

# Introduction to E8 Physics

by Frank Dodd (Tony) Smith Jr.

Abstract:

An E8 Physics model based on Nested Real Clifford Algebras is described.

Its contents are:

Abstract - page 0;

Cover - page 1;

Table of Contents - page 2;

E8 Physics Overview - page 3;

Lagrangian - page 19;

AQFT - page 21;

EPR - page 22;

Chirality - page 24;

NonUnitary Octonionic Inflation - page 26;

E8, Bosonic String Theory, and the Monster - page 36;

Coleman-Mandula - page 40;

Mayer-Trautman Mechanism - page 41;

MacDowell-Mansouri Mechanism - page 44;

Second and Third Fermion Generations - page 48;

Calculations - page 50;

Force Strengths - page 54;

Fermion Masses - page 63;

Higgs and W-boson Masses - page 76;

Kobayashi-Maskawa Parameters - page 80;

Neutrino Masses - page 84;

Proton-Neutron Mass Difference - page 88;

Pion Mass - page 90;

Planck Mass - page 102;

Dark Energy : Dark Matter : Ordinary Matter - page 104;

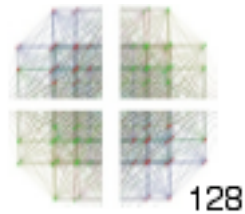
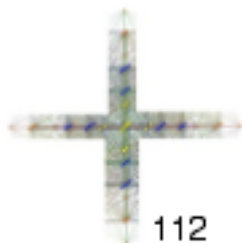
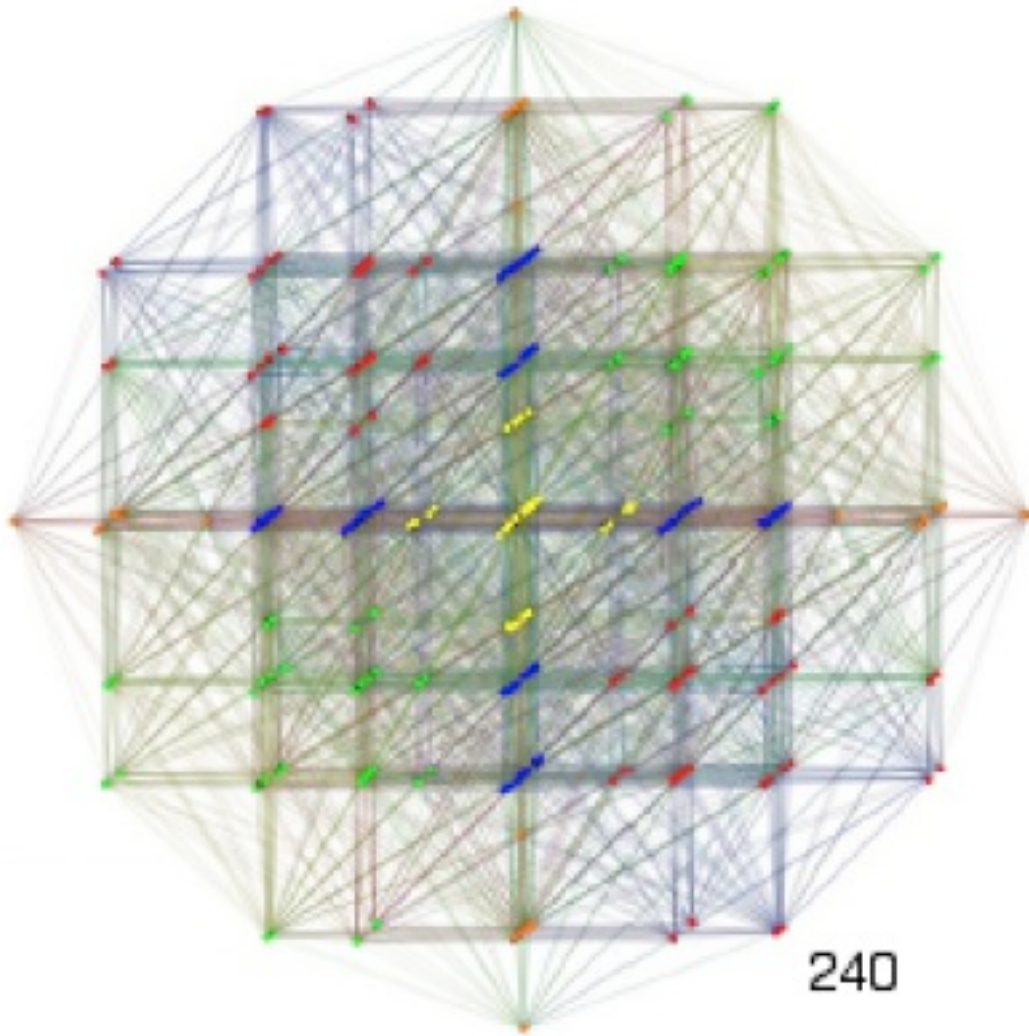
Pioneer Anomaly - page 110;

Truth Quark - Higgs 3-State System - page 120;

Historical Appendix - page 138.

(References are included in the body of the paper and in linked material.)

***$E_8$  and  $Cl(16) = Cl(8) \times Cl(8)$***



Frank Dodd (Tony) Smith, Jr. – Georgia – 2011

# Table of Contents

Cover .....	page 1
Table of Contents .....	page 2
E8 Physics Overview .....	page 3
Lagrangian .....	page 19
AQFT .....	page 21
EPR .....	page 22
Chirality .....	page 24
NonUnitary Octonionic Inflation .....	page 26
E8, Bosonic String Theory, and the Monster .....	page 36
Coleman-Mandula .....	page 40
Mayer-Trautman Mechanism .....	page 41
MacDowell-Mansouri Mechanism .....	page 44
Second and Third Fermion Generations .....	page 48
Calculations .....	page 50
Force Strengths .....	page 54
Fermion Masses .....	page 63
Higgs and W-boson Masses .....	page 76
Kobayashi-Maskawa Parameters .....	page 80
Neutrino Masses .....	page 84
Proton-Neutron Mass Difference .....	page 88
Pion Mass .....	page 90
Planck Mass .....	page 102
Dark Energy : Dark Matter : Ordinary Matter .....	page 104
Pioneer Anomaly .....	page 110
Truth Quark - Higgs 3-State System .....	page 120
Historical Appendix .....	page 138

## E8 Physics:

David Finkelstein's Cl(16) Fundamental Quantum Structure  
of Nested Real Clifford Algebras:

Start with Empty Set = 0

$$1 = \text{Cl}(0)$$

\

$$1 + 1 = \text{Cl}(1) = \text{Cl}(\text{Cl}(0))$$

\

$$1 + 2 + 1 = \text{Cl}(2) = \text{Cl}(\text{Cl}(1)) = \text{Cl}(\text{Cl}(\text{Cl}(0)))$$

\

$$1 + 4 + 6 + 4 + 1 = \text{Cl}(4) = \text{Cl}(\text{Cl}(2)) = \text{Cl}(\text{Cl}(\text{Cl}(\text{Cl}(0))))$$

\

$$1 + 16 + 120 + \dots = \text{Cl}(16) = \text{Cl}(\text{Cl}(4)) = \text{Cl}(\text{Cl}(\text{Cl}(\text{Cl}(\text{Cl}(0)))))$$

\

$$1 + 65,536 + \dots = \text{Cl}(65,536) = \text{Cl}(\text{Cl}(16)) =$$

(by Real Clifford Algebra 8-Periodicity) = Cl(16) x...(16 times)...x Cl(16)

John von Neumann said (see “Why John von Neumann did not Like the Hilbert Space Formalism of Quantum Mechanics (and What he Liked Instead)” by Miklos Redei in Studies in the History and Philosophy of Modern Physics 27 (1996) 493-510):

“... if we wish to generalize the lattice of all linear closed subspaces from a Euclidean space to infinitely many dimensions, then one does not obtain Hilbert space ... our “case I\_infinity” ... but that configuration, which Murray and I called “case II1” ...”.

Completion of the Union of All Finite Tensor Products of Cl(16) with itself gives a generalized Hyperfinite III von Neumann Factor that in turn gives a realistic Algebraic Quantum Field Theory (AQFT).

Since Cl(16) is the Fundamental Building Block of a realistic AQFT with the structure of a generalized Hyperfinite III von Neumann Factor, in order to understand how realistic AQFT works in detail, we must understand the Geometric Structure of Cl(16).

Cl(16) has  $2^{16} = 65,536$  elements with graded structure

**1**  
**16**  
**120**  
**560**  
**1820**  
**4368**  
**8008**  
**11440**  
**12870**  
**11440**  
**8008**  
**4368**  
**1820**  
**560**  
**120**  
**16**  
**1**

The 16-dim grade-1 Vectors of Cl(16) are D8 = Spin(16) Vectors that are acted upon by the 120-dim grade-2 Bivectors of Cl(16) which form the D8 = Spin(16) Lie algebra.

Cl(16) has, in addition to its 16-dim D8 Vector and 120-dim D8 Bivector bosonic commutator structure, a fermionic anticommutator structure related to its  $\sqrt{65,536} = 256$ -dim spinors which reduce to 128-dim D8 +half-spinors plus 128-dim D8 -half-spinors.

Pierre Ramond in hep-th/0112261 said:

“... the coset  $F4 / SO(9)$  ... is the sixteen-dimensional Cayley projective plane ... [ represented by ]... the  $SO(9)$  spinor operators [ which ] satisfy Bose-like commutation relations ... Curiously, if ...[ the scalar and spinor 16 of  $F4$  are both ]... anticommuting, the  $F4$  algebra is still satisfied ...”.

The same reasoning applies to other exceptional groups that have octonionic structure and spinor component parts, including:

$$E6 = D5 + U(1) + 32\text{-dim full spinor of } D5$$

and

$$\mathbf{248\text{-dim } E8 = 120\text{-dim } D8 + 128\text{-dim half-spinor of } D8.}$$

To study the E8 substructure of Cl(16), note that the 120-dimensional bosonic Cl(16) bivector part of E8 decomposes, with respect to factoring Cl(16) into the tensor product Cl(8) x Cl(8) allowed by 8-periodicity, into  $1 \times 28 + 8 \times 8 + 28 \times 1$

				<b>1</b>
				<b>16</b>
				<b>120</b>
				<b>560</b>
				<b>1820</b>
				<b>4368</b>
				<b>8008</b>
				<b>11440</b>
				<b>12870</b>
<b>1</b>	<b>1</b>			<b>1</b>
<b>8</b>	<b>8</b>			<b>16</b>
<b>28</b>	<b>28</b>			<b>120</b>
<b>56</b>	<b>56</b>			<b>560</b>
<b>70</b>	<b>70</b>	<b>x</b>	<b>=</b>	<b>1820</b>
<b>56</b>	<b>56</b>			<b>560</b>
<b>28</b>	<b>28</b>			<b>120</b>
<b>8</b>	<b>8</b>			<b>16</b>
<b>1</b>	<b>1</b>			<b>1</b>
<b>Cl(8)</b>	<b>x Cl(8)</b>	<b>=</b>		<b>Cl(16)</b>

Spinors:

$$\begin{aligned}
 (8s+8c) \times (8s+8c) &= (8s \times 8s + 8c \times 8c) \\
 &+ (8s \times 8c + 8c \times 8s)
 \end{aligned}$$

The 256-dim spinor of  $Cl(16)$  decomposes as the direct sum of the two 128-dim half-spinor representations, i.e., as one generation and one anti-generation.

248-dim  $E_8$  contains the 128-dim  $D_8 Cl(16)$  half-spinor representation of one generation of Fermion Particles and AntiParticles, but does not contain any of the anti-generation  $D_8 Cl(16)$  half-spinor.

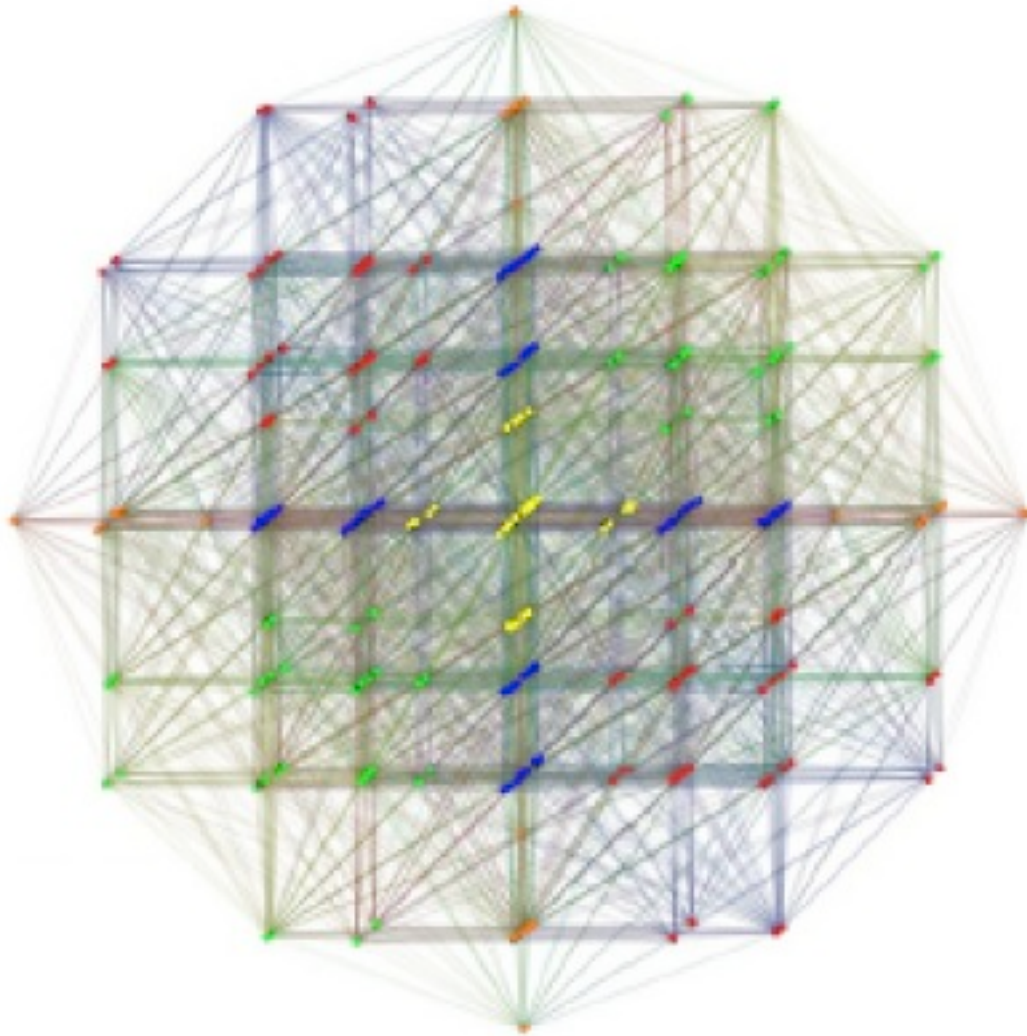
Note that if you tried to build a larger Lie Algebra than  $E_8$  within  $Cl(16)$  by using the anti-generation  $D_8 Cl(16)$  half-spinor, you would fail because the construction would be mathematically inconsistent, so  $E_8$  is the Maximal Lie Algebra within  $Cl(16)$ .

Decompose, with respect to factoring  $Cl(16)$  into  $Cl(8) \times Cl(8)$ , the 128-dim fermion one-generation representation into two 64-dim fermion representations in terms of their 8 covariant components with respect to 8-dim spacetime as:

one  $64 = 8 \times 8$  representing 8 fundamental left-handed fermion particles in terms of their 8 covariant components with respect to 8-dim spacetime and the other  $64 = 8 \times 8$  representing 8 fundamental right-handed fermion antiparticles.

To visualize the  $E_8$  structure, look at the 240 Root Vectors of  $E_8$ :

The 240 root vectors of the 248-dimensional Lie Algebra E8



The 240 Root Vectors are color-keyed as:

24 Yellow

24 Orange

64 Blue

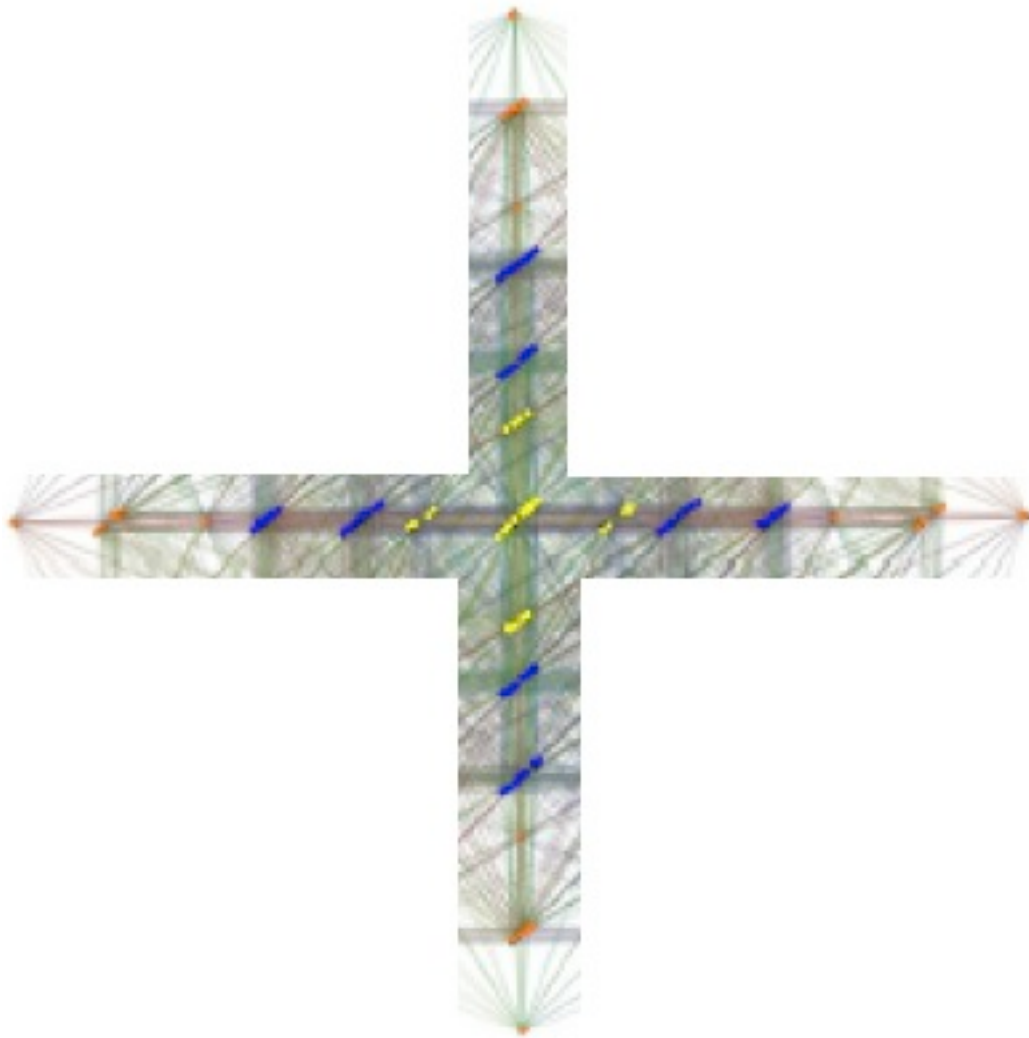
64 Red

64 Green

They are made up of



112 Root Vectors that represent the 112 Root Vectors of the 120-dimensional Lie Algebra D8



These 112 Root Vectors are color-keyed as:

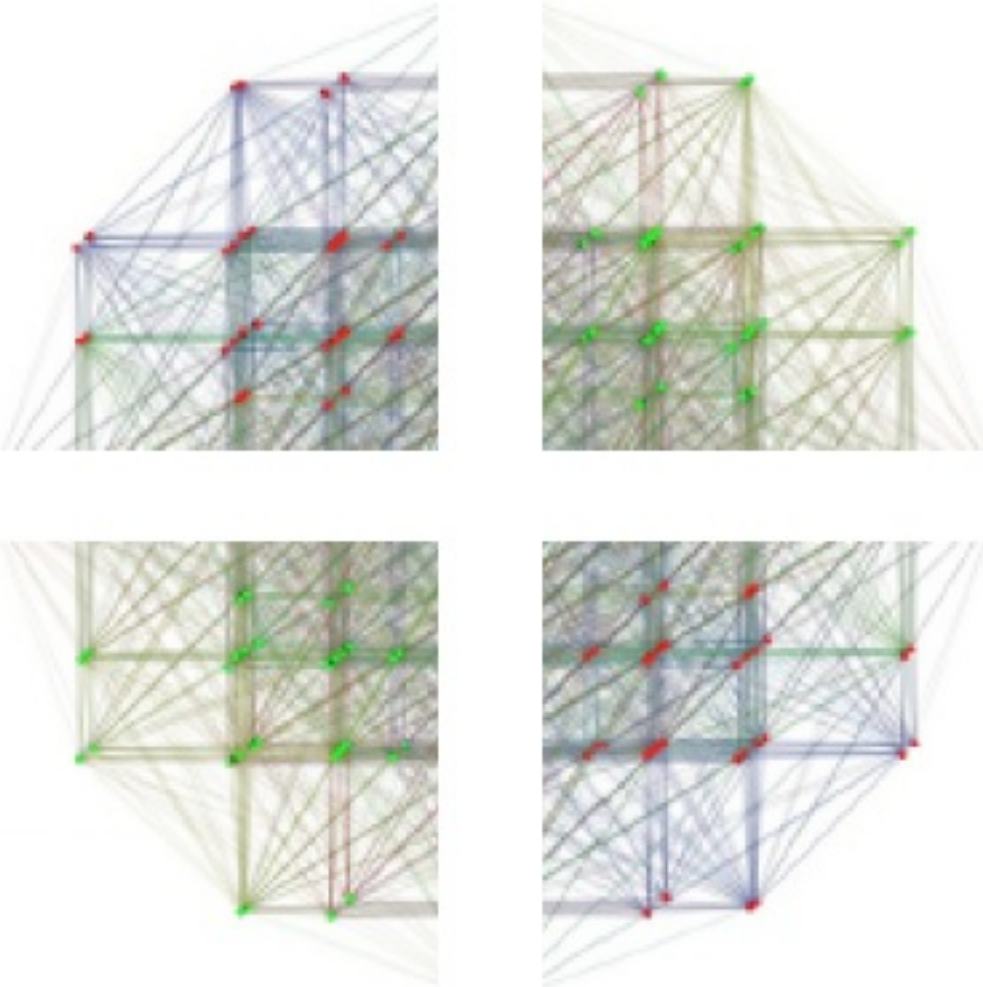
24 Yellow

24 Orange

64 Blue

plus

128 Root Vectors that correspond to one of the 128-dimensional half-spinor representations of the Lie Algebra  $D_8$



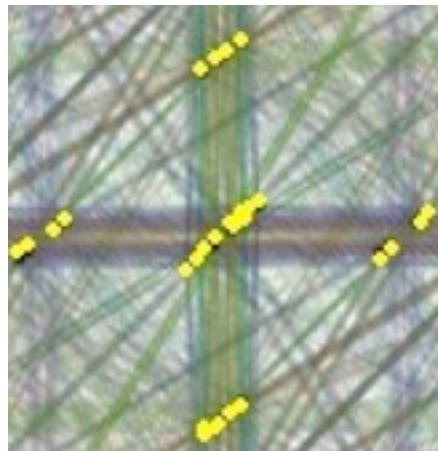
These 128 Root Vectors are color-keyed as:

64 Red

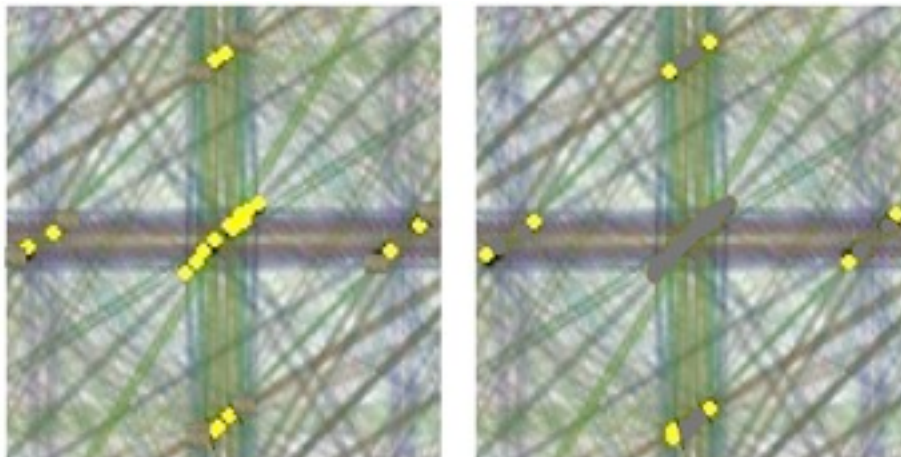
64 Green

**Physical interpretations of the 240  $E_8$  Root Vectors  
are given on the following pages:**

The 24 Yellow Root Vectors correspond to the Standard Model Gauge Bosons which act on CP2 Internal Symmetry Space of M4xCP2 Kaluza-Klein Spacetime.

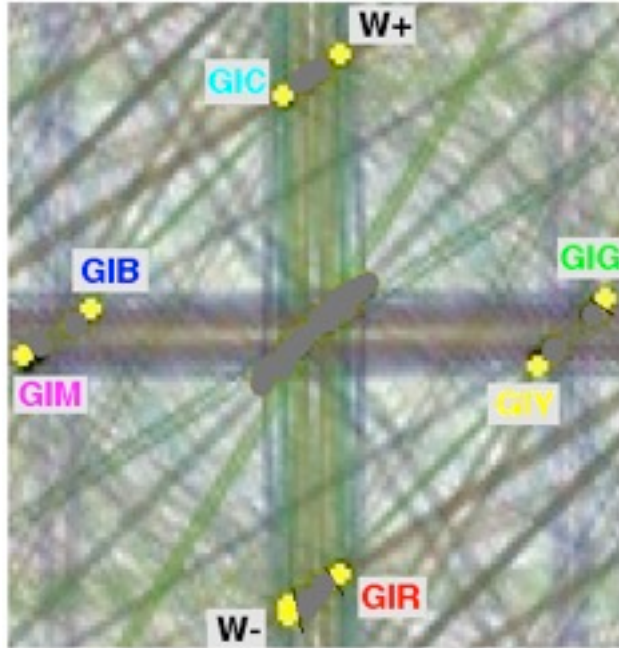


The 16 inner Root Vectors act to coordinate the Standard Model Gauge Bosons with the M4 Minkowski Space of M4xCP2 Kaluza-Klein Spacetime



while the 8 outer Root Vectors form a cube that represents

the W+ and W- Weak Bosons  
and  
the 6 Gluons that carry Color Charge:



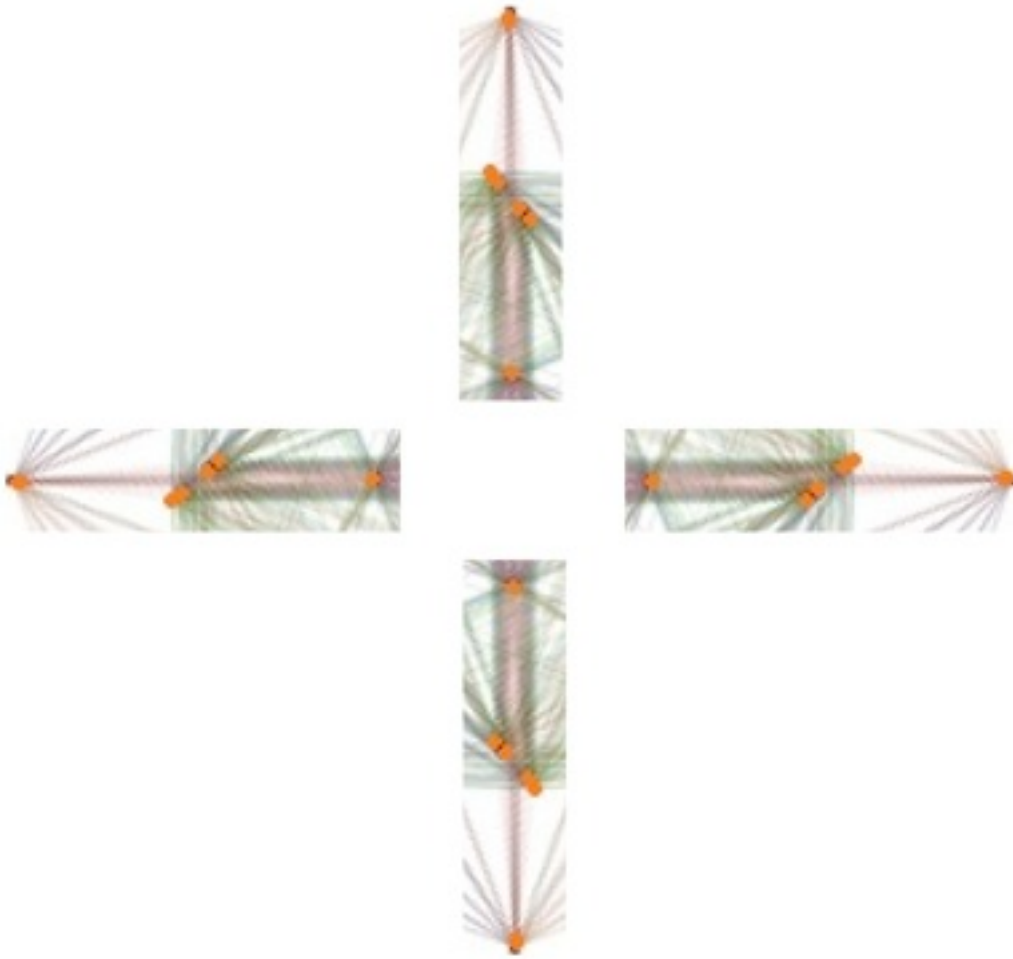
When combined with 4 of the 8 Cartan Subalgebra elements of  $E_8$  ( that is, 4 of the 8 elements that are not represented by the 240 Root Vectors ) these 8 Root Vectors form the Standard Model Gauge Groups of:

8-dimensional  $SU(3)$  Color Force

3-dimensional  $SU(2)$  Weak Force

1-dimensional  $U(1)$  Electromagnetic Force.

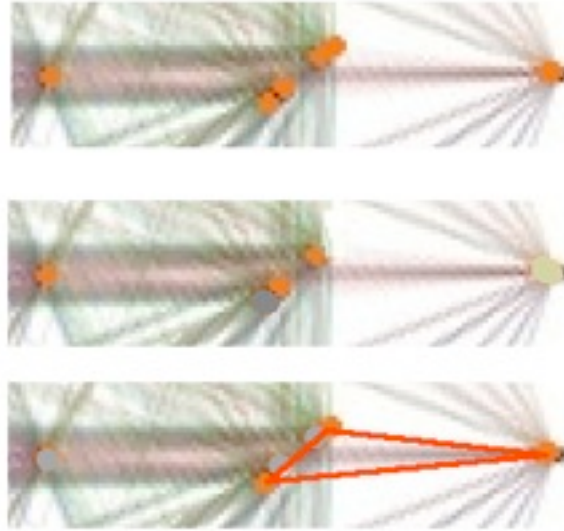
The 24 Orange Root Vectors correspond to the  $U(2,2)$  Conformal Group that by a MacDowell-Mansouri mechanism produces Gravity which acts on the  $M_4$  Minkowski space of  $M_4 \times CP^2$  Kaluza-Klein Spacetime.



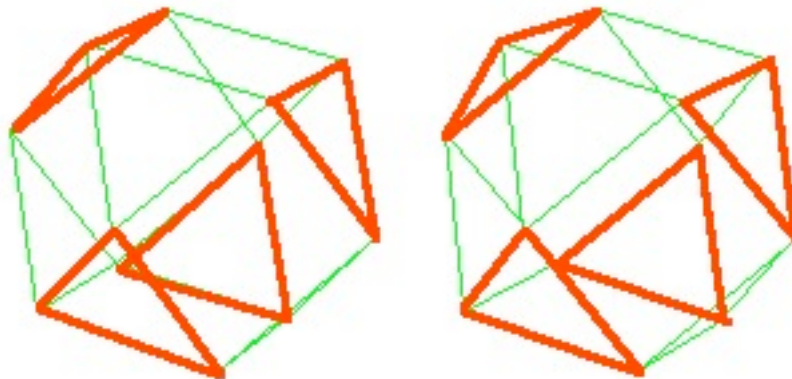
The 24 Orange Root Vectors are composed of 4 sets of 6 as shown above.

Each set of 6 breaks down

into 3 inner Root Vectors plus 3 outer Root Vectors



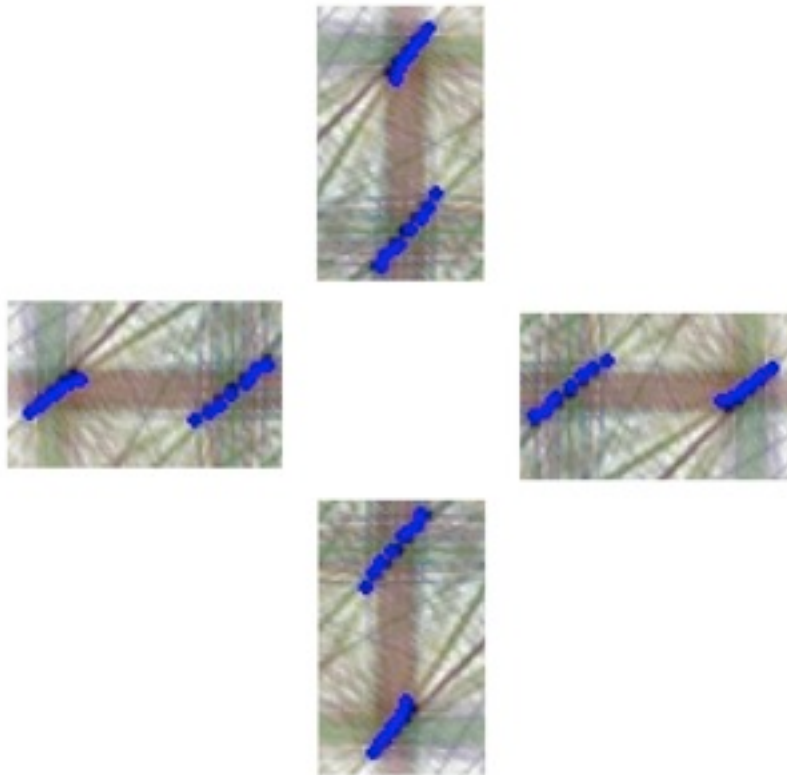
The 3 outer Root Vectors form a triangle,  
and  
the 12 vertices of the 4 triangles of the outer Root Vectors correspond to  
a cuboctahedron



that is the Root Vector Polytope for the  $U(2,2)$  Lie Algebra.

The 12 inner Root Vectors act to coordinate the Conformal Group with  
the  $CP^2$  Internal Symmetry Space of  $M_4 \times CP^2$  Kaluza-Klein Spacetime  
while the 12 outer Root Vectors combine with 4 of the 8 Cartan Subalgebra  
elements of  $E_8$  ( that is, 4 of the 8 elements that are not represented by the 240  
Root Vectors ) to form the 16-dimensional  $U(2,2)$  Conformal Group.

The  $8 \times 8 = 64$  Blue Root Vectors correspond to the 8 position dimensions of Kaluza-Klein Spacetime and the corresponding 8 dual momentum dimensions.



63 of the  $8 \times 8 = 64$  Blue Root Vectors correspond to the 63 dimensions of the  $SL(8)$  Lie Algebra that is the subalgebra of  $E_8$  to which  $E_8$  contracts in its maximal contraction

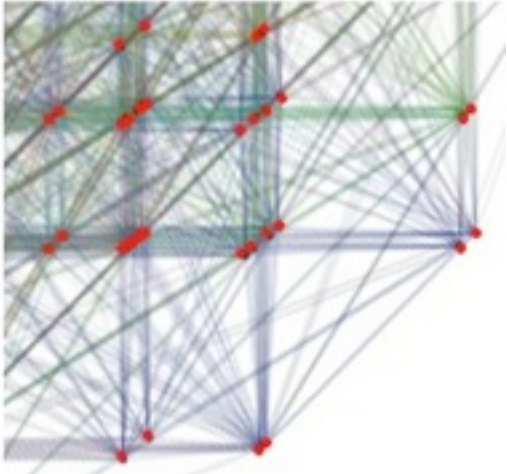
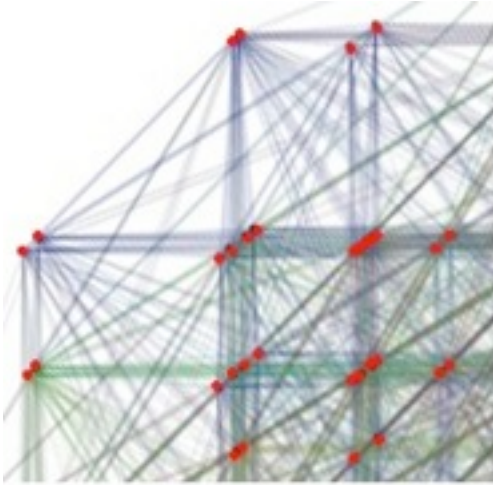
$$E_8 \rightarrow SL(8) + \mathfrak{h}_{92}$$

where  $\mathfrak{h}_{92}$  is a 185-dimensional Heisenberg Lie Algebra for 92 sets of creation-annihilation operators:

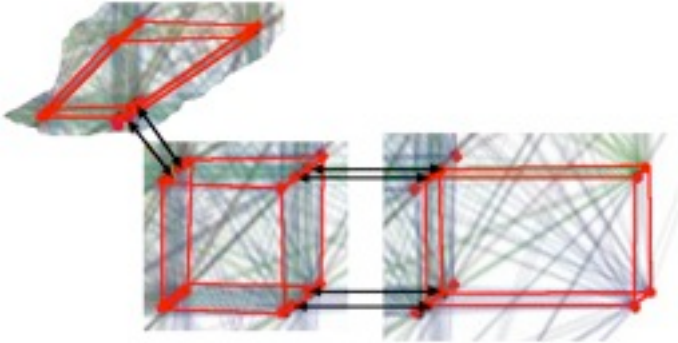
- 64 Fermion Particle Creators + 64 Fermion AntiParticle Creators
- 28 Gravity Boson Creators + 28 Standard Model Boson Creators.

The 64th Blue Root Vector corresponds to the 1 central element of  $\mathfrak{h}_{92}$ .

The  $8 \times 8 = 64$  Red Root Vectors correspond to the 8 covariant components of the 8 fundamental (First-Generation) Fermion Particles

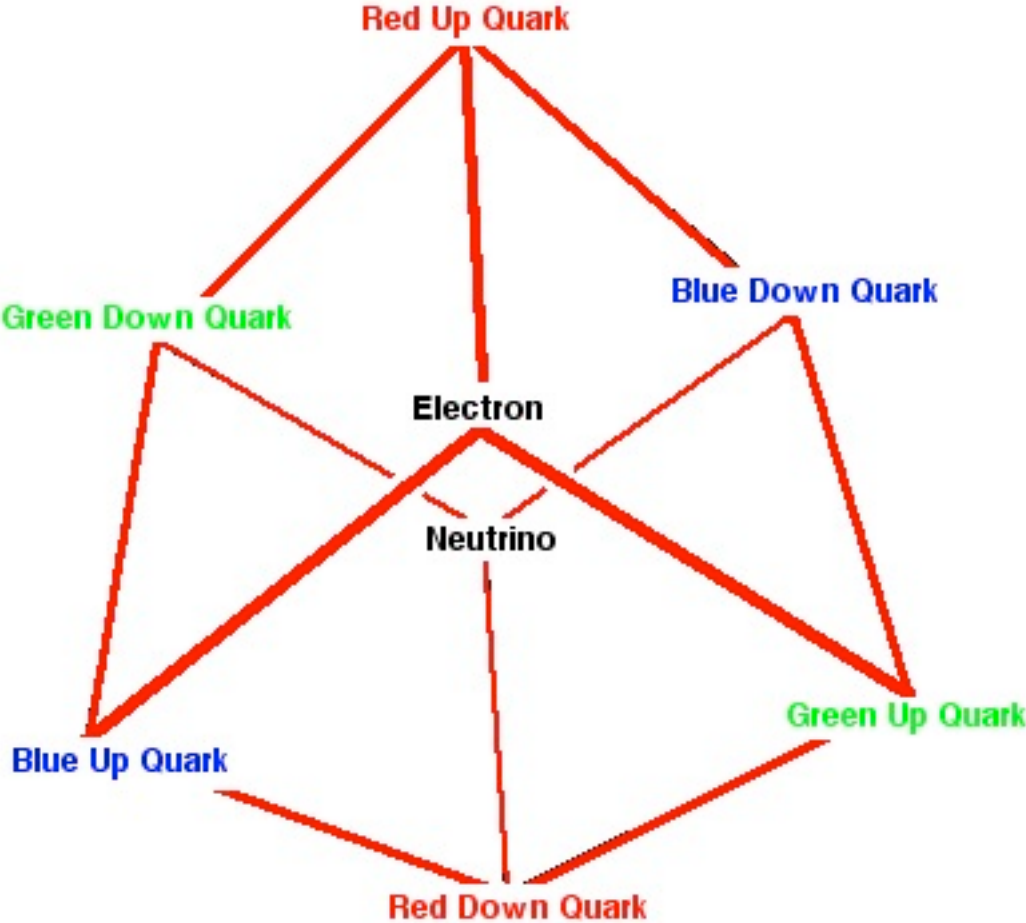


Each subset of 32 is geometrically equivalent to 4 cubes. Here is a diagram of how some of the cubes fit together:



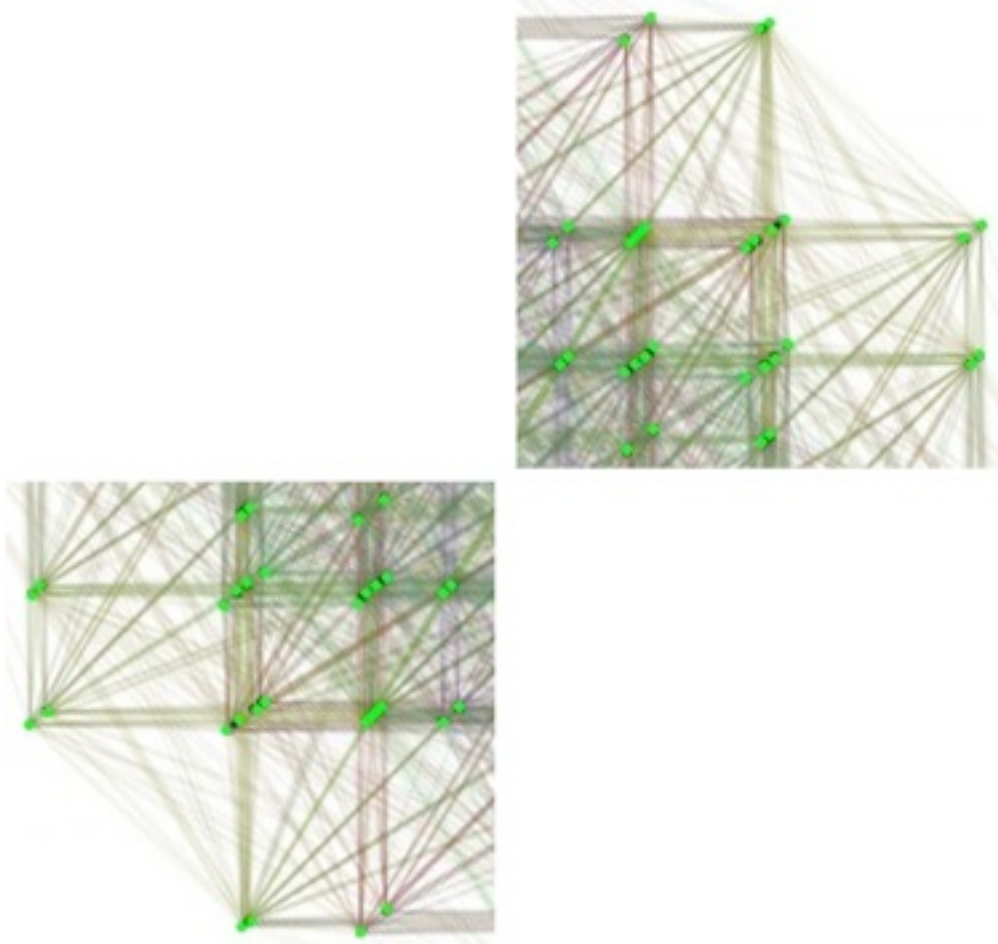


Each cube represents a set of 8 fundamental Fermion Particles:



There are  $4+4 = 8$  cubes, so each cube corresponds to one of the 8 covariant components of its set of 8 fundamental Fermion Particles.

The  $8 \times 8 = 64$  Green Root Vectors correspond to the 8 covariant components of the 8 fundamental (First-Generation) Fermion AntiParticles



The geometry of the representation of Fermion AntiParticles by the  $32+32 = 64$  Root Vectors corresponds to that of Fermion Particles described on the preceding two pages.

You can also visualize the E8 Root Vector structure by writing the Root Vectors in terms of 8-dimensional coordinates of one of the 7 independent E8 lattices. If you use the same color code as above (except that here I use Orange for 48 Root Vectors that are shown above as 24 Yellow and 24 Orange), you can get:

112 = 64 + 48 Root Vectors corresponding to D8:

$$\begin{aligned}
 & \pm 1, \quad \pm i, \quad \pm j, \quad \pm k, \quad \pm e, \quad \pm ie, \quad \pm je, \quad \pm ke, \\
 & (\pm 1 \quad \pm i \quad \quad \quad \quad \quad \pm e \quad \pm ie \quad \quad \quad \quad \quad) / 2 \\
 & (\pm 1 \quad \quad \quad \pm j \quad \quad \quad \pm e \quad \quad \quad \pm je \quad \quad \quad \quad) / 2 \\
 & (\pm 1 \quad \quad \quad \quad \pm k \quad \pm e \quad \quad \quad \quad \pm ke \quad \quad) / 2 \\
 & \\
 & ( \quad \quad \quad \pm j \quad \pm k \quad \quad \quad \pm je \quad \pm ke \quad \quad) / 2 \\
 & ( \quad \quad \pm i \quad \quad \pm k \quad \quad \quad \pm ie \quad \quad \quad \pm ke \quad \quad) / 2 \\
 & ( \quad \pm i \quad \pm j \quad \quad \quad \pm ie \quad \pm je \quad \quad \quad \quad) / 2
 \end{aligned}$$

128 = 64 + 64 Root Vectors corresponding to half-spinor of D8:

$$\begin{aligned}
 & (\pm 1 \quad \quad \quad \quad \quad \pm ie \quad \pm je \quad \pm ke \quad \quad) / 2 \\
 & (\pm 1 \quad \quad \quad \pm j \quad \pm k \quad \quad \pm ie \quad \quad \quad \quad) / 2 \\
 & (\pm 1 \quad \pm i \quad \quad \pm k \quad \quad \quad \pm je \quad \quad \quad \quad) / 2 \\
 & (\pm 1 \quad \pm i \quad \pm j \quad \quad \quad \quad \quad \pm ke \quad \quad) / 2 \\
 & \\
 & ( \quad \pm i \quad \pm j \quad \pm k \quad \pm e \quad \quad \quad \quad \quad) / 2 \\
 & ( \quad \pm i \quad \quad \quad \quad \pm e \quad \quad \quad \pm je \quad \pm ke \quad \quad) / 2 \\
 & ( \quad \quad \quad \pm j \quad \quad \pm e \quad \pm ie \quad \quad \pm ke \quad \quad) / 2 \\
 & ( \quad \quad \quad \pm k \quad \pm e \quad \pm ie \quad \pm je \quad \quad \quad \quad) / 2
 \end{aligned}$$

Use the physical interpretations of the 240 E8 Root Vectors  
to construct a **Lagrangian** by  
**integration over 8-dim Spacetime Base Manifold** (64 Root Vectors) of  
**the Gravity and the Standard Model** from the two D4 (48 Root Vectors) and  
**a Dirac Fermion Particle-AntiParticle term** (64+64 Root Vectors).

This Lagrangian differs from conventional Gravity plus Standard Model  
in four respects:

- 1 - 8-dimensional spacetime with NonUnitary Octonionic Inflation
- 2 - no Higgs
- 3 - two D4 producing gauge groups
- 4 - 1 generation of fermions

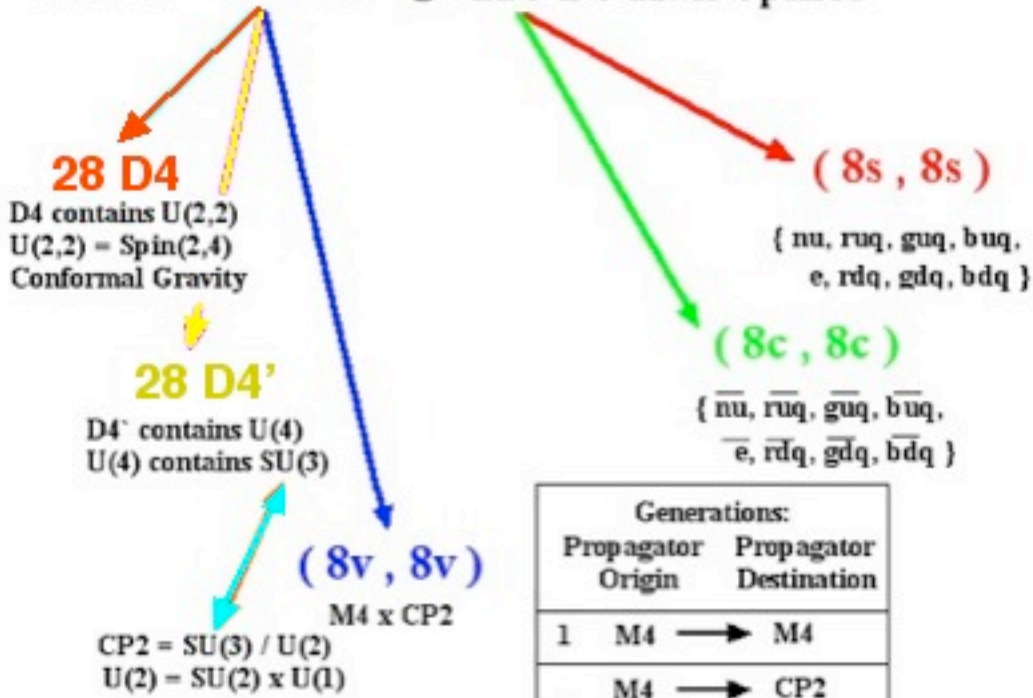
These differences can be reconciled by freezing out at lower-than-Planck energies  
a preferred Quaternionic 4-dim subspace of the original (high-energy) 8-dim  
spacetime, thus forming an **8-dim Kaluza-Klein spacetime M4xCP2** where  
**M4 is 4-dim Minkowski Physical Spacetime** and  
**CP2 is a 4-dim Internal Symmetry Space.**

This Octonionic to Quaternionic symmetry breaking  
makes the Lagrangian consistent with experimental observations:

- 1 and 2 - The Octonionic to Quaternionic symmetry breaking  
from 8-dim Spacetime with NonUnitary Octonionic Inflation of our  
Universe to Unitary Quaternionic Post-Inflation M4 Minkowski Physical  
Spacetime produces the Higgs by a Mayer-Trautman mechanism.
- 3 - The CP2 = SU(3)/U(2) structure of Internal Symmetry Space allows  
one D4 to act with respect to M4 as the Conformal Group to produce  
Gravity by a MacDowell-Mansouri mechanism and the other D4 to act  
as the Standard Model with respect to CP2 by a Batakis mechanism.
- 4 - The 4+4 dimensional structure of M4xCP2 Kaluza-Klein produces  
the Second and Third Generations of Fermions and  
accurate calculation of the Truth Quark mass for the Middle State of  
a 3-State Higgs-Tquark system with Higgs as Tquark Condensate  
by a model of Yamawaki et al.

The resulting structure looks like:

$$248 E8 = 120 D8 \oplus 128 D8 \text{ Half Spinor}$$



Generations:		
	Propagator Origin	Propagator Destination
1	M4	M4
2	M4	CP2
	CP2	M4
3	CP2	CP2

Lagrangian:

$$\int_{\text{KKspacetime}} \text{gauge term} + \text{fermion term}$$

KKspacetime

Higgs-Mayer:

**Kobayashi-Nomizu:**

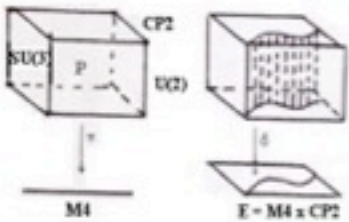
**THEOREM 11.7.** Assume in Theorem 11.5 that  $\mathfrak{t}$  admits a subspace  $\mathfrak{m}$  such that  $\mathfrak{t} = \mathfrak{j} + \mathfrak{m}$  (direct sum) and  $\text{ad}(J)(\mathfrak{m}) = \mathfrak{m}$ , where  $\text{ad}(J)$  is the adjoint representation of  $J$  in  $\mathfrak{t}$ . Then

(1) There is a 1:1 correspondence between the set of  $K$ -invariant connections in  $P$  and the set of linear mappings  $\Lambda_{\mathfrak{m}}: \mathfrak{m} \rightarrow \mathfrak{g}$  such that  $\Lambda_{\mathfrak{m}}(\text{ad}(j)(X)) = \text{ad}(j)(\Lambda_{\mathfrak{m}}(X))$  for  $X \in \mathfrak{m}$  and  $j \in J$ ; the correspondence is given via Theorem 11.5 by

$$\Lambda(X) = \begin{cases} \lambda(X) & \text{if } X \in \mathfrak{j}, \\ \Lambda_{\mathfrak{m}}(X) & \text{if } X \in \mathfrak{m}. \end{cases}$$

(2) The curvature form  $\Omega$  of the  $K$ -invariant connection defined by  $\Lambda_{\mathfrak{m}}$  satisfies the following condition:

$$2\Omega_{\mathfrak{m}}(X, Y) = [\Lambda_{\mathfrak{m}}(X), \Lambda_{\mathfrak{m}}(Y)] - \Lambda_{\mathfrak{m}}([X, Y]_{\mathfrak{m}}) - \lambda([X, Y]_{\mathfrak{j}}) \text{ for } X, Y \in \mathfrak{m},$$



The Higgs and the T-quark form a system in which the Higgs is effectively a T-quark condensate.

Here are details on how it all works:

### **AQFT:**

Since the E8 classical Lagrangian is Local, it is necessary to patch together Local Lagrangian Regions to form a Global Structure describing a Global E8 Algebraic Quantum Field Theory (AQFT).

Mathematically, this is done by using Clifford Algebras to embed E8 into  $Cl(16)$  and using a copy of  $Cl(16)$  to represent each Local Lagrangian Region. A Global Structure is then formed by taking the tensor products of the copies of  $Cl(16)$ . Due to Real Clifford Algebra 8-periodicity,  $Cl(16) = Cl(8) \times Cl(8)$  and any Real Clifford Algebra, no matter how large, can be embedded in a tensor product of factors of  $Cl(8)$ , and therefore of  $Cl(8) \times Cl(8) = Cl(16)$ . Just as the completion of the union of all tensor products of  $2 \times 2$  complex Clifford algebra matrices produces the usual Hyperfinite III von Neumann factor that describes creation and annihilation operators on the fermionic Fock space over  $C^{(2n)}$  (see John Baez's Week 175), we can take the completion of the union of all tensor products of  $Cl(16) = Cl(8) \times Cl(8)$  to produce a generalized Hyperfinite III von Neumann factor that gives a natural Algebraic Quantum Field Theory structure to the E8 model.

## EPR:

For the E8 model AQFT to be realistic, it must be consistent with EPR entanglement relations. Joy Christian in arXiv 0904.4259 “Disproofs of Bell, GHZ, and Hardy Type Theorems and the Illusion of Entanglement” said: “... a [geometrically] correct local-realistic framework ... provides exact, deterministic, and local underpinnings for at least the Bell, GHZ-3, GHZ-4, and Hardy states. ... The alleged non-localities of these states ... result from misidentified [geometries] of the EPR elements of reality. ... The correlations are ... the classical correlations among the points of a 3 or 7-sphere ...  $S^3$  and  $S^7$  ... are ... parallelizable ... The correlations ... can be seen most transparently in the elegant language of Clifford algebra ...”.

To go beyond the interesting but not completely physically realistic Bell, GHZ-3, GHZ-4, and Hardy states, we must consider more complicated spaces than  $S^3$  and  $S^7$ , but still require that they be parallelizable and be related to Clifford algebra structure.

As Martin Cederwall said in hep-th/9310115: “... The only simply connected compact parallelizable manifolds are the Lie groups [including  $S^3 = SU(2)$ ] and  $S^7$  ...”.

We know that  $S^3 = SU(2) = Spin(4) / SU(2)$  so that it has global symmetry of  $Spin(4)$  transformations and that 6-dimensional  $Spin(4)$  is the grade-2 part of the 16-dimensional  $Cl(4)$  Clifford algebra with graded structure  $16 = 1 + 4 + 6 + 4 + 1$  (where grades are 0,1,2, ... ).

We also know that  $S^7 = Spin(8) / Spin(7)$  so that it has global symmetry of  $Spin(8)$  transformations and that 28-dimensional  $Spin(8)$  is the grade-2 part of the 256-dimensional  $Cl(8)$  Clifford algebra with graded structure  $256 = 1 + 8 + 28 + 56 + 70 + 56 + 28 + 8 + 1$ .

To get a Clifford algebra related parallelizable Lie group large enough to represent a realistic physics model, take the tensor product  $Cl(8) \times Cl(8)$  which by the 8-periodicity property of Real Clifford algebras is  $256 \times 256 = 65,536$ -dimensional  $Cl(16)$  with graded structure  $(1 \times 1) + (1 \times 8 + 8 \times 1) + (1 \times 28 + 28 \times 1 + 8 \times 8) + \dots = 1 + 16 + 120 + \dots$  whose  $28 + 28 + 64 = 120$ -dimensional grade-2 part is  $Spin(16)$  and whose spinor representation has  $256 = 128 + 128$  dimensions.

$Spin(16)$  has  $Cl(16)$  Clifford algebra structure and is a Lie group, and therefore parallelizable, but it has grade-2 bivector bosonic structure and so can only represent physical things like gauge bosons and vector spacetime, and cannot represent physical things like fermions with spinor structure.

However, if we add one of the two 128-dimensional  $Cl(16)$  half-spinor representations to the bosonic adjoint 120-dimensional representation of  $Spin(16)$ , we get the  $120 + 128 = 248$ -dimensional exceptional Lie group  $E_8$ .

248-dimensional  $E_8$  has a 7-grading (due to Thomas Larsson)  
 $8 + 28 + 56 + 64 + 56 + 28 + 8$   
 (where grades are  $-3, -2, -1, 0, 1, 2, 3$ )

If 8 of the 64 central grade-0 elements are assigned to an 8-dimensional Cartan subalgebra of  $E_8$ , the remaining  $248 - 8 = 240$  elements are the 240 Root Vectors of  $E_8$  which have a graded structure

$$8 \quad 28 \quad 56 \quad 56 \quad 56 \quad 28 \quad 8$$

that is consistent with the physical interpretations of my  $E_8$  model described earlier in this paper.

Since  $E_8$  is a Lie Group and therefore parallelizable and lives in Clifford Algebra  $Cl(16)$  my  $E_8$  Physics model should be consistent with EPR.



## Chirality:

Since  $E_8 = \text{adjoint } D_8 + \text{half-spinor } D_8$  and  $D_8$  lives in  $Cl(16)$   
look at these  $D_8$  representations

120-dim adjoint - denoted by  $D_8^{\text{adj}}$

128-dim +half-spinor - denoted by  $D_8^{s+}$

128-dim -half-spinor - denoted by  $D_8^{s-}$

if you make the physical interpretations:

$D_8^{\text{adj}}$  as gauge bosons plus spacetime

$D_8^{s+}$  as one generation of fermion particles and antiparticles

$D_8^{s-}$  as one antigeneration of fermion particles and antiparticles

then

if you try to form a Lie algebra from

$D_8^{\text{adj}} + D_8^{s+} + D_8^{s-}$

it does not work,

but

if you try to form a Lie algebra from

$D_8^{\text{adj}} + D_8^{s+}$

you succeed and get  $E_8$

with the  $64+64 = 128$ -dim  $D_8^{s+}$  representing one generation of fermion particles  
(one 64 of  $D_8^{s+}$ ) and one generation of fermion antiparticles (the other 64 of  $D_8^{s+}$ ).

The math structure of Lie algebras is telling you  
that there is no physical  $D_8^{s-}$  antigeneration of fermions,  
and  
that one generation of  $D_8^{s+}$  fermions lives inside  $E_8$ .

Then you have to deal with the Atiyah-Singer index giving the net number of  
generations, which is an issue conventionally formulated  
in terms of the Euler index of the compact manifold (6-dim)  
used to reduce 10-dim spacetime to physical 4-dim.

If do start with a 10-dim spacetime  
you could reduce it using the compact  $CP^2$   
leaving an 6-dim conformal spacetime that, by Conformal Group structure,  
naturally gives you 4-dim spacetime (compare twistors etc).

For an E8 model,  
spacetime is 8-dim reduced to a Kaluza-Klein  $M4 \times CP2$

Look at the index structure of the CP2.

CP2 has:

no spin structure

Euler number  $2+1 = 3$

no need to have zero Hirzebruch signature as CP2 is 4-dimensional

Atiyah-Singer index  $-1/8$  which is not an integer for generation number.

Since CP2 has no spin structure,

you have to give it a generalized spin structure following

Hawking and Pope (Phys. Lett. 73B (1978) 42-44)

and Chakraborty and Parthasarathy (Class. Quantum Grav. 7 (1990) 1217-1224)

to get

(for integral  $m$ ) for the index  $n_R - n_L = (1/2) m (m+1)$

For  $m = 1$ ,  $n_R - n_L = (1/2) \times 1 \times 2 = 1$  for 1 generation

For  $m = 2$ ,  $n_R - n_L = (1/2) \times 2 \times 3 = 3$  for 3 generations

so

the E8 Physics model with CP2 Internal Symmetry Space

has consistent Chiral Fermions:

for index = 1 for 1 generation as in the E8 prior to dimensional reduction;

for index = 3 for 3 generations as the E8 model after dimensional reduction induces the second and third generations to emerge as effective composites of the first.

## NonUnitary Octonionic Inflation:

In his book Quaternionic Quantum Mechanics and Quantum Fields ((Oxford 1995), Stephen L. Adler says at pages 50-52, 561:

"... If the multiplication is associative, as in the complex and quaternionic cases, we can remove parentheses in ... Schroedinger equation dynamics ... to conclude that ... the inner product  $\langle f(t) | g(t) \rangle$  ... is invariant ... this proof fails in the octonionic case, and hence one cannot follow the standard procedure to get a unitary dynamics. ...[so there is a]... **failure of unitarity in octonionic quantum mechanics...**".

The non-associativity and non-unitarity of octonions might account for particle creation without the need for tapping the energy of an inflaton field.

The non-associative structure of octonions manifests itself in interesting ways:

The 7-sphere  $S^7$  EXPANDS TO  $S^7 \times G_2 \times S^7 = D_4$  Lie Algebra.

The 480 Octonion multiplications double-cover the 240 Root Vectors of  $E_8$ .

There are 7 independent  $E_8$  lattices, each corresponding to an integral domain, differing in the configuration of the 240  $E_8$  Root Vectors that are the innermost shell surrounding the origin of the lattice at unit distance (also sometimes normalized as 2) from the origin. Here is a list of them with points on the line with  $iE_8, jE_8$  notation being common points with the  $iE_8$  and  $jE_8$  lattices):

```

1E8:  ±1,  ±i,  ±j,  ±k,  ±e,  ±ie,  ±je,  ±ke,
      (±1 ±je ±i ±j)/2          (±k ±e ±ie ±ke)/2
      (±1 ±j ±ie ±ke)/2      5E8, 6E8  (±i ±k ±e ±je)/2
      (±1 ±ke ±k ±i)/2          (±j ±e ±ie ±je)/2
      (±1 ±i ±e ±ie)/2      7E8, 3E8  (±j ±k ±je ±ke)/2
      (±1 ±ie ±je ±k)/2      2E8, 4E8  (±i ±j ±e ±ke)/2
      (±1 ±k ±j ±e)/2          (±i ±ie ±je ±ke)/2
      (±1 ±e ±ke ±je)/2          (±i ±j ±k ±ie)/2

```

2E8:  $\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke,$   
 $(\pm 1 \pm i \pm k \pm e)/2$   $(\pm j \pm ie \pm je \pm ke)/2$   
 $(\pm 1 \pm e \pm je \pm j)/2$  7E8, 6E8  $(\pm i \pm k \pm ie \pm ke)/2$   
 $(\pm 1 \pm j \pm ke \pm k)/2$   $(\pm i \pm e \pm ie \pm je)/2$   
 $(\pm 1 \pm k \pm ie \pm je)/2$  1E8, 4E8  $(\pm i \pm j \pm e \pm ie)/2$   
 $(\pm 1 \pm je \pm i \pm ke)/2$  3E8, 5E8  $(\pm j \pm k \pm e \pm ie)/2$   
 $(\pm 1 \pm ke \pm e \pm ie)/2$   $(\pm i \pm j \pm k \pm je)/2$   
 $(\pm 1 \pm ie \pm j \pm i)/2$   $(\pm k \pm e \pm je \pm ke)/2$

3E8:  $\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke,$   
 $(\pm 1 \pm k \pm ke \pm ie)/2$   $(\pm i \pm j \pm e \pm je)/2$   
 $(\pm 1 \pm ie \pm i \pm e)/2$  E8, 1E8  $(\pm j \pm k \pm je \pm ke)/2$   
 $(\pm 1 \pm e \pm j \pm ke)/2$   $(\pm i \pm k \pm ie \pm je)/2$   
 $(\pm 1 \pm ke \pm je \pm i)/2$  2E8, 5E8  $(\pm j \pm k \pm e \pm ie)/2$   
 $(\pm 1 \pm i \pm k \pm j)/2$  4E8, 6E8  $(\pm e \pm ie \pm je \pm ke)/2$   
 $(\pm 1 \pm j \pm ie \pm je)/2$   $(\pm i \pm k \pm e \pm ke)/2$   
 $(\pm 1 \pm je \pm e \pm k)/2$   $(\pm i \pm j \pm ie \pm ke)/2$

4E8:  $\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke,$   
 $(\pm 1 \pm ke \pm j \pm je)/2$   $(\pm i \pm k \pm e \pm ie)/2$   
 $(\pm 1 \pm je \pm k \pm ie)/2$  1E8, 2E8  $(\pm i \pm j \pm e \pm ke)/2$   
 $(\pm 1 \pm ie \pm e \pm j)/2$   $(\pm i \pm k \pm je \pm ke)/2$   
 $(\pm 1 \pm j \pm i \pm k)/2$  3E8, 6E8  $(\pm e \pm ie \pm je \pm ke)/2$   
 $(\pm 1 \pm k \pm ke \pm e)/2$  7E8, 5E8  $(\pm i \pm j \pm ie \pm je)/2$   
 $(\pm 1 \pm e \pm je \pm i)/2$   $(\pm j \pm k \pm ie \pm ke)/2$   
 $(\pm 1 \pm i \pm ie \pm ke)/2$   $(\pm j \pm k \pm e \pm je)/2$

5E8:  $\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke,$   
 $(\pm 1 \pm j \pm e \pm i)/2$   $(\pm k \pm ie \pm je \pm ke)/2$   
 $(\pm 1 \pm i \pm ke \pm je)/2$  2E8, 3E8  $(\pm j \pm k \pm e \pm ie)/2$   
 $(\pm 1 \pm je \pm ie \pm e)/2$   $(\pm i \pm j \pm k \pm ke)/2$   
 $(\pm 1 \pm e \pm k \pm ke)/2$  7E8, 4E8  $(\pm i \pm j \pm ie \pm je)/2$   
 $(\pm 1 \pm ke \pm j \pm ie)/2$  1E8, 6E8  $(\pm i \pm k \pm e \pm je)/2$   
 $(\pm 1 \pm ie \pm i \pm k)/2$   $(\pm j \pm e \pm je \pm ke)/2$   
 $(\pm 1 \pm k \pm je \pm j)/2$   $(\pm i \pm e \pm ie \pm ke)/2$

6E8:  $\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke,$   
 $(\pm 1 \pm e \pm ie \pm k)/2$   $(\pm i \pm j \pm je \pm ke)/2$   
 $(\pm 1 \pm k \pm j \pm i)/2$  3E8, 4E8  $(\pm e \pm ie \pm je \pm ke)/2$   
 $(\pm 1 \pm i \pm je \pm ie)/2$   $(\pm j \pm k \pm e \pm ke)/2$   
 $(\pm 1 \pm ie \pm ke \pm j)/2$  5E8, 1E8  $(\pm i \pm k \pm e \pm je)/2$   
 $(\pm 1 \pm j \pm e \pm je)/2$  7E8, 2E8  $(\pm i \pm k \pm ie \pm ke)/2$   
 $(\pm 1 \pm je \pm k \pm ke)/2$   $(\pm i \pm j \pm e \pm ie)/2$   
 $(\pm 1 \pm ke \pm i \pm e)/2$   $(\pm j \pm k \pm ie \pm je)/2$

7E8:  $\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke,$   
 $(\pm 1 \pm ie \pm je \pm ke)/2$   $(\pm e \pm i \pm j \pm k)/2$   
 $(\pm 1 \pm ke \pm e \pm k)/2$  5E8, 4E8  $(\pm i \pm j \pm ie \pm je)/2$   
 $(\pm 1 \pm k \pm i \pm je)/2$   $(\pm j \pm ie \pm ke \pm e)/2$   
 $(\pm 1 \pm je \pm j \pm e)/2$  6E8, 2E8  $(\pm ie \pm ke \pm k \pm i)/2$   
 $(\pm 1 \pm e \pm ie \pm i)/2$  3E8, 1E8  $(\pm ke \pm k \pm je \pm j)/2$   
 $(\pm 1 \pm i \pm ke \pm j)/2$   $(\pm k \pm je \pm e \pm ie)/2$   
 $(\pm 1 \pm j \pm k \pm ie)/2$   $(\pm je \pm e \pm i \pm ke)/2$

The vertices that appear in more than one lattice are:

$\pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke$	in	all of them;
$(\pm 1 \pm i \pm j \pm k)/2$ and $(\pm e \pm ie \pm je \pm ke)/2$	in	3E8, 4E8, and 6E8 ;
$(\pm 1 \pm i \pm e \pm ie)/2$ and $(\pm j \pm k \pm je \pm ke)/2$	in	7E8, 1E8, and 3E8 ;
$(\pm 1 \pm j \pm e \pm je)/2$ and $(\pm i \pm k \pm ie \pm ke)/2$	in	7E8, 2E8, and 6E8 ;
$(\pm 1 \pm k \pm e \pm ke)/2$ and $(\pm i \pm j \pm ie \pm je)/2$	in	7E8, 4E8, and 5E8 ;
$(\pm 1 \pm i \pm je \pm ke)/2$ and $(\pm j \pm k \pm e \pm ie)/2$	in	2E8, 3E8, and 5E8 ;
$(\pm 1 \pm j \pm ie \pm ke)/2$ and $(\pm i \pm k \pm e \pm je)/2$	in	1E8, 5E8, and 6E8 ;
$(\pm 1 \pm k \pm ie \pm je)/2$ and $(\pm i \pm j \pm e \pm ke)/2$	in	1E8, 2E8, and 4E8 .

The unit vertices in the E8 lattices do not include any of the 256 E8 light cone vertices, of the form  $(\pm 1 \pm i \pm j \pm k \pm e \pm ie \pm je \pm ke)/2$ .

They appear in the next layer out from the origin, at radius sqrt 2, which layer contains in all 2160 vertices:

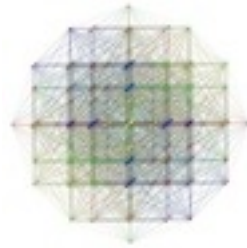
$$2160 = 112 + 256 + 1792 = 112 + (128+128) + 7(128+128)$$

the 112 = root vectors of D8

the (128+128) = 8-cube = two mirror image D8 half-spinors

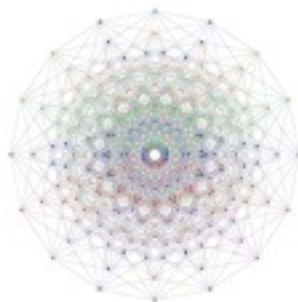
the 7(128+128) = 7 copies of 8-cube for 7 independent E8 lattices, each 8-cube = two mirror image D8 half-spinors related by triality to the 112 and thus to the (128+128) and thus to each other.

All 7 E8 lattices have the same second layer or shell. In the image below,



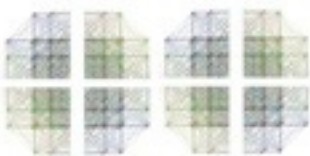
the 240 in the first layer look like

the 112 look like

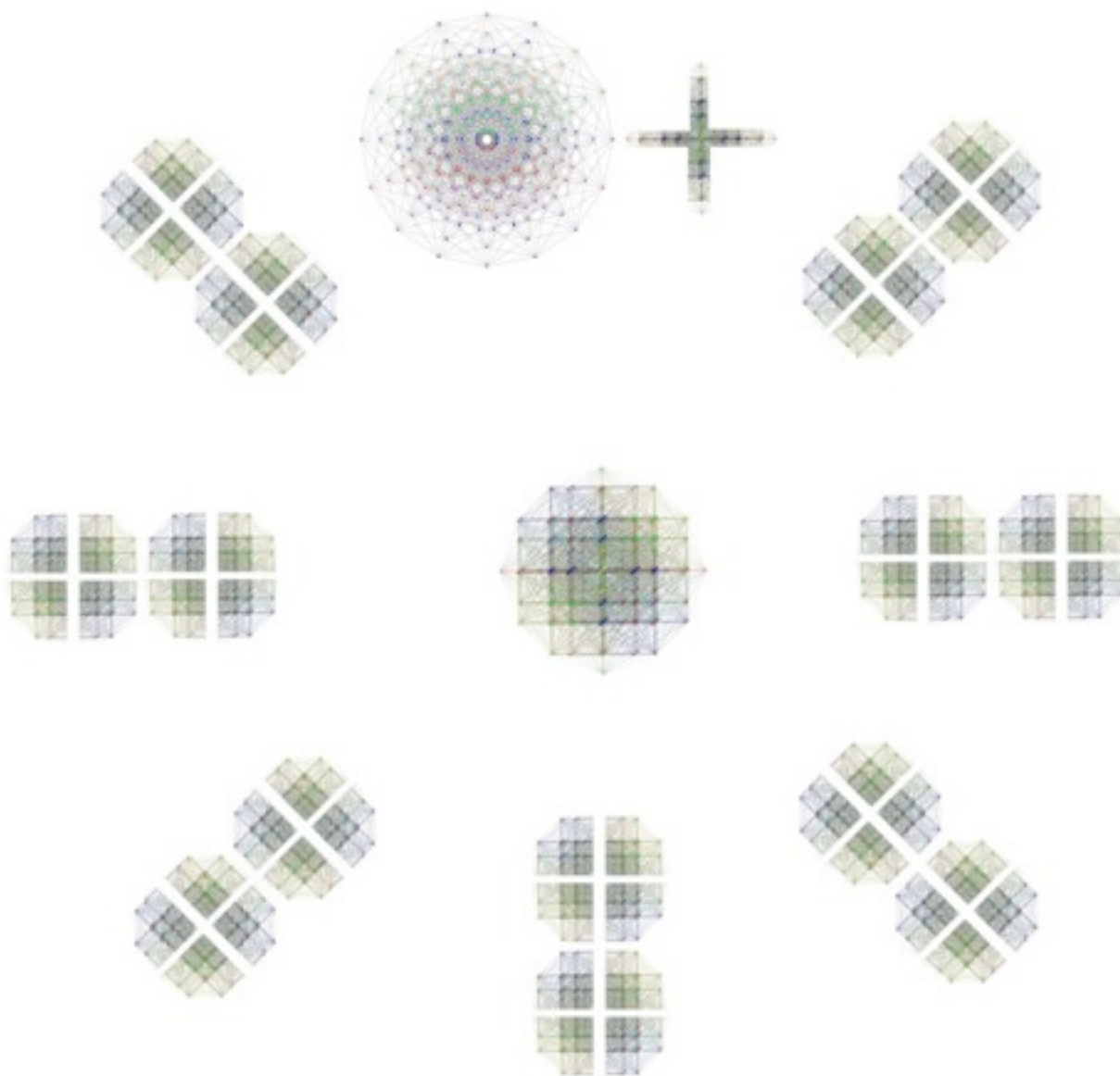


the 256 look like

in the second the 1792 look like



(7 copies of 128+128).



The real  $4_{21}$  Witting polytope of the  $E_8$  lattice in  $R^8$  has  
 240 vertices;  
 6,720 edges;  
 60,480 triangular faces;  
 241,920 tetrahedra;  
 483,840 4-simplexes;  
 483,840 5-simplexes  $4_{00}$ ;  
 138,240 + 69,120 6-simplexes  $4_{10}$  and  $4_{01}$ ; and  
 17,280 7-simplexes  $4_{20}$  and 2,160 7-cross-polytopes  $4_{11}$ .

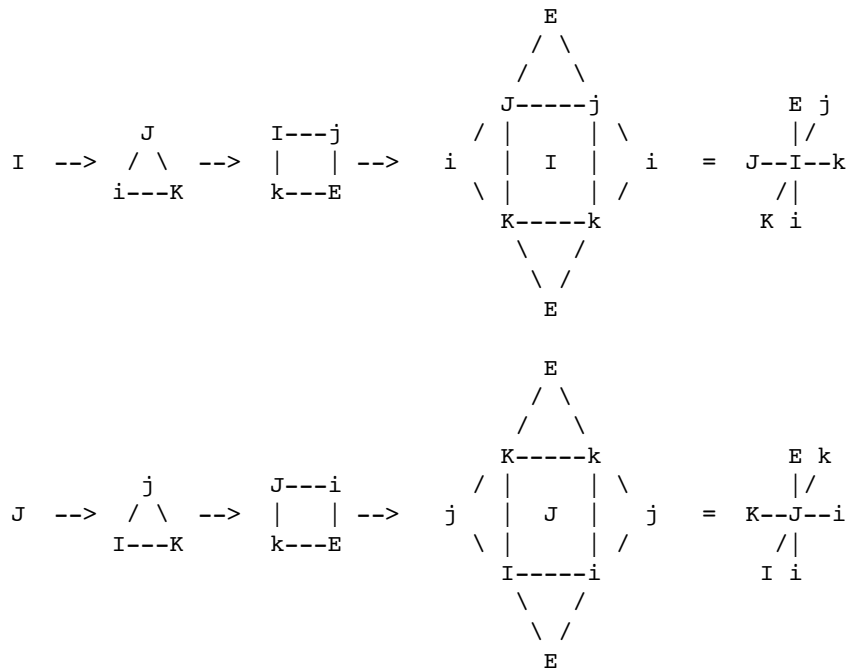
The E8 lattice in R8 has a counterpart in complex C4,  
the self-reciprocal honeycomb of Witting polytopes,  
a lattice of all points whose 4 coordinates are Eisenstein integers with the  
equivalent congruences

$$u_1 + u_2 + u_3 = u_2 - u_3 + u_4 = 0 \pmod{i \sqrt{3}} \text{ and} \\
u_3 - u_2 = u_1 - u_3 = u_2 - u_1 = u_4 \pmod{i \sqrt{3}}.$$

The self-reciprocal Witting polytope in C4 has  
240 vertices,  
2,160 edges,  
2,160 faces, and  
240 cells.

It has 27 edges at each vertex.  
Its symmetry group has order 155,520 = 3 x 51,840.  
It is 6-symmetric, so its central quotient group has order 25,920.  
It has 40 diameters orthogonal to which are 40 hyperplanes of symmetry, each  
of which contains 72 vertices.  
It has a van Oss polygon in C2, its section by a plane joining an edge to the  
center, that is the 3{4}3 in C2, with 24 vertices and 24 edges.

The 7 Imaginary Octonions correspond to the 7 independent E8 lattices  
and therefore to the 7 Onarhedra/Heptavertons:



$$\begin{array}{c}
K \quad \longrightarrow \quad \begin{array}{c} J \\ / \quad \backslash \\ I \text{---} k \end{array} \quad \longrightarrow \quad \begin{array}{c} K \text{---} i \\ | \quad | \\ j \text{---} E \end{array} \quad \longrightarrow \quad \begin{array}{c} E \\ / \quad \backslash \\ I \text{---} i \\ | \quad | \quad | \\ / \quad K \quad \backslash \\ | \quad | \quad | \\ \backslash \quad J \quad / \\ | \quad | \quad | \\ E \end{array} \quad \longrightarrow \quad \begin{array}{c} E \quad i \\ | \quad / \\ I \text{---} K \text{---} j \\ / \quad | \\ J \quad k \end{array}
\end{array}$$

$$\begin{array}{c}
i \quad \longrightarrow \quad \begin{array}{c} I \\ / \quad \backslash \\ E \text{---} i \end{array} \quad \longrightarrow \quad \begin{array}{c} J \text{---} j \\ | \quad | \\ K \text{---} k \end{array} \quad \longrightarrow \quad \begin{array}{c} k \\ / \quad \backslash \\ I \text{---} J \\ | \quad | \quad | \\ / \quad i \quad \backslash \\ | \quad | \quad | \\ \backslash \quad K \quad / \\ | \quad | \quad | \\ E \end{array} \quad \longrightarrow \quad \begin{array}{c} k \quad J \\ | \quad / \\ I \text{---} i \text{---} E \\ / \quad | \\ K \quad j \end{array}
\end{array}$$

$$\begin{array}{c}
j \quad \longrightarrow \quad \begin{array}{c} J \\ / \quad \backslash \\ E \text{---} j \end{array} \quad \longrightarrow \quad \begin{array}{c} K \text{---} k \\ | \quad | \\ I \text{---} i \end{array} \quad \longrightarrow \quad \begin{array}{c} k \\ / \quad \backslash \\ J \text{---} I \\ | \quad | \quad | \\ / \quad j \quad \backslash \\ | \quad | \quad | \\ \backslash \quad K \quad / \\ | \quad | \quad | \\ E \end{array} \quad \longrightarrow \quad \begin{array}{c} k \quad I \\ | \quad / \\ J \text{---} j \text{---} E \\ / \quad | \\ K \quad i \end{array}
\end{array}$$

$$\begin{array}{c}
k \quad \longrightarrow \quad \begin{array}{c} K \\ / \quad \backslash \\ E \text{---} k \end{array} \quad \longrightarrow \quad \begin{array}{c} I \text{---} i \\ | \quad | \\ J \text{---} j \end{array} \quad \longrightarrow \quad \begin{array}{c} i \\ / \quad \backslash \\ K \text{---} J \\ | \quad | \quad | \\ / \quad k \quad \backslash \\ | \quad | \quad | \\ \backslash \quad I \quad / \\ | \quad | \quad | \\ E \end{array} \quad \longrightarrow \quad \begin{array}{c} i \quad J \\ | \quad / \\ K \text{---} k \text{---} E \\ / \quad | \\ I \quad j \end{array}
\end{array}$$

$$\begin{array}{c}
E \quad \longrightarrow \quad \begin{array}{c} j \\ / \quad \backslash \\ i \text{---} k \end{array} \quad \longrightarrow \quad \begin{array}{c} I \text{---} J \\ | \quad | \\ K \text{---} E \end{array} \quad \longrightarrow \quad \begin{array}{c} i \\ / \quad \backslash \\ J \text{---} k \\ | \quad | \quad | \\ / \quad E \quad \backslash \\ | \quad | \quad | \\ \backslash \quad K \quad / \\ | \quad | \quad | \\ I \end{array} \quad \longrightarrow \quad \begin{array}{c} I \quad k \\ | \quad / \\ J \text{---} E \text{---} j \\ / \quad | \\ K \quad i \end{array}
\end{array}$$



Just as each of the 7 imaginary octonions correspond, in my E8 physics model, to the 7 types of charged fermions (electron; red, blue, green up quarks; red, blue, green down quarks), each Onarhedron/Heptaverton corresponds to a charge-neutral set of all 7 charged fermions. Consider that the initial Big Bang produced a particle-antiparticle pair of the 7 charged fermions, plus the 8th fermion (neutrino) corresponding to the real number 1.

As 8-dimensional Spacetime remains Octonionic throughout Inflation, the paper gr-qc/0007006 by Paola Zizzi shows that

"... during inflation, the universe can be described as 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 =  $10^{(-34)}$  sec ] ... and corresponds to a superposed state of ... [  $10^{19} = 2^{64}$  qubits ]. ... This is also the number of superposed tubulins-qubits in our brain ... leading to a conscious event. ...".

The number of doublings (also known as e-foldings) is estimated in astro-ph/0107459 by Banks and Fischler, who say:

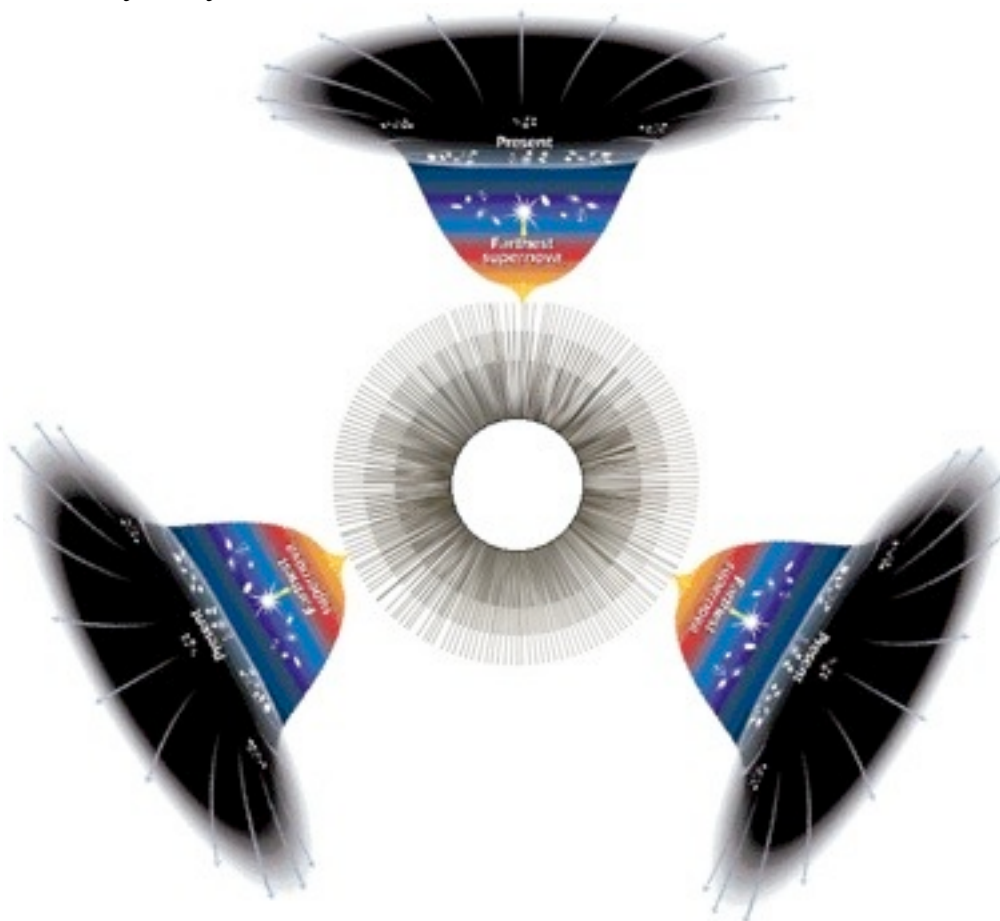
"... If the present acceleration of the universe is due to an asymptotically deSitter universe with small cosmological constant, then the number of e-foldings during inflation is bounded. ... The essential ingredient is that because of the UV-IR connection, entropy requires storage space. The existence of a small cosmological constant restricts the available storage space. ... We obtain the upper bound ...  $N_e = 85$  ... where we took [the cosmological constant]  $\wedge$  to be of  $O(10^{(-3)} \text{ eV})$ . For the sake of comparison, the case  $k = 1/3$  [ corresponding to the equation of state for a radiation-dominated fluid, such as the cosmic microwave background ] yields ...  $N_e = 65$  ... This value for the maximum number of e-foldings is close to the value necessary to solve the "horizon problem".

If at each of the 64 doubling stages of Zizzi inflation the 2 particles of a pair produced  $8+8 = 16$  fermions, then at the end of inflation such a non-unitary octonionic process would have produced about  $2 \times 16^{64} = 4 \times (2^4)^{64} = 4 \times 2^{256} = 4 \times 10^{77}$  fermion particles. The figure of  $4 \times 10^{77}$  is similar number of particles estimated by considering the initial fluctuation to be a Planck mass Black Hole and the 64 doublings to act on such Black Holes.

**Roger Penrose**, in his book *The Emperor's New Mind* (Oxford 1989, pages 316-317) said:

"... in our universe ... Entropy ... increases ... Something forced the entropy to be low in the past. ... the low-entropy states in the past are a puzzle. ...".

The Zizzi Inflation phase of our universe ends with decoherence "collapse" of the  $2^{64}$  Superposition Inflated Universe into Many Worlds of the Many-Worlds Quantum Theory, only one of which Worlds is our World.



In this image:  
the central white circle is the Inflation Era in which everything is in Superposition;  
the boundary of the central circle marks the decoherence/collapse at the End of Inflation;  
and each line radiating from the central circle corresponds to one decohered/collapsed Universe World (of course, there are many more lines than actually shown), only three of which are explicitly indicated in the image, and only one of which is Our Universe World. Since our World is only a tiny fraction of all the Worlds, it carries only a tiny fraction of the entropy of the  $2^{64}$  Superposition Inflated Universe, thus solving Penrose's Puzzle.

Paola Zizzi drew **analogy between the Inflation Era of our Universe and the Quantum Consciousness process of human thought formation.**  
 The human brain contains about  $10^{18}$  tubulins in cylindrical microtubules.  
 Each tubulin contains a Dimer that can be in one of two binary states.



## The Microtubule

in the illustration (from a Rhett Savage web site), the red dimer has its electron in the down state and the blue dimer has its electron in the up state.

Each tubulin is about  $8 \times 4 \times 4$  nanometers in size  
 and contains about 450 molecules (amino acids) each with about 20 atoms.

If about 10% of the brain is involved in a given conscious thought,  
 it involves about 10% of  $10^{18}$  or about  $10^{17}$  tubulins.

Since  $10^{17}$  is about  $2^{56}$ ,  
 the mathematics of that thought is described by the Clifford algebra  $Cl(56)$   
 which  
 is (by 8-periodicity)  $Cl(56) = Cl(7 \times 8) =$   
 $= Cl(8) \times \dots (7 \text{ times tensor product}) \dots \times Cl(8) =$   
 $= 7 \text{ states of the basic Clifford algebra } Cl(8)$

That may account for

"The Magical Number Seven, Plus or Minus Two:

Some Limits on our Capacity for Processing Information"

by George Miller available on the web at [psychclassics.yorku.ca/Miller/](http://psychclassics.yorku.ca/Miller/)

Wikipedia (I am not sure of the accuracy of the article) says  
"... the correct number is probably around three or four ...".  
which would be the case for thoughts that use a much smaller portion  
of human brain capacity.

As to how a thought is formed, the Penrose-Hameroff type model  
indicates that all  $2^{56}$  of the tubulins are coherently in phase together,  
forming a coherent quantum state containing all possible outcomes of the  
thought that is being formed  
(all Bohmian possibilities or all possible Worlds of the Many-Worlds)  
and  
after a time the coherent state decoheres into a single outcome state  
that is the thought that is the result of the process  
(Some call it collapse of the wave function. Penrose calls it  
"Orchestrated Objective Reduction of Quantum Coherence", or Orch OR.)

Penrose proposes that Quantum Gravity causes the Orch OR collapse  
that forms each thought after expiration of the time allowed  
for that many tubulin states to be held in a coherent superposition.

That time, the time at which decoherence takes place and a thought is formed,  
can be calculated using quantum gravity ideas  
( see [tony5m17h.net/QuantumMind2003.html](http://tony5m17h.net/QuantumMind2003.html) and related pages )  
and  
the calculation results are consistent with the data of the human brain  
(such as number of tubulins etc).

Another aspect of human consciousness is psychic connections which are readily  
explained in terms of resonances between brains (or other things) holding patterns  
of states that resonate with a state of a given human brain (some humans are better  
than others is getting into such states and holding them, which accounts for some  
people like curanderos being more talented than others, and also accounts for the  
erratic nature of experimental results about psychic phenomena).

The book "Collective Electrodynamics" by Carver Mead is the best reference  
that I know of about quantum theory and resonance.

## **E8, Bosonic String Theory, and the Monster:**

My E8 Physics model can be formulated in terms of Bosonic String Theory:

An 8-Brane is constructed as a superposition of all of the 8 E8 lattices, that is, the 7 independent E8 lattices corresponding to the 7 Imaginary Octonions plus an eighth dependent E8 lattice corresponding to the Real Octonion. Each 8-Brane represents a local neighborhood of spacetime.

Global spacetime is a collection of 8-Branes parameterized by two real variables  $a, b$  that are analogous to the conformal dimensions  $(1,1)$  that extend  $(1,3)$  Minkowski physical spacetime of  $\text{Spin}(1,3)$  to the  $(2,4)$  Conformal spacetime of  $\text{Spin}(2,4) = \text{SU}(2,2)$ .

Physical Gauge Bosons link an 8-Brane to a successor 8-Brane along the World Line of that Gauge Boson as follows:

A Gauge Boson emanating from only the 8E8 lattice in the 8-Brane is a  $U(1)$  Electromagnetic Photon;

A Gauge Boson emanating from only the 8E8 and the 4E8 lattice in the 8-Brane is a  $U(2)$  Weak Boson (note that their common 8E8 unifies the Electromagnetic Photon with the Weak Bosons);

A Gauge Boson emanating from only the 5E8, 6E8, and 7E8 lattices in the 8-Brane is a  $U(3)$  Gluon;

A Gauge Boson emanating from only the 8E8 lattice and the 1E8, 2E8, and 3E8 lattices in the 8-Brane is a  $U(2,2) = U(1) \times \text{SU}(2,2) = U(1) \times \text{Spin}(2,4)$  Conformal Gauge Boson that gives Gravity by the MacDowell-Mansouri mechanism.

We now have constructed the 10 dimensions of the base manifold of 26-dim Closed Unoriented Bosonic String Theory, as well as the Gauge Bosons of the Standard Model plus Gravity, in which Strings are physically interpreted as World-Lines, with relatively large Closed Strings corresponding to World-Lines of particles that locally appear to be free  
and  
relatively small Closed Strings corresponding to paths of virtual particles in the Path Integral Sum-Over-Histories picture.

To describe the one fundamental generation of Fermion Particles and AntiParticles of the E8 model add, to the 10 dimensions we already have, a 16-dimensional space that is discretized by Orbifolding it with respect to the 16-element discrete Octonionic multiplicative group

$\{+/-1,+/-i,+/-j,+/-k,+/-E,+/-I,+/-J,+/-K\}$

to reduce the 16-dim Fermionic representation space

to 16 points  $\{-1,-i,-j,-k,-E,-I,-J,-K,+1,+i,+j,+k,+E,+I,+J,+K\}$

for which Fermion Particles (nu, ru, gu, bu, e, rd, gd, bu)

are represented by  $\{-1,-i,-j,-k,-E,-I,-J,-K\}$

and the corresponding Fermion AntiParticles

are represented by  $\{+1,+i,+j,+k,+E,+I,+J,+K\}$ .

Now our E8 model has realistic first-generation Fermions as well as a base manifold with the Standard Model plus Gravity.

M4 x CP2 Kaluza-Klein spacetime, with its 4-dim physical spacetime,

and the second and third generations of Fermions,

emerge at low temperatures when a preferred Quaternionic substructure freezes out from the high-temperature Octonionic structure.

Interaction of Closed Bosonic Strings as World-Lines

looks like Andrew Gray's idea in quant-ph/9712037

"... probabilities are ... assigned to entire fine-grained histories ...

this new formulation makes

the same experimental predictions as quantum field theory ..."

String Tachyons can be physically interpreted as describing the virtual particle-antiparticle clouds that dress the orbifold Fermion particles

As Lubos Motl said in his on 13 July 2005:

"... closed string tachyons ... can be localized if they appear

in a twisted sector of an orbifold ... tachyons condense near the tip

which smears out the tip of the cone which makes the tip nice and round. ..."

and as Bert Schroer said in hep-th/9908021:

"... any compactly localized operator applied to the vacuum

generates clouds of pairs of particle/antiparticles ...".

String spin-2 Gravitons can be physically interpreted as describing a Bohm-like Quantum Potential and what Penrose (in "Shadows of the Mind" (Oxford 1994) with respect to Quantum Consciousness) describes as "... the gravitational self-energy of that mass distribution which is the difference between the mass distributions of ... states that are to be considered in quantum linear superposition ...".

Since the E8 String Theory construction is not supersymmetric, but has Fermions constructed from Orbifolding in the 26-dim space of Bosonic String Theory,

E8 AQFT can be seen to have symmetry of the Monster Group by considering that James Lepowsky in math.QA/0706.4072 said:

"... the Fischer-Griess Monster M ... was constructed by Griess as a symmetry group (of order about  $10^{54}$ ) of a remarkable new commutative but very, very highly nonassociative, seemingly ad-hoc, algebra B of dimension 196,883. ... The Monster is the automorphism group of the smallest nontrivial string theory that nature allows ... Bosonic 26-dimensional space-time ... "compactified" on 24 dimensions, using the orbifold construction V [flat] ... or more precisely, the automorphism group of the vertex operator algebra with the canonical "smallness" properties. ...".

Further, P. West in hep-th/0104081 said:

"... The Closed Bosonic String and K27  
The closed bosonic string on a torus is invariant under the fake monster Lie algebra ...  
The closed bosonic string in 26 dimensions can also be formulated as a non-linear realisation ...[as]... a Kac-Moody algebra of rank 27. We call this algebra K27. ... the algebra K27 contains the algebra E11 ...".

Paul P. Cook and Peter West in 0805.4451 said:

"... E11 is described completely by its Dynkin diagram which is found by attaching three additional roots to the longest leg of the E8 diagram, each extra simple root having the same length as any root of E8. ...".

Here is a chart of the interrelationships of E8, its AQFT, and the Monster:

# Bosonic String: Monster Gnome Fake Monster

Compactification: Leech Torus Longitudinal Torus Transversal

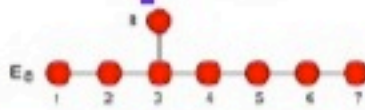
K27



E11 = E8+++



E8



Cl(16)

Contains E8 = Adjoint D8 + Conjugate Spinor D8

Cl(16) x ... (N times tensor product) ... x Cl(16)  
by 8-periodicity is Cl(16N)

hyperfinite factor AQFT

Completion of Union of All Cl(16) Tensor Products



## Coleman-Mandula:

Steven Weinberg said at pages 382-384 of his book  
The Quantum Theory of Fields, Vol. III (Cambridge 2000):  
"... The proof of the Coleman-Mandula theorem ... makes it clear  
that the list of possible bosonic symmetry generators is essentially the same  
in  $d$  greater than 2 spacetime dimensions as in four spacetime dimensions:

...

there are only the momentum  $d$ -vector  $P_u$ , a Lorentz generator  $J_{uv} = -J_{vu}$   
( with  $u$  and  $v$  here running over the values  $1, 2, \dots, d-1, 0$  ), and various  
Lorentz scalar 'charges' ...

the fermionic symmetry generators furnish a representation of the  
homogeneous Lorentz group ... or, strictly speaking, of its covering group  
 $\text{Spin}(d-1,1)$ . ...

The anticommutators of the fermionic symmetry generators with each other  
are bosonic symmetry generators, and therefore must be a linear  
combination of the  $P_u$ ,  $J_{uv}$ , and various conserved scalars. ...

the general fermionic symmetry generator must transform according to the  
fundamental spinor representations of the Lorentz group ...

and not in higher spinor representations,  
such as those obtained by adding vector indices to a spinor. ...".

In short, the important thing about Coleman-Mandula is that fermions in a unified  
model must "... transform according to the fundamental spinor representations of  
the Lorentz group ... or, strictly speaking, of its covering group  $\text{Spin}(d-1,1)$ . ..."  
where  $d$  is the dimension of spacetime in the model.

In my E8 Physics model, E8 is the sum of  
the adjoint representation and a half-spinor representation of  $\text{Spin}(16)$ ,  
and

the  $\text{Spin}(16)$  structure ( since  $\text{Cl}(16) = \text{Cl}(8) \times \text{Cl}(8)$  ) leads  
to  $\text{Spin}(8)$  or  $\text{Spin}(1,7)$  structure with Triality automorphisms among  
8-dim spacetime vectors and the two 8-dim half-spinors

and

the fermionic fundamental spinor representations of the E8 model are  
therefore built with respect to Lorentz, spinor, etc representations based on  
 $\text{Spin}(1,7)$  spacetime consistently with Weinberg's work,

so

the E8 model is consistent with Coleman-Mandula.

## Mayer-Trautman Mechanism:

The objective is to reduce the integral over the 8-dim Kaluza-Klein  $M_4 \times CP^2$  to an integral over the 4-dim  $M_4$ .

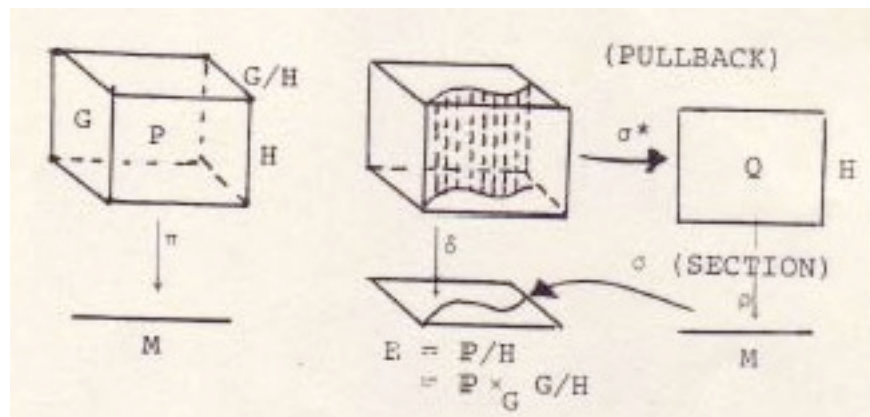
Since the  $D_4 = U(2,2)$  acts on the  $M_4$ , there is no problem with it.  
 Since the  $CP^2 = SU(3) / U(2)$  has global  $SU(3)$  action, the  $SU(3)$  can be considered as a local gauge group acting on the  $M_4$ , so there is no problem with it.

However, the  $U(2)$  acts on the  $CP^2 = SU(3) / U(2)$  as little group, and so has local action on  $CP^2$  and then on  $M_4$ , so the local action of  $U(2)$  on  $CP^2$  must be integrated out to get the desired  $U(2)$  local action directly on  $M_4$ .

Since the  $U(1)$  part of  $U(2) = U(1) \times SU(2)$  is Abelian, its local action on  $CP^2$  and then  $M_4$  can be composed to produce a single  $U(1)$  local action on  $M_4$ , so there is no problem with it.

That leaves non-Abelian  $SU(2)$  with local action on  $CP^2$  and then on  $M_4$ , and the necessity to integrate out the local  $CP^2$  action to get something acting locally directly on  $M_4$ .

This is done by a mechanism due to Meinhard Mayer and A. Trautman in "A Brief Introduction to the Geometry of Gauge Fields" and "The Geometry of Symmetry Breaking in Gauge Theories", Acta Physica Austriaca, Suppl. XXIII (1981) where they say:  
 "...



... We start out from ... four-dimensional  $M$  [  $M_4$  ] ...[and]...  $R$  ...[that is]... obtained from ...  $G/H$  [  $CP^2 = SU(3) / U(2)$  ] ... the physical surviving components of  $A$  and  $F$ , which we will denote by  $A$  and  $F$ , respectively, are a one-form and two form on

M [M4] with values in H [SU(2)] ... the remaining components will be subjected to symmetry and gauge transformations, thus reducing the Yang-Mills action ... [on M4 x CP2]... to a Yang-Mills-Ginzburg-Landau action on M [M4] ... Consider the Yang-Mills action on R ...

$$S_{YM} = \text{Integral Tr} ( F \wedge *F )$$

... We can ... split the curvature F into components along M [M4] (spacetime) and those along directions tangent to G/H [CP2] .

We denote the former components by  $F_{\mu\nu}$  and the latter by  $F_{ab}$  , whereas the mixed components (one along M, the other along G/H) will be denoted by  $F_{\mu a}$  ... Then the integrand ... becomes

$$\text{Tr} ( F_{\mu\nu} F^{\mu\nu} + 2 F_{\mu a} F^{a\mu} + F_{ab} F^{ab} )$$

...

The first term .. becomes the [SU(2)] Yang-Mills action for the reduced [SU(2)] Yang-Mills theory

...

the middle term .. becomes, symbolically,

$$\text{Tr} \text{Sum} D_{\mu} \text{PHI}(?) D^{\mu} \text{PHI}(?)$$

where PHI(?) is the Lie-algebra-valued 0-form corresponding to the invariance of A with respect to the vector field  $\xi$  , in the G/H [CP2] direction

...

the third term ... involves the contraction  $F_{\mu\nu}$  of F with two vector fields lying along G/H [CP2] ... we make use of the equation [from Mayer-Trautman, Acta Physica Austriaca, Suppl. XXIII (1981) 433-476, equation 6.18]

$$2 F_{\mu\nu} = [ \text{PHI}(?) , \text{PHI}(?) ] - \text{PHI}([\xi, \xi])$$

... Thus,

the third term ... reduces to what is essentially a Ginzburg-Landau potential in the components of PHI:

$$\text{Tr} F_{\mu\nu} F^{\mu\nu} = (1/4) \text{Tr} ( [ \text{PHI} , \text{PHI} ] - \text{PHI} )^2$$

... special cases which were considered show that ... [the equation immediately above]... has indeed the properties required of a Ginzburg-Landau-Higgs potential, and moreover the relative signs of the quartic and quadratic terms are correct, and only one overall normalization constant ... is needed. ...".

See S. Kobayashi and K. Nomizu, Foundations of Differential Geometry, Volume I, Wiley (1963), especially section II.11:

“ ...

**THEOREM 11.7.** *Assume in Theorem 11.5 that  $\mathfrak{k}$  admits a subspace  $\mathfrak{m}$  such that  $\mathfrak{k} = \mathfrak{j} + \mathfrak{m}$  (direct sum) and  $\text{ad}(J)(\mathfrak{m}) = \mathfrak{m}$ , where  $\text{ad}(J)$  is the adjoint representation of  $J$  in  $\mathfrak{k}$ . Then ...*

*The curvature form  $\Omega$  of the  $K$ -invariant connection defined by  $\Lambda_{\mathfrak{m}}$  satisfies the following condition:*

$$2\Omega_{u_0}(\tilde{X}, \tilde{Y}) = [\Lambda_{\mathfrak{m}}(X), \Lambda_{\mathfrak{m}}(Y)] - \Lambda_{\mathfrak{m}}([X, Y]_{\mathfrak{m}}) - \lambda([X, Y]_{\mathfrak{j}})$$

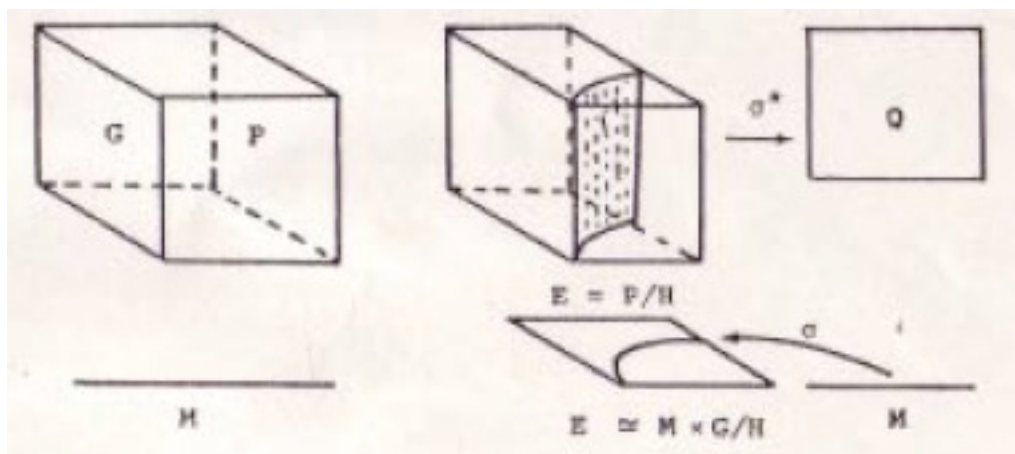
*for  $X, Y \in \mathfrak{m}$ ,*

...”

Along the same lines,

Meinhard E. 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  $G/H$  [  $= SU(3)/U(2)$  ] 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. ...”

## MacDowell-Mansouri Mechanism:

Rabindra Mohapatra (in section 14.6 of Unification and Supersymmetry, 2nd edition, Springer-Verlag 1992) says:

### §14.6. Local Conformal Symmetry and Gravity

Before we study supergravity, with the new algebraic approach developed, we would like to discuss how gravitational theory can emerge from the gauging of conformal symmetry. For this purpose we briefly present the general notation for constructing gauge covariant fields. The general procedure is to start with the Lie algebra of generators  $X_A$  of a group

$$[X_A, X_B] = f_{AB}^C X_C, \quad (14.6.1)$$

where  $f_{AB}^C$  are structure constants of the group. We can then introduce a gauge field connection  $h_\mu^A$  as follows:

$$h_\mu = h_\mu^A X_A. \quad (14.6.2)$$

Let us denote the parameter associated with  $X_A$  by  $\varepsilon^A$ . The gauge transformations on the fields  $h_\mu^A$  are given as follows:

$$\delta h_\mu^A = \partial_\mu \varepsilon^A + h_\mu^B \varepsilon^C f_{CB}^A = (D_\mu \varepsilon)^A. \quad (14.6.3)$$

We can then define a covariant curvature

$$R_{\mu\nu}^A = \partial_\nu h_\mu^A - \partial_\mu h_\nu^A + h_\nu^B h_\mu^C f_{CB}^A. \quad (14.6.4)$$

Under a gauge transformation

$$\delta_{\text{gauge}} R_{\mu\nu}^A = R_{\mu\nu}^B \varepsilon^C f_{CB}^A. \quad (14.6.5)$$

We can then write the general gauge invariant action as follows:

$$I = \int d^4x Q_{AB}^{\mu\nu\rho\sigma} R_{\mu\nu}^A R_{\rho\sigma}^B. \quad (14.6.6)$$

Let us now apply this formalism to conformal gravity. In this case

$$h_\mu = P_\mu e_\nu^\alpha + M_{\alpha\beta} \omega_\mu^{\alpha\beta} + K_\alpha f_\mu^\alpha + D b_\mu. \quad (14.6.7)$$

The various  $R_{\mu\nu}$  are

$$R_{\mu\nu}(P) = \partial_\nu e_\mu^\alpha - \partial_\mu e_\nu^\alpha + \omega_\mu^{\alpha\beta} e_\nu^\beta - \omega_\nu^{\alpha\beta} e_\mu^\beta - b_\mu e_\nu^\alpha + b_\nu e_\mu^\alpha, \quad (14.6.8)$$

$$R_{\mu\nu}(M) = \partial_\nu \omega_\mu^{\alpha\beta} - \partial_\mu \omega_\nu^{\alpha\beta} - \omega_\nu^{\alpha\gamma} \omega_\mu^\beta{}_\gamma + \omega_\mu^{\alpha\gamma} \omega_\nu^\beta{}_\gamma - 4(e_\mu^\alpha f_\nu^\beta - e_\nu^\alpha f_\mu^\beta), \quad (14.6.9)$$

$$R_{\mu\nu}(K) = \partial_\nu f_\mu^\alpha - \partial_\mu f_\nu^\alpha - b_\mu f_\nu^\alpha + b_\nu f_\mu^\alpha + \omega_\mu^{\alpha\beta} f_\nu^\beta - \omega_\nu^{\alpha\beta} f_\mu^\beta, \quad (14.6.10)$$

$$R_{\mu\nu}(D) = \partial_\nu b_\mu - \partial_\mu b_\nu + 2e_\mu^\alpha f_\nu^\alpha - 2e_\nu^\alpha f_\mu^\alpha. \quad (14.6.11)$$

The gauge invariant Lagrangian for the gravitational field can now be written down, using eqn. (14.6.6), as

$$S = \int d^4x \varepsilon_{\alpha\beta\gamma\delta} e^{\alpha\mu} e^{\beta\nu} R_{\mu\nu}^{\alpha\beta}(M) R_{\rho\sigma}^{\gamma\delta}(M). \quad (14.6.12)$$

We also impose the constraint that

$$R_{\mu\nu}(P) = 0, \quad (14.6.13)$$

which expresses  $\omega_a^{mn}$  as a function of  $(e, b)$ . The reason for imposing this constraint has to do with the fact that  $P_a$  transformations must be eventually identified with coordinate transformation. To see this point more explicitly let us consider the vierbein  $e_a^\mu$ . Under coordinate transformations

$$\delta_{GC}(\xi^\nu)e_a^\mu = \partial_\nu \xi^\lambda e_\lambda^\mu + \xi^\lambda \partial_\lambda e_a^\mu. \quad (14.6.14)$$

Using eqn. (14.6.8) we can rewrite

$$\delta_{GC}(\xi^\nu)e_a^\mu = \delta_P(\xi^\nu)e_a^\mu + \delta_M(\xi^\nu \omega^{mn})e_a^\mu + \delta_D(\xi^\nu b) e_a^\mu + \xi^\nu R_{\nu a}^\mu(P),$$

where

$$\delta_P(\xi^\nu)e_a^\mu = \partial_\nu \xi^\mu + \xi^\nu \omega_a^{\mu n} + \xi^{\nu n} b_\nu. \quad (14.6.15)$$

If  $R^{\mu\nu}(P) = 0$ , the general coordinate transformation becomes related to a set of gauge transformations via eqn. (14.6.15).

At this point we also wish to point out how we can define the covariant derivative. In the case of internal symmetries  $D_\mu = \partial_\mu - iX_A h_\mu^A$ ; now since momentum is treated as an internal symmetry we have to give a rule. This follows from eqn. (14.6.15) by writing a redefined translation generator  $\tilde{P}$  such that

$$\delta_{\tilde{P}}(\xi) = \delta_{GC}(\xi^\nu) - \sum_{A'} \delta_{A'}(\xi^{\nu n} h_n^A), \quad (14.6.16)$$

where  $A'$  goes over all gauge transformations excluding translation. The rule is

$$\delta_{\tilde{P}}(\xi^{\nu n})\phi = \xi^{\nu n} D_\nu^C \phi. \quad (14.6.17)$$

We also wish to point out that for fields which carry spin or conformal charge, only the intrinsic parts contribute to  $D_\mu^C$  and the orbital parts do not play any role.

Coming back to the constraints we can then vary the action with respect to  $f_a^m$  to get an expression for it, i.e.,

$$e_a^\nu f_{\nu m} = -\frac{1}{4}[e_a^\lambda e_{\lambda m} R_{\lambda 2}^{\nu n} - \frac{1}{2}g_{\lambda\nu} R], \quad (14.6.18)$$

where  $f_a^m$  has been set to zero in  $R$  written in the right-hand side.

This eliminates (from the theory the degrees of freedom)  $\omega_a^{mn}$  and  $f_a^m$  and we are left with  $e_a^\mu$  and  $b_\nu$ . Furthermore, these constraints will change the transformation laws for the dependent fields so that the constraints do not change.

Let us now look at the matter coupling to see how the familiar gravity theory emerges from this version. Consider a scalar field  $\phi$ . It has conformal weight  $\lambda = 1$ . So we can write a covariant derivative for it, eqn. (14.6.17)

$$D_\mu^C \phi = \partial_\mu \phi - \phi b_\mu. \quad (14.6.19)$$

We note that the conformal charge of  $\phi$  can be assumed to be zero since  $K_\mu = x^2 \partial$  and is the dimension of inverse mass. In order to calculate  $\square^C \phi$  we

start with the expression for d'Alembertian in general relativity

$$\frac{1}{e} \partial_\nu (g^{\mu\nu} e D_\mu^c \phi). \quad (14.6.20)$$

The only transformations we have to compensate for are the conformal transformations and the scale transformations. Since

$$\delta b_\alpha = -2\xi_k^\alpha e_{\mu\alpha}, \quad \delta(\phi b_\alpha) = \phi \delta b_\alpha = -2\phi f_\mu^\alpha e_\alpha^\mu + \frac{1}{12} \phi R, \quad (14.6.21)$$

where, in the last step, we have used the constraint equation (14.6.18). Putting all these together we find

$$\square^c \phi = \frac{1}{e} \partial_\nu (g^{\mu\nu} e D_\mu^c \phi) + b_\alpha D_\alpha^c \phi + \frac{1}{12} \phi R. \quad (14.6.22)$$

Thus, the Lagrangian for conformal gravity coupled to matter fields can be written as

$$S = \int e d^4x \frac{1}{2} \phi \square^c \phi. \quad (14.6.23)$$

Now we can use conformal transformation to gauge  $b_\alpha = 0$  and local scale transformation to set  $\phi = \kappa^{-1}$  leading to the usual Hilbert action for gravity. To summarize, we start with a Lagrangian invariant under full local conformal symmetry and fix conformal and scale gauge to obtain the usual action for gravity. We will adopt the same procedure for supergravity. An important technical point to remember is that,  $\square^c$ , the conformal d'Alembertian contains  $R$ , which for constant  $\phi$ , leads to gravity. We may call  $\phi$  the auxiliary field.

After the scale and conformal gauges have been fixed, the conformal Lagrangian becomes a de Sitter Lagrangian. Einstein-Hilbert gravity can be derived from the de Sitter Lagrangian, as was first shown by **MacDowell and Mansouri (Phys. Rev. Lett. 38 (1977) 739)**. (Note that Frank Wilczek, in [hep-th/9801184](https://arxiv.org/abs/hep-th/9801184), says that the MacDowell-Mansouri "... approach to casting gravity as a gauge theory was initiated by MacDowell and Mansouri ... S. MacDowell and F. Mansouri, Phys. Rev. Lett. 38 739 (1977) ... , and independently Chamseddine and West ... A. Chamseddine and P. West Nucl. Phys. B 129, 39 (1977); also quite relevant is A. Chamseddine, Ann. Phys. 113, 219 (1978). ...".

The minimal group required to produce Gravity, and therefore the group that is used in calculating Force Strengths, is the de Sitter group, as is described by Freund in chapter 21 of his book Supersymmetry (Cambridge 1986) (Note that chapter 21 is a Non-Supersymmetry chapter leading up to a Supergravity description in the following chapter 22):

"... Einstein gravity as a gauge theory ... we expect a set of gauge fields  $w^{ab}_u$  for the Lorentz group and a further set  $e^a_u$  for the translations, ...

Everybody knows though, that Einstein's theory contains but one spin two field, originally chosen by Einstein as  $g_{uv} = e^a_u e^b_v \eta_{ab}$

( $n_{ab}$  = Minkowski metric).

What happened to the  $w^{ab}_u$  ?

The field equations obtained from the Hilbert-Einstein action by varying the  $w^{ab}_u$  are algebraic in the  $w^{ab}_u$  ... permitting us to express the  $w^{ab}_u$  in terms of the  $e^a_u$

...

The  $w$  do not propagate ...

We start from the four-dimensional de-Sitter algebra ...  $so(3,2)$ .

Technically this is the anti-de-Sitter algebra ...

We envision space-time as a four-dimensional manifold  $M$ .

At each point of  $M$  we have a copy of  $SO(3,2)$  (a fibre ...) ...

and we introduce the gauge potentials (the connection)  $h^A_\mu(x)$

$A = 1, \dots, 10$ ,  $\mu = 1, \dots, 4$ . Here  $x$  are local coordinates on  $M$ .

From these potentials  $h^A_\mu$  we calculate the field-strengths

(curvature components) [let  $@$  denote partial derivative]

$R^A_{\mu\nu} = @_\mu h^A_\nu - @_\nu h^A_\mu + f^A_{BC} h^B_\mu h^C_\nu$

...[where]...

the structure constants  $f^C_{AB}$  ...[are for]... the anti-de-Sitter algebra ....

We now wish to write down the action  $S$  as an integral over

the four-manifold  $M$  ...  $S(Q) = \text{INTEGRAL}_M R^A \wedge R^B Q_{AB}$

where  $Q_{AB}$  are constants ... to be chosen ... we require

... the invariance of  $S(Q)$  under local Lorentz transformations

... the invariance of  $S(Q)$  under space inversions ...

...[ AFTER A LOT OF ALGEBRA THAT I WON'T TYPE HERE ]...

we shall see ...[that]... the action becomes invariant under all local [anti]de-Sitter transformations ...[and]... we recognize ... the familiar

Hilbert-Einstein action with cosmological term in vierbein notation ...

Variation of the vierbein leads to the Einstein equations with cosmological term.

Variation of the spin-connection ... in turn ... yield the torsionless Christoffel connection ... the torsion components ... now vanish.

So at this level full  $sp(4)$  invariance has been checked.

... Were it not for the assumed space-inversion invariance ...

we could have had a parity violating gravity. ...

Unlike Einstein's theory ...[MacDowell-Mansouri].... does not require Riemannian invertibility of the metric. ... the solution has torsion ... produced by an interference between parity violating and parity conserving amplitudes.

Parity violation and torsion go hand-in-hand.

Independently of any more realistic parity violating solution of the gravity equations this raises the cosmological question whether

the universe as a whole is in a space-inversion symmetric configuration. ...".



At this stage, we have reconciled the first 3 of the 4 differences between our E8 Physics Model and conventional Gravity plus the Standard Model. Now we turn attention to

### **Second and Third Fermion Generations:**

As to the existence of 3 Generations of Fermions, note that the 8 First Generation Fermion Particles and the 8 First Generation Fermion AntiParticles can each be represented by the 8 basis elements of the Octonions O, and

that the **Second and Third Generations** can be represented by

**Pairs of Octonions  $OxO$**

and

**Triples of Octonions  $OxOxO$**

respectively.

When the non-unitary Octonionic 8-dim spacetime is reduced to the Kaluza-Klein  $M4 \times CP2$  at the End of Inflation, there are 3 possibilities for a fermion propagator from point A to point B:

1 - A and B are both in  $M4$ , so its path can be represented by the single O;

2 - Either A or B, but not both, is in  $CP2$ , so its path must be augmented by one projection from  $CP2$  to  $M4$ , which projection can be represented by a second O, giving a second generation  $OxO$ ;

3 - Both A and B are in  $CP2$ , so its path must be augmented by two projections from  $CP2$  to  $M4$ , which projections can be represented by a second O and a third O, giving a third generation  $OxOxO$ .

At this point, all four differences have been reconciled, and our classical Lagrangian E8 Physics Model describes Gravity as well as the Standard Model with a BEHK Higgs mechanism, but we must now show how to calculate Force Strengths, Particle Masses, KM Parameters, and the ratio Dark Energy : Dark Matter : Ordinary Matter and then compare those calculations with Experimental Observations.

Here is a summary of E8 model calculation results. Since ratios are calculated, values for one particle mass and one force strength are assumed. Quark masses are constituent masses. Some higher-order results are listed.

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

Particle/Force	Tree-Level	Higher-Order	
e-neutrino	0	0 for nu_1	
mu-neutrino	0	$9 \times 10^{-3}$ eV for nu_2	
tau-neutrino	0	$5.4 \times 10^{-2}$ eV for nu_3	
electron	0.5110 MeV		
down	312.8 MeV	charged pion = 139 MeV	
up	312.8 MeV	proton = 938.25 MeV neutron - proton = 1.1 MeV	
muon	104.8 MeV	106.2 MeV	
strange	625 MeV		
charm	2090 MeV		
tauon	1.88 GeV		
beauty	5.63 GeV		
truth(low state)	130 GeV		
truth(middle state)	174 GeV		
truth(high state)	218 GeV		
W+	80.326 GeV		
W-	80.326 GeV		
W0	98.379 GeV	Z0 = 91.862 GeV	
Higgs VEV	252.5 GeV (assumed)	Mplanck=1.217x10 <sup>19</sup> GeV	
Higgs(low state)	145.8 GeV		
Higgs(middle state)	182 GeV		
Higgs(high state)	239 GeV		
Gravity Gg	1(assumed)		
(Gg)(Mproton <sup>2</sup> / Mplanck <sup>2</sup> )		$5 \times 10^{-39}$	
EM fine structure	1/137.03608		
Weak Gw	0.2535		
Gw(Mproton <sup>2</sup> / (Mw+ <sup>2</sup> + Mw- <sup>2</sup> + Mz0 <sup>2</sup> ))		$1.05 \times 10^{-5}$	
color force at 0.245 GeV	0.6286	0.106 at 91 GeV	
Kobayashi-Maskawa parameters for W+ and W- processes are:			
	d	s	b
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 d13 is taken to be 1 radian.			

```

neutrino mixing matrix:
      nu_1      nu_2      nu_3
nu_e   0.87      0.50      0
nu_m  -0.35      0.61      0.71
nu_t   0.35     -0.61      0.71

```

As to some higher-order and nonperturbative calculations, one motivation for my value of 245 MeV for the basic  $\Lambda_{\text{QCD}}$  of the color force is the paper of Shifman at hep-ph/9501222 in which Shifman said:

"... a set of data ("high-energy data") yield values of  $\alpha_s(M_Z)$  in the  $\overline{\text{MS}}$  scheme which cluster around 0.125 ... with the error bars 0.005 ...

The corresponding value of  $\Lambda_{\text{QCD}}$  is about 500 MeV ... These numbers, accepted as the most exact results for the strong coupling constant existing at present, propagate further into a stream of papers ... devoted to various aspects of QCD. The question arises whether Quantum Chromodynamics can tolerate these numbers. I will argue below that the answer is negative.

... I believe that  $\alpha_s(M_Z)$  must be close to 0.11 and the corresponding value of  $\Lambda_{\text{QCD}}$  close to 200 MeV (or even smaller). ...

The value of  $\alpha_s(M_Z)$  emerging from the so called global fits based mainly on the data at the  $Z$  peak (and assuming the standard model) is three standard deviations higher than the one stemming from the low-energy phenomenology. ...".

Patrascioiu and Seiler in hep-ph/9609292 said:

"... the running of  $\alpha_s$  predicted by perturbation (PT) theory is not correctly describing the accelerator experiments at the highest energies. A natural explanation is provided by the authors' 1992 proposal that in fact the true running predicted by the nonperturbatively defined lattice QCD is different ...".

The Patrascioiu and Seiler paper indicates that my crude use of simple perturbative QCD running may not be correct. If you look at Figure 2 of their paper, you see that their "possible modified running of  $\alpha_s$ " curve is at 100 GeV close to the 0.12 range, while their 2-loop PT curve is close to the 0.10 range of my crude perturbative calculation.

So, it may be that nonperturbative effects might bring calculations of my model closer to observations.

Further, it may be difficult to do very accurate nonperturbative QCD calculations, based in part on what Morozov and Niemi say in hep-th/0304178 :

"... The field theoretical renormalization group equations have many common features with the equations of dynamical systems. ... we propose that besides isolated fixed points, the couplings in a renormalizable field theory may also flow towards more general, even fractal attractors. This could lead to Big Mess scenarios ...".

I am not contending that my tree-level calculations are in exact agreement with currently accepted observations.

I am contending that the overall approximate agreement of my calculations with observations of many parameters does indicate that the fundamental structure of my E8 physics model is sound.

My view of constituent quark masses is that they can be (and are in my model) meaningful, particularly in nonrelativistic quark models of light-quark hadrons (for heavier quarks, the percentage difference between current and constituent masses can be relatively small). For example, Guidry, in his book Gauge Field Theories, John Wiley (1991), says:

"... the current masses of the quarks ... are considerably smaller than the constituent masses for the lightest quarks  $M_u = 300 \text{ MeV}$   $M_d = 300 \text{ MeV}$  ...  
... the masses of the constituent quarks presumably reflect a dressing by the confinement mechanism ... understanding of the relationship between current masses and constituent masses awaits a first-principles solution of the QCD bound-state problem. ... Nevertheless, nonrelativistic models of quark structure for hadrons have been found to work surprisingly well, even for light hadrons. ...".

As I said in quant-ph/9806023 :

"... The effectiveness of the NonRelativistic Quark Model of hadrons can be explained by Bohm's quantum theory applied to a fermion confined in a box, in which the fermion is at rest because its kinetic energy is transformed into PSI-field potential energy. ...".

Further, Georgi, in his book Weak Interactions and Modern Particle Theory, Benjamin-Cummings (1984), says:

"... Successes of the Nonrelativistic Quark Model ...

... The first striking success is that the baryon masses are given correctly by this picture ... The leading contribution to the baryon mass in the nonrelativistic limit is just the sum of the constituent quark masses. ... A good picture of the baryon masses is obtained if we take ...  $\mu = m_d = \dots = 360 \text{ MeV}$  ...  $m_s = 540 \text{ MeV}$  ...  
... With these masses, the octet baryon magnetic moments are ...[in]... excellent ... agreement ... with the data ... The success ... in giving not only the ratios of the baryon magnetic moments, but even their overall scale, seems ... to be very significant. ... The mystery of the connection between QCD and the quark model remains ...".

My view is that the structure of my E8 model, in which constituent quark masses are calculated from volumes of bounded complex domains and their Shilov boundaries, may shed some light on the connection between QCD current masses and constituent masses. In particular, those geometric volumes may be related to effective summation over a lot of QCD states to produce a bound-state constituent result.

Two other higher-order calculations in my E8 model are:

1 - For the muon, my tree-level calculation is 104.8 MeV and the accepted observational value is about 105.6 MeV. All I have done is to note that the difference seems to me to be well within the range of radiative corrections. For example, following Bailin and Love, in their book Introduction to Gauge Field Theory, IOP (rev ed 1993):

Radiative corrections to order  $\alpha$  for the muon decay rate using Sirlin's on-mass-shell renormalization scheme give a 7% increase<sup>35</sup> in the muon decay rate compared to the tree graph prediction:

$$\Gamma(\mu) = \frac{G_F^2 m_\mu^5}{192\pi^3} \left( 1 - \frac{m_e^2}{m_\mu^2} + \frac{m_e^2}{m_\mu^2} \left( \frac{m_\mu^2}{m_e^2} \right)^3 - \left( \frac{m_\mu^2}{m_e^2} \right)^4 - 12 \left( \frac{m_\mu^2}{m_e^2} \right)^2 \ln \left( \frac{m_\mu^2}{m_e^2} \right) \right)$$

Since the decay rate is directly proportional to  $m\mu^5$ , the increase can be considered to be an increase in the muon mass of about 1.36%, from the uncorrected theoretical value of 104.8 MeV to 106.2 MeV.

The experimental value is 105.7 MeV.

2 - For the proton-neutron mass difference (which is zero in my E8 model at tree level) further calculation involving connections between down valence quarks and virtual sea strange quarks gives a value of 1.1 MeV for the neutron mass excess over the proton mass, which is close to the accepted value of about 1.3 MeV.

## Force Strengths:

The primary postulate for my E8 physics model is:

0 - I start with the emergence from the void of a binary choice, like Yin-Yang, which naturally gives a real Clifford algebra, so that physics is described by a very large real Clifford algebra (a generalized hyperfinite III von Neumann factor) that can be seen as a tensor product of a lot of  $Cl(16)$  Clifford Algebras, each of which contains an E8 Lie Algebra.

Then:

1 - Since  $Cl(16) = Cl(8) \times Cl(8)$  it is clear that  $Cl(8)$  describes physics locally and it is also clear that 248-dim E8 in  $Cl(16)$  can be described in terms of 256-dim  $Cl(8)$  which has an Octonionic 8-dim Vector Space.

2 - At low (after Inflation) energies a specific quaternionic submanifold freezes out, splitting the 8-dim spacetime into a  $4+4 = 8$ -dim  $M4 \times CP2$  Kaluza-Klein.

3 -  $Cl(8)$  bivector  $Spin(8)$  is the D4 Lie algebra two copies of which are in the E8 Physics Lagrangian that is integrated over a base manifold that is 8-dim  $M4 \times CP2$  Kaluza-Klein. This shows that the **Force Strength is made up of two parts:**  
the relevant spacetime manifold of gauge group global action  
and  
the relevant symmetric space manifold of gauge group local action.

4 -Roughly, the 4-dim spacetime Lagrangian gauge boson term is:  
the integral over spacetime as seen by gauge boson acting globally of the gauge force term of the gauge boson acting locally for the gauge bosons of each of the four forces:

U(1) for electromagnetism

SU(2) for weak force

SU(3) for color force

Spin(5) - compact version of antiDeSitter Spin(2,3) for gravity by  
the MacDowell-Mansouri mechanism.

Look at the basic Lagrangian of a gauge theory model:

Integral over Spacetime of  
Gauge Boson Force Term

In the conventional picture,  
for each gauge force the gauge boson force term contains the force strength,  
which in Feynman's picture is the amplitude to emit a gauge boson,  
and can also be thought of as the probability = square of amplitude,  
in an explicit ( like  $g |F|^2$  ) or an implicit ( incorporated into the  $|F|^2$  ) form.  
Either way,  
the conventional picture is that the force strength  $g$  is an ad hoc inclusion.

My E8 Physics model does not put in force strength  $g$  ad hoc,  
but  
constructs the integral such that the force strength emerges naturally from the  
geometry of each gauge force.

To do that, for each gauge force:

1 - make the spacetime over which the integral is taken be spacetime as it is seen  
by that gauge boson, that is, in terms of the symmetric space with global  
symmetry of the gauge boson:

the U(1) photon sees 4-dim spacetime as  $T^4 = S^1 \times S^1 \times S^1 \times S^1$   
the SU(2) weak boson sees 4-dim spacetime as  $S^2 \times S^2$   
the SU(3) weak boson sees 4-dim spacetime as  $CP^2$   
the Spin(5) of gravity sees 4-dim spacetime as  $S^4$ .

2 - make the gauge boson force term have the volume of the Shilov boundary  
corresponding to the symmetric space with local symmetry of the gauge boson.  
The nontrivial Shilov boundaries are:

for SU(2) Shilov =  $RP^1 \times S^2$   
for SU(3) Shilov =  $S^5$   
for Spin(5) Shilov =  $RP^1 \times S^4$

The result is (ignoring technicalities for exposition) the geometric factor for force  
strength calculation.



Each force is related to a gauge group:

U(1) for electromagnetism

SU(2) for weak force

SU(3) for color force

Spin(5) - compact version of antiDeSitter Spin(2,3) for gravity by the MacDowell-Mansouri mechanism

Global:

Each gauge group is the global symmetry of a symmetric space

S<sup>1</sup> for U(1)

S<sup>2</sup> = SU(2)/U(1) = Spin(3)/Spin(2) for SU(2)

CP<sup>2</sup> = SU(3)/SU(2) × U(1) for SU(3)

S<sup>4</sup> = Spin(5)/Spin(4) for Spin(5)

Local:

Each gauge group is the local symmetry of a symmetric space

U(1) for itself

SU(2) for Spin(5) / SU(2) × U(1)

SU(3) for SU(4) / SU(3) × U(1)

Spin(5) for Spin(7) / Spin(5) × U(1)

The nontrivial local symmetry symmetric spaces correspond to bounded complex domains

SU(2) for Spin(5) / SU(2) × U(1) corresponds to IV<sub>3</sub>

SU(3) for SU(4) / SU(3) × U(1) corresponds to B<sup>6</sup> (ball)

Spin(5) for Spin(7) / Spin(5) × U(1) corresponds to IV<sub>5</sub>

The nontrivial bounded complex domains have Shilov boundaries

SU(2) for Spin(5) / SU(2) × U(1) corresponds to IV<sub>3</sub> Shilov = RP<sup>1</sup> × S<sup>2</sup>

SU(3) for SU(4) / SU(3) × U(1) corresponds to B<sup>6</sup> (ball) Shilov = S<sup>5</sup>

Spin(5) for Spin(7) / Spin(5) × U(1) corresponds to IV<sub>5</sub> Shilov = RP<sup>1</sup> × S<sup>4</sup>

Global and Local Together:

Very roughly (see my web site [tony5m17h.net](http://tony5m17h.net) and papers for details), think of the force strength as  
the integral over the global symmetry space of  
the physical (ie Shilov Boundary) volume=strength of the force.

That is (again very roughly and intuitively):

the geometric strength of the force is given by the product of  
the volume of a 4-dim thing with global symmetry of the force and  
the volume of the Shilov Boundary for the local symmetry of the force.

When you calculate the product volumes (using some tricky normalization stuff), you see that roughly:

Volume product for gravity is the largest volume  
so since (as Feynman says) force strength = probability to emit a gauge boson means that the highest force strength or probability should be 1  
I normalize the gravity Volume product to be 1, and so roughly get:

Volume product for gravity = 1  
Volume product for color = 2/3  
Volume product for weak = 1/4  
Volume product for electromagnetism = 1/137

There are two further main components of a force strength:

- 1 - for massive gauge bosons, a suppression by a factor of  $1 / M^2$
- 2 - renormalization running (important for color force).

Consider Massive Gauge Bosons:

I consider gravity to be carried by virtual Planck-mass black holes, so that the geometric strength of gravity should be reduced by  $1/M_p^2$

I consider the weak force to be carried by weak bosons, so that the geometric strength of gravity should be reduced by  $1/M_W^2$

That gives the result:

gravity strength = G (Newton's G)

color strength =  $2/3$

weak strength =  $G_F$  (Fermi's weak force G)

electromagnetism =  $1/137$

Consider Renormalization Running for the Color Force::

That gives the result:

gravity strength = G (Newton's G)

color strength =  $1/10$  at weak boson mass scale

weak strength =  $G_F$  (Fermi's weak force G)

electromagnetism =  $1/137$

The use of compact volumes is itself a calculational device, because it would be more nearly correct, instead of

the integral over the compact global symmetry space of  
the compact physical (ie Shilov Boundary) volume=strength of the force  
to use

the integral over the hyperbolic spacetime global symmetry space of  
the noncompact invariant measure of the gauge force term.

However, since the strongest (gravitation) geometric force strength is to be normalized to 1, the only thing that matters is ratios, and the compact volumes (finite and easy to look up in the book by Hua) have the same ratios as the noncompact invariant measures.

In fact, I should go on to say that continuous spacetime and gauge force geometric objects are themselves also calculational devices, and that it would be even more nearly correct to do the calculations with respect to a discrete generalized hyperdiamond Feynman checkerboard.

## Here are more details about the force strength calculations:

The force strength of a given force is

$$\text{alphaforce} = \frac{1}{M\text{force}^2} \left( \frac{\text{Vol}(\text{MISforce})}{\text{Vol}(\text{Qforce}) / \text{Vol}(\text{Dforce})^{1/m\text{force}}} \right)$$

where:

alphaforce represents the force strength;

Mforce represents the effective mass;

MISforce represents the part of the target Internal Symmetry Space that is available for the gauge boson to go to;

Vol(MISforce) stands for volume of MISforce, and is sometimes also denoted by the shorter notation Vol(M);

Qforce represents the link from the origin to the target that is available for the gauge boson to go through;

Vol(Qforce) stands for volume of Qforce;

Dforce represents the complex bounded homogeneous domain of which Qforce is the Shilov boundary;

mforce is the dimensionality of Qforce, which is 4 for Gravity and the Color force, 2 for the Weak force (which therefore is considered to have two copies of QW for each spacetime HyperDiamond link), and 1 for Electromagnetism (which therefore is considered to have four copies of QE for each spacetime HyperDiamond link)

Vol(Dforce)<sup>( 1 / mforce )</sup> 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).

The Qforce, Hermitian symmetric space,  
and Dforce manifolds for the four forces are:

Gauge Group	Hermitian Symmetric Space	Type of Dforce	mforce	Qforce
Spin(5)	Spin(7) / Spin(5)xU(1)	IV5	4	RP <sup>1</sup> xS <sup>4</sup>
SU(3)	SU(4) / SU(3)xU(1)	B <sup>6</sup> (ball)	4	S <sup>5</sup>
SU(2)	Spin(5) / SU(2)xU(1)	IV3	2	RP <sup>1</sup> xS <sup>2</sup>
U(1)	-	-	1	-

The geometric volumes needed for the calculations are mostly taken from the book Harmonic Analysis of Functions of Several Complex Variables in the Classical Domains (AMS 1963, Moskva 1959, Science Press Peking 1958) by L. K. Hua [with unit radius scale].

Note that

Force	M	Vol(M)
gravity	S <sup>4</sup>	8pi <sup>2</sup> /3 - S <sup>4</sup> is 4-dimensional
color	CP <sup>2</sup>	8pi <sup>2</sup> /3 - CP <sup>2</sup> is 4-dimensional
weak	S <sup>2</sup> x S <sup>2</sup>	2 x 4pi - S <sup>2</sup> is a 2-dim boundary of 3-dim ball 4-dim S <sup>2</sup> x S <sup>2</sup> = = topological boundary of 6-dim 2-polyball Shilov Boundary of 6-dim 2-polyball = S <sup>2</sup> + S <sup>2</sup> = = 2-dim surface frame of 4-dim S <sup>2</sup> x S <sup>2</sup>
e-mag	T <sup>4</sup>	4 x 2pi - S <sup>1</sup> is 1-dim boundary of 2-dim disk 4-dim T <sup>4</sup> = S <sup>1</sup> x S <sup>1</sup> x S <sup>1</sup> x S <sup>1</sup> = = topological boundary of 8-dim 4-polydisk Shilov Boundary of 8-dim 4-polydisk = = S <sup>1</sup> + S <sup>1</sup> + S <sup>1</sup> + S <sup>1</sup> = = 1-dim wire frame of 4-dim T <sup>4</sup>

Note ( thanks to Carlos Castro for noticing this ) that the volume listed for S5 is for a squashed S5, a Shilov boundary of the complex domain corresponding to the symmetric space  $SU(4) / SU(3) \times U(1)$ .

Note ( thanks again to Carlos Castro for noticing this ) also that the volume listed for CP2 is unconventional, but physically justified by noting that S4 and CP2 can be seen as having the same physical volume, with the only difference being structure at infinity.

Also note that for U(1) electromagnetism, whose photon carries no charge, the factors Vol(Q) and Vol(D) do not apply and are set equal to 1, and from another point of view, the link manifold to the target vertex is trivial for the abelian neutral U(1) photons of Electromagnetism, so we take QE and DE to be equal to unity.

Force	M	Vol(M)	Q	Vol(Q)	D	Vol(D)
gravity	$S^4$	$8\pi^2/3$	$RP^1 \times S^4$	$8\pi^3/3$	$IV5$	$\pi^{5/2} 4^5!$
color	$CP^2$	$8\pi^2/3$	$S^5$	$4\pi^3$	$B^6(\text{ball})$	$\pi^3/6$
weak	$S^2 \times S^2$	$2 \times 4\pi$	$RP^1 \times S^2$	$4\pi^2$	$IV3$	$\pi^3/24$
e-mag	$T^4$	$4 \times 2\pi$	-	-	-	-

Using these numbers, the results of the calculations are the relative force strengths at the characteristic energy level of the generalized Bohr radius of each force:

Gauge Group	Force	Characteristic Energy	Geometric Force Strength	Total Force Strength
Spin(5)	gravity	approx $10^{19}$ GeV	1	$G G m_{\text{proton}}^2$ approx $5 \times 10^{-39}$
SU(3)	color	approx 245 MeV	0.6286	0.6286
SU(2)	weak	approx 100 GeV	0.2535	$G W m_{\text{proton}}^2$ approx $1.05 \times 10^{-5}$
U(1)	e-mag	approx 4 KeV	1/137.03608	1/137.03608

The force strengths are given at the characteristic energy levels of their forces, because the force strengths run with changing energy levels.

The effect is particularly pronounced with the color force.

The color force strength was calculated using a simple perturbative QCD renormalization group equation at various energies, with the following results:

Energy Level	Color Force Strength
245 MeV	0.6286
5.3 GeV	0.166
34 GeV	0.121
91 GeV	0.106

Taking other effects, such as Nonperturbative QCD, into account, should give a Color Force Strength of about 0.125 at about 91 GeV

## Fermion Masses:

The primary postulate for my E8 physics model is:

0 - I start with the emergence from the void of a binary choice, like Yin-Yang, which naturally gives a real Clifford algebra, so that physics is described by a very large real Clifford algebra (a generalized hyperfinite III von Neumann factor) that can be seen as a tensor product of a lot of Cl(16) Clifford Algebras, each of which contains an E8 Lie Algebra.

Then:

1 - Since  $Cl(16) = Cl(8) \times Cl(8)$  it is clear that Cl(8) describes physics locally and it is also clear that 248-dim E8 in Cl(16) can be described in terms of 256-dim Cl(8) which has two Octonionic 8-dim half-spinor spaces with physical interpretation by which first-generation fermion particles correspond to octonion basis of Spin(8) +half-spinors

l to e-neutrino  
i to red down quark  
j to green down quark  
k to blue down quark  
E to electron  
I to red up quark  
J to green up quark  
K to blue up quark

and first-generation fermion antiparticles correspond to octonion basis of Spin(8) -half-spinors

l to e-antineutrino  
i to red down antiquark  
j to green down antiquark  
k to blue down antiquark  
E to positron  
I to red up antiquark  
J to green up antiquark  
K to blue up antiquark



2 - The two Spin(8) 8-dim half-spinors and the Spin(8) 8-dim vectors are all related to each other by Triality. Modifying Steven Weinberg's description of physics Lagrangians in his book "Elementary Particles and the Laws of Physics: The 1986 Dirac Memorial Lectures" to apply to 8-dim spacetime gives this quote

**All terms in the Lagrangian density must have units [mass]<sup>8</sup>, because length and time have units of inverse mass and the Lagrangian density integrated over spacetime must have no units. From the  $m\psi\psi$  term, we see that the electron field must have units [mass]<sup>7/2</sup>, because  $\frac{7}{2} + \frac{7}{2} + 1 = 8$**

from which it is clear that at high (UltraViolet) energies in the E8 physics model gauge boson terms have dimension 1 in the Lagrangian and fermion terms have dimension 7/2 in the Lagrangian, so that the Triality gives a Subtle Supersymmetry whereby

$$\text{Total Boson Lagrangian Dimensionality} = 28 \times 1 = 28$$

is exactly balanced by

$$\text{Total Fermion Lagrangian Dimensionality} = 8 \times 7 / 2 = 28$$

thus

the Triality Subtle Supersymmetry shows UltraViolet Finiteness of the E8 model

3 - At low (after Inflation) energies a specific quaternionic submanifold freezes out, splitting the 8-dim spacetime into a 4+4 = 8-dim M4xCP2 Kaluza-Klein and creating second and third generation fermions that can live in the 4-dim internal symmetry space and correspond respectively to pairs and triples of octonion basis elements,

4 - Cl(8) bivector Spin(8) is the D4 Lie algebra two copies of which are in the E8 Physics Lagrangian that is integrated over a base manifold that is 8-dim M4xCP2 Kaluza-Klein.

5 - Roughly, the 4-dim spacetime Lagrangian fermion term is integral over spacetime of spinor fermion term

In the conventional picture, the spinor fermion term is of the form  $m S S^*$  where  $m$  is the fermion mass and  $S$  and  $S^*$  represent the given fermion.

Although the mass  $m$  is derived from the Higgs mechanism, the Higgs coupling constants are, in the conventional picture, ad hoc parameters, so that effectively the mass term is, in the conventional picture, an ad hoc inclusion.

My E8 model does not put in the mass  $m$  as an ad hoc Higgs coupling value, but

constructs the Lagrangian integral such that the mass  $m$  emerges naturally from the geometry of the spinor fermions.

To do that,

make the spinor fermion mass term have the volume of the Shilov boundary corresponding to

the symmetric space with LOCAL symmetry of the Spin(8) gauge group with respect to which the first generation spinor fermions are seen as +half-spinor and -half-spinor spaces.

Note that due to Triality,

Spin(8) can act on those 8-dimensional half-spinor spaces similarly to the way it acts on 8-dimensional vector spacetime prior to dimensional reduction.

Then, take the the spinor fermion volume to be the Shilov boundary corresponding to the same symmetric space on which Spin(8) acts as a local gauge group that is used to construct 8-dimensional vector spacetime:

the symmetric space  $\text{Spin}(10) / \text{Spin}(8) \times U(1)$   
corresponds to a bounded domain of type IV8  
whose Shilov boundary is  $\mathbb{R}P^1 \times S^7$

Since all the first generation fermions see the spacetime over which the integral is taken in the same way ( unlike what happens for the force strength calculation ), the only geometric volume factor relevant for calculating first generation fermion mass ratios is in the spinor fermion volume term.

Since fermions in this model correspond to Kerr-Newman Black Holes, the quark mass in this model is a constituent mass.

Consider a first-generation massive lepton (or antilepton, i.e., electron or positron). For definiteness, consider an electron  $E$  (a similar line of reasoning applies to the positron).

Gluon interactions do not affect the colorless electron ( $E$ )

By weak boson interactions or decay, an electron ( $E$ ) can only be taken into itself or a massless (at tree level) neutrino.

As the lightest massive first-generation fermion, the electron cannot decay into a quark.

Since the electron cannot be related to any other massive Dirac fermion, its volume  $V(\text{electron})$  is taken to be 1.

Consider a first-generation quark (or antiquark).

For definiteness, consider a red down quark  $I$  (a similar line of reasoning applies to the others of the first generation).

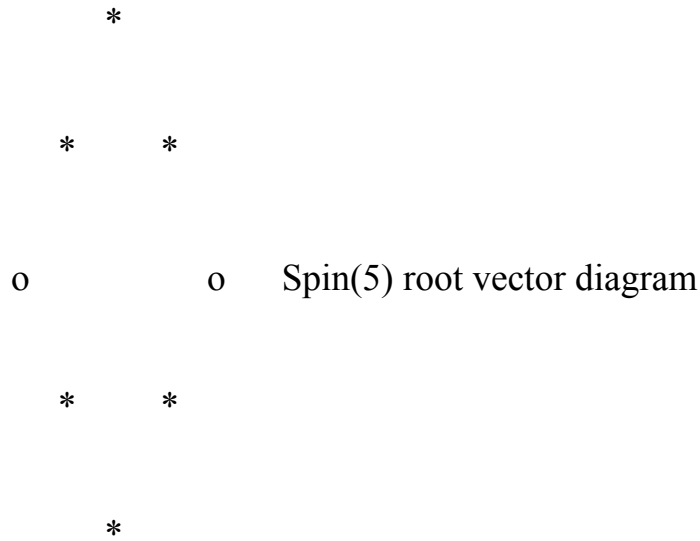
By gluon interactions, the red quark ( $I$ ) can be interchanged with the blue and green down quarks ( $J$  and  $K$ ).

By weak boson interactions, it can be taken into the red, blue, and green up quarks ( $i$ ,  $j$ , and  $k$ ).

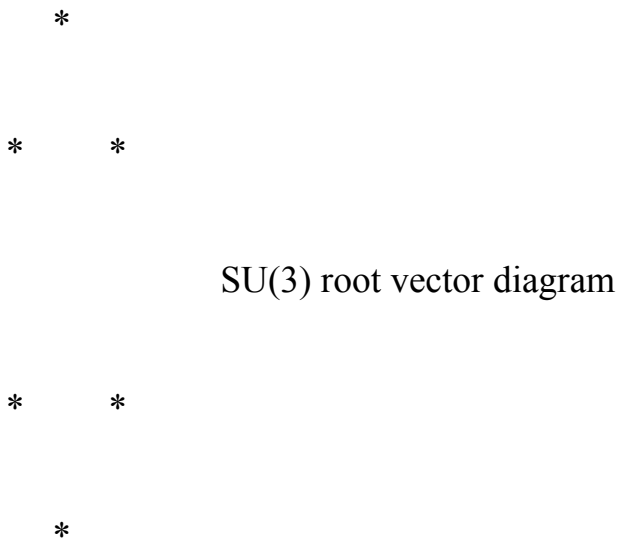
Given the up and down quarks, pions can be formed from quark-antiquark pairs, and the pions can decay to produce electrons ( $E$ ) and neutrinos ( $\nu$ ).

Therefore first-generation quarks or antiquarks can by gluons, weak bosons, or decay occupy the entire volume of the Shilov boundary  $RP^1 \times S^7$ , which volume is  $\pi^5 / 3$ , so its volume  $V(\text{quark})$  is taken to be  $\pi^5 / 3$ .

Consider graviton interactions with first-generation fermions.  
 Since MacDowell-Mansouri gravitation comes from 10 Spin(5) gauge bosons,  
 8 of which are charged (carrying color or electric charge)  
 as shown in the root Spin(5) root vector diagram



in which the 6 root vectors \* correspond to color carrying gauge bosons act  
 similarly to the action of the 6 color-charged SU(3) gluons shown in the SU(3) root  
 vector diagram



The 2 charged Spin(5) gravitons denoted by o carry electric charge.

However, even though the electron carries electric charge,  
the electric charge carrying Spin(5) gravitons can only change the electron into a  
( tree-level ) massless neutrino,  
so the Spin(5) gravitons do not enhance the electron volume factor,  
which remains electron volume (taking gravitons into account) =  $V(\text{electron}) = 1$

Since the quark carries color charge,  
Spin(5) graviton action on its color charge multiplies its volume  $V(\text{quark})$  by 6,  
giving  
quark gravity-enhanced volume =  $6 \times V(\text{quark}) = 6 \pi^5 / 3 = 2 \pi^5$   
The 2 Spin(5) gravitons carrying electric charge only cannot change quarks into  
leptons, so they do not enhance the quark volume factor, so we have (where  $m_d$  is  
down quark mass,  $m_u$  is up quark mass, and  $m_e$  is electron mass)  
 $m_d / m_e = m_u / m_e = 2 \pi^5 / 1 = 2 \pi^5 = 612.03937$

The proton mass is calculated as the sum of the constituent masses of its  
constituent quarks  
 $m_{\text{proton}} = m_u + m_u + m_d = 938.25 \text{ MeV}$   
which is close to the experimental value of 938.27 MeV.

In the first generation,  
each quark corresponds to a single octonion basis element  
and the up and down quark constituent masses are the same:  
First Generation - 8 singletons -  $m_u / m_d = 1$   
Down - corresponds to 1 singleton - constituent mass 312 MeV  
Up - corresponds to 1 singleton - constituent mass 312 MeV

Second and third generation calculations are generally more complicated.  
Combinatorics indicates that in higher generations the up-type quarks are heavier  
than the down-type quarks.

The third generation case,  
in which the fermions correspond to triples of octonions,  
is simple enough to be used here as an illustration of the combinatoric effect:

Third Generation  
 $8^3 = 512$  triples  
 $m_t / m_b = 483 / 21 = 161 / 7 = 23$   
down-type (Beauty) - corresponds to 21 triples - constituent mass 5.65 GeV  
up-type (Truth) - corresponds to 483 triples - constituent mass 130 GeV

## Here are more details about the fermion mass calculations:

Fermion masses are calculated as a product of four factors:

$$V(\text{Qfermion}) \times N(\text{Graviton}) \times N(\text{octonion}) \times \text{Sym}$$

$V(\text{Qfermion})$  is the volume of the part of the half-spinor fermion particle manifold  $S^7 \times \mathbb{R}P^1$  that is related to the fermion particle by photon, weak boson, and gluon interactions.

$N(\text{Graviton})$  is the number of types of  $\text{Spin}(0,5)$  graviton related to the fermion. The 10 gravitons correspond to the 10 infinitesimal generators of  $\text{Spin}(0,5) = \text{Sp}(2)$ . 2 of them are in the Cartan subalgebra. 6 of them carry color charge, and may therefore be considered as corresponding to quarks. The remaining 2 carry no color charge, but may carry electric charge and so may be considered as corresponding to electrons. One graviton takes the electron into itself, and the other can only take the first-generation electron into the massless electron neutrino. Therefore only one graviton should correspond to the mass of the first-generation electron. The graviton number ratio of the down quark to the first-generation electron is therefore  $6/1 = 6$ .

$N(\text{octonion})$  is an octonion number factor relating up-type quark masses to down-type quark masses in each generation.

$\text{Sym}$  is an internal symmetry factor, relating 2nd and 3rd generation massive leptons to first generation fermions. It is not used in first-generation calculations.

The ratio of the down quark constituent mass to the electron mass is then calculated as follows:

Consider the electron, E.

By photon, weak boson, and gluon interactions, E can only be taken into 1, the massless neutrino. The electron and neutrino, or their antiparticles, cannot be combined to produce any of the massive up or down quarks. The neutrino, being massless at tree level, does not add anything to the mass formula for the electron. Since the electron cannot be related to any other massive Dirac fermion, its volume  $V(Q_{\text{electron}})$  is taken to be 1.

Next consider a red down quark ie. By gluon interactions, ie can be taken into je and ke, the blue and green down quarks. By also using weak boson interactions, it can be taken into i, j, and k, the red, blue, and green up quarks. Given the up and down quarks, pions can be formed from quark-antiquark pairs, and the pions can decay to produce electrons and neutrinos. Therefore the red down quark (similarly, any down quark) is related to any part of  $S^7 \times RP^1$ , the compact manifold corresponding to  $\{ 1, i, j, k, ie, ie, ke, e \}$  and therefore a down quark should have a spinor manifold volume factor  $V(Q_{\text{down quark}})$  of the volume of  $S^7 \times RP^1$ . The ratio of the down quark spinor manifold volume factor to the electron spinor manifold volume factor is just

$$V(Q_{\text{down quark}}) / V(Q_{\text{electron}}) = V(S^7 \times RP^1) / 1 = \pi^5 / 3.$$

Since the first generation graviton factor is 6,

$$m_d / m_e = 6V(S^7 \times RP^1) = 2\pi^5 = 612.03937$$

As the up quarks correspond to i, j, and k, which are the octonion transforms under e of ie, je, and ke of the down quarks, the up quarks and down quarks have the same constituent mass

$$m_u = m_d.$$

Antiparticles have the same mass as the corresponding particles.

Since the model only gives ratios of masses, the mass scale is fixed so that the electron mass  $m_e = 0.5110 \text{ MeV}$ .

Then, the constituent mass of the down quark is  $m_d = 312.75 \text{ MeV}$ , and the constituent mass for the up quark is  $m_u = 312.75 \text{ MeV}$ .

These results when added up give a total mass of first generation fermion particles:  $\Sigma m_f = 1.877 \text{ GeV}$

As the proton mass is taken to be the sum of the constituent masses of its constituent quarks

$$m_{\text{proton}} = m_u + m_u + m_d = 938.25 \text{ MeV}$$

The theoretical calculation is close to the experimental value of 938.27 MeV.

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:

$$\begin{aligned} & \{ e, e, e \} \\ & \{ e, e, 1 \} \\ & \{ e, 1, e \} \\ & \{ 1, e, e \} \\ & \{ 1, 1, e \} \\ & \{ 1, e, 1 \} \\ & \{ e, 1, 1 \} \end{aligned}$$

The symmetry of the 7 tauon triples is the same as the symmetry of the 3 down quarks, the 3 up quarks, and the electron, so 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 calculated Tauon mass of 1.88 GeV is a sum of first generation fermion masses, all of which are valid at the energy level of about 1 GeV.

However, as the Tauon mass is about 2 GeV, the effective Tauon mass should be renormalized from the energy level of 1 GeV (where the mass is 1.88 GeV) to the energy level of 2 GeV.

Such a renormalization should reduce the mass. If the renormalization reduction were about 5 percent, the effective Tauon mass at 2 GeV would be about 1.78 GeV.

The 1996 Particle Data Group Review of Particle Physics gives a Tauon mass of 1.777 GeV.

Note that all triples corresponding to the tau and the tau-neutrino are colorless.



The beauty quark corresponds to 21 triples.

They are triples of the same form as the 7 tauon triples, but for 1 and ie, 1 and je, and 1 and ke, which correspond to the red, green, and blue beauty quarks, respectively.

The seven triples of the red beauty quark correspond to the seven triples of the tauon, except that the beauty quark interacts with 6 Spin(0,5) gravitons while the tauon interacts with only two.

The beauty quark constituent mass should be the tauon mass times the third generation graviton factor  $6/2 = 3$ , so the B-quark mass is  $m_b = 5.63111 \text{ GeV}$ .

The calculated Beauty Quark mass of 5.63 GeV is a constituent mass, that is, it corresponds to the conventional pole mass plus 312.8 MeV.

Therefore, the calculated Beauty Quark mass of 5.63 GeV corresponds to a conventional pole mass of 5.32 GeV.

The 1996 Particle Data Group Review of Particle Physics gives a lattice gauge theory Beauty Quark pole mass as 5.0 GeV.

The pole mass can be converted to an MSbar mass if the color force strength constant  $\alpha_s$  is known. The conventional value of  $\alpha_s$  at about 5 GeV is about 0.22.

Using  $\alpha_s(5 \text{ GeV}) = 0.22$ , a pole mass of 5.0 GeV gives an MSbar 1-loop Beauty Quark mass of 4.6 GeV, and an MSbar 1,2-loop Beauty Quark mass of 4.3, evaluated at about 5 GeV.

If the MSbar mass is run from 5 GeV up to 90 GeV, the MSbar mass decreases by about 1.3 GeV, giving an expected MSbar mass of about 3.0 GeV at 90 GeV. DELPHI at LEP has observed the Beauty Quark and found a 90 GeV MSbar Beauty Quark mass of about 2.67 GeV, with error bars  $\pm 0.25$  (stat)  $\pm 0.34$  (frag)  $\pm 0.27$  (theo).

Note that the theoretical model calculated Beauty Quark mass of 5.63 GeV corresponds to a pole mass of 5.32 GeV, which is somewhat higher than the conventional value of 5.0 GeV.

However,

the theoretical model calculated value of the color force strength constant  $\alpha_s$  at about 5 GeV is about 0.166,

while the conventional value of the color force strength constant  $\alpha_s$  at about 5 GeV is about 0.216,

and the theoretical model calculated value of the color force strength constant  $\alpha_s$  at about 90 GeV is about 0.106,

while the conventional value of the color force strength constant  $\alpha_s$  at about 90 GeV is about 0.118.

The theoretical model calculations gives a Beauty Quark pole mass (5.3 GeV) that is about 6 percent higher than the conventional Beauty Quark pole mass (5.0 GeV), and a color force strength  $\alpha_s$  at 5 GeV (0.166)

such that  $1 + \alpha_s = 1.166$  is about 4 percent lower than the conventional value of  $1 + \alpha_s = 1.216$  at 5 GeV.

Note particularly that triples of the type  $\{ 1, ie, je \}$ ,  $\{ ie, je, ke \}$ , etc., do not correspond to the beauty quark, but to the truth quark.

The truth quark corresponds to the remaining 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

$$m_t = 129.5155 \text{ GeV}$$

The blue and green truth quarks are defined similarly.

All other masses than the electron mass

(which is the basis of the assumption of the value of the Higgs scalar field vacuum expectation value  $v = 252.514 \text{ GeV}$ ),

including the Higgs scalar mass and Truth quark mass, are calculated (not assumed) masses in the E8 model.

These results when added up give a total mass of third generation fermion particles:

$$\Sigma_{f3} = 1,629 \text{ GeV}$$

The second generation fermion particles correspond to pairs of octonions.

There are  $8^2 = 64$  such pairs. The pair  $\{ 1, 1 \}$  corresponds to the mu-neutrino.

The pairs  $\{ 1, e \}$ ,  $\{ e, 1 \}$ , and  $\{ e, e \}$  correspond to the muon.

Compare the symmetries of the muon pairs to the symmetries of the first generation fermion particles.

The pair  $\{ e, e \}$  should correspond to the e electron.

The other two muon pairs have a symmetry group  $S_2$ , which is  $1/3$  the size of the color symmetry group  $S_3$  which gives the up and down quarks their mass of 312.75 MeV.

Therefore the mass of the muon should be the sum of the  $\{ e, e \}$  electron mass and

the  $\{ 1, e \}$ ,  $\{ e, 1 \}$  symmetry mass, which is  $1/3$  of the up or down quark mass.

Therefore,  $m_{\mu} = 104.76 \text{ MeV}$ .

According to the 1998 Review of Particle Physics of the Particle Data Group, the experimental muon mass is about 105.66 MeV.

Note that all pairs corresponding to the muon and the mu-neutrino are colorless.

The red, blue and green strange quark each corresponds to the 3 pairs involving 1 and ie, je, or ke.

The red strange quark is defined as the three pairs 1 and i, because i is the red down quark.

Its mass should be the sum of two parts:

the  $\{ i, i \}$  red down quark mass, 312.75 MeV, and

the product of the symmetry part of the muon mass, 104.25 MeV, times the graviton factor.

Unlike the first generation situation,

massive second and third generation leptons can be taken,

by both of the colorless gravitons that may carry electric charge, into massive particles.

Therefore the graviton factor for the second and third generations is  $6/2 = 3$ .

Therefore the symmetry part of the muon mass times the graviton factor 3 is 312.75 MeV,

and the red strange quark constituent mass is

$m_s = 312.75 \text{ MeV} + 312.75 \text{ MeV} = 625.5 \text{ MeV}$

The blue strange quarks correspond to the three pairs involving j, the green strange quarks correspond to the three pairs involving k, and their masses are determined similarly.

The charm quark corresponds to the other 51 pairs. Therefore, the mass of the red charm quark should be the sum of two parts: the  $\{i, i\}$ , red up quark mass, 312.75 MeV; and the product of the symmetry part of the strange quark mass, 312.75 MeV, and the charm to strange octonion number factor 51/9, which product is 1,772.25 MeV. Therefore the red charm quark constituent mass is  $m_c = 312.75 \text{ MeV} + 1,772.25 \text{ MeV} = 2.085 \text{ GeV}$

The blue and green charm quarks are defined similarly, and their masses are calculated similarly.

The calculated Charm Quark mass of 2.09 GeV is a constituent mass, that is, it corresponds to the conventional pole mass plus 312.8 MeV.

Therefore, the calculated Charm Quark mass of 2.09 GeV corresponds to a conventional pole mass of 1.78 GeV.

The 1996 Particle Data Group Review of Particle Physics gives a range for the Charm Quark pole mass from 1.2 to 1.9 GeV.

The pole mass can be converted to an  $\overline{\text{MS}}$  mass if the color force strength constant  $\alpha_s$  is known. The conventional value of  $\alpha_s$  at about 2 GeV is about 0.39, which is somewhat lower than the theoretical model value. Using  $\alpha_s(2 \text{ GeV}) = 0.39$ , a pole mass of 1.9 GeV gives an  $\overline{\text{MS}}$  1-loop mass of 1.6 GeV, evaluated at about 2 GeV.

These results when added up give a total mass of second generation fermion particles:

$$\Sigma_{\text{2nd}} = 32.9 \text{ GeV}$$

## Higgs and W-boson Masses:

As with forces strengths, the calculations produce ratios of masses, so that only one mass need be chosen to set the mass scale.

In the E8 model, the value of the fundamental mass scale vacuum expectation value  $v = \langle \text{PHI} \rangle$  of the Higgs scalar field is set to be the sum of the physical masses of the weak bosons,  $W^+$ ,  $W^-$ , and  $Z^0$ , whose tree-level masses will then be shown by ratio calculations to be 80.326 GeV, 80.326 GeV, and 91.862 GeV, respectively, and so that the electron mass will then be 0.5110 MeV.

The relationship between the Higgs mass and  $v$  is given by the Ginzburg-Landau term from the Mayer Mechanism as

$$(1/4) \text{Tr} ( [ \text{PHI} , \text{PHI} ] - \text{PHI} )^2$$

or, in the notation of hep-ph/9806009 by Guang-jiong Ni

$$(1/4!) \lambda \text{PHI}^4 - (1/2) \sigma \text{PHI}^2$$

where the Higgs mass  $M_H = \sqrt{2 \sigma}$

Ni says:

"... the invariant meaning of the constant  $\lambda$  in the Lagrangian is not the coupling constant, the latter will change after quantization ... The invariant meaning of  $\lambda$  is nothing but the ratio of two mass scales:

$$\lambda = 3 ( M_H / \text{PHI} )^2$$

which remains unchanged irrespective of the order ...".

Since  $\langle \text{PHI} \rangle^2 = v^2$ , and assuming at tree-level that  $\lambda = 1$  ( a value consistent with the Higgs-Tquark condensate model of Michio Hashimoto, Masaharu Tanabashi, and Koichi Yamawaki in their paper at hep-ph/0311165, we have, at tree-level

$$M_H^2 / v^2 = 1 / 3$$

In the E8 model, the fundamental mass scale vacuum expectation value  $v$  of the Higgs scalar field is the fundamental mass parameter that is to be set to define all other masses by the mass ratio formulas of the model and

$$v \text{ is set to be } 252.514 \text{ GeV}$$

so that

$$M_H = v / \sqrt{3} = 145.789 \text{ GeV}$$

To get W-boson masses,  
denote the 3 SU(2) high-energy weak bosons  
(massless at energies higher than the electroweak unification)  
by  $W^+$ ,  $W^-$ , and  $W_0$ ,  
corresponding to the massive physical weak bosons  $W^+$ ,  $W^-$ , and  $Z_0$ .

The triplet  $\{ W^+, W^-, W_0 \}$  couples directly with the  $T - Tbar$  quark-antiquark pair,  
so that the total mass of the triplet  $\{ W^+, W^-, W_0 \}$  at the electroweak unification  
is equal to the total mass of a  $T - Tbar$  pair, 259.031 GeV.

The triplet  $\{ W^+, W^-, Z_0 \}$  couples directly with the Higgs scalar,  
which carries the Higgs mechanism by which the  $W_0$  becomes the physical  $Z_0$ ,  
so that the total mass of the triplet  $\{ W^+, W^-, Z_0 \}$   
is equal to the vacuum expectation value  $v$  of the Higgs scalar field,  
 $v = 252.514$  GeV.

What are individual masses of members of the triplet  $\{ W^+, W^-, Z_0 \}$  ?

First, look at the triplet  $\{ W^+, W^-, W_0 \}$   
which can be represented by the 3-sphere  $S^3$ .  
The Hopf fibration of  $S^3$  as  
 $S^1 \rightarrow S^3 \rightarrow S^2$   
gives a decomposition of the W bosons  
into the neutral  $W_0$  corresponding to  $S^1$   
and the charged pair  $W^+$  and  $W^-$  corresponding to  $S^2$ .

The mass ratio of the sum of the masses of  $W^+$  and  $W^-$  to the mass of  $W_0$   
should be the volume ratio of the  $S^2$  in  $S^3$  to the  $S^1$  in  $S^3$ .  
The unit sphere  $S^3$  in  $R^4$  is normalized by  $1 / 2$ .  
The unit sphere  $S^2$  in  $R^3$  is normalized by  $1 / \sqrt{3}$ .  
The unit sphere  $S^1$  in  $R^2$  is normalized by  $1 / \sqrt{2}$ .  
The ratio of the sum of the  $W^+$  and  $W^-$  masses to the  $W_0$  mass should then be  
 $(2 / \sqrt{3}) V(S^2) / (2 / \sqrt{2}) V(S^1) = 1.632993$

Since the total mass of the triplet  $\{ W^+, W^-, W_0 \}$  is 259.031 GeV, the total mass  
of a  $T - Tbar$  pair, and the charged weak bosons have equal mass, we have  
 $M_{W^+} = M_{W^-} = 80.326$  GeV and  $M_{W_0} = 98.379$  GeV.

The charged  $W^{+/-}$  neutrino-electron interchange must be symmetric with the electron-neutrino interchange, so that the absence of right-handed neutrino particles requires that the charged  $W^{+/-}$  SU(2) weak bosons act only on left-handed electrons.

Each gauge boson must act consistently on the entire Dirac fermion particle sector, so that the charged  $W^{+/-}$  SU(2) weak bosons act only on left-handed fermion particles of all types.

The neutral  $W_0$  weak boson does not interchange Weyl neutrinos with Dirac fermions, and so is not restricted to left-handed fermions, but also has a component that acts on both types of fermions, both left-handed and right-handed, conserving parity.

However, the neutral  $W_0$  weak bosons are related to the charged  $W^{+/-}$  weak bosons by custodial SU(2) symmetry, so that the left-handed component of the neutral  $W_0$  must be equal to the left-handed (entire) component of the charged  $W^{+/-}$ .

Since the mass of the  $W_0$  is greater than the mass of the  $W^{+/-}$ , there remains for the  $W_0$  a component acting on both types of fermions.

Therefore the full  $W_0$  neutral weak boson interaction is proportional to  $(M_{W^{+/-}}^2 / M_{W_0}^2)$  acting on left-handed fermions and  $(1 - (M_{W^{+/-}}^2 / M_{W_0}^2))$  acting on both types of fermions.

If  $(1 - (M_{W^{+/-}}^2 / M_{W_0}^2))$  is defined to be  $\sin(\theta_w)^2$  and denoted by  $K$ , and if the strength of the  $W^{+/-}$  charged weak force (and of the custodial SU(2) symmetry) is denoted by  $T$ , then the  $W_0$  neutral weak interaction can be written as  $W_0L = T + K$  and  $W_0R = K$ .

Since the  $W_0$  acts as  $W_0L$  with respect to the parity violating SU(2) weak force and as  $W_0R$  with respect to the parity conserving U(1) electromagnetic force of the U(1) subgroup of SU(2), the  $W_0$  mass  $m_{W_0}$  has two components: the parity violating SU(2) part  $m_{W_0L}$  that is equal to  $M_{W^{+/-}}$  and the parity conserving part  $M_{W_0R}$  that acts like a heavy photon.

As  $M_{W0} = 98.379 \text{ GeV} = M_{W0L} + M_{W0LR}$ , and as  $M_{W0L} = M_{W\pm} = 80.326 \text{ GeV}$ , we have  $M_{W0LR} = 18.053 \text{ GeV}$ .

Denote by  $*\alpha_E = *e^2$  the force strength of the weak parity conserving U(1) electromagnetic type force that acts through the U(1) subgroup of SU(2).

The electromagnetic force strength  $\alpha_E = e^2 = 1 / 137.03608$  was calculated above using the volume  $V(S^1)$  of an  $S^1$  in  $R^2$ , normalized by  $1 / \sqrt{2}$ .

The  $*\alpha_E$  force is part of the SU(2) weak force whose strength  $\alpha_W = w^2$  was calculated above using the volume  $V(S^2)$  of an  $S^2 \subset R^3$ , normalized by  $1 / \sqrt{3}$ .

Also, the electromagnetic force strength  $\alpha_E = e^2$  was calculated above using a 4-dimensional spacetime with global structure of the 4-torus  $T^4$  made up of four  $S^1$  1-spheres, while the SU(2) weak force strength  $\alpha_W = w^2$  was calculated above using two 2-spheres  $S^2 \times S^2$ , each of which contains one 1-sphere of the  $*\alpha_E$  force.

Therefore

$$*\alpha_E = \alpha_E \left( \frac{\sqrt{2}}{\sqrt{3}} \right) \left( \frac{2}{4} \right) = \alpha_E / \sqrt{6},$$

$$*e = e / (\text{4th root of } 6) = e / 1.565,$$

and the mass  $m_{W0LR}$  must be reduced to an effective value

$$M_{W0LR\text{eff}} = M_{W0LR} / 1.565 = 18.053 / 1.565 = 11.536 \text{ GeV}$$

for the  $*\alpha_E$  force to act like an electromagnetic force in the E8 model:

$$*e M_{W0LR} = e (1/1.565) M_{W0LR} = e M_{Z0},$$

where the physical effective neutral weak boson is denoted by  $Z0$ .

Therefore, the correct E8 model values for weak boson masses and the Weinberg angle  $\theta_w$  are:

$$M_{W+} = M_{W-} = 80.326 \text{ GeV};$$

$$M_{Z0} = 80.326 + 11.536 = 91.862 \text{ GeV};$$

$$\sin(\theta_w)^2 = 1 - (M_{W\pm} / M_{Z0})^2 = 1 - (80.326 / 91.862)^2 = 0.235.$$

Radiative corrections are not taken into account here, and may change these tree-level values somewhat.



## Kobayashi-Maskawa Parameters:

The Kobayashi-Maskawa parameters are determined in terms of the sum of the masses of the 30 first-generation fermion particles and antiparticles, denoted by  $S_{mf1} = 7.508 \text{ GeV}$ , and the similar sums for second-generation and third-generation fermions, denoted by  $S_{mf2} = 32.94504 \text{ GeV}$  and  $S_{mf3} = 1,629.2675 \text{ GeV}$ .

The reason for using sums of all fermion masses (rather than sums of quark masses only) is that all fermions are in the same spinor representation of Spin(8), and the Spin(8) representations are considered to be fundamental.

The following formulas use the above masses to calculate Kobayashi-Maskawa parameters:

phase angle  $d_{13} = 1 \text{ radian}$  ( unit length on a phase circumference )

$$\sin(\alpha) = s_{12} = \frac{[m_e + 3m_d + 3m_u]}{\sqrt{[m_e^2 + 3m_d^2 + 3m_u^2] + [m_\mu^2 + 3m_s^2 + 3m_c^2]}} = 0.222198$$

$$\sin(\beta) = s_{13} = \frac{[m_e + 3m_d + 3m_u]}{\sqrt{[m_e^2 + 3m_d^2 + 3m_u^2] + [m_\tau^2 + 3m_b^2 + 3m_t^2]}} = 0.004608$$

$$\sin(*\gamma) = \frac{[m_\mu + 3m_s + 3m_c]}{\sqrt{[m_\tau^2 + 3m_b^2 + 3m_t^2] + [m_\mu^2 + 3m_s^2 + 3m_c^2]}}$$

$$\sin(\gamma) = s_{23} = \sin(*\gamma) \sqrt{S_{mf2} / S_{mf1}} = 0.04234886$$

The factor  $\sqrt{S_{mf2} / S_{mf1}}$  appears in  $s_{23}$  because an  $s_{23}$  transition is to the second generation and not all the way to the first generation, so that the end product of an  $s_{23}$  transition has a greater available energy than  $s_{12}$  or  $s_{13}$  transitions by a factor of  $S_{mf2} / S_{mf1}$ .

Since the width of a transition is proportional to the square of the modulus of the relevant KM entry and the width of an  $s_{23}$  transition has greater available energy than the  $s_{12}$  or  $s_{13}$  transitions by a factor of  $S_{mf2} / S_{mf1}$  the effective magnitude of the  $s_{23}$  terms in the KM entries is increased by the factor  $\sqrt{S_{mf2} / S_{mf1}}$ .

The Chau-Keung parameterization is used, as it allows the K-M matrix to be represented as the product of the following three 3x3 matrices:

$$\begin{array}{ccc}
 1 & 0 & 0 \\
 0 & \cos(\gamma) & \sin(\gamma) \\
 0 & -\sin(\gamma) & \cos(\gamma)
 \end{array}$$


---


$$\begin{array}{ccc}
 \cos(\beta) & 0 & \sin(\beta)\exp(-i d_{13}) \\
 0 & 1 & 0 \\
 -\sin(\beta)\exp(i d_{13}) & 0 & \cos(\beta)
 \end{array}$$


---


$$\begin{array}{ccc}
 \cos(\alpha) & \sin(\alpha) & 0 \\
 -\sin(\alpha) & \cos(\alpha) & 0 \\
 0 & 0 & 1
 \end{array}$$

The resulting Kobayashi-Maskawa parameters for  $W^+$  and  $W^-$  charged weak boson processes, are:

	d	s	b
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 matrix is labelled by either (u c t) input and (d s b) output, or, as above, (d s b) input and (u c t) output.

For  $Z^0$  neutral weak boson processes, which are suppressed by the GIM mechanism of cancellation of virtual subprocesses, the matrix is labelled by either (u c t) input and (u'c't') output, or, as below, (d s b) input and (d's'b') output:

	d	s	b
d'	0.975	0.222	0.00249 -0.00388i
s'	-0.222 -0.000161i	0.974 -0.0000365i	0.0423
b'	0.00698 -0.00378i	-0.0418 -0.00086i	0.999

Since neutrinos of all three generations are massless at tree level, the lepton sector has no tree-level K-M mixing.

According to a Review on the KM mixing matrix by Gilman, Kleinknecht, and Renk in the 2002 Review of Particle Physics: "... Using the eight tree-level constraints discussed below together with unitarity, and assuming only three generations, the 90% confidence limits on the magnitude of the elements of the complete matrix are

	d	s	b
u	0.9741 to 0.9756	0.219 to 0.226	0.00425 to 0.0048
c	0.219 to 0.226	0.9732 to 0.9748	0.038 to 0.044
t	0.004 to 0.014	0.037 to 0.044	0.9990 to 0.9993

... The constraints of unitarity connect different elements, so choosing a specific value for one element restricts the range of others. ... The phase  $\delta_{13}$  lies in the range  $0 < \delta_{13} < 2\pi$ , with non-zero values generally breaking CP invariance for the weak interactions. ... Using tree-level processes as constraints only, the matrix elements ... [ of the 90% confidence limit shown above ] ... correspond to values of the sines of the angles of  $s_{12} = 0.2229 \pm 0.0022$ ,  $s_{23} = 0.0412 \pm 0.0020$ , and  $s_{13} = 0.0036 \pm 0.0007$ . If we use the loop-level processes discussed below as additional constraints, the sines of the angles remain unaffected, and the CKM phase, sometimes referred to as the angle  $\gamma = \phi_3$  of the unitarity triangle ... is restricted to  $\delta_{13} = (1.02 \pm 0.22)$  radians =  $59 \pm 13$  degrees. ... CP-violating amplitudes or differences of rates are all proportional to the product of CKM factors ...  $s_{12} s_{13} s_{23} c_{12} c_{13}^2 c_{23} \sin\delta_{13}$ . This is just twice the area of the unitarity triangle. ... All processes can be quantitatively understood by one value of the CKM phase  $\delta_{13} = 59 \pm 13$  degrees. The value of  $\beta = 24 \pm 4$  degrees from the overall fit is consistent with the value from the CP-asymmetry measurements of  $26 \pm 4$  degrees. The invariant measure of CP violation is  $J = (3.0 \pm 0.3) \times 10^{-5}$ . ... From a combined fit using the direct measurements, B mixing,  $\epsilon$ , and  $\sin 2\beta$ , we obtain:  $\text{Re } V_{td} = 0.0071 \pm 0.0008$ ,  $\text{Im } V_{td} = -0.0032 \pm 0.0004$  ... Constraints... on the position of the apex of the unitarity triangle following from  $|V_{ub}|$ , B mixing,  $\epsilon$ , and  $\sin 2\beta$ . ...".

In hep-ph/0208080, Yosef Nir says: "... Within the Standard Model, the only source of CP violation is the Kobayashi-Maskawa (KM) phase ... The study of CP violation is, at last, experiment driven. ... The CKM matrix provides a consistent picture of all the measured flavor and CP violating processes. ... There is no signal of new flavor physics. ... Very likely, the KM mechanism is the dominant source of CP violation in flavor changing processes. ... The result is consistent with the SM predictions. ...".

## Neutrino Masses:

Consider the three generations of neutrinos:

$\nu_e$  (electron neutrino);

$\nu_\mu$  (muon neutrino);

$\nu_\tau$  (tauon neutrino)

and

three neutrino mass states:  $\nu_1$  ;  $\nu_2$  :  $\nu_3$

and

the division of 8-dimensional spacetime into  
4-dimensional physical M4 Minkowski spacetime  
plus 4-dimensional CP2 internal symmetry space.

The lightest mass state  $\nu_1$  corresponds to a neutrino whose propagation begins and ends in physical Minkowski spacetime, lying entirely therein. According to the E8 model, the mass of  $\nu_1$  is zero at tree-level and it picks up no first-order correction while propagating entirely through physical Minkowski spacetime, so the first-order corrected mass of  $\nu_1$  is zero.

Since only two of the three neutrinos have first-order mass, and since in the E8 model the neutrinos are not Majorana particles, there is no neutrino CP-violation or phase at first order.

Consider the neutrino mixing matrix

	$\nu_1$	$\nu_2$	$\nu_3$
$\nu_e$	Ue1	Ue2	Ue3
$\nu_\mu$	Um1	Um2	Um3
$\nu_\tau$	Ut1	Ut2	Ut3

Assume the simplest mixing scheme  
 with a massless  $\nu_1$  and  $\nu_3$  with no  $\nu_e$  component so that  $U_{e3} = 0$   
 or, in conventional notation,  
 mixing angle  $\theta_{13} = 0 = \sin(\theta_{13})$  and  $\cos(\theta_{13}) = 1$ .

Then we have (as described in the 2004 Particle Data Book):

	$\nu_1$	$\nu_2$	$\nu_3$
$\nu_e$	$\cos(\theta_{12})$	$\sin(\theta_{12})$	0
$\nu_\mu$	$-\sin(\theta_{12})\cos(\theta_{23})$	$\cos(\theta_{12})\cos(\theta_{23})$	$\sin(\theta_{23})$
$\nu_\tau$	$\sin(\theta_{12})\sin(\theta_{23})$	$-\cos(\theta_{12})\sin(\theta_{23})$	$\cos(\theta_{23})$

Assume that  $\nu_3$  has equal components of  $\nu_\mu$  and  $\nu_\tau$   
 so that  $U_{\mu 3} = U_{\tau 3} = 1/\sqrt{2}$   
 or, in conventional notation, mixing angle  $\theta_{23} = \pi/4$ .

Then we have:

	$\nu_1$	$\nu_2$	$\nu_3$
$\nu_e$	$\cos(\theta_{12})$	$\sin(\theta_{12})$	0
$\nu_\mu$	$-\sin(\theta_{12})/\sqrt{2}$	$\cos(\theta_{12})/\sqrt{2}$	$1/\sqrt{2}$
$\nu_\tau$	$\sin(\theta_{12})/\sqrt{2}$	$-\cos(\theta_{12})/\sqrt{2}$	$1/\sqrt{2}$

The heaviest mass state  $\nu_3$  corresponds to a neutrino whose propagation begins and ends in CP2 internal symmetry space, lying entirely therein.

According to the E8 model the mass of  $\nu_3$  is zero at tree-level but it picks up a first-order correction propagating entirely through internal symmetry space by merging with an electron through the weak and electromagnetic forces, effectively acting not merely as a point but as a point plus an electron loop at both beginning and ending points so the first-order corrected mass of  $\nu_3$  is given by

$$M_{\nu_3} \times (1/\sqrt{2}) = M_e \times GW(m_{\text{proton}}^2) \times \alpha_E$$

where the factor  $(1/\sqrt{2})$  comes from the Ut3 component of the neutrino mixing matrix so that

$$\begin{aligned} M_{\nu_3} &= \sqrt{2} \times M_e \times GW(m_{\text{proton}}^2) \times \alpha_E = \\ &= 1.4 \times 5 \times 10^5 \times 1.05 \times 10^{(-5)} \times (1/137) \text{ eV} = \\ &= 7.35 / 137 = 5.4 \times 10^{(-2)} \text{ eV}. \end{aligned}$$

Note that the neutrino-plus-electron loop can be anchored by weak force action through any of the 6 first-generation quarks at each of the beginning and ending points, and that the anchor quark at the beginning point can be different from the anchor quark at the ending point, so that there are  $6 \times 6 = 36$  different possible anchorings.

The intermediate mass state  $\nu_2$  corresponds to a neutrino whose propagation begins or ends in CP2 internal symmetry space and ends or begins in physical Minkowski spacetime, thus having only one point (either beginning or ending) lying in CP2 internal symmetry space where it can act not merely as a point but as a point plus an electron loop.

According to the E8 model the mass of  $\nu_2$  is zero at tree-level but it picks up a first-order correction at only one (but not both) of the beginning or ending points so that so that there are 6 different possible anchorings for  $\nu_2$  first-order corrections, as opposed to the 36 different possible anchorings for  $\nu_3$  first-order corrections, so that the first-order corrected mass of  $\nu_2$  is less than the first-order corrected mass of  $\nu_3$  by a factor of 6,

so the first-order corrected mass of  $\nu_2$  is

$$\begin{aligned} M_{\nu_2} &= M_{\nu_3} / \text{Vol}(\text{CP}2) = 5.4 \times 10^{(-2)} / 6 \\ &= 9 \times 10^{(-3)} \text{eV}. \end{aligned}$$

Therefore: the mass-squared difference  $D(M_{23}^2)$  is

$$\begin{aligned} D(M_{23}^2) &= M_{\nu_3}^2 - M_{\nu_2}^2 = \\ &= (2916 - 81) \times 10^{(-6)} \text{eV}^2 = \\ &= 2.8 \times 10^{(-3)} \text{eV}^2 \end{aligned}$$

and

the mass-squared difference  $D(M_{12}^2)$  is

$$\begin{aligned} D(M_{12}^2) &= M_{\nu_2}^2 - M_{\nu_1}^2 = \\ &= (81 - 0) \times 10^{(-6)} \text{eV}^2 = \\ &= 8.1 \times 10^{(-5)} \text{eV}^2 \end{aligned}$$

Set  $\theta_{12} = \pi/6 = 0.866$  so that  $\cos(\theta_{12}) = 0.866 = \sqrt{3}/2$   
and  $\sin(\theta_{12}) = 0.5 = 1/2 = U_{e2}$  = fraction of  $\nu_2$  begin/end points that  
are in the physical spacetime where massless  $\nu_e$  lives.

Then we have for the neutrino mixing matrix:

	$\nu_1$	$\nu_2$	$\nu_3$
$\nu_e$	0.87	0.50	0
$\nu_m$	-0.35	0.61	0.71
$\nu_t$	0.35	-0.61	0.71

The E8 model calculations are substantially consistent with experimental results as described in the 2004 Particle Data Book and in the presentation by deGouvea at the 2004 APS DPF meeting at UC Riverside.



## Proton-Neutron Mass Difference:

According to the 1986 CODATA Bulletin No. 63, the experimental value of the neutron mass is 939.56563(28) Mev, and the experimental value of the proton is 938.27231(28) Mev.

The neutron-proton mass difference 1.3 Mev is due to the fact that the proton consists of two up quarks and one down quark, while the neutron consists of one up quark and two down quarks.

The magnitude of the electromagnetic energy difference  $m_N - m_P$  is about 1 Mev, but the sign is wrong:  $m_N - m_P = -1$  Mev, and the proton's electromagnetic mass is greater than the neutron's.

The difference in energy between the bound states, neutron and proton, is not due to a difference between the Pre-Quantum constituent masses of the up quark and the down quark, which are calculated in the E8 model to be equal.

It is due to the difference between the Quantum color force interactions of the up and down constituent valence quarks with the gluons and virtual sea quarks in the neutron and the proton.

An up valence quark, constituent mass 313 Mev, does not often swap places with a 2.09 Gev charm sea quark, but a 313 Mev down valence quark can more often swap places with a 625 Mev strange sea quark.

Therefore the Quantum color force constituent mass of the down valence quark is heavier by about

$$(m_s - m_d) (m_d/m_s)^2 a(w) |V_{ds}| = 312 \times 0.25 \times 0.253 \times 0.22 \text{ Mev} = 4.3 \text{ Mev},$$

(where  $a(w) = 0.253$  is the geometric part of the weak force strength and  $|V_{ds}| = 0.22$  is the magnitude of the K-M parameter mixing first generation down and second generation strange)

so that the Quantum color force constituent mass  $Q_{md}$  of the down quark is

$$Q_{md} = 312.75 + 4.3 = 317.05 \text{ MeV}.$$

Similarly, the up quark Quantum color force mass increase is about  
 $(m_c - m_u) (m_u/m_c)^2 a(w) |V_{uc}| = 1777 \times 0.022 \times 0.253 \times 0.22 \text{ MeV} = 2.2 \text{ MeV},$

(where  $|V_{uc}| = 0.22$  is the magnitude of the K-M parameter mixing first generation up and second generation charm)

so that the Quantum color force constituent mass  $Q_{mu}$  of the up quark is

$$Q_{mu} = 312.75 + 2.2 = 314.95 \text{ MeV}.$$

Therefore, the Quantum color force Neutron-Proton mass difference is

$$m_N - m_P = Q_{md} - Q_{mu} = 317.05 \text{ MeV} - 314.95 \text{ MeV} = 2.1 \text{ MeV}.$$

Since the electromagnetic Neutron-Proton mass difference is roughly

$$m_N - m_P = -1 \text{ MeV}$$

the total theoretical Neutron-Proton mass difference is

$$m_N - m_P = 2.1 \text{ MeV} - 1 \text{ MeV} = 1.1 \text{ MeV},$$

an estimate that is fairly close to the experimental value of 1.3 MeV.

Note that in the equation  $(m_s - m_d) (m_d/m_s)^2 a(w) |V_{ds}| = 4.3 \text{ MeV} ,$

$V_{ds}$  is a mixing of down and strange by a neutral  $Z_0$ ,

compared to the more conventional  $V_{us}$  mixing by charged  $W$ .

Although real neutral  $Z_0$  processes are suppressed by the GIM mechanism, which is a cancellation of virtual processes,

the process of the equation is strictly a virtual process.

Note also that the K-M mixing parameter  $|V_{ds}|$  is linear.

Mixing (such as between a down quark and a strange quark) is a two-step process, that goes approximately as the square of  $|V_{ds}|$ :

First the down quark changes to a virtual strange quark, producing one factor of  $|V_{ds}|$ .

Then, second, the virtual strange quark changes back to a down quark, producing a second factor of  $|V_{ds}|$ , which is approximately equal to  $|V_{ds}|$ .

Only the first step (one factor of  $|V_{ds}|$ ) appears in the Quantum mass formula used to determine the neutron mass.

Measurement of a neutron mass includes a sum over histories of the valence quarks inside the neutron in some of which you will "see" some of the two valence down quarks in a virtual transition state or change from down to strange before the second action, or change back. Therefore, you should take into account those histories in the sum in which you see a strange valence quark, and you get the linear factor  $|V_{ds}|$  in the above equation.

## Pion Mass:

The quark content of a charged pion is a quark - antiquark pair: either Up plus antiDown or Down plus antiUp. Experimentally, its mass is about 139.57 MeV.

The quark is a Naked Singularity Kerr-Newman Black Hole, with electromagnetic charge  $e$  and spin angular momentum  $J$  and constituent mass  $M$  312 MeV, such that  $e^2 + a^2$  is greater than  $M^2$  (where  $a = J / M$ ).

The antiquark is a also Naked Singularity Kerr-Newman Black Hole, with electromagnetic charge  $e$  and spin angular momentum  $J$  and constituent mass  $M$  312 MeV, such that  $e^2 + a^2$  is greater than  $M^2$  (where  $a = J / M$ ).

According to General Relativity, by Robert M. Wald (Chicago 1984) page 338 [Problems] ... 4. ...:

"... Suppose two widely separated Kerr black holes with parameters  $(M_1, J_1)$  and  $(M_2, J_2)$  initially are at rest in an axisymmetric configuration, i.e., their rotation axes are aligned along the direction of their separation.

Assume that these black holes fall together and coalesce into a single black hole.

Since angular momentum cannot be radiated away in an axisymmetric spacetime, the final black hole will have momentum  $J = J_1 + J_2$ . ...".

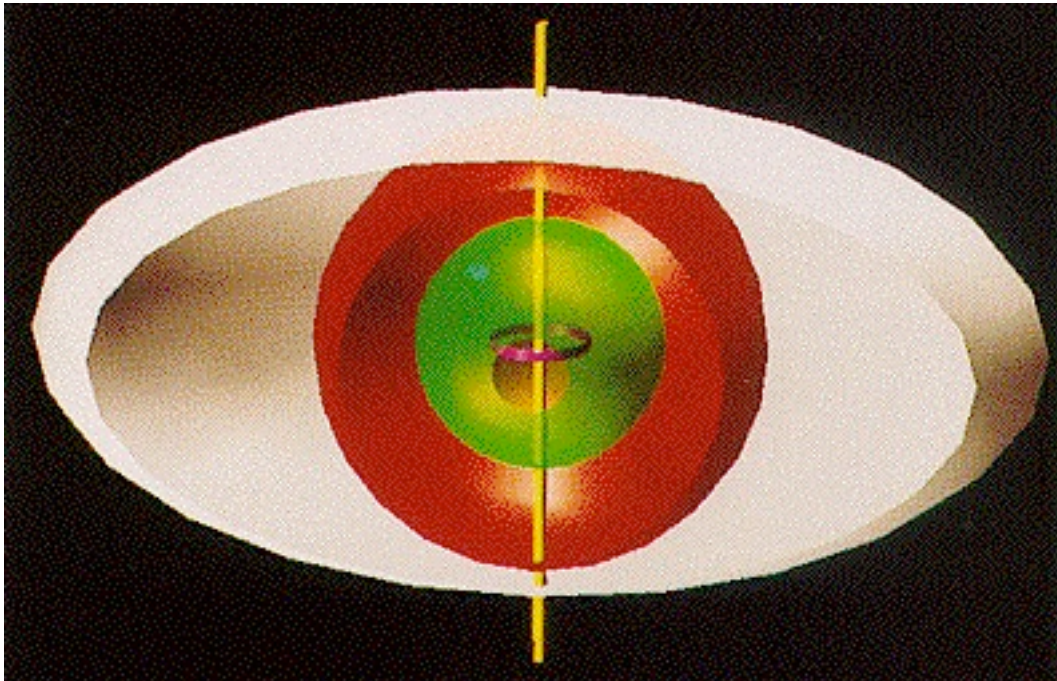
The neutral pion produced by the quark - antiquark pair would have zero angular momentum, thus reducing the value of  $e^2 + a^2$  to  $e^2$ .

For fermion electrons with spin  $1/2$ ,  $1/2 = e / M$  (see for example Misner, Thorne, and Wheeler, Gravitation (Freeman 1972), page 883) so that  $M^2 = 4 e^2$  is greater than  $e^2$  for the electron. In other words, the angular momentum term  $a^2$  is necessary to make  $e^2 + a^2$  greater than  $M^2$  so that the electron can be seen as a Kerr-Newman naked singularity.

Since the magnitude of electromagnetic charge of each quarks or antiquarks less than that of an electron, and since the mass of each quark or antiquark (as well as the pion mass) is greater than that of an electron, and since the quark - antiquark pair (as well as the pion) has angular momentum zero, the quark - antiquark pion has  $M^2$  greater than  $e^2 + a^2 = e^2$ .

( Note that color charge, which is nonzero for the quark and the antiquark and is involved in the relation  $M^2$  less than sum of spin-squared and charges-squared by which quarks and antiquarks can be see as Kerr-Newman naked singularities, is not relevant for the color-neutral pion. )

Therefore, the pion itself is a normal Kerr-Newman Black Hole with Outer Event Horizon = Ergosphere at  $r = 2M$  ( the Inner Event Horizon is only the origin at  $r = 0$  ) as shown in this image



from Black Holes - A Traveller's Guide, by Clifford Pickover (Wiley 1996) in which the Ergosphere is white, the Outer Event Horizon is red, the Inner Event Horizon is green, and the Ring Singularity is purple. In the case of the pion, the white and red surfaces coincide, and the green surface is only a point at the origin.

According to section 3.6 of Jeffrey Winicour's 2001 Living Review of the Development of Numerical Evolution Codes for General Relativity (see also a 2005 update):

"... The black hole event horizon associated with ... slightly broken ... degeneracy [ of the axisymmetric configuration ]... reveals new features not seen in the degenerate case of the head-on collision ... If the degeneracy is slightly broken, the individual black holes form with spherical topology but as they approach, tidal distortion produces two sharp pincers on each black hole just prior to merger.

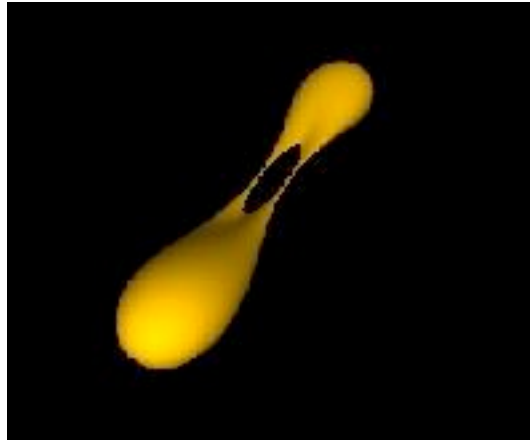
... Tidal distortion of approaching black holes ...



... Formation of sharp pincers just prior to merger ..



... toroidal stage just after merger ...



At merger, the two pincers join to form a single ... toroidal black hole.

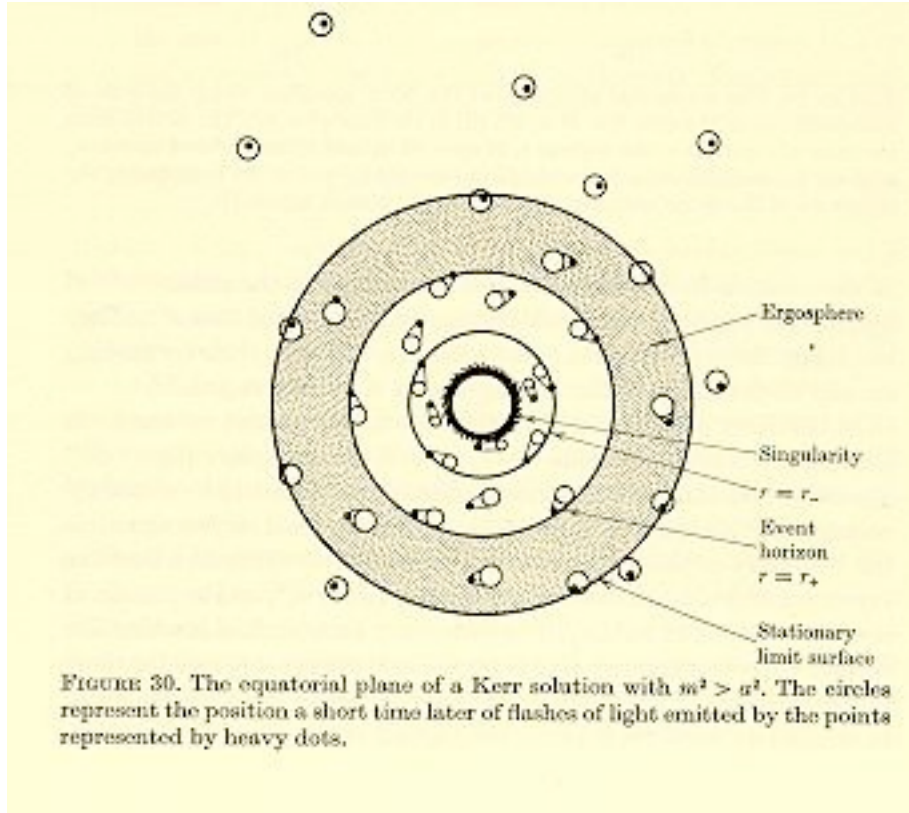
The inner hole of the torus subsequently [ begins to] close... up (superluminally) ... [ If the closing proceeds to completion, it ]... produce[s] first a peanut shaped black hole and finally a spherical black hole. ...".

In the physical case of quark and antiquark forming a pion, the toroidal black hole remains a torus. The torus is an event horizon and therefore is not a 2-spacelike dimensional torus, but is a (1+1)-dimensional torus with a timelike dimension.

The effect is described in detail in Robert Wald's book *General Relativity* (Chicago 1984). It can be said to be due to extreme frame dragging, or to timelike translations becoming spacelike as though they had been Wick rotated in Complex SpaceTime.

As Hawking and Ellis say in *The LargeScale Structure of Space-Time* (Cambridge 1973):

"... The surface  $r = r_+$  is ... the event horizon ... and is a null surface ...



... On the surface  $r = r_+$  .... the wavefront corresponding to a point on this surface lies entirely within the surface. ...".

A (1+1)-dimensional torus with a timelike dimension can carry a Sine-Gordon Breather, and the soliton and antisoliton of a Sine-Gordon Breather correspond to the quark and antiquark that make up the pion.

Sine-Gordon Breathers are described by Sidney Coleman in his Erica lecture paper Classical Lumps and their Quantum Descendants (1975), reprinted in his book Aspects of Symmetry (Cambridge 1985), where Coleman writes the Lagrangian for the Sine-Gordon equation as ( Coleman's eq. 4.3 ):

$$L = (1 / B^2) ( (1/2) (df)^2 + A ( \cos(f) - 1 ) )$$

and Coleman says:

"... We see that, in classical physics, B is an irrelevant parameter: if we can solve the sine-Gordon equation for any non-zero B, we can solve it for any other B. The only effect of changing B is the trivial one of changing the energy and momentum assigned to a given solution of the equation. This is not true in quantum physics, because the relevant object for quantum physics is not L but [ eq. 4.4 ]

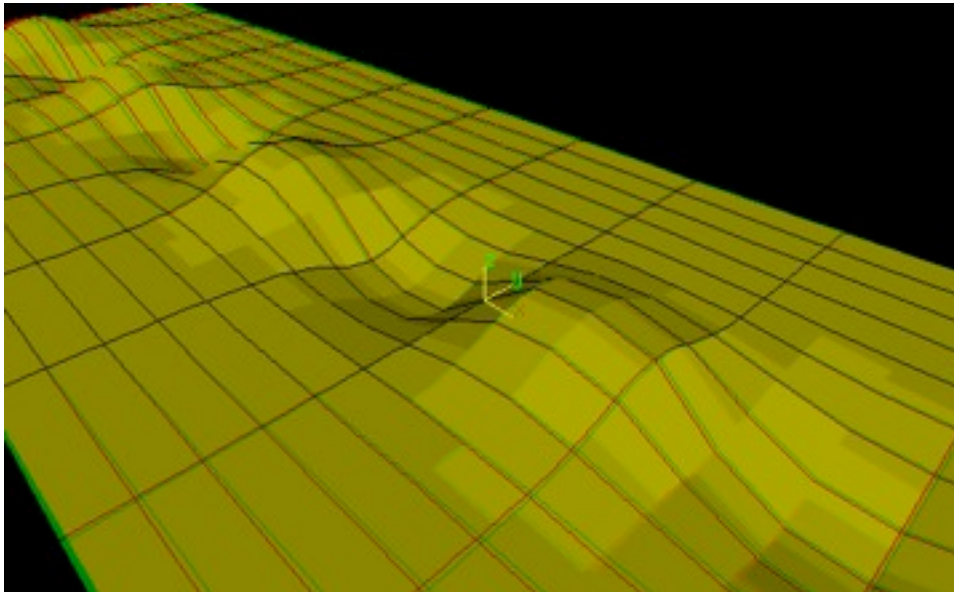
$$L / \hbar = (1 / ( B^2 \hbar )) ( (1/2) (df)^2 + A ( \cos( f ) - 1 ) )$$

An other way of saying the same thing is to say that in quantum physics we have one more dimensional constant of nature, Planck's constant, than in classical physics. ... the classical limit, vanishing  $\hbar$ , is exactly the same as the small-coupling limit, vanishing  $B$  ... from now on I will ... set  $\hbar$  equal to one. ...

... the sine-Gordon equation ... [ has ]... an exact periodic solution ... [ eq. 4.59 ]...

$$f( x, t ) = ( 4 / B ) \arctan( ( n \sin( w t ) / \cosh( n w x ) )$$

where [ eq. 4.60 ]  $n = \sqrt{A - w^2} / w$  and  $w$  ranges from 0 to  $A$ . This solution has a simple physical interpretation ... a soliton far to the left ... [ and ]... an antisoliton far to the right. As  $\sin( w t )$  increases, the soliton and antisoliton mover farther apart from each other. When  $\sin( w t )$  passes through one, they turn around and begin to approach one another. As  $\sin( w t )$  comes down to zero ... the soliton and antisoliton are on top of each other ... when  $\sin( w t )$  becomes negative .. the soliton and antisoliton have passed each other. ... [



This stereo image of a Sine-Gordon Breather was generated by the program 3D-Filmstrip for Macintosh by Richard Palais. You can see the stereo with red-green or red-cyan 3D glasses. The program is on the WWW at <http://rsp.math.brandeis.edu/3D-Filmstrip>. The Sine-Gordon Breather is confined in space (y-axis) but periodic in time (x-axis), and therefore naturally lives on the (1+1)-dimensional torus with a timelike dimension of the Event Horizon of the pion. ...]



... Thus, Eq. (4.59) can be thought of as a soliton and an antisoliton oscillation about their common center-of-mass. For this reason, it is called 'the doublet [ or Breather ] solution'. ... the energy of the doublet ... [ eq. 4.64 ]

$$E = 2 M \sqrt{1 - (w^2 / A)}$$

where [ eq. 4.65 ]  $M = 8 \sqrt{A} / B^2$  is the soliton mass. Note that the mass of the doublet is always less than twice the soliton mass, as we would expect from a soliton-antisoliton pair. ... Dashen, Hasslacher, and Neveu ... Phys. Rev. D10, 4114; 4130; 4138 (1974). A pedagogical review of these methods has been written by R. Rajaraman ( Phys. Reports 21, 227 (1975 ... Phys. Rev. D11, 3424 (1975) ... [ Dashen, Hasslacher, and Neveu found that ]... there is only a single series of bound states, labeled by the integer N ... The energies ... are ... [ eq. 4.82 ]

$$E_N = 2 M \sin(B'^2 N / 16)$$

where  $N = 0, 1, 2 \dots < 8 \pi / B'^2$ , [ eq. 4.83 ]

$$B'^2 = B^2 / (1 - (B^2 / 8 \pi))$$

and M is the soliton mass. M is not given by Eq. ( 4.675 ), but is the soliton mass corrected by the DHN formula, or, equivalently, by the first-order weak coupling expansion. ... I have written the equation in this form .. to eliminate A, and thus avoid worries about renormalization conventions. Note that the DHN formula is identical to the Bohr-Sommerfeld formula, except that B is replaced by B'. ... Bohr and Sommerfeld[s] ... quantization formula says that if we have a one-parameter family of periodic motions, labeled by the period, T, then an energy eigenstate occurs whenever [ eq. 4.66 ]

$$[\text{Integral from } 0 \text{ to } T](dt \dot{p} = 2 \pi N,$$

where N is an integer. ... Eq.( 4.66 ) is cruder than the WKB formula, but it is much more general; it is always the leading approximation for any dynamical system ... Dashen et al speculate that Eq. ( 4.82 ) is exact. ...

the sine-Gordon equation is equivalent ... to the massive Thirring model. This is surprising, because the massive Thirring model is a canonical field theory whose Hamiltonian is expressed in terms of fundamental Fermi fields only. Even more surprising, when  $B^2 = 4 \pi$ , that sine-Gordon equation is equivalent to a free massive Dirac theory, in one spatial dimension. ... Furthermore, we can identify the

mass term in the Thirring model with the sine-Gordon interaction,  
[ eq. 5.13 ]

$$M = - ( A / B^2 ) N_m \cos( B f )$$

.. to do this consistently ... we must say [ eq. 5.14 ]

$$B^2 / ( 4 \pi ) = 1 / ( 1 + g / \pi )$$

....[where]...  $g$  is a free parameter, the coupling constant [ for the Thirring model ]... Note that if  $B^2 = 4 \pi$ ,  $g = 0$ , and the sine-Gordon equation is the theory of a free massive Dirac field. ... It is a bit surprising to see a fermion appearing as a coherent state of a Bose field. Certainly this could not happen in three dimensions, where it would be forbidden by the spin-statistics theorem. However, there is no spin-statistics theorem in one dimension, for the excellent reason that there is no spin. ... the lowest fermion-antifermion bound state of the massive Thirring model is an obvious candidate for the fundamental meson of sine-Gordon theory. ... equation ( 4.82 ) predicts that all the doublet bound states disappear when  $B^2$  exceeds  $4 \pi$ . This is precisely the point where the Thirring model interaction switches from attractive to repulsive. ... these two theories ... the massive Thirring model .. and ... the sine-Gordon equation ... define identical physics. ... I have computed the predictions of ...[various]... approximation methods for the ration of the soliton mass to the meson mass for three values of  $B^2$  :  $4 \pi$  (where the qualitative picture of the soliton as a lump totally breaks down),  $2 \pi$ , and  $\pi$ . At  $4 \pi$  we know the exact answer

... I happen to know the exact answer for  $2\pi$ , so I have included this in the table. ...

Method	$B^2 = \pi$	$B^2 = 2\pi$	$B^2 = 4\pi$
Zeroth-order weak coupling expansion eq2.13b	2.55	1.27	0.64
Coherent-state variation	2.55	1.27	0.64
First-order weak coupling expansion	2.23	0.95	0.32
Bohr-Sommerfeld eq4.64	2.56	1.31	0.71
DHN formula eq4.82	2.25	1.00	0.50
Exact	?	1.00	0.50

...[eq. 2.13b ]  $E = 8 \sqrt{A} / B^2$  ...[ is the ]... energy of the lump ... of sine-Gordon theory ... frequently called 'soliton...' in the literature ... [ Zeroth-order is the classical case, or classical limit. ] ...

... Coherent-state variation always gives the same result as the ... Zeroth-order weak coupling expansion ... .

The ... First-order weak-coupling expansion ... explicit formula ... is  $( 8 / B^2 ) - ( 1 / \pi )$ . ...".

Note that, using the VoDou Physics constituent mass of the Up and Down quarks and antiquarks, about 312.75 MeV, as the soliton and antisoliton masses, and setting  $B^2 = \pi$  and using the DHN formula, the mass of the charged pion is calculated to be

$$( 312.75 / 2.25 ) \text{ MeV} = 139 \text{ MeV}$$

which is in pretty good agreement with the experimental value of about 139.57 MeV.

Why is the value  $B^2 = \pi$  ( or, using Coleman's eq. ( 5.14 ), the Thirring coupling constant  $g = 3\pi$  ) the special value that gives the pion mass ?

Because  $B^2 = \pi$  is where the First-order weak coupling expansion substantially coincides with the ( probably exact ) DHN formula.

In other words, the physical quark - antiquark pion lives where the first-order weak coupling expansion is exact.

Near the end of his article, Coleman expressed "Some opinions":

"... This has been a long series of physics lectures with no reference whatsoever to experiment. This is embarrassing.

... Is there any chance that the lump will be more than a theoretical toy in our field? I can think of two possibilities.

One is that there will appear a theory of strong-interaction dynamics in which hadrons are thought of as lumps, or, ... as systems of quarks bound into lumps. ... I am pessimistic about the success of such a theory. ... However, I stand ready to be converted in a moment by a convincing computation.

The other possibility is that a lump will appear in a realistic theory ... of weak and electromagnetic interactions ... the theory would have to imbed the  $U(1) \times SU(2)$  group ... in a larger group without  $U(1)$  factors ... it would be a magnetic monopole. ...".

This description of the hadronic pion as a quark - antiquark system governed by the sine-Gordon - massive Thirring model should dispel Coleman's pessimism about his first stated possibility and relieve his embarrassment about lack of contact with experiment.

As to his second stated possibility, very massive monopoles related to  $SU(5)$  GUT are still within the realm of possible future experimental discoveries.

Further material about the sine-Gordon doublet Breather and the massive Thirring equation can be found in the book Solitons and Instantons (North-Holland 1982,1987) by R. Rajaraman, who writes:

"... the doublet or breather solutions ... can be used as input into the WKB method. ... the system is ... equivalent to the massive Thirring model, with the SG soliton state identifiable as a fermion. ... Mass of the quantum soliton ... will consist of a classical term followed by quantum corrections. The energy of the classical soliton ... is ... [ eq. 7.3 ]

$$E_{cl}[f_{sol}] = 8 m^3 / L$$

The quantum corrections ... to the 'soliton mass' ... is finite as the momentum cut-off goes to infinity and equals  $(- m / \pi)$ . Hence the quantum soliton's mass is [ eq. 7.10 ]

$$M_{sol} = ( 8 m^3 / L ) - ( m / \pi ) + O(L).$$

The mass of the quantum antisoliton will be, by ... symmetry, the same as  $M_{\text{sol}}$ . ...

The doublet solutions ... may be quantised by the WKB method. ... we see that the coupling constant ( $L / m^2$ ) has been replaced by a 'renormalised' coupling constant  $G$  ... [ eq. 7.24 ]

$$G = (L / m^2) / (1 - (L / 8 \pi m^2))$$

... as a result of quantum corrections. ... the same thing had happened to the soliton mass in eq. ( 7.10 ). To leading order, we can write [ eq. 7.25 ]

$$M_{\text{sol}} = (8 m^3 / L) - (m / \pi) = 8 m / G$$

... The doublet masses ... bound-state energy levels ...  $E = M_N$ , where ... [ eq. 7.28 ]

$$M_N = (16 m / G) \sin(N G / 16) ; N = 1, 2, \dots < 8 \pi / G$$

Formally, the quantisation condition permits all integers  $N$  from 1 to  $\infty$ , but we run out of classical doublet solutions on which these bound states are based when  $N > 8 \pi / G$ . ... The classical solutions ... bear the same relation to the bound-state wavefunctionals ... that Bohr orbits bear to hydrogen atom wavefunctions. ...

Coleman ... show[ed] explicitly ... the SG theory equivalent to the charge-zero sector of the MT model, provided ...  $L / 4 \pi m^2 = 1 / (1 + g / \pi)$

...[ where in Coleman's work set out above such as his eq. ( 5.14 ),  $B^2 = L / m^2$  ]...

Coleman ... resurrected Skyrme's conjecture that the quantum soliton of the SG model may be identified with the fermion of the MT model. ... "

What about the Neutral Pion?

The quark content of the charged pion is  $u_{\bar{d}}$  or  $d_{\bar{u}}$ , both of which are consistent with the sine-Gordon picture. Experimentally, its mass is 139.57 Mev.

The neutral pion has quark content  $(u_{\bar{u}} + d_{\bar{d}})/\sqrt{2}$  with two components, somewhat different from the sine-Gordon picture, and a mass of 134.96 Mev.

The effective constituent mass of a down valence quark increases (by swapping places with a strange sea quark) by about

$$\begin{aligned} DcMdquark &= (M_s - M_d) (M_d/M_s)^2 \text{ aw } V_{12} = \\ &= 312 \times 0.25 \times 0.253 \times 0.22 \text{ Mev} = 4.3 \text{ Mev.} \end{aligned}$$

Similarly, the up quark color force mass increase is about

$$\begin{aligned} DcMuquark &= (M_c - M_u) (M_u/M_c)^2 \text{ aw } V_{12} = \\ &= 1777 \times 0.022 \times 0.253 \times 0.22 \text{ Mev} = 2.2 \text{ Mev.} \end{aligned}$$

The color force increase for the charged pion  $DcMpion_{\pm} = 6.5 \text{ Mev}$ .

Since the mass  $M_{pion_{\pm}} = 139.57 \text{ Mev}$  is calculated from a color force sine-Gordon soliton state, the mass 139.57 Mev already takes  $DcMpion_{\pm}$  into account.

For  $pion_0 = (u_{\bar{u}} + d_{\bar{d}})/\sqrt{2}$ , the  $d$  and  $\bar{d}$  of the  $d_{\bar{d}}$  pair do not swap places with strange sea quarks very often because it is energetically preferential for them both to become a  $u_{\bar{u}}$  pair.

Therefore, from the point of view of calculating  $DcMpion_0$ , the  $pion_0$  should be considered to be only  $u_{\bar{u}}$ , and  $DcMpion_0 = 2.2 + 2.2 = 4.4 \text{ Mev}$ .

If, as in the nucleon,  $DeM(pion_0 - pion_{\pm}) = -1 \text{ Mev}$ , the theoretical estimate is

$$\begin{aligned} DM(pion_0 - pion_{\pm}) &= DcM(pion_0 - pion_{\pm}) + DeM(pion_0 - pion_{\pm}) = \\ &= 4.4 - 6.5 - 1 = -3.1 \text{ Mev,} \end{aligned}$$

roughly consistent with the experimental value of -4.6 Mev.

## **Planck Mass:**

In the E8 model, a Planck-mass black hole is not a tree-level classical particle such as an electron or a quark, but a quantum entity resulting from the Many-Worlds quantum sum over histories at a single point in spacetime.

Consider an isolated single point, or vertex in the lattice picture of spacetime. In the E8 model, fermions live on vertices, and only first-generation fermions can live on a single vertex. (The second-generation fermions live on two vertices that act at our energy levels very much like one, and the third-generation fermions live on three vertices that act at our energy levels very much like one.)

At a single spacetime vertex, a Planck-mass black hole is the Many-Worlds quantum sum of all possible virtual first-generation particle-antiparticle fermion pairs permitted by the Pauli exclusion principle to live on that vertex.

Once a Planck-mass black hole is formed, it is stable in the E8 model. Less mass would not be gravitationally bound at the vertex. More mass at the vertex would decay by Hawking radiation.

In the E8 model, a Planck-mass black hole can be formed:  
as the end product of Hawking radiation decay of a larger black hole;  
by vacuum fluctuation;  
or perhaps by using a pion laser.

Since Dirac fermions in 4-dimensional spacetime can be massive (and are massive at low enough energies for the Higgs mechanism to act), the Planck mass in 4-dimensional spacetime is the sum of masses of all possible virtual first-generation particle-antiparticle fermion pairs permitted by the Pauli exclusion principle.

There are 8 fermion particles and 8 fermion antiparticles for a total of 64 particle-antiparticle pairs.

A typical combination should have several quarks, several antiquarks, a few colorless quark-antiquark pairs that would be equivalent to pions, and some leptons and antileptons.

Due to the Pauli exclusion principle, no fermion lepton or quark could be present at the vertex more than twice unless they are in the form of boson pions, colorless first-generation quark-antiquark pairs not subject to the Pauli exclusion principle. Of the 64 particle-antiparticle pairs, 12 are pions.

A typical combination should have about 6 pions.

If all the pions are independent,  
the typical combination should have a mass of about  $.14 \times 6 \text{ GeV} = 0.84 \text{ GeV}$ .

However, just as the pion mass of  $.14 \text{ GeV}$  is less than  
the sum of the masses of a quark and an antiquark,  
pairs of oppositely charged pions may form a bound state of less mass  
than the sum of two pion masses.

If such a bound state of oppositely charged pions has a mass as small as  $.1 \text{ GeV}$ ,  
and  
if the typical combination has one such pair and 4 other pions, then the typical  
combination could have a mass in the range of  $0.66 \text{ GeV}$ .

Summing over all  $2^{64}$  combinations,  
the total mass of a one-vertex universe should give a Planck mass roughly around  
 $0.66 \times 2^{64} = 1.217 \times 10^{19} \text{ GeV}$ .

Since each fermion particle has a corresponding antiparticle,  
a Planck-mass Black Hole is neutral with respect to electric and color charges.

The value for the Planck mass given in the Particle Data Group's 1998 review is  
 $1.221 \times 10^{19} \text{ GeV}$ .



## Dark Energy : Dark Matter : Ordinary Matter:

Gravity and the Cosmological Constant come from the MacDowell-Mansouri Mechanism and the 15-dimensional  $\text{Spin}(2,4) = \text{SU}(2,2)$  Conformal Group, which is made up of:

- 3 Rotations;
- 3 Boosts;
- 4 Translations;
- 4 Special Conformal transformations; and
- 1 Dilatation.

According to gr-qc/9809061 by R. Aldrovandi and J. G. Peireira:

"... If the fundamental spacetime symmetry of the laws of Physics is that given by the de Sitter instead of the Poincare group, the P-symmetry of the weak cosmological-constant limit and the Q-symmetry of the strong cosmological-constant limit can be considered as limiting cases of the fundamental symmetry. ...  
... N ...[ is the space ]... whose geometry is gravitationally related to an infinite cosmological constant ...[and]... is a 4-dimensional cone-space in which  $ds = 0$ , and whose group of motion is Q. Analogously to the Minkowski case, N is also a homogeneous space, but now under the kinematical group Q, that is,  $N = Q/L$  [ where L is the Lorentz Group of Rotations and Boosts ]. In other words, the point-set of N is the point-set of the special conformal transformations.  
Furthermore, the manifold of Q is a principal bundle  $P(Q/L, L)$ , with  $Q/L = N$  as base space and L as the typical fiber. The kinematical group Q, like the Poincare group, has the Lorentz group L as the subgroup accounting for both the isotropy and the equivalence of inertial frames in this space. However, the special conformal transformations introduce a new kind of homogeneity. Instead of ordinary translations, all the points of N are equivalent through special conformal transformations. ...

... Minkowski and the cone-space can be considered as dual to each other, in the sense that their geometries are determined respectively by a vanishing and an infinite cosmological constants. The same can be said of their kinematical group of motions: P is associated to a vanishing cosmological constant and Q to an infinite cosmological constant.

The dual transformation connecting these two geometries is the spacetime inversion  $x^\mu \rightarrow x^\mu / \sigma^2$ . Under such a transformation, the Poincare group P is transformed into the group Q, and the Minkowski space M becomes the cone-space N. The points at infinity of M are concentrated in the vertex of the cone-space N, and those on the light-cone of M becomes the infinity of N. It is

interesting to notice that, despite presenting an infinite scalar curvature, the concepts of space isotropy and equivalence between inertial frames in the cone-space  $N$  are those of special relativity. The difference lies in the concept of uniformity as it is the special conformal transformations, and not ordinary translations, which act transitively on  $N$ . ..."

Since the Cosmological Constant comes from the 10 Rotation, Boost, and Special Conformal generators of the Conformal Group  $\text{Spin}(2,4) = \text{SU}(2,2)$ , the fractional part of our Universe of the Cosmological Constant should be about  $10 / 15 = 67\%$ .

Since Black Holes, including Dark Matter Primordial Black Holes, are curvature singularities in our 4-dimensional physical spacetime, and since Einstein-Hilbert curvature comes from the 4 Translations of the 15-dimensional Conformal Group  $\text{Spin}(2,4) = \text{SU}(2,2)$  through the MacDowell-Mansouri Mechanism (in which the generators corresponding to the 3 Rotations and 3 Boosts do not propagate), the fractional part of our Universe of Dark Matter Primordial Black Holes should be about  $4 / 15 = 27\%$ .

Since Ordinary Matter gets mass from the Higgs mechanism which is related to the 1 Scale Dilatation of the 15-dimensional Conformal Group  $\text{Spin}(2,4) = \text{SU}(2,2)$ , the fractional part of our universe of Ordinary Matter should be about  $1 / 15 = 6\%$ .

Therefore, our Flat Expanding Universe should, according to the cosmology of the model, have (without taking into account any evolutionary changes with time) roughly:

67% Cosmological Constant

27% Dark Matter - possibly primordial stable Planck mass black holes

6% Ordinary Matter

As Dennis Marks pointed out to me,  
 since density  $\rho$  is proportional to  $(1+z)^3(1+w)$  for red-shift factor  $z$   
 and a constant equation of state  $w$ :

$w = -1$  for  $\Lambda$  and the average overall density of  $\Lambda$  Dark Energy remains constant  
 with time and the expansion of our Universe;

and

$w = 0$  for nonrelativistic matter so that the overall average density of Ordinary  
 Matter declines as  $1 / R^3$  as our Universe expands;

and

$w = 0$  for primordial black hole dark matter - stable Planck mass black holes - so  
 that Dark Matter also has density that declines as  $1 / R^3$  as our Universe expands;  
 so that the ratio of their overall average densities must vary with time, or scale  
 factor  $R$  of our Universe, as it expands.

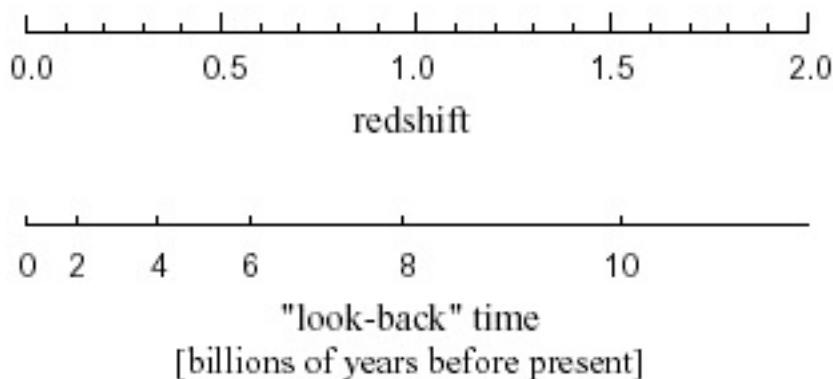
Therefore, the above calculated ratio  $0.67 : 0.27 : 0.06$  is valid  
 only for a particular time, or scale factor, of our Universe.

When is that time ? Further, what is the value of the ratio now ?

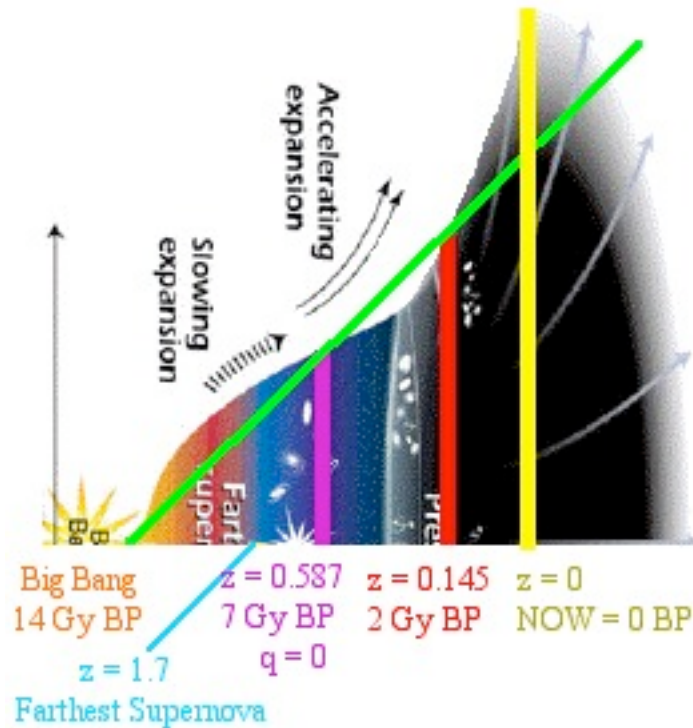
Since WMAP observes Ordinary Matter at 4% NOW,  
 the time when Ordinary Matter was 6% would be  
 at redshift  $z$  such that

$$1 / (1+z)^3 = 0.04 / 0.06 = 2/3, \text{ or } (1+z)^3 = 1.5, \text{ or } 1+z = 1.145, \text{ or } z = 0.145.$$

To translate redshift into time,  
 in billions of years before present, or Gy BP, use this chart



from a [www.supernova.lbl.gov](http://www.supernova.lbl.gov) file SNAPoverview.pdf to see that  
 the time when Ordinary Matter was 6%  
 would have been a bit over 2 billion years ago, or 2 Gy BP.



In the diagram, there are four Special Times in the history of our Universe:  
the Big Bang Beginning of Inflation (about 13.7 Gy BP);

1 - the End of Inflation = Beginning of Decelerating Expansion  
(beginning of green line also about 13.7 Gy BP);

2 - the End of Deceleration ( $q=0$ ) = Inflection Point =  
= Beginning of Accelerating Expansion  
(purple vertical line at about  $z = 0.587$  and about 7 Gy BP).

According to a hubblesite web page credited to Ann Feild, the above diagram "... reveals changes in the rate of expansion since the universe's birth 15 billion years ago. The more shallow the curve, the faster the rate of expansion. The curve changes noticeably about 7.5 billion years ago, when objects in the universe began flying apart as a faster rate. ...".

According to a CERN Courier web page: "... Saul Perlmutter, who is head of the Supernova Cosmology Project ... and his team have studied altogether some 80 high red-shift type Ia supernovae. Their results imply that the universe was decelerating for the first half of its existence, and then began accelerating approximately 7 billion years ago. ...".

According to astro-ph/0106051 by Michael S. Turner and Adam G. Riess: "... current supernova data ... favor deceleration at  $z > 0.5$  ... SN 1997ff at  $z = 1.7$

provides direct evidence for an early phase of slowing expansion if the dark energy is a cosmological constant ...".

3 - the Last Intersection of the Accelerating Expansion of our Universe of Linear Expansion (green line) with the Third Intersection (at red vertical line at  $z = 0.145$  and about 2 Gy BP), which is also around the times of the beginning of the Proterozoic Era and Eukaryotic Life, Fe<sub>2</sub>O<sub>3</sub> Hematite ferric iron Red Bed formations, a Snowball Earth, and the start of the Oklo fission reactor. 2 Gy is also about 10 Galactic Years for our Milky Way Galaxy and is on the order of the time for the process of a collision of galaxies.

4 - Now.

Those four Special Times define four Special Epochs:

The Inflation Epoch, beginning with the Big Bang and ending with the End of Inflation. The Inflation Epoch is described by Zizzi Quantum Inflation ending with Self-Decoherence of our Universe ( see gr-qc/0007006 ).

The Decelerating Expansion Epoch, beginning with the Self-Decoherence of our Universe at the End of Inflation. During the Decelerating Expansion Epoch, the Radiation Era is succeeded by the Matter Era, and the Matter Components (Dark and Ordinary) remain more prominent than they would be under the "standard norm" conditions of Linear Expansion.

The Early Accelerating Expansion Epoch, beginning with the End of Deceleration and ending with the Last Intersection of Accelerating Expansion with Linear Expansion. During Accelerating Expansion, the prominence of Matter Components (Dark and Ordinary) declines, reaching the "standard norm" condition of Linear Expansion at the end of the Early Accelerating Expansion Epoch at the Last Intersection with the Line of Linear Expansion.

The Late Accelerating Expansion Epoch, beginning with the Last Intersection of Accelerating Expansion and continuing forever, with New Universe creation happening many times at Many Times. During the Late Accelerating Expansion Epoch, the Cosmological Constant  $\Lambda$  is more prominent than it would be under the "standard norm" conditions of Linear Expansion.

Now happens to be about 2 billion years into the Late Accelerating Expansion Epoch.

What about Dark Energy : Dark Matter : Ordinary Matter now ?

As to how the Dark Energy  $\Lambda$  and Cold Dark Matter terms have evolved during the past 2 Gy, a rough estimate analysis would be:

$\Lambda$  and CDM would be effectively created during expansion in their natural ratio  $67 : 27 = 2.48 = 5 / 2$ , each having proportionate fraction  $5 / 7$  and  $2 / 7$ , respectively;

CDM Black Hole decay would be ignored; and

pre-existing CDM Black Hole density would decline by the same  $1 / R^3$  factor as Ordinary Matter, from 0.27 to  $0.27 / 1.5 = 0.18$ .

The Ordinary Matter excess  $0.06 - 0.04 = 0.02$  plus the first-order CDM excess  $0.27 - 0.18 = 0.09$  should be summed to get a total first-order excess of 0.11, which in turn should be distributed to the  $\Lambda$  and CDM factors in their natural ratio  $67 : 27$ , producing, for NOW after 2 Gy of expansion:

$$\text{CDM Black Hole factor} = 0.18 + 0.11 \times 2/7 = 0.18 + 0.03 = 0.21$$

for a total calculated Dark Energy : Dark Matter : Ordinary Matter ratio for now of

$$0.75 : 0.21 : 0.04$$

so that the present ratio of  $0.73 : 0.23 : 0.04$  observed by WMAP seems to me to be substantially consistent with the cosmology of the E8 model.



68 light years away ... it should take Pioneer 10 over 2 million years to reach its neighborhood...

[ the above image is ] Ecliptic pole view of Pioneer 10, Pioneer 11, and Voyager trajectories. Digital artwork by T. Esposito. NASA ARC Image # AC97-0036-3. ... on 1 October 1990 ... Pioneer 11 ... was [about] 30 AU away from the Sun ... The last communication from Pioneer 11 was received in November 1995, when the spacecraft was at distance of [about] 40 AU from the Sun. ... Pioneer 11 should pass close to the nearest star in the constellation Aquila in about 4 million years ... ... Calculations of the motion of a spacecraft are made on the basis of the range time-delay and/or the Doppler shift in the signals. This type of data was used to determine the positions, the velocities, and the magnitudes of the orientation maneuvers for the Pioneer, Galileo, and Ulysses spacecraft considered in this study. ... The Pioneer spacecraft only have two- and three-way S-band Doppler. ... analyses of radio Doppler ... data ... indicated that an apparent anomalous acceleration is acting on Pioneer 10 and 11 ... The data implied an **anomalous, constant acceleration with a magnitude  $a_P = 8 \times 10^{-8}$  cm/cm/s<sup>2</sup>, directed towards the Sun** ...

**... the size of the anomalous acceleration is of the order  $c H$ , where  $H$  is the Hubble constant** ...

... Without using the apparent acceleration, CHASMP shows a steady frequency drift of about  $-6 \times 10^{-9}$  Hz / s, or 1.5 Hz over 8 years (one-way only). ... This equates to a clock acceleration,  $-a_t$ , of  $-2.8 \times 10^{-18}$  s / s<sup>2</sup> . The identity with the apparent Pioneer acceleration is  $a_P = a_t c$  ...

... Having noted the relationships

$$a_P = c a_t$$

and that of ...

$$a_H = c H \rightarrow 8 \times 10^{-8} \text{ cm} / \text{s}^2$$

if  $H = 82 \text{ km} / \text{s} / \text{Mpc}$  ...

we were motivated to try to think of any ... "time" distortions that might ... fit the CHASMP Pioneer results ... In other words ...

Is there any evidence that some kind of "time acceleration" is being seen?

... In particular we considered ... Quadratic Time Augmentation. This model adds a quadratic-in-time augmentation to the TAI-ET ( International Atomic Time - Ephemeris Time ) time transformation, as follows

$$ET \rightarrow ET + (1/2) a_{ET} ET^2$$

The model fits Doppler fairly well ...



... There was one [other] model of the ...[time acceleration]... type that was especially fascinating. This model adds a quadratic in time term to the light time as seen by the DSN station:

$$\begin{aligned} \text{delta\_TAI} &= \text{TAI\_received} - \text{TAI\_sent} \rightarrow \\ \rightarrow \text{delta\_TAI} &+ (1/2) a\_quad (\text{TAI\_received}^2 - \text{TAI\_sent}^2) \end{aligned}$$

It mimics a line of sight acceleration of the spacecraft, and could be thought of as an expanding space model.

Note that  $a\_quad$  affects only the data. This is in contrast to the  $a\_t$  ... that affects both the data and the trajectory. ... This model fit both Doppler and range very well. Pioneers 10 and 11 ... the numerical relationship between the Hubble constant and  $a\_P$  ... remains an interesting conjecture. ...".

In his book *Mathematical Cosmology and Extragalactic Astronomy* (Academic Press 1976) (pages 61-62 and 72), Segal says:

"... Temporal evolution in ... Minkowski space ... is

$$H \rightarrow H + s I$$

... unispace temporal evolution ... is ...

$$H \rightarrow (H + 2 \tan(a/2)) / (1 - (1/2) H \tan(a/2)) = H + a I + (1/4) a H^2 + O(s^2)$$

..."

Therefore,

the Pioneer Doppler anomalous acceleration is an experimental observation of a system that is not gravitationally bound in the Earth-Sun Solar System, and its results are consistent with Segal's Conformal Theory.

Rosales and Sanchez-Gomez say, at gr-qc/9810085:

"... the recently reported anomalous acceleration acting on the Pioneers spacecrafts should be a consequence of the existence of some local curvature in light geodesics when using the coordinate speed of light in an expanding spacetime. This suggests that the Pioneer effect is nothing else but the detection of cosmological expansion in the solar system. ... the ... problem of the detected misfit between the calculated and the measured position in the spacecrafts ... this quantity differs from the expected ... just in a systematic "bias" consisting on an effective residual acceleration directed toward the center of coordinates;

its constant value is ...  $H c$  ...

This is the acceleration observed in Pioneer 10/11 spacecrafts. ... a periodic orbit does not experience the systematic bias but only a very small correction ... which is not detectable ... in the old Foucault pendulum experiment ... the motion of the

pendulum experiences the effect of the Earth based reference system being not an inertial frame relatively to the "distant stars". ... Pioneer effect is a kind of a new cosmological Foucault experiment, the solar system based coordinates, being not the true inertial frame with respect to the expansion of the universe, mimics the role that the rotating Earth plays in Foucault's experiment ...".

The Rosales and Sanchez-Gomez idea of a 2-phase system in which objects bound to the solar system (in a "periodic orbit") are in one phase (non-expanding pennies-on-a-balloon) while unbound (escape velocity) objects are in another phase (expanding balloon) that "feels" expansion of our universe is very similar to my view of such things as described on this page.

The Rosales and Sanchez-Gomez paper very nicely unites:  
the physical 2-phase (bounded and unbounded orbits) view;  
the Foucault pendulum idea; and the cosmological value  $H_0$ .

My view, which is consistent with that of Rosales and Sanchez-Gomez,  
can be summarized as a 2-phase model based on Segal's work  
which has two phases with different metrics:

a metric for outside the inner solar system, a dark energy phase in which gravity is described in which all 15 generators of the conformal group are effective, some of which are related to the dark energy by which our universe expands;  
and

a metric for where we are, in regions dominated by ordinary matter, in which the 4 special conformal and 1 dilation degrees of freedom of the conformal group are suppressed and the remaining 10 generators (antideSitter or Poincare, etc) are effective, thus describing ordinary matter phenomena.

If you look closely at the difference between the metrics in those two regions, you see that the full conformal dark energy region gives an "extra acceleration" that acts as a "quadratic in time term" that has been considered as an explanation of the Pioneer effect by John D. Anderson, Philip A. Laing, Eunice L. Lau, Anthony S. Liu, Michael Martin Nieto, and Slava G. Turyshev in their paper at gr-qc/0104064.

Jack Sarfatti has a 2-phase dark energy / dark matter model that can give a similar anomalous acceleration in regions where  $c^2 \wedge$  dark energy / dark matter is effectively present. If there is a phase transition (around Uranus at 20 AU) whereby ordinary matter dominates inside that distance from the sun and exotic dark energy / dark matter appears at greater distances, then Jack's model could also explain the Pioneer anomaly and it may be that Jack's model with ordinary and exotic phases and my model with deSitter/Poincare and Conformal phases may be two ways of looking at the same thing.

As to what might be the physical mechanism of the phase transition, Jack says "... Rest masses of [ordinary matter] particles ... require the smooth non-random Higgs Ocean ... which soaks up the choppy random troublesome zero point energy ...".

In other words in a region in which ordinary matter is dominant, such as the Sun and our solar system, the mass-giving action of the Higgs mechanism "soaks up" the Dark Energy zero point conformal degrees of freedom that are dominant in low-ordinary mass regions of our universe (which are roughly the intergalactic voids that occupy most of the volume of our universe). That physical interpretation is consistent with my view.

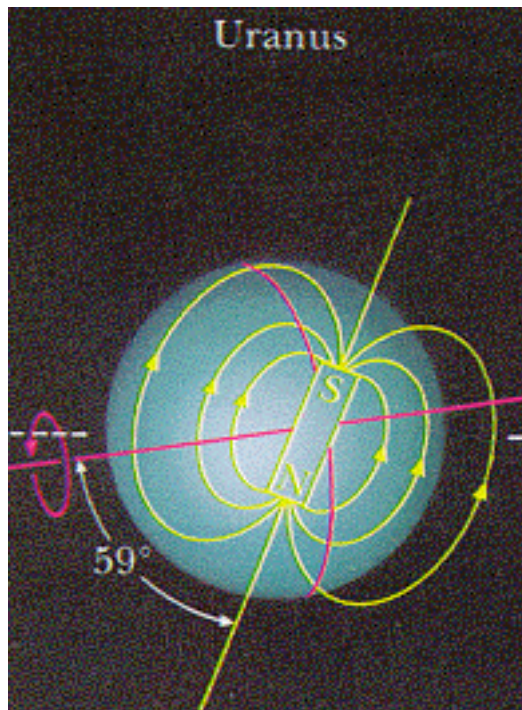
## Transition at Orbit of Uranus:

It may be that the observation of the Pioneer phase transition at Uranus from ordinary to anomalous acceleration is an experimental result that gives us a first look at dark energy / dark matter phenomena that could lead to energy sources that could be even more important than the nuclear energy discovered during the past century.

In gr-qc/0104064 Anderson et al say:

"... Beginning in 1980 ... at a distance of 20 astronomical units (AU) from the Sun ... we found that the largest systematic error in the acceleration residuals was a constant bias,  $a_P$ , directed toward the Sun. Such anomalous data have been continuously received ever since. ...",

so that the transition from inner solar system Minkowski acceleration to outer Segal Conformal acceleration occurs at about 20 AU, which is about the radius of the orbit of Uranus. That phase transition may account for the unique rotational axis of Uranus,



which lies almost in its orbital plane.

The most stable state of Uranus may be with its rotational axis pointed toward the Sun, so that the Solar hemisphere would be entirely in the inner solar system Minkowski acceleration phase and the anti-Solar hemisphere would be in entirely in the outer Segal Conformal acceleration phase.

Then the rotation of Uranus would not take any material from one phase to the other, and there would be no drag on the rotation due to material going from phase to phase.

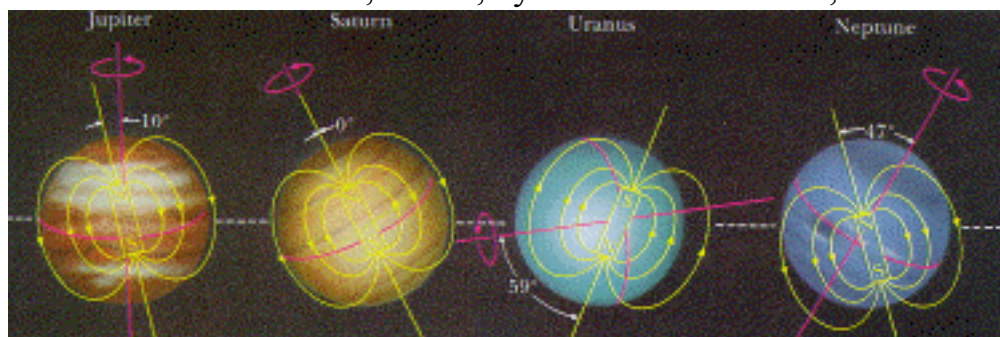
Of course, as Uranus orbits the Sun, it will only be in that most stable configuration twice in each orbit, but an orbit in the ecliptic containing that most stable configuration twice (such as its present orbit) would be in the set of the most stable ground states, although such an effect would be very small now.

However, such an effect may have been more significant on the large gas/dust cloud that was condensing into Uranus and therefore it may have caused Uranus to form initially with its rotational axis pointed toward the Sun.

In the pre-Uranus gas/dust cloud, any component of rotation that carried material from one phase to another would be suppressed by the drag of undergoing phase transition, so that, after Uranus condensed out of the gas/dust cloud, the only remaining component of Uranus rotation would be on an axis pointing close to the Sun, which is what we now observe.

In the pre-Uranus gas/dust cloud, any component of rotation that carried material from one phase to another would be suppressed by the drag of undergoing phase transition, so that, after Uranus condensed out of the gas/dust cloud, the only remaining component of Uranus rotation would be on an axis pointing close to the Sun, which is what we now observe.

Much of the perpendicular (to Uranus orbital plane) angular momentum from the original gas/dust cloud may have been transferred (via particles "bouncing" off the phase boundary) to the clouds forming Saturn (inside the phase boundary) or Neptune (outside the phase boundary, thus accounting for the substantial (relative to Jupiter) deviation of their rotation axes from exact perpendicularity (see images above and below from Universe, 4th ed, by William Kaufmann, Freeman 1994).



According to Utilizing Minor Planets to Assess the Gravitational Field in the Outer Solar System, astro-ph/0504367, by Gary L. Page, David S. Dixon, and John F. Wallin:

"... the great distances of the outer planets from the Sun and the nearly circular orbits of Uranus and Neptune makes it very difficult to use them to detect the

Pioneer Effect. ... The ratio of the Pioneer acceleration to that produced by the Sun at a distance equal to the semimajor axis of the planets is 0.005, 0.013, and 0.023 percent for Uranus, Neptune, and Pluto, respectively. ... Uranus' period shortens by 5.8 days and Neptune's by 24.1, while Pluto's period drops by 79.7 days. ... an equivalent change in aphelion distance of  $3.8 \times 10^{10}$ ,  $1.2 \times 10^{11}$ , and  $4.3 \times 10^{11}$  cm for Uranus, Neptune, and Pluto. In the first two cases, this is less than the accepted uncertainty in range of  $2 \times 10^6$  km [ or  $2 \times 10^{11}$  cm ] (Seidelmann 1992). ... Pluto[s] ... orbit is even less well-determined ... than the other outer planets. ... [C]ometes ... suffer ... from outgassing ... [ and their nuclei are hard to locate precisely ] ...".

According to a google cache of an Independent UK 23 September 2002 article by Marcus Chown:

"... The Pioneers are "spin-stabilised", making them a particularly simple platform to understand. Later probes ... such as the Voyagers and the Cassini probe ... were stabilised about three axes by intermittent rocket boosts. The unpredictable accelerations caused by these are at least 10 times bigger than a small effect like the Pioneer acceleration, so they completely cloak it. ...".

Can we use Laboratory Experiments on Earth to get access to the energy of all 15 generators of Conformal Spin(2,4)?

In astro-ph/0512327 Christian Beck says: "... if dark energy is produced by vacuum fluctuations then there is a chance to probe some of its properties by simple laboratory tests based on Josephson junctions. These electronic devices can be used to perform 'vacuum fluctuation spectroscopy', by directly measuring a noise spectrum induced by vacuum fluctuations. One would expect to see a cutoff near 1.7 THz in the measured power spectrum, provided the new physics underlying dark energy couples to electric charge.

The effect exploited by the Josephson junction is a subtle nonlinear mixing effect and has nothing to do with the Casimir effect or other effects based on van der Waals forces. A Josephson experiment of the suggested type will now be built, and we should know the result within the next 3 years. ...".

That Josephson experiment is by P A Warburton of University College London. It is EPSRC Grant Reference: EP/D029783/1, "Externally-Shunted High-Gap Josephson Junctions: Design, Fabrication and Noise Measurements", starting 1 February 2006 and ending 31 January 2009 with £ Value: 242,348. Its abstract states:

"... In the late 1990's measurements of the cosmic microwave background radiation and distant supernovae confirmed that around 70% of the energy in the universe is in the form of gravitationally-repulsive dark energy. This dark energy is not only responsible for the accelerating expansion of the universe but also was the driving force for the big bang. A possible source of this dark energy is vacuum fluctuations which arise from the finite zero-point energy of a quantum mechanical oscillator,  $hf/2$  (where  $f$  is the oscillator frequency). ... dark energy may be measured in the laboratory using resistively-shunted Josephson junctions (RS-JJ's). Vacuum fluctuations in the resistive shunt at low temperatures can be measured by non-linear mixing within the Josephson junction. If vacuum fluctuations are responsible for dark energy, the finite value of the dark energy density in the universe (as measured by astronomical observations) sets an upper frequency limit on the spectrum of the quantum fluctuations in this resistive shunt. Beck and Mackey calculated an upper bound on this cut-off frequency of 1.69 THz. ... We therefore propose to perform measurements of the quantum noise in RS-JJ's fabricated using superconductors with sufficiently large gap energies that the full noise spectrum up to and beyond 1.69 THz can be measured. ... Nitride junctions have cut-off frequencies of around 2.5 THz, which should give sufficiently low quasiparticle current noise around 1.69 THz at accessible measurement temperatures. Cuprate superconductors have an energy gap an order of magnitude higher than the nitrides, but here there is finite quasiparticle tunnelling at voltages less than the gap voltage, due to the d-wave pairing symmetry. By performing experiments on both the nitrides and the cuprates we will have two independent measurements of the possible cut-off frequency in two very different materials systems. This would give irrefutable confirmation (or indeed refutation) of the vacuum fluctuations hypothesis. ...".

Beck and Mackey in astro-ph/0406504 say: "... the zero-point term has proved important in explaining X-ray scattering in solids ... ; understanding of the Lamb shift ... in hydrogen ... ; predicting the Casimir effect ... ; understanding the origin of Van der Waals forces ... ; interpretation of the Aharonov-Bohm effect ... ; explaining Compton scattering ... ; and predicting the spectrum of noise in electrical circuits ... .

It is this latter effect that concerns us here. ... We predict that the measured spectrum in Josephson junction experiments must exhibit a cutoff at the critical frequency  $\nu_c$  ... [ corresponding to the currently observed Dark Energy density  $0.73 \times \text{critical density} = 0.73 \times 5.3 \text{ GeV/m}^3 = 3.9 \text{ GeV/m}^3$  ]... If not, the corresponding vacuum energy density would exceed the currently measured dark energy density of the universe. ... The energy associated with the computed cutoff frequency  $\nu_c$  ... [ about  $1.7 \times 10^{12} \text{ Hz}$  ]...

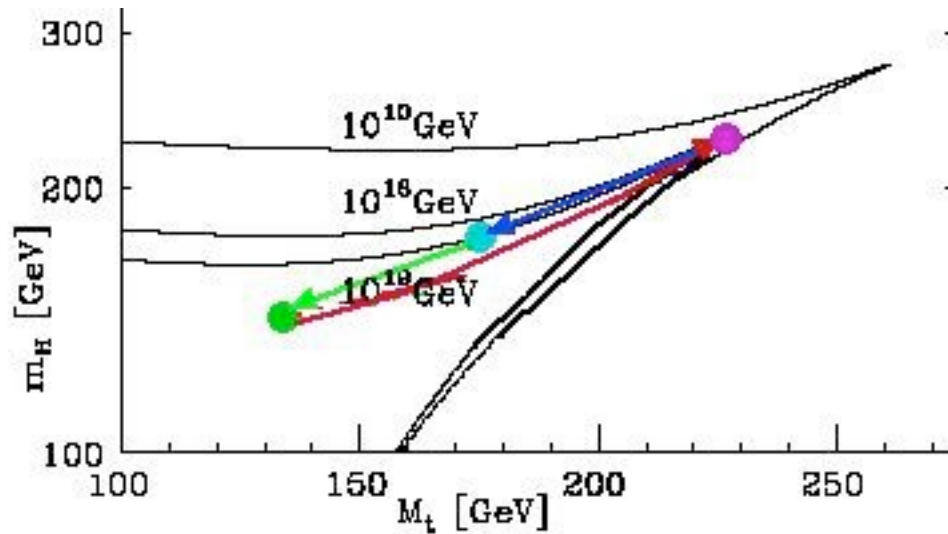
$$E_c = h \nu_c = (7.00 \pm 0.17) \times 10^{-3} \text{ eV} \dots$$

coincides with current experimental estimates of neutrino masses. .. It is likely that the Josephson junction experiment only measures the photonic part of the vacuum fluctuations, since this experiment is purely based on electromagnetic interaction. ... If the frequency cutoff is observed, it could be used to determine the fraction ... of dark energy density that is produced by electromagnetic processes ... Finally, we conjecture that it will be interesting to re-analyze experimentally observed  $1/f$  noise in electrical circuits under the hypothesis that it could be a possible manifestation of suppressed zero-point fluctuations. ... Our simple theoretical considerations show that  $1/f$  noise arises naturally if bosonic vacuum fluctuations are suppressed by fermionic ones. ...".



### Truth Quark - Higgs 3-State System:

My physics model has 3 states (green, cyan, magenta) for the Higgs-Tquark system:



The low state (green) is in the usual stable-vacuum no-triviality space-time region.

The middle state (cyan) is on the Triviality boundary where the Higgs is composite T-Tbar condensate in 8-dim Kaluza-Klein spacetime with high-energy cut-off scale at the Planck energy  $10^{19}$  GeV which is the lowest of the three Triviality boundary upper bound curves.

The high state (magenta) is at the critical point where the Triviality boundary (upper bound curves) intersects the vacuum stability boundary (right-side bound curves).

As to composite Higgs and the Triviality boundary, Pierre Ramond says in his book *Journeys Beyond the Standard Model* ( Perseus Books 1999 ) at pages 175-176:

"... The Higgs quartic coupling has a complicated scale dependence. It evolves according to

$$d \lambda / d t = ( 1 / 16 \pi^2 ) \beta_{\lambda}$$

where the one loop contribution is given by

$$\beta_{\lambda} = 12 \lambda^2 - \dots - 4 H \dots$$

The value of  $\lambda$  at low energies is related [to] the physical value of the Higgs mass according to the tree level formula \

$$m_H = v \sqrt{2 \lambda}$$

while the vacuum value is determined by the Fermi constant

...

for a fixed vacuum value  $v$ , let us assume that the Higgs mass and therefore  $\lambda$  is large. In that case,  $\beta_{\lambda}$  is dominated by the  $\lambda^2$  term, which drives the coupling towards its Landau pole at higher energies.

Hence the higher the Higgs mass, the higher  $\lambda$  is and the closer the Landau pole to experimentally accessible regions.

This means that for a given (large) Higgs mass,

we expect the standard model to enter a strong coupling regime

at relatively low energies, losing in the process our ability to calculate.

This does not necessarily mean that the theory is incomplete,

only that we can no longer handle it ...

it is natural to think that this effect is caused by new strong interactions,

and that the Higgs actually is a composite ...

The resulting bound on  $\lambda$  is sometimes called the **triviality bound**.

The reason for this unfortunate name (the theory is anything but trivial)

stems from lattice studies where the coupling is assumed to be finite everywhere;

in that case the coupling is driven to zero, yielding in fact a trivial theory.

In the standard model  $\lambda$  is certainly not zero. ...".

Composite Higgs as Tquark condensate studies by Yamawaki et al have produced realistic models that are consistent with my E8 model with a 3-State System:

1 - My basic E8 Physic model state

with Tquark mass = 130 GeV and Higgs mass = 146 GeV

2 - Triviality boundary 8-dim Kaluza-Klein state described by Hashimoto, Tanabashi, and Yamawaki in hep-ph/0311165 where they say:

"... "... We perform the most attractive channel (MAC) analysis in the top mode standard model with TeV-scale extra dimensions, where the standard model gauge bosons and the third generation of quarks and leptons are put in  $D(=6,8,10,\dots)$  dimensions. In such a model, bulk gauge couplings rapidly grow in the ultraviolet region. In order to make the scenario viable, only the attractive force of the top condensate should exceed the critical coupling, while other channels such as the bottom and tau condensates should not. We then find that the top condensate can be the MAC for  $D=8$  ... We predict masses of the top ( $m_t$ ) and the Higgs ( $m_H$ ) ... based on the renormalization group for the top Yukawa and Higgs quartic couplings with the compositeness conditions at the scale where the bulk top condenses ... for ... [ Kaluza-Klein type ]... dimension...  $D=8$  ...  $m_t = 172-175$  GeV and  $m_H = 176-188$  GeV ...".

3 - Critical point BHL state

with Tquark mass =  $218 \pm 3$  GeV and Higgs mass =  $239 \pm 3$  GeV

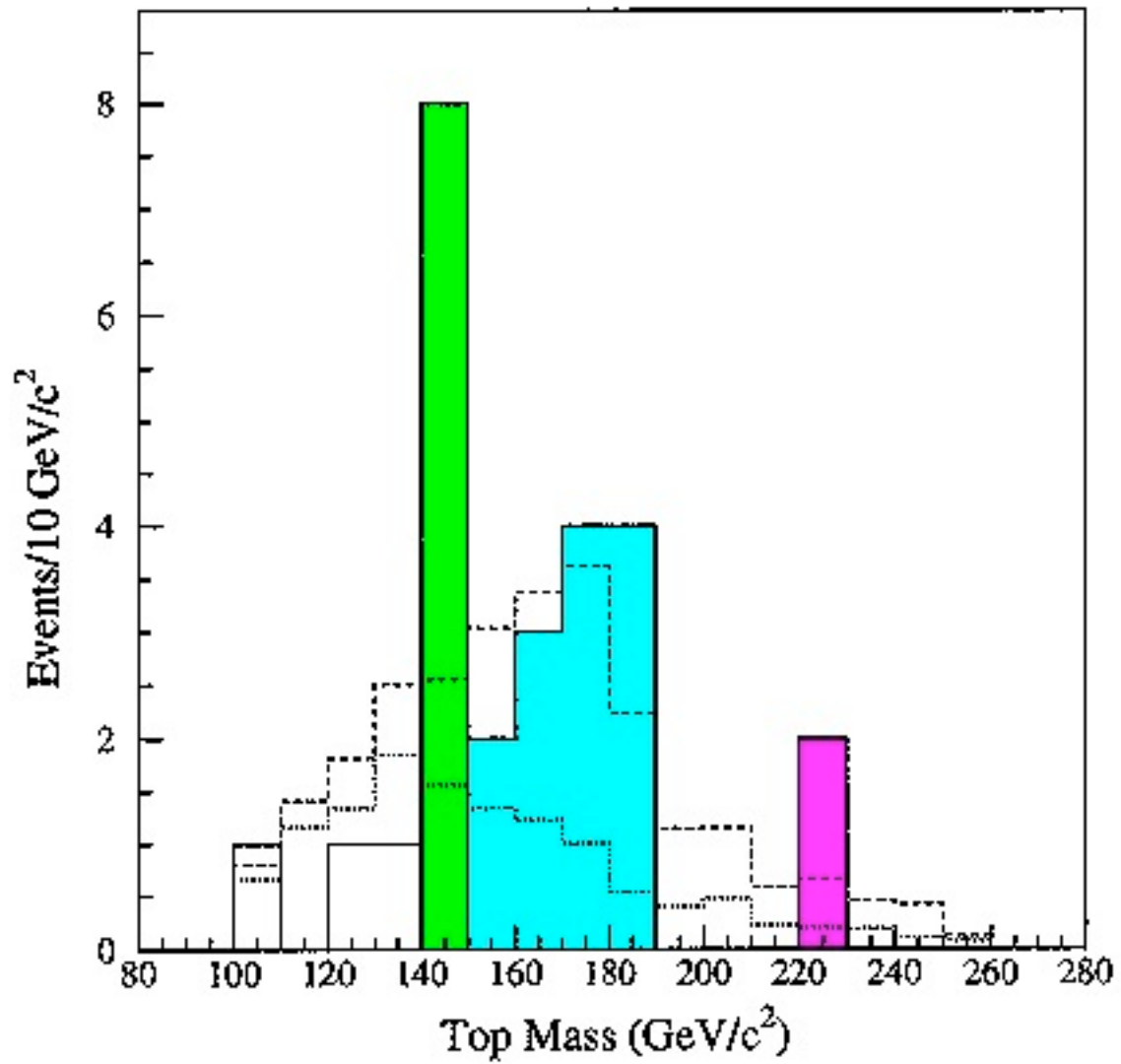
As Yamawaki said in hep-ph/9603293: "... **the BHL formulation of the top quark condensate ... is based on the RG equation combined with the compositeness condition ... start[s] with the SM Lagrangian which includes explicit Higgs field at the Lagrangian level ... BHL is crucially based on the perturbative picture ... [which] ... breaks down at high energy near the compositeness scale / \ ... [  $10^{19}$  GeV ] ... there must be a certain matching scale  $\Lambda_{\text{Matching}}$  such that the perturbative picture (BHL) is valid for  $\mu < \Lambda_{\text{Matching}}$ , while only the nonperturbative picture (MTY) becomes consistent for  $\mu > \Lambda_{\text{Matching}}$  ... However, **thanks to the presence of a quasi-infrared fixed point, BHL prediction is numerically quite stable against ambiguity at high energy region, namely, rather independent of whether this high energy region is replaced by MTY or something else.** ... Then we expect  $m_t = m_t(\text{BHL}) = \dots = 1/(\text{sqrt}(2)) y_{\text{bart}} v$  within 1-2%, where  $y_{\text{bart}}$  is the quasi-infrared fixed point given by  $\text{Beta}(y_{\text{bart}}) = 0$  in ... the one-loop RG equation ... The composite Higgs loop changes  $y_{\text{bart}}^2$  by roughly the factor  $N_c/(N_c + 3/2) = 2/3$  compared with the MTY value, i.e., 250 GeV  $\rightarrow 250 \times \text{sqrt}(2/3) = 204$  GeV, while the electroweak gauge boson loop with opposite sign pulls it back a little bit to a higher value. **The BHL value is then****

given by  $m_t = 218 \pm 3 \text{ GeV}$ , at  $\Lambda = 10^{19} \text{ GeV}$ . The Higgs boson was predicted as a  $t\bar{t}$  bound state with a mass  $M_H = 2m_t$  based on the pure NJL model calculation<sup>1</sup>. Its mass was also calculated by BHL through the full RG equation ... the result being ...  $M_H / m_t = 1.1$  ) at  $\Lambda = 10^{19} \text{ GeV}$  ...".

... the top quark condensate proposed by Miransky, Tanabashi and Yamawaki (MTY) and by Nambu independently ... **entirely replaces the standard Higgs doublet by a composite one formed by a strongly coupled short range dynamics (four-fermion interaction) which triggers the top quark condensate.** The Higgs boson emerges as a  $t\bar{t}$  bound state and hence is deeply connected with the top quark itself. ... MTY introduced explicit four-fermion interactions responsible for the top quark condensate in addition to the standard gauge couplings. Based on the explicit solution of the ladder SD equation, MTY found that even if all the dimensionless four-fermion couplings are of  $O(1)$ , only the coupling larger than the critical coupling yields non-zero (large) mass ... The model was further formulated in an elegant fashion by Bardeen, Hill and Lindner (BHL) in the SM language, based on the RG equation and the compositeness condition. BHL essentially incorporates  $1/N_c$  sub-leading effects such as those of the composite Higgs loops and ... gauge boson loops which were disregarded by the MTY formulation. We can explicitly see that **BHL is in fact equivalent to MTY at  $1/N_c$ -leading order**. Such effects turned out to reduce the above MTY value 250 GeV down to 220 GeV ...".

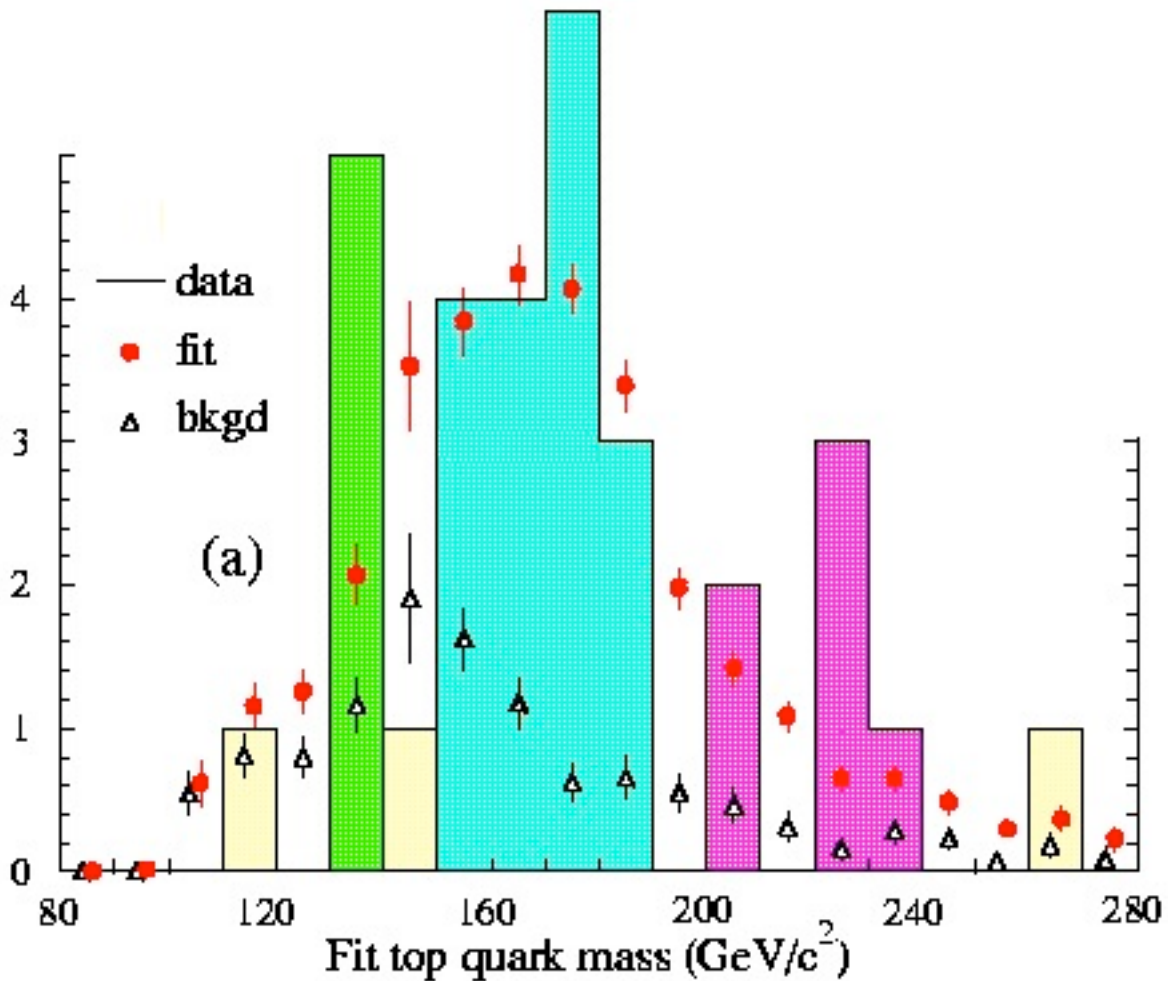
8-dim Kaluza-Klein spacetime physics as required by Hashimoto, Tanabashi, and Yamawaki for the Middle State of the 3-State System was described by N. A. Batakis in Class. Quantum Grav. 3 (1986) L99-L105 in terms a  $M_4 \times CP_2$  structure similar to that of my E8 Physics model. Although spacetime and Standard Model gauge bosons worked well for Batakis, he became discouraged by difficulties with fermions, perhaps because he did not use Clifford Algebras with natural spinor structures for fermions.

In 1994 a semileptonic histogram from CDF



seems to me to show all three states of the T-quark.

In 1997 a semileptonic histogram from D0

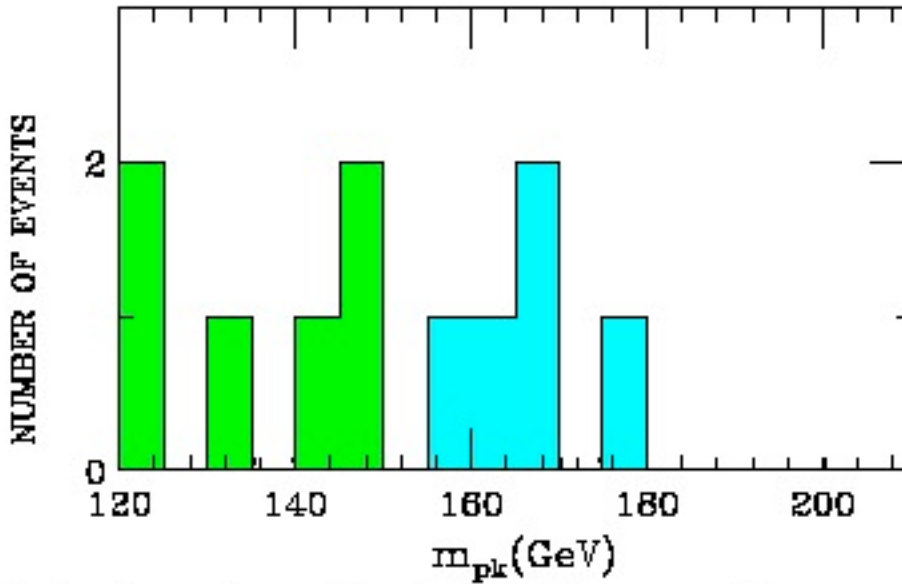


also seems to me to show all three states of the T-quark.

The fact that the low (green) state showed up in both independent detectors indicates a significance of 4 sigma.

Some object that the low (green) state peak should be as wide as the peak for the middle (cyan) state, but my opinion is that the middle (cyan) state should be wide because it is on the Triviality boundary where the composite nature of the Higgs as T-Tbar condensate becomes manifest and the low (cyan) state should be narrow because it is in the usual non-trivial region where the T-quark acts more nearly as a single individual particle.

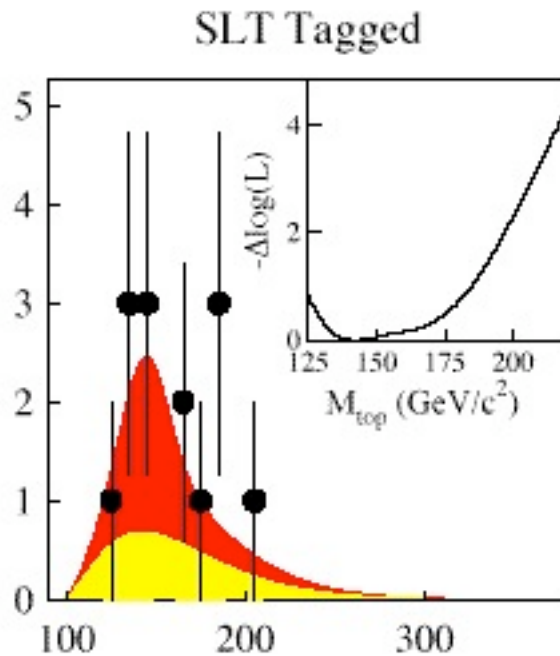
In 1998 a dilepton histogram from CDF



The distribution of  $m_{p\ell}$  values determined from 11 CDF dilepton events available empirically.

seems to me to show both the low (green) state and the middle (cyan) state of the T-quark.

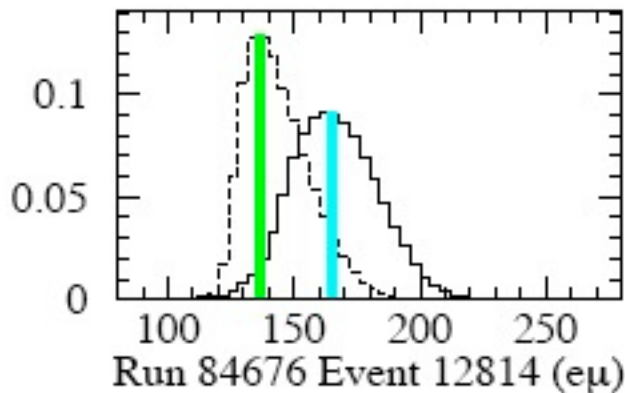
In 1998 an analysis of 14 SLT tagged lepton + 4 jet events by CDF



showed a T-quark mass of 142 GeV (+33,-14) that seems to me to be consistent with the low (green) state of the T-quark.

In 1997 the Ph.D. thesis of Erich Ward Varnes (Varnes-fermilab-thesis-1997-28) at page 159 said:

"... distributions for the dilepton candidates. For events with more than two jets, the dashed curves show the results of considering only the two highest ET jets in the reconstruction ...



..." (colored bars added by me)

The event for all 3 jets (solid curve) seems to me to correspond to decay of a middle (cyan) T-quark state with one of the 3 jets corresponding to decay from the Triviality boundary down to the low (green) T-quark state, whose immediately subsequent decay is corresponds to the 2-jet (dashed curve) event at the low (green) energy level.

**After 1998 until very recently** Fermilab focussed its attention on detailed analysis of the middle (cyan) T-quark state, getting much valuable detailed information about it but **not producing much information about the low or high states.**

**In 2010** the thesis of Viviana Cavaliere (FERMILAB-THESIS-2010-51) said:

"... We present the measurement of the WW and WZ production cross section in p pbar collisions

at  $\sqrt{s} = 1.96$  TeV, in a final state consisting of an electron or muon, neutrino and jets. ...

**for the [ 120 , 160 ] GeV/c<sup>2</sup> mass range ... an excess is observed ...**

**corresponding to**

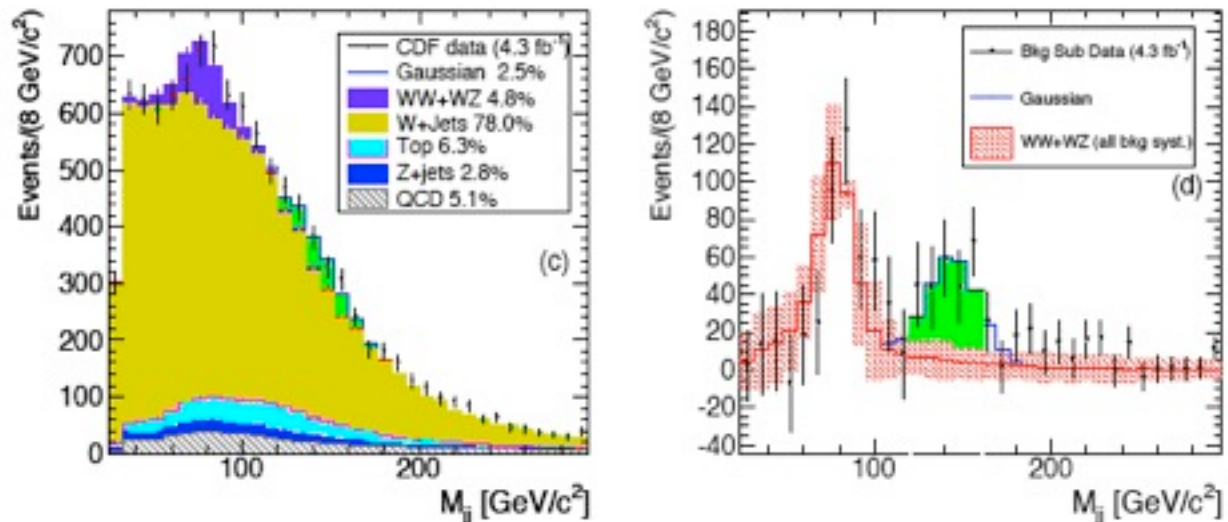
**a significance of 3.3 sigma ...".**

Those results are also presented by her Fermilab collaboration CDF in arXiv



1104.0699 which says:

"... the invariant mass distribution of jet pairs produced in association with a W boson using data ... which correspond to an integrated luminosity of  $4.3 \text{ fb}^{-1}$  ...



(some colors altered and green added by me)

... has an excess in the 120-160 GeV/c<sup>2</sup> mass range which is not described by current theoretical predictions ...".

The events corresponding to the middle (cyan) state of the T-quark are shown in the left chart as being part of the background, and after subtracting the background (including the middle (cyan) state) the right chart shows a Gaussian corresponding to events in the 120-160 GeV /c<sup>2</sup> range of the low (green) state of the T-quark.

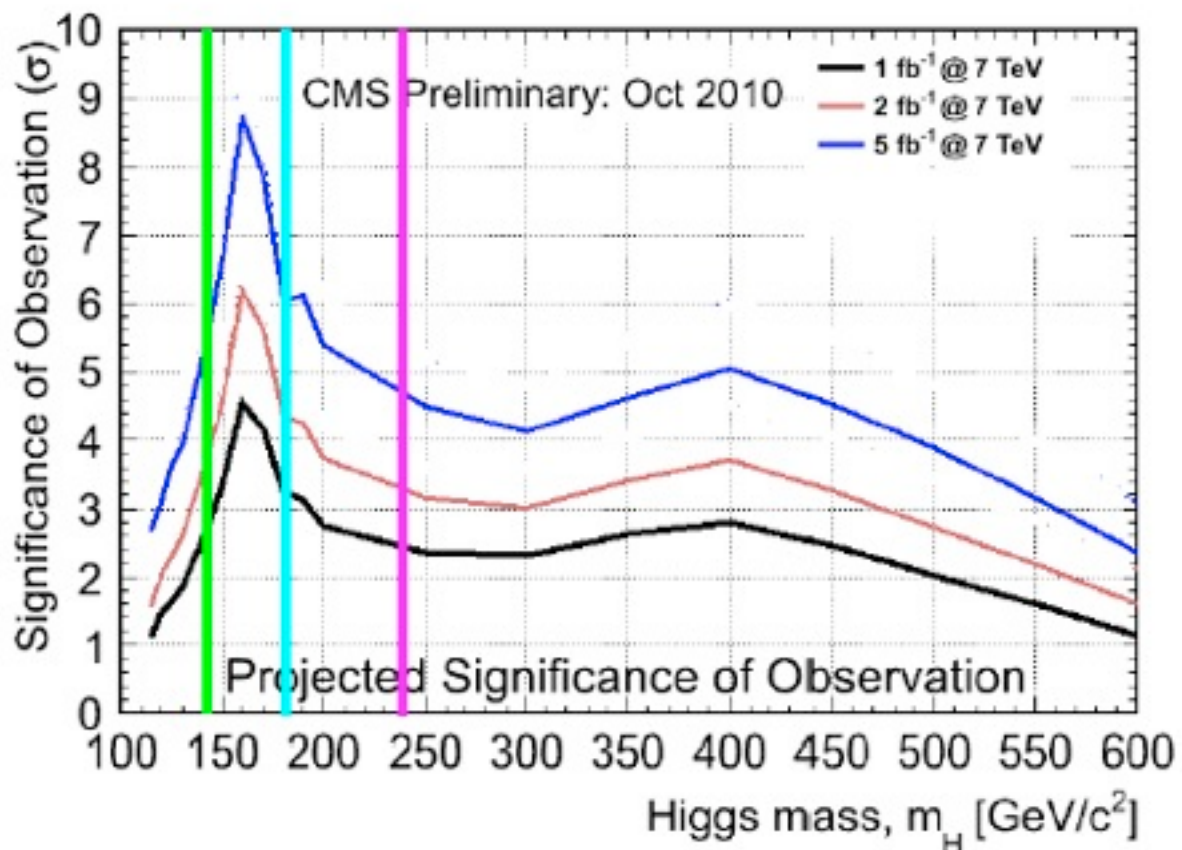
What about the 3 Higgs states?

The Higgs has not yet been observed, but Tommaso Dorigo said in his blog entry 31 Jan 2011:

"The LHC Will Run At 7 TeV in 2011 and 2012"

"... the Tevatron will finally shut down at the end of 2011 ...

LHC will continue to run through 2012, increasing as much as possible the instantaneous luminosity of the beams. This means that while at the end of 2011 CMS and ATLAS might still only have one inverse femtobarn of collisions to play with, by the end of 2012 it is reasonable to expect at least a factor of 5 more data. ... then ...[in]... 2013 ... a long shutdown ... to allow the retro-fitting of LHC with systems which will prevent future incidents such as the one of September 2008 ... The graph below ...



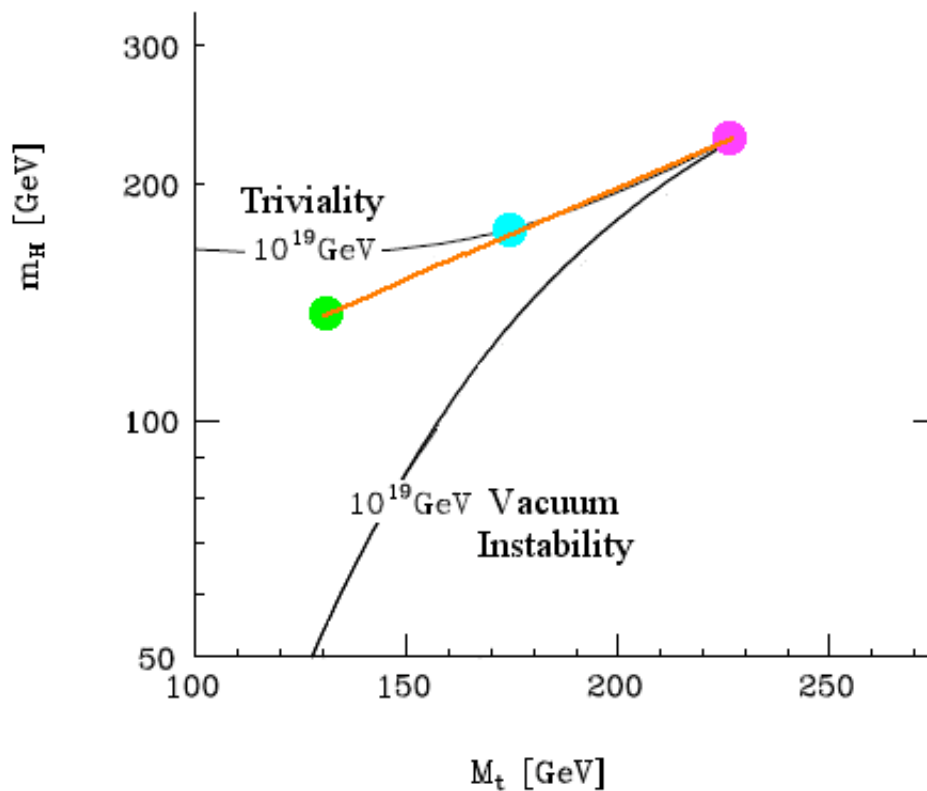
[ I have altered the graph by omitting irrelevant material and adding three vertical lines at the Higgs masses for the three states in my physics model. The cyan line also corresponds to the Higgs mass predicted in hep-ph/0311165 by Hashimoto, Tanabashi, and Yamawaki in the context of an 8-dim Kaluza-Klein Higgs-as-Tquark-condensate model. ]

... shows the number of standard deviations equivalent to the observable ... Standard Model Higgs boson ... signals that may be obtained by a combination of sensitive search channels by CMS. The curves show the median sensitivity, i.e. they show the minimum significance achievable 50% of the time. Different curves refer to ... different integrated luminosities. As you clearly see, 50% chances of a 3-sigma or larger evidence for the Higgs boson exist in a wide range of masses, even with the 7 TeV running and 5 inverse femtobarns ( the full blue line -a reasonable estimate for 2012!). And bear in mind that this is CMS only: a combination with ATLAS would typically make a 3-sigma signal become a 4-sigma one, roughly. If it were real! ...".

At EPS HEP 2011 the LHC had produced 1/fb of data and ATLAS presented a plot that I think is relevant to my E8 Physics 3-state Higgs. The Higgs to ZZ to 4l channel is the Golden Channel that "... provides a rather clean signature over the full possible range of Higgs masses, with a statistics smaller than for other channels. For

Higgs masses above 200 GeV, this channel becomes the "golden" channel for SM Higgs searches. ...".  
(quoted from "Standard Model Higgs Boson Searches at ATLAS" by Stefano Rosati at the 2007 Europhysics Conference of High Energy Physics)

At EPS HEP 2011 ATLAS, based on 1/fb of data, showed 18 Golden Channel events that seem to me to be relevant to my E8 Physics model 3-state Higgs system in which:

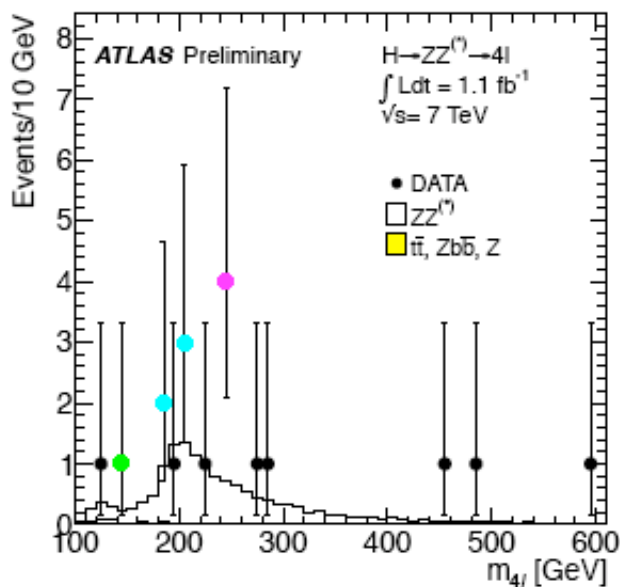


The Green Dot ● is the low-mass state of a 130 GeV Truth Quark and a 145 GeV Higgs. That low-mass Higgs is in the 110-160 GeV range where a Higgs is needed for the Standard Model to work up to the Planck Scale.

The Cyan Dot ● is the middle-mass state of a 174 GeV Truth Quark and a 180 GeV Higgs. That mid-mass Higgs is in the 160-210 GeV range of the Higgs Triviality Boundary.

The Magenta Dot ● is the high-mass state of a 220 GeV Truth Quark and a 240 GeV Higgs. That high-mass Higgs is in the 210-260 GeV range of the Higgs Vacuum Instability Boundary which range includes the Higgs VEV.

ATLAS saw 18 Golden Channel events for 1/fb in which



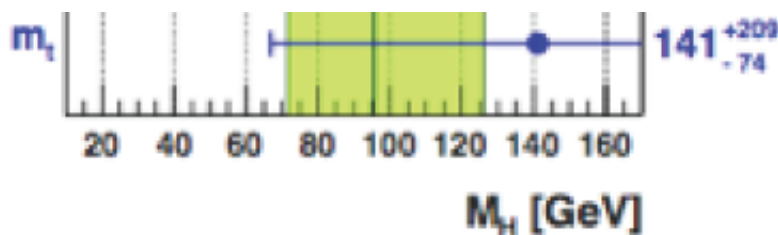
- 1 event ● over background is around 140 GeV
- 3 events ● over background are around 180 and 210 GeV
- 3 events ● over background are around 240 GeV.

### Consistency with ElectroWeak experimental results.

Phil Gibbs, in a viXra log blog entry 13 August 2011, said:

"... At Higgs Hunting 2011 Matthias Schott from the gfitter group told us that a Higgs at 140 GeV has just a p-value of 23% in which the fit includes the Tevatron data [ with Tquark mass 173.3 +/- 1.1 GeV ]

... This plot shows the effect on the electroweak fit of leaving out ... the measurement...

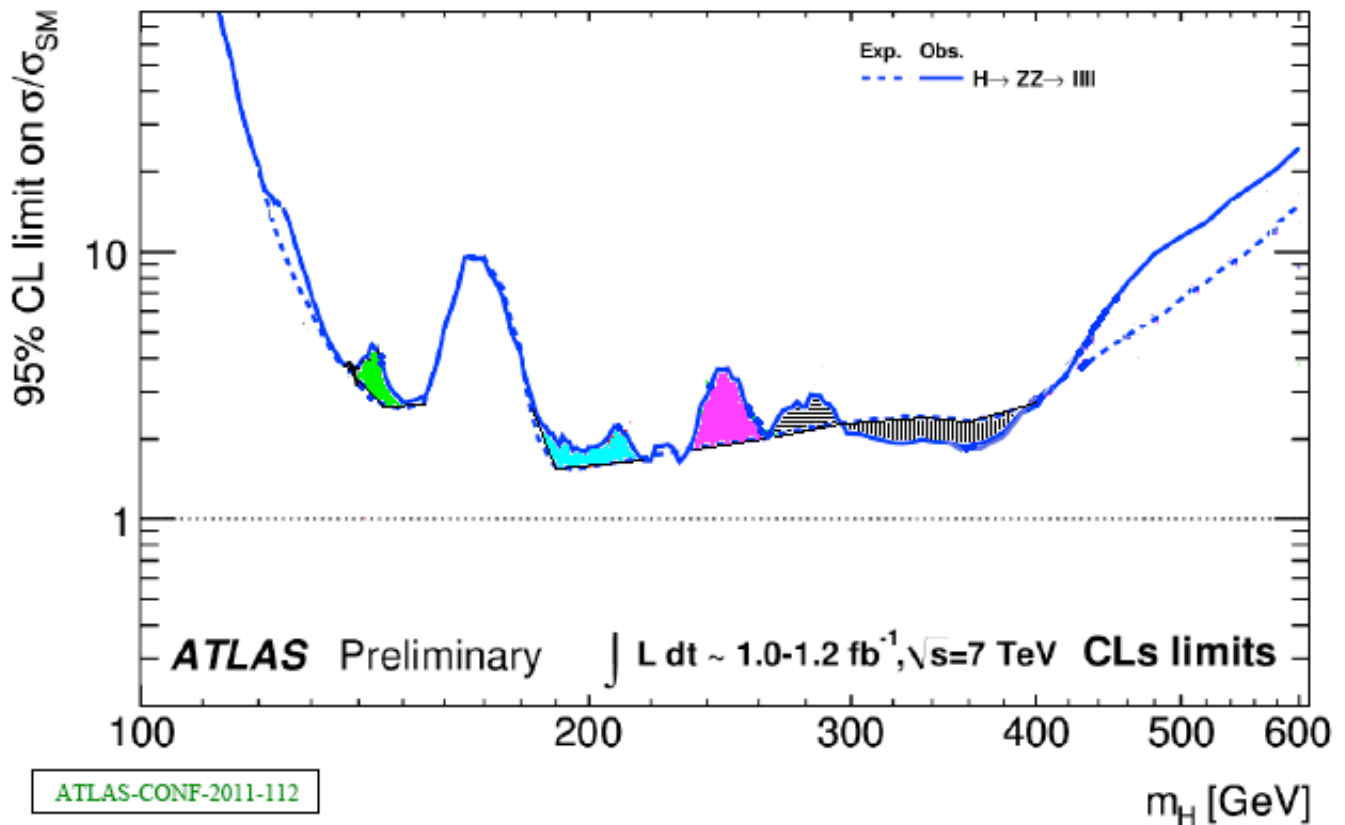


..."

Since my 3-state model has 3 mass states for the Tquark, evaluation of my 3-state model should be done by removing the fit to the Tevatron mid-mass Tquark mass value of 173.3 +/- 1.1 GeV and allowing the Tquark mass to float freely so that it also includes a low-mass Tquark around 130 GeV and a high-mass Tquark around 220 GeV. When that is done, the Gfitter plot shows that

the preferred Higgs mass is 141 GeV which is consistent with the low-mass ● Higgs of my 3-state model and the mid-mass ● and high-mass ● Higgs of my 3-state model are well within the upper bound of 341 GeV.

I am happy with the above interpretation coming from counting events in a Golden Channel, but some people like to see Confidence Level (CL) statistical stuff, so here is an ATLAS plot



from that point of view showing, based on the same 18 Golden Channel events of 1/fb of data, the low-mass ● Higgs and the mid-mass ● Higgs and the high-mass ● Higgs of my 3-state model.

In my view:

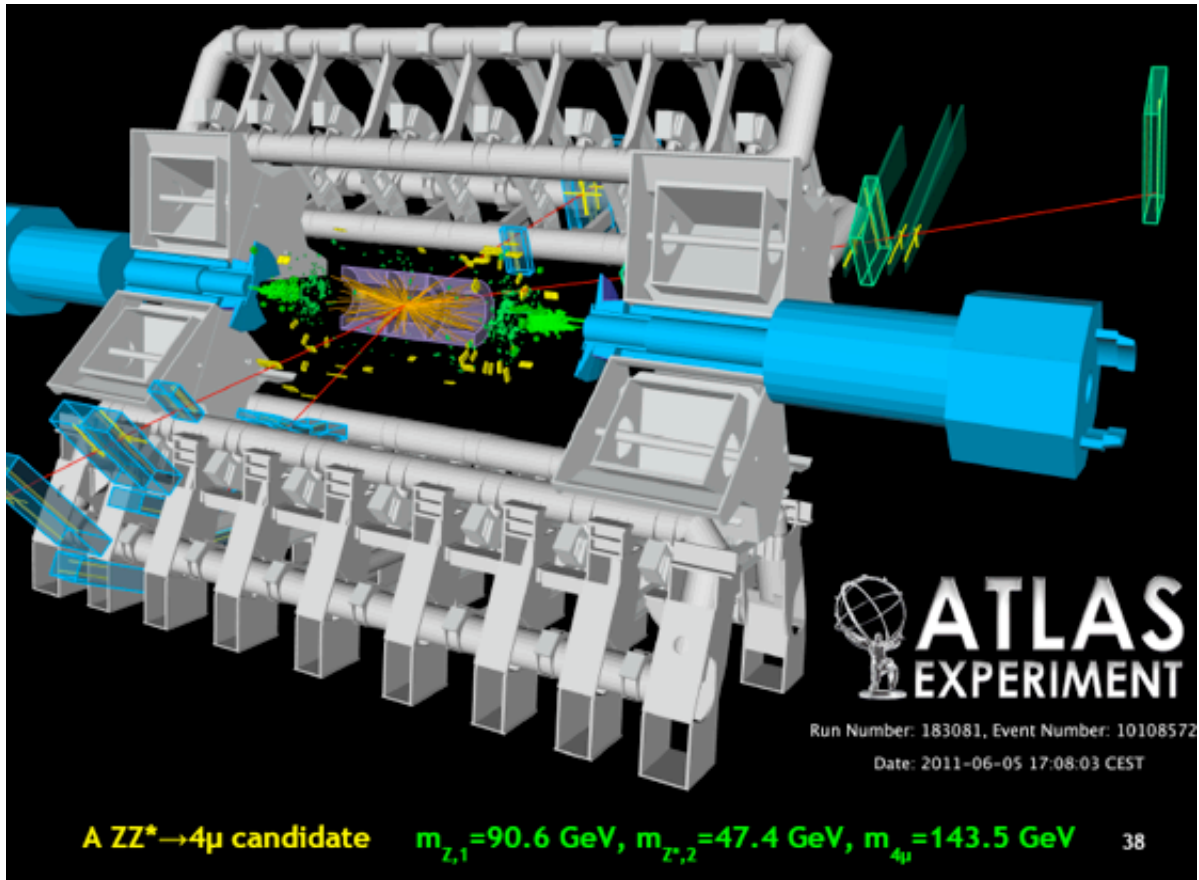
the horizontal hatched  $\equiv$  excess and the vertical hatched  $\equiv$  deficit are Tquark condensate phenomena; the excess over 400 GeV is also due to Higgs being a 3-state Tquark condensate; the small bump around 120-130 GeV is due to single-T phenomena at the low-mass Tquark (thus explaining the  $W_{jj}$  CDF bump described in arXiv 1104.0699 in terms of single-T cross section of 2.90 pb (see arxiv 1104.4087)); the small bump around 220 GeV is due to single-T phenomena at the high-mass Tquark; and the absence of any bump around 170 GeV is due to inclusion of mid-mass Tquark phenomena in background.

In this view, the Higgs is not a simple single particle but is part of a 3-state Higgs-Tquark system based on Higgs as a Tquark condensate similar to descriptions in the works of Yamawaki, Hashimoto, et. al. in hep-ph/960e293, hep-ph0311165, etc., in which the mid-mass Higgs Tquark state is associated with an 8-

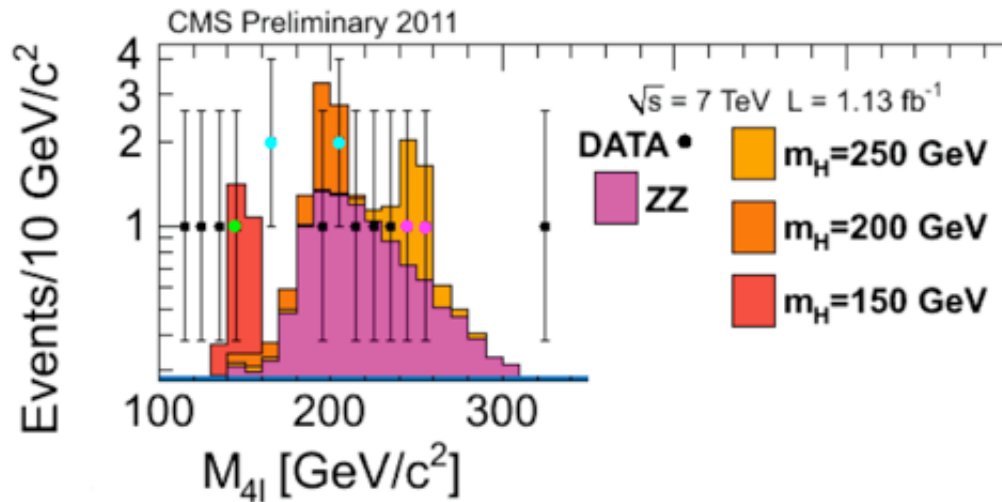
dimensional Kaluza-Klein spacetime ala the  $M4 \times CP2$  of Batakis (Class. Quantum Grav. 3 (1986) L99-L105).

I leave it for the reader to decide whether or not, in the reader's opinion, the above is an early indication that ATLAS has with 1/fb of data begun to see how the Higgs Tquark system works with respect to the Standard Model.

Here is an image of an ATLAS Golden Channel candidate Higgs event from the 1/fb data:



Of course, CMS also had 1/fb of data at EPS HEP 2011, and CMS produced a Golden Channel plot with 15 events, but no bin had more than 2 events so to me the CMS plot is not as clearly indicative of 3-state Higgs as is the ATLAS plot, but as shown below my interpretation (event dots colored by me) is consistent with ATLAS



CMS has 2 events in the 160 GeV bin that I colored as mid-mass ● Higgs

but it might have been equally valid to have colored them as low-mass ● Higgs.

I colored the 2 events at 240 GeV and 260 GeV as high-mass ● Higgs

but it might have been equally valid to have colored one of them as background (black dot - no color). Since the CMS Golden Channel plot for 1/fb of data is not clearly indicative to me of 3-state Higgs, I mention it here primarily to show that it is consistent with the ATLAS Golden Channel plot, which clearly indicates to me that the Higgs is a 3-state system.

My view is that the LHC 1/fb data is consistent with my E8 Physics model and with the (suitably augmented) Standard Model remaining valid up to the Planck scale, so that a useful program of future LHC exploration might be:

Since the LHC can explore the energy region above electroweak symmetry breaking (order of 1 TeV), and, in that region, assuming only the Standard Model plus Gravity as described by E8 Physics, the Higgs mechanism will not be around to generate mass, so everything will be massless, and:

1 – The T and B quarks may not be so different, and the Kobayashi-Maskawa matrix may look very different,  
with possible consequences for CP violation.

2 – Massive neutrinos may lose their mass,  
so neutrino oscillation phenomena may change in interesting ways.

3 – With no massive stuff, Conformal Symmetry may become important,  
leading to phenomena such as:

a – Twistor stuff may be directly observable. See for example the book Mathematics and Physics by Manin, who says there:

“... What binds us to space-time is our rest mass, which prevents us from flying at the speed of light, when time stops and space loses meaning. In a [massless] world ... there are neither points nor moments of time; beings ... would live nowhere and nowhen; only poetry and mathematics [ and the LHC ] are capable of speaking meaningfully about such things. One point of CP3 is the whole life

history of a free ...[ massless particle ]... the smallest event that can happen to ...[ it ]...”.

b – Segal conformal cosmological stuff (maybe Dark Energy) may be observable;

c – Since the Conformal group acts in 6-dim spacetime that could be denoted by  $C_6$ , maybe two new large physical spacetime dimensions might emerge, with  $4+4 = 8$ -dim  $M_4 \times CP^2$  Kaluza-Klein becoming  $6+4 = 10$ -dim  $C_6 \times CP^2$  Kaluza-Klein perhaps leading to a connection emerging between non-supersymmetric Bosonic String Theory whose Lattice Affinization has Monster Group symmetry and

a Bohm-type Quantum Theory based on interpreting Strings as World-Lines ( see [tony5m17h.net/MonsterStringCell.pdf](http://tony5m17h.net/MonsterStringCell.pdf) and [tony5m17h.net/QM03.pdf](http://tony5m17h.net/QM03.pdf) ).

Unless such an exploration program is adopted and advocated by the LHC, I fear that if, by the end of 2011 or 2012, the LHC sees nothing beyond the Standard Model (which term I use to include my 3-state Higgs-Tquark system) then:

If Europe (outside Germany) and the USA are suffering financial collapse, the LHC repair/maintenance year 2013 might become the LHC ShutDown Year.

If Fermilab might be then already be ShutDown,

the End of 2012 might see the End of Large-Collaboration Collider Physics and

the Beginning of an Era in which the Fundamental Laws of Physics

i.e., the Standard Model plus Gravity

(perhaps unified as in my E8 physics model)

are understood so well that we can devote our energy to

Engineering a Better World, on Earth and Beyond

by centrally-directed programs such as

Safe Nuclear Energy for Desalted Sea Water, Hydrogen Fuel, Electricity

Worldwide Network of Rapid Rail

Worldwide New Towns in poor rural areas

Free Basic Education and Medical Care

Basic Research into controlling Cold Fusion and Dark Energy



i.e., effectively following the Real-Growth-Oriented Ideas of China, which, being governed by descendants of the revolutionary PLA who understand the standards of military realism, the utility of productive manufacturing, and the value of all the people who are its citizens, is printing trillions of yuan each year and investing them at zero interest in projects such as mega-cities and high-speed rail serving all the country.

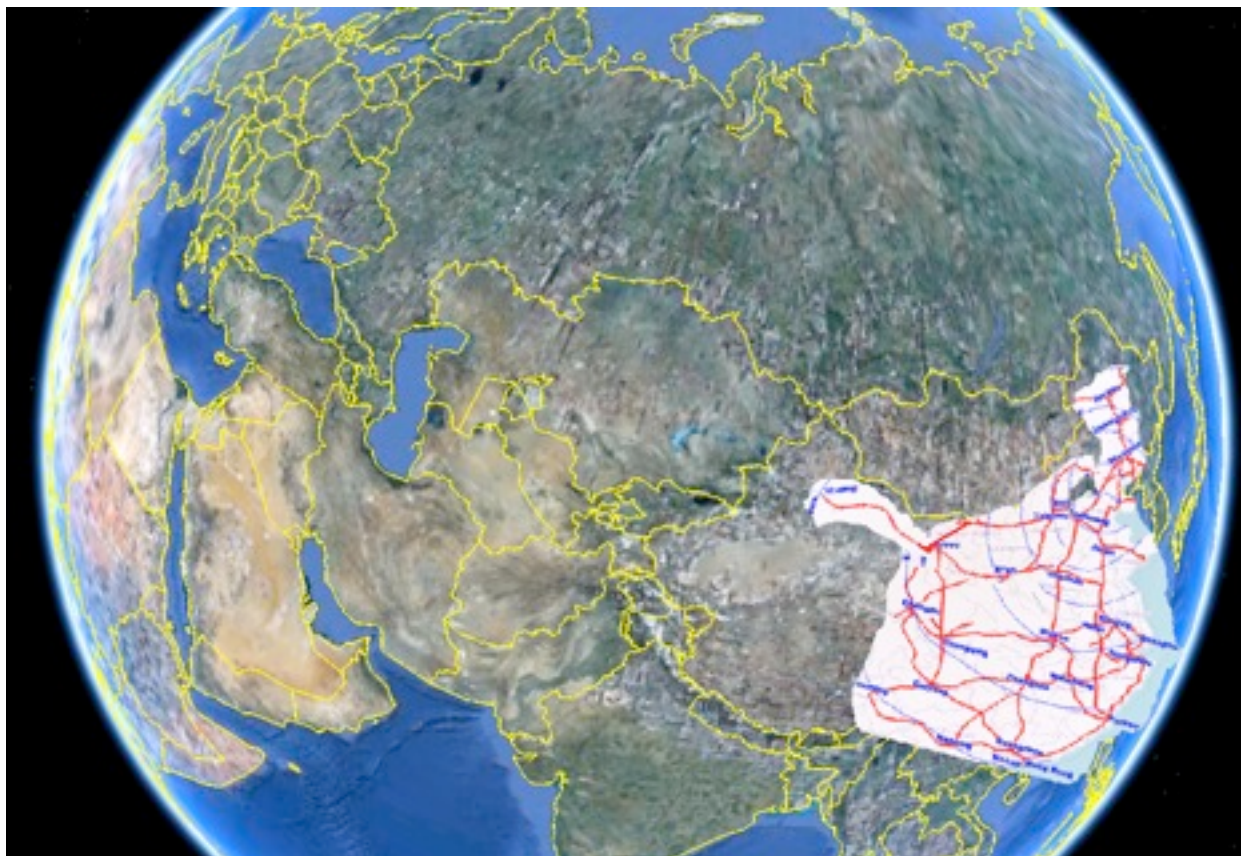


The timetable for such construction is until about 2020.

Some USA economists are pessimistic about China's Real-Growth-Oriented ideas, such as Nouriel Roubini of New York University, who said (Al Jazeera 18 April 2011):

“... China is rife with overinvestment in physical capital, infrastructure, and property. To a visitor, this is evident in sleek but empty airports and bullet trains ... highways ... thousands of colossal new central and provincial government buildings, ghost towns, and brand-new aluminum smelters ... overcapacity will lead inevitably to serious deflationary pressures, starting with the manufacturing and real-estate sectors. Eventually, most likely after 2013, China will suffer ... a financial crisis and/or a long period of slow growth ... once further fixed-investment growth becomes impossible ...”.

What Roubini and his fellow USA apologists do not understand is that when Siberia, Kazakhstan, Central Asia, the Middle East, and Africa see the Chinese bullet trains, highways, buildings, etc.,



they will contract with China to build those things in their countries, so that China's capacity in 2020 will not be “overcapacity” but will be used to become the World's Building Contractor.

## Historical Appendix

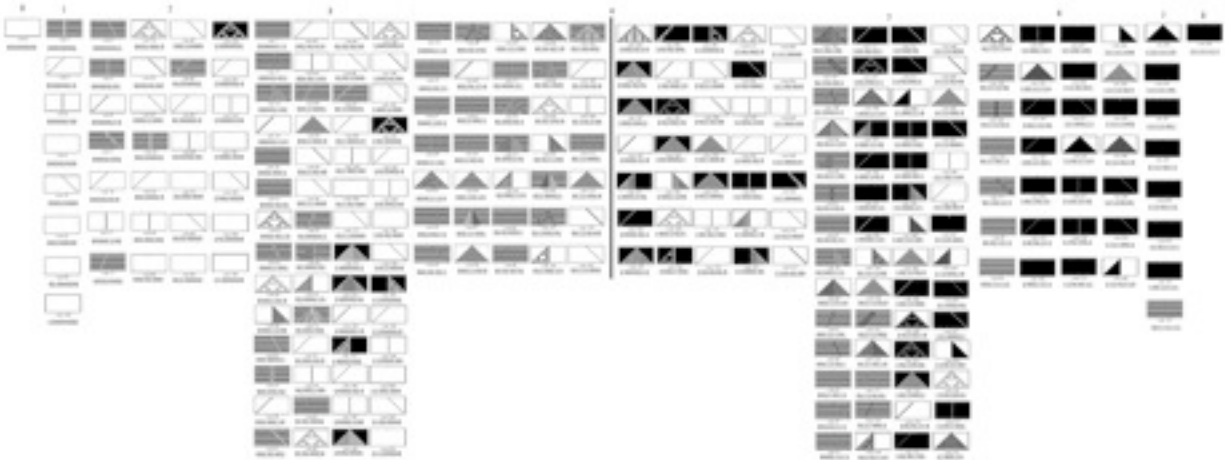
A little less than 15 billion years ago, our Universe emerged from the Void.

4 billion years ago, our Earth and Moon were orbiting our Sun.

2 billion years ago, bacteria built a nuclear fission reactor in Africa.

100,000 years ago, Humans were expanding from the African home-land to Eurasia and beyond.

12,000 years ago, Africans knew that the knowledge-patterns of 8 binary choices giving  $2^8 = 256 = 16 \times 16$  possibilities could act as an Oracle. Did they realize then that those 256 possibilities corresponded to the



256 Fundamental Cellular Automata, some of which act as Universal Computers?

From Africa, the 16x16 Oracle-patterns spread, so that by the 13th century parts of them were found in:

Judaism as the 248 positive Commandments plus the 365 negative Commandments given to Moses during the 50 days from Egypt to Sinai;

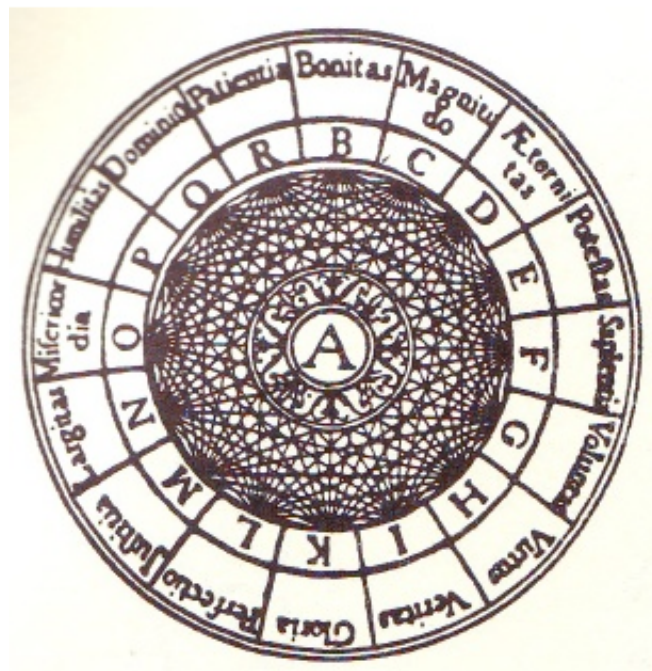
India as the 240 parts of the first sukt of the Rig Veda;

Japan as the 128 possibilities of Shinto Futomani Divination;

China as the 64 possibilities of the I Ching;

Mediterranean Africa as the 16 possibilities of the Ilm al Raml.

Near the end of the 13th century, Ramon Llull of Mallorca studied the 16 possibilities of the Ilm al Raml and realized that the 16x16 African Oracle-patterns had a Fundamental Organizational Principle that he summarized in a Wheel Diagram



with 16 vertices connected to each other by 120 lines, like the 120 bivectors of the  $Cl(16)$  Clifford Algebra that correspond to the  $D_8$  Lie Algebra that lives inside  $E_8$ . He used such structures to show the underlying unity of all human religions. However, the establishments of the various religions refused to accept Ramon Llull's revelations, and his ideas were relegated to a few obscure publications, plus an effort to preserve some aspects of the 16x16 Oracle-patterns in the form of the 78 Tarot cards and the subset of 52 cards that remains popular into the 21st century.

Since Llull was Roman Catholic, the Islamic and Judaic bureaucracies could (and did) ignore his work as that of an irrelevant outsider. As to the Christians, in the 14th century, Dominican Inquisitors had Ramon Llull condemned as a heretic, his works were suppressed, and his ideas were relegated to a few obscure publications, plus an effort to preserve some aspects of the 16x16 Oracle-patterns in the form of the 78 Tarot cards and the subset of 52 cards that remains popular into the 21st century.

In the 17th century the Roman Inquisition burned Giordano Bruno at the stake and sentenced Galileo to house arrest for the rest of his life, all for the sake of the Roman Inquisition's enforcement of conformity to its Consensus.

Rediscovery of the full significance of Ramon Llull's Oracle-patterns did not happen until:

after 20th century science experiments progressed beyond Gravity, Electromagnetism, and early Quantum Mechanics, and

after Lise Meitner discovered the Uranium Fission Chain Reaction Process that led to the Fission Bombs that ended the Japanese part of World War II.

The Japanese defeat liberated Saul-Paul Sirag, a child of Dutch-American Baptist missionaries, from a Japanese concentration camp in Java.

During the 1950s and 1960s, David Finkelstein described Black Holes and worked on Quaternionic Physics, Hua Luogeng 华罗庚 returned to China where he wrote his book "Harmonic Analysis of Functions of Several Complex Variables in the Classical Domains", Jack Sarfatti studied physics ( BA from Cornell and PhD from U. C. Riverside ), and I learned about Lie Groups and Lie Algebras ( AB in math from Princeton ).

During the 1970s, Saul-Paul Sirag learned math and physics working with Arthur Young and the physics community developed the Standard Model showing how everything other than Gravity could be described, consistent with experimental results, by 3 forces of a Standard Model:

Electromagnetism, with the symmetry of a circle, denoted by  $S1 = U(1)$

Weak Force with Higgs, with the symmetry of a 3-dimensional sphere, denoted by  $S3 = SU(2)$

Color Force, with symmetry related to a Star of David, denoted by  $SU(3)$

From the 1980s on, I learned about Clifford Algebras from David Finkelstein at Georgia Tech; about Weyl Groups and Root Vectors from the work of Saul-Paul Sirag; about Quantum Consciousness, Space-Time and Higgs as Condensates, and Bohmian Back-Reaction from the work of Jack Sarfatti; and about Compton Radius Vortices from the work of B. G. Sidharth.

In contrast to the advances in experimental results and construction of the Standard Model of physics, the social structure of the Physics Scientific Community evolved during the 20th century into a rigid Physics Consensus Community much like the Inquisitorial Consensus Community of a few hundred years ago.

For example, in the USA physics community around the middle of the 20th century, J. Robert Oppenheimer enforced his dislike of the ideas of David Bohm by declaring, as head of the Princeton Institute for Advanced Study:

“... if we cannot disprove Bohm, then we must agree to ignore him ...”

As the 20th century ended and the 21st century began, the Physics Consensus Community continued to enforce conformity to Consensus so strongly that Stanford physicist Burton Richter said:

“... scientists are imprisoned by golden bars of consensus ...”

The rigidly enforced Physics Consensus Community was so void of independent thought that the 20th century ended without anyone seeing how Ramon Llull’s Oracle-patterns explained both Gravity and the Standard Model in a unified way,

but

in January 2008 the cover of the magazine of Science & Vie declared:

“Theorie du tout Enfin!”



Un physicien ... chercheur hors norme ... aurait trouve la piece manquante”

The missing piece was a 248-dimensional Lie Algebra known as E8.

The beyond-the-norm physics researcher was a California-Hawaii Surfer Dude, Garrett Lisi, who realized that the structure of E8 could unify Gravity and the Standard Model in a way that satisfied Einstein's Criterion for a structure

“... based ... upon a faith in the simplicity ... of nature: there are no arbitrary constants ... only rationally completely determined constants ... whose ... value could ... not ... be changed without destroying the theory ...”.

Motivated by Garrett Lisi's E8 work, I constructed from E8 a Lagrangian that realistically describes physics in a Local Region. Since E8 lives inside the Clifford Algebra  $Cl(16) = Cl(8) \times Cl(8)$ , if you let a copy of  $Cl(16)$  represent a Local Lagrangian Region, you can construct a Global Structure by taking the tensor products of the copies of  $Cl(16)$ . Due to Real Clifford Algebra 8-periodicity, any Real Clifford Algebra, no matter how large, can be embedded in a tensor product of factors of  $Cl(8)$ , and therefore of  $Cl(8) \times Cl(8) = Cl(16)$ .

Just as the completion of the union of all tensor products of  $2 \times 2$  complex Clifford algebra matrices produces the usual Hyperfinite III von Neumann factor that describes creation and annihilation operators on fermionic Fock space over  $C^{(2n)}$  (see John Baez's Week 175), we can take the completion of the union of all tensor products of  $Cl(16) = Cl(8) \times Cl(8)$  to produce a generalized Hyperfinite III von Neumann factor that gives a natural Algebraic Quantum Field Theory structure for E8 Physics, and corresponds to the El Aleph of Jorge Luis Borges.

In some sense, the 240 Root Vectors of E8 are a seed from which El Aleph grows.