqrt{5})$

The central part of the tiling has 5 pentagonal sectors

Each of the 5 pentagonal sectors of the tiling contains a 2-dim projected version
of the 8-dim E8 Root Vector structure of E8 Physics corresponding to the Complex E6
subalgebra of Octonionic E8. The outer boundary of each sector is not a straight line but
is curved with Conformal Symmetry and pentagonal sectors further out are conformally
curved rather than straight-line pentagons.

Each pentagonal sector represents the Complex part of Octonionic E8 Physics
whose 240 E8 Root Vectors project to the 72 Root Vectors of E6 subalgebra of E8
which 72 E6 Root Vectors have the following physical interpretation

- 16 = 2x8 of which represent Complex Fermion Particles
- 16 = 2x8 of which represent Complex Fermion AntiParticles
- 16 = 2(1+4) of which represent Complex (4+4)-dim Kaluza-Klein SpaceTime
- 12 of which represent the Standard Model
- 12 of which represent Gravity + Dark Energy

as shown in the following image of one of the pentagonal sectors:
The Bohm Quantum Potential interacts between two Pentagonal Sectors by 24 Bohm Carrier Tiles of one Pentagonal Sector carrying E8 Configuration Information and comparing it with 24 Bohm Carrier Tiles of the Other Sector carrying E8 Configuration Information. If the resulting 24 x 24 Matrix shows that the two E8 Configurations are similar, then a Bohm Quantum Potential Resonant Connection is established.

The Bohm Quantum Potential 24x24 Matrix is traceless because Configuration Resonance is sensitive to similarity rather than dilation scale and is symmetric because Configuration Resonance is symmetric between Sectors.
1 + 8 + 28 + 56 + (35 + 35) + 56 + 28 + 8 + 1
In (Cl(8) of CP2) x (Cl(8) of Cnf6 -> M4) = Cl(16) containing E8
at each of the 256 points of Cl(8) of Cnf6 -> M4 there are all 256 points of Cl(8) of CP2
D8 = Cl(16) BiVectors = 120
E8 / D8 = 128-dim Fermion Spinor Space = 8 components of 8+8 Fermions
D8 / D4 x D4 = A7+1 = 64 = 8-dim position x 8-dim momentum
D4 containing D3 = Spin(2,4) = A3 = SU(2,2) for Conformal Gravity + Dark Energy
D4 containing D3 = SU(4) containing Color Force SU(3)
10xFr3(O) = Cl(16) TriVectors = 560

F4 / B4 = OP2 = Spinor Fermions = 8 Particles + 8 AntiParticles
B4 / D4 = 8-dim SpaceTime = Kaluza-Klein M4 x CP2
D4 = Spin(8) contains Spin(6) = SU(4) contains SU(3) Color Force
SU(3) Color Force = Global Symmetry of CP2 = SU(3) x SU(2)xU(1)
SU(2)xU(1) ElectroWeak Force = Local Symmetry of CP2

56-dim Fr3(O) in 256-dim Cl(8)

52-dim F4 of CP2 in 256-dim Cl(8)

256 x 256 = 65,536
<table>
<thead>
<tr>
<th>Cl(8) that contains</th>
<th>Cl(8) that contains</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 = D4 for M4 Gravity</td>
<td>28 = D4 for CP2 Std Model</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>120</td>
</tr>
<tr>
<td>120</td>
<td>11440</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>11440</td>
<td>12870</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>4368</td>
<td>4368</td>
</tr>
<tr>
<td>70 x 70 = 1820</td>
<td>1820</td>
</tr>
<tr>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>560</td>
<td>560</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

\[ Cl(8) \times Cl(8) = Cl(16) \]

Spinors:

- (8s + 8c) \times (8s + 8c) = (8s, 8c)
- (8c, 8s) + (8c, 8s) = (8s, 8c)

Cl(0,16) \times Cl(0,8) = Cl(0,24)

\[ M(2, Cl(0,24)) = Cl(1,25) \]

Completion of Union of All Tensor Products of Cl(1,25) = AQFT

---

Kaluza-Klein Spacetime:

- M4 x CP2

BJL Quantum Condensate

Quantum Resonant Connection

Penrose-Hameroff Quantum Condensate

Microtubules 40 nanometers long
Nano 60,000 Tubulin Dimers

10^19 E8 Lattice 240-vertex Polytope Cells in Universe at End of Inflation

Inflation

Dark Ages Development of Complex Beings, etc.

Dark Energy Accelerated Expansion

Adiabatic Light Emission over 10^20 years

Big Bang Eruption

30.7 trillion years

10^19 Tubulin Dimers in a Human Brain

---

Frontal Lobe

Parietal Lobe

Occipital Lobe

Temporal Lobe

Planning

Executive Function

Emotion

Language Reception

Vision

Visual cortex receives and processes signals from the retina of the eyes