

# Minimal Math Structures needed for E8 Physics

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This is a rough outline of the minimal math structure needed for my E8 Physics model. It makes clear that a major barrier to understanding it is the amount of not-well-known mathematics of Real Clifford Algebras, Lie Algebras, Bounded Complex Domains, etc. ... No details are given here as they can be found in viXra 1312.0036 and my other viXra papers and my web sites at [tony5m17h.net](http://tony5m17h.net) and [valdostamuseum.com/hamsmith/](http://valdostamuseum.com/hamsmith/). As to why anyone should expend the effort to understand the necessary math, the payoff is the substantially realistic results of E8 Physics calculations set out at the end of this paper. The calculations are mostly tree-level with a few first-order results so further calculation work might bring even closer correspondence with observations.

Cl(8) contains 52-dim  $F_4 = 8\text{-dim vector} + 28\text{-dim bivector} + 16\text{-dim full spinor}$

$F_4$  has the basic structure of a realistic physics model:

8-dim  $M_4 \times CP^2$  Kaluza-Klein spacetime

28 = 16-dim  $U(2,2)$  Conformal Gravity + 12-dim  $SU(3) \times SU(2) \times U(1)$  Standard Model

8 first-generation fermion +half-spinor particles

8 first-generation fermion -half-spinor antiparticles

but

$F_4$  does not have complex domain structure or spacetime momentum structure or detailed component structure. To get all that structure you must go beyond  $F_4$  to 248-dim  $E_8$ .

$E_8$  is naturally contained in the 8-Periodicity tensor product  $Cl(8) \times Cl(8) = Cl(16)$  as

$E_8 = 120\text{-dim bivector of } Cl(16) +$

$+ 128\text{-dim half-spinor of } Cl(16) =$

$= 8 \times 8 \text{ of } Cl(8) \times Cl(8) + 1 \times 28 \text{ of } Cl(8) \times Cl(8) + 28 \times 1 \text{ of } Cl(8) \times Cl(8) +$

$+ 8 \times 8 \text{ } Cl(8)\text{-half-spinor} \times Cl(8)\text{-half-spinor} + 8 \times 8 \text{ } Cl(8)\text{-half-spinor} \times Cl(8)\text{-half-spinor}$

Local 28-dim Spin(8) symmetry gives Complex Bounded Domain structure by 8-complex-dim Spin(10) / Spin(8)xU(1) with 8-real-dim RP1 x S7 Shilov Boundary.

Triality among 8 Cl(8)+half-spinor and 8 Cl(8)-half-spinor and 8 Cl(8)vector extends that Complex Bounded Domain and RP1 x S7 Shilov Boundary structure to fermion representation spaces.

Gauge boson representation space Complex Bounded Domain structures are:

local D4 and D3=A3 subalgebra B2

with B3 / B2xU(1) and Shilov RP1xS4

local D4 and A3 subalgebras A2 and A1 and A0=U(1)

with A3 / A2xU(1) and Shilov S5

and with B2 / A1xU(1) and Shilov RP1xS2

and with A0 = U(1) and trivial Shilov

The 8x8 of Cl(8)xCl(8) has 8x8 spacetime position x momentum structure.

8-dim Kaluza-Klein has

CP2 = A2 / A1xA0 Internal Symmetry Space and M4 Physical Spacetime.

M4 has symmetry for each force gauge group:

S4 = B2 / D2 for B2 Gravity

CP2 = A2 / A1xS0 for A2 of Color Force

S2 x S2 = A1/A0 x A1/A0 for A1 Weak Force

S1 x S1 x S1 x S1 = A0 x A0 x A0 x A0 for A0 ElectroMagnetism

The 64-dim ++half-spinors have 8 components for each of the 8 fermion particles.

The 64-dim +-half-spinors have 8 components for each of the 8 fermion particles.

With World-Lines regarded as Strings, E8 Physics can be represented as

26D Bosonic String Theory with 8+8 = 16 dimensions Orbifolded to represent Fermions

and 26-16 = 10 dimensions representing 4-dim CP2 Internal Symmetry Space

and 6-dim D3 = A3 Conformal Spacetime that effectively reduces to Minkowski M4.

Each cell of its local 26D Lorentz Leech lattice structure has Monster Group symmetry.

These structures, along with a MacDowell-Mansouri mechanism of Gravity,

the Dark Energy of D3 / B2, the emergence of second and third generation fermions

from formation of (4+4)-dim Kaluza-Klein spacetime, and a Mayer mechanism Higgs as

fermion (predominantly Truth quark) condensate allow the construction of a realistic E8

Physics Local Lagrangian associated with Cl(16) with calculation, based on Schwinger

Sources and Hua/Wyler geometry, of particle masses, force strengths, K-M parameters,

and the ratio Dark Energy : Dark Matter : Ordinary Matter

and

a realistic Algebraic Quantum Field Theory by using Real Clifford 8-Periodicity to

construct the completion of the union of all tensor products of Cl(16) thus

producing a generalization of the type II1 hyperfinite von Neumann factor algebra.

Within that AQFT, Creation and Annihilation Operators are described by the Maximal Contraction of  $E_8$  = semidirect product  $H_{92} \times A_7$  where

$H_{92}$  is the Heisenberg Algebra with graded structure  $8+28+56+1+56+28+8$  with bosonic even part  $28+1+28$  and fermionic odd part  $8+56 + 0 + 56+8$ :

grade -3 : 8 =( by Triality ) = +half-spinor of  $Cl(8)$  = Fermion Particle  
 = Creation of 8-component Neutrino Fermion =  $R_8$  in Jordan Algebra  $R_1+R_8 = J(Spin(8))$   
 $Spin(8) = D_4$

+

grade -2 : 28 = Creation of Gauge Bosons = Jordan Algebra  $J(4,Q)$  with  $J(4,Q)_o = J(3,O)$   
 $Aut(J(3,O)) = F_4$

+

grade -1 : 56 = Creation of 8-component Electron / Quark Fermions = Freudenthal Algebra  $Fr(3,O)$   
 $Aut(Fr(3,O)) = E_6$

+

grade 0 : 1 =  $R_1$  in Jordan Algebra  $R_1+R_8 = J(Spin(8))$

+

grade +1 : 56 = Annihilation of 8-component Electron / Quark Fermions

+

grade +2 : 28 = Annihilation of Gauge Bosons

+

grade +3 : 8 =( by Triality ) = -half-spinor of  $Cl(8)$  = Fermion AntiParticle  
 = Annihilation of 8-component Neutrino Fermion

$A_7$  is the Lie Algebra  $Sl(8)$  that by semidirect product goes into grade 0 of  $H_{92} \times A_7$  :  
 grade 0 : 1 +  $A_7$  where 1 =  $R_1$  in Jordan Algebra  $R_1+R_8 = J(Spin(8))$  and 63-dim  $A_7 = Sl(8)$   
 so that the dimension of  $H_{92} \times A_7 = 8+28+56+(1+63)+56+28+8 = 248$

Zero Grade Spacetime Algebra:  
 grade 0 Spacetime Position / Momentum Algebra =  $1+Sl(8)$

Odd Grade Fermionic Creation Algebras:  
 grade -1 Electron / Quark Creation Jordan-type Algebra  $Fr(3,O)$   
 grade -3 Neutrino Creation Jordan Algebra  $J(Spin(8))$  is in the  $2^8 \times 2^8$  matrix algebra  
 which is  $Cl(8) \times Cl(8) = Cl(16)$  the home of  $E_8$ .

Even Grade Bosonic Creation Algebra:  
 grade -2 Gauge Boson Creation Jordan Algebra  $J(4,Q)$  has  $J(4,Q)_o = J(3,O)$

The relative symmetries of the relative grades are:  
 grade -2 / grade -3 :  $F_4 / D_4 = 24$ -dim  $OxOxO$   
 grade -1 / grade -2 :  $E_6 / F_4 = 26$ -dim  $J(3,O)_o$   
 total algebra / grade -1 :  $E_8 / E_6 \times A_0 \times A_0 = 168$ -dim  $PSL(2,7) = SL(3,2)$

The payoff for understanding all this math is the substantially realistic  $E_8$  Physics calculation data set listed on the next page.

Here is a summary of E8 Physics model calculation results. Since ratios are calculated, values for one particle mass and one force strength are assumed. Quark masses are constituent masses. Most of the calculations are tree-level, so more detailed calculations might be even closer to observations.

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

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

| 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<br>neutron - proton = 1.1 MeV   |
| muon  | 104.8 MeV           | 106.2 MeV   |
| strange   | 625 MeV             |   |
| charm   | 2090 MeV            |   |
| tauton  | 1.88 GeV            |   |
| beauty  | 5.63 GeV            |   |
| truth(low state)  | 130 GeV             | truth(middle state) = 174 GeV<br>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= $1.217 \times 10^{19}$ GeV<br>Higgs(low state) = 126 GeV<br>Higgs(middle state) = 182 GeV<br>Higgs(high state) = 239 GeV |
| Gravity Gg<br>(Gg)(Mproton <sup>2</sup> / Mplanck <sup>2</sup> )                                | 1(assumed)          | $5 \times 10^{(-39)}$   |
| EM fine structure   | 1/137.03608         |   |
| Weak Gw<br>Gw(Mproton <sup>2</sup> / (Mw+ <sup>2</sup> + Mw- <sup>2</sup> + Mz0 <sup>2</sup> )) | 0.2535              | $1.05 \times 10^{(-5)}$   |
| 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.