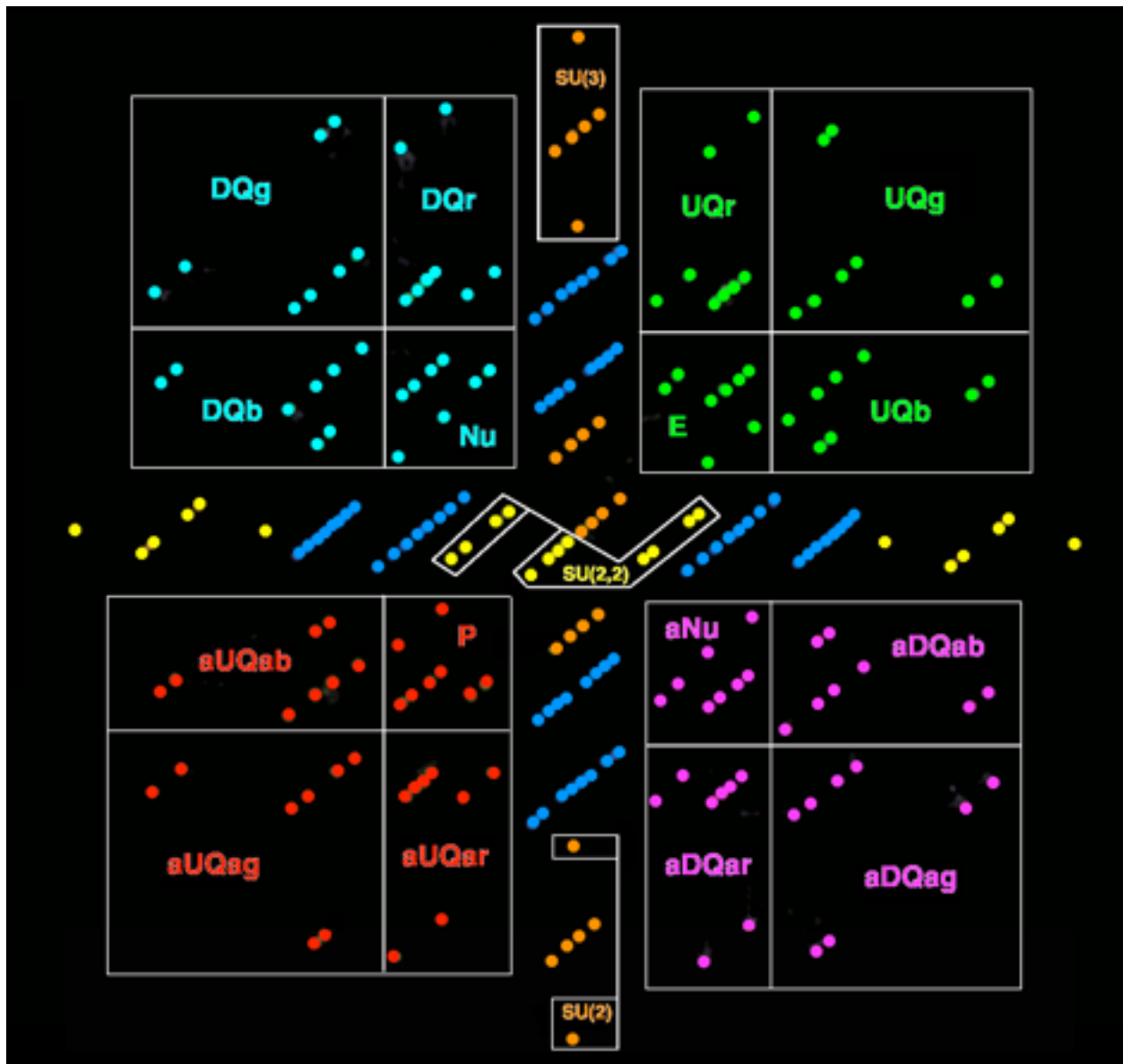
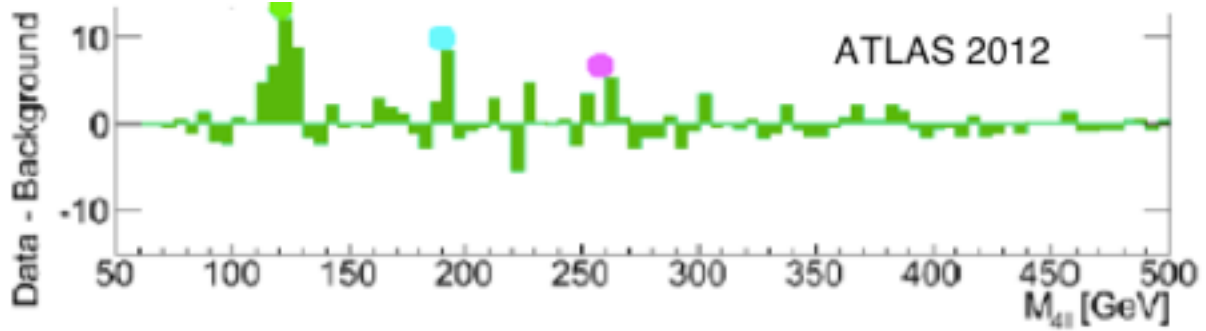


LHC 2015-16 and E8 Physics



Abstract:

Run-2 2015-16 of the LHC will probably, when enough data is collected, show whether or not there exist two new Standard Model Higgs mass states, around 200 GeV and around 250 GeV, each with cross sections around 25% of the full Standard Model cross section for the 125 GeV state.

Run-1 results were consistent with the existence of those two new Higgs mass states, but were also consistent with their peaks being statistical fluctuations that could go away with more data from Run-2.

The purpose of this paper is two-fold:

1 - To describe my E8 Physics Model, which predicts the existence of those two new Higgs mass states around 200 GeV and 250 GeV, and which allows calculation of realistic particle masses, force strengths, K-M parameters, Dark Energy : Dark Matter : Ordinary Matter ratio, etc, a description of which takes up pages 6 through 105 (the end) of this paper; and

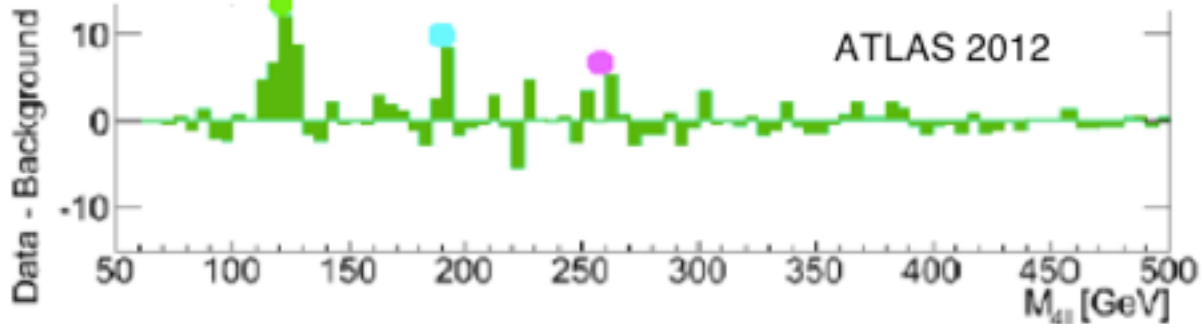
2 - To describe the status of the LHC Run-2 data that will show the existence or non-existence of the two new Higgs mass states around 200 GeV and 250 GeV with cross sections about 25% or so of the 125 GeV Higgs mass state cross section, and therefore either support my E8 Physics Model or kill it. Since it may be well into 2016 before Run-2 has enough data to decide the issue, I expect to replace this paper with updated versions throughout Run-2 until it has decided the issue.

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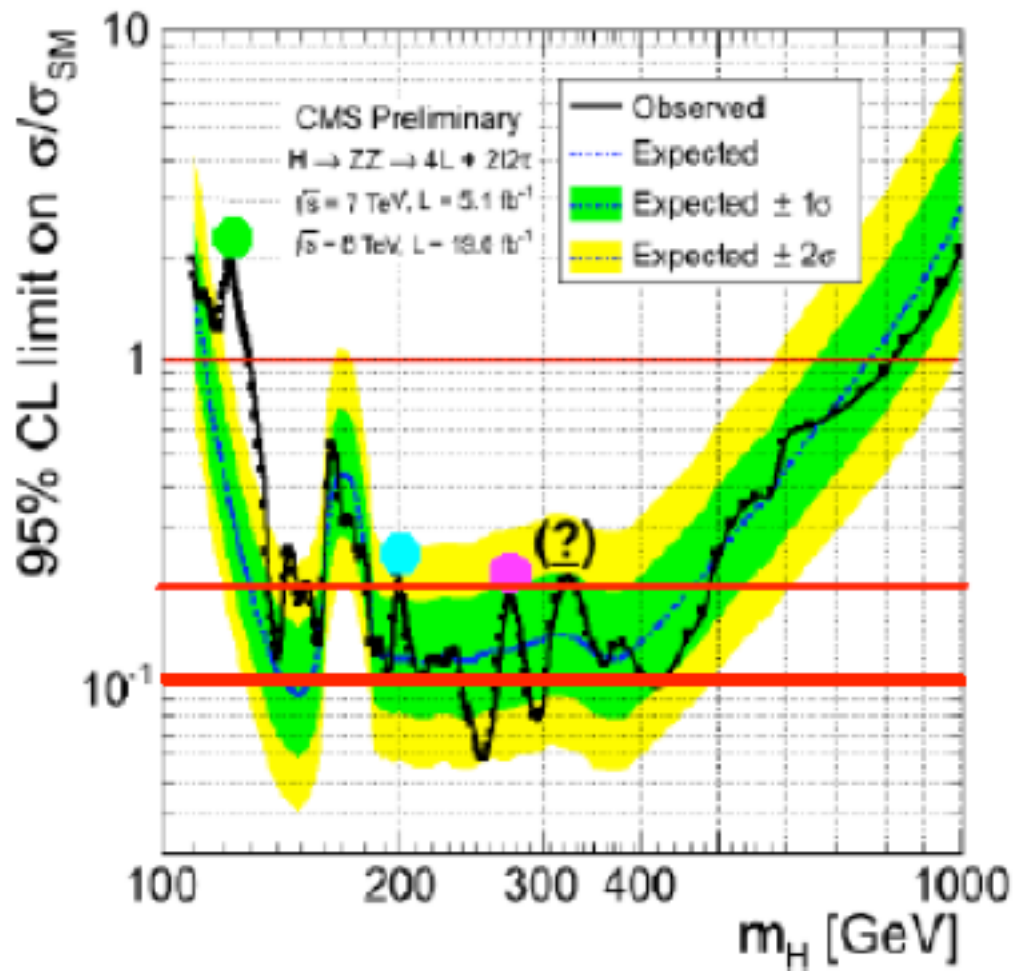
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LHC Run-1 (2012) and Run-2 (2015-16) and Higgs mass states:

By the end of Run-1 in 2012 the LHC had seen clear evidence for a Higgs (green dot) with mass around 125 GeV and the expected Standard Model cross section.



The LHC also saw indications of two more Higgs mass states (cyan and magenta dots), around 200 GeV and 250 GeV, with cross sections around 25% of SM expectation,



and of a (?) peak around 320 GeV that I expect to go away with Run-2 data.

As to

WHEN LHC Run-2 might confirm or reject the two new Higgs states and the (?) peak, the Resonaances blog on **21 May 2015** said "... The plan is to collect **5-10 inverse femtobarn (fb-1) of data before winter comes** ... let us forget ... the fine-print, and calculate the *ratio* of 13 and 8 TeV cross sections for a few particles popular among the general public. This will give us a rough estimate of the threshold *luminosity* when things should get interesting ...

300 GeV Higgs partner: Ratio = 2.7 ; Luminosity = 9 fb-1 ...".

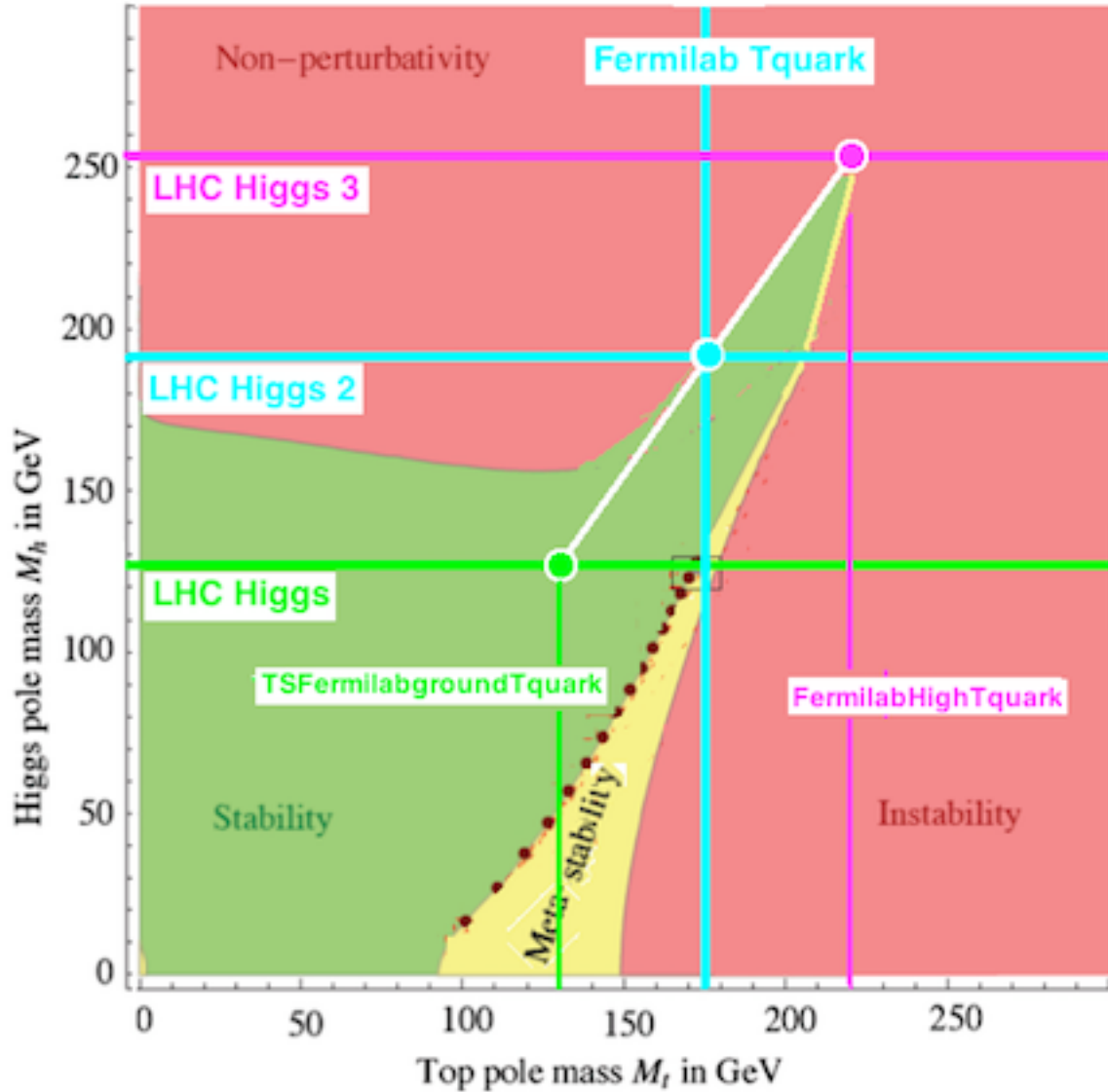
New Scientist on **19 August 2015** said "... **High-energy LHC plans held up by UFOs and electron clouds** ... this week ... the first report on the LHC's performance at an conference in Ljubljana, Slovenia, ... revealed that things haven't quite gone as planned ... Clouds of electrons created by ionised gas in the beam chamber and microscopic dust particles - playfully known as unidentified falling objects, or UFOs - are interrupting the beams ... the higher energies, plus efforts to produce more frequent collisions by bunching particles in the beam closer together, make them a larger problem than before. The researchers now expect to **only reach 3 inverse femtobarns (3 fb-1) ... this year**, down from a planned 10.


To put this in context, the ... Higgs ... was discovered after the LHC reached 12 fb⁻¹. ...".


Phys Org on **4 November 2015** said: "... The Large Hadron Collider (LHC) has successfully completed its planned proton run for 2015, delivering the equivalent of about 400 trillion (10¹²) proton-proton collisions - some **4 inverse femtobarns** of data - to both the ATLAS and CMS experiments. ... "The accelerator has been performing well given the challenges of running at the new collision energy of 13 teraelectronvolts (TeV)," says Mike Lamont of the LHC Operations team. "We're currently running with 2244 bunches of protons in the machine, spaced at intervals of 25 nanoseconds, which is an achievement in itself." The new energy regime highlighted several issues for the Operations team, including increased electron-cloud effects at high beam intensities, and falling particles of dust inside the beam-pipe causing premature beam dumps. To resolve these issues, the team has been patiently ramping up the beam intensity over a period of weeks using small numbers of bunches in various configurations ...[so that]... the LHC ...[is]... now confidently colliding protons at 13 TeV ...".

Why E8 Physics has two new Higgs mass states

As to **WHY** two new Higgs mass states are expected in my E8 Physics Model: The Cl(16)-E8 model identifies the Higgs with Primitive Idempotents of the Cl(8) real Clifford algebra, whereby the Higgs is not seen as a simple-minded single fundamental scalar particle, but rather the Higgs is seen as a quantum process that creates a fermionic condensate and effectively a 3-state Higgs-Tquark System.



The Green Dot  where the White Line originates in our Ordinary Phase is the low-mass state of a 130 GeV Truth Quark and a 125 GeV Higgs.

The Cyan Dot  where the White Line hits the Triviality Boundary leaving the Ordinary Phase is the middle-mass state of a 174 GeV Truth Quark and Higgs around 200 GeV. It corresponds to the Higgs mass calculated 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 ...".**

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 $d\lambda/dt = (1/16\pi^2)\beta_\lambda$ where the one loop contribution is given by $\beta_\lambda = 12\lambda^2 - \dots - 4H$... The value of λ 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 λ is large. In that case, β_λ is dominated by the λ^2 term, which drives the coupling towards its Landau pole at higher energies. Hence the higher the Higgs mass, the higher λ is and the closer the Landau pole to experimentally accessible regions.

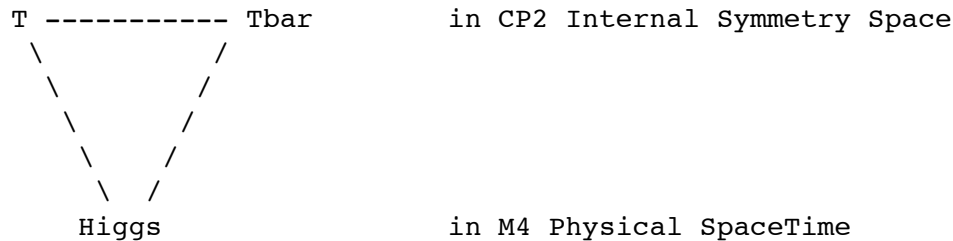
This means that for a given (large) Higgs mass, we expect the standard model to enter a strong coupling regime at relatively low energies, losing in the process our ability to calculate. This does not necessarily mean that the theory is incomplete, only that we can no longer handle it ... it is natural to think that this effect is caused by new strong interactions, and that the Higgs actually is a composite ...

The resulting bound on λ 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 λ is certainly not zero. ...".

Middle Mass State Cross Section:

In the Cl(16)-E8 model, the Middle-Mass Higgs has structure that is not restricted to Effective M4 Spacetime as is the case with the Low-Mass Higgs Ground State

but extends to the full $4+4 = 8$ -dim structure of $M4 \times CP2$ Kaluza-Klein.



Therefore the Mid-Mass Higgs looks like a 3-particle system of Higgs + T + Tbar.

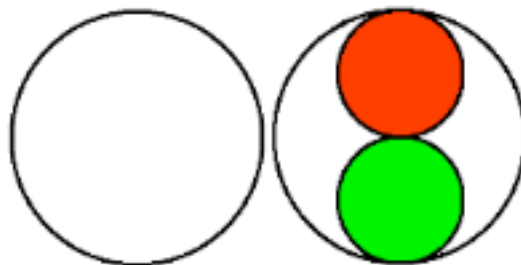
The T and Tbar form a Pion-like state.

Since Tquark Mid-Mass State is 174 GeV

the Middle-Mass T-Tbar that lives in the $CP2$ part of $(4+4)$ -dim Kaluza-Klein has mass $(174+174) \times (135 / (312+312)) = 75$ GeV.

The Higgs that lives in the $M4$ part of $(4+4)$ -dim Kaluza-Klein has, by itself, its Low-Mass Ground State Effective Mass of 125 GeV. So, the total Mid-Mass Higgs lives in full 8-dim Kaluza-Klein with mass $75+125 = 200$ GeV.

This is consistent with the Mid-Mass States of the Higgs and Tquark being on the Triviality Boundary of the Higgs - Tquark System and with the 8-dim Kaluza-Klein model in hep-ph/0311165 by Hashimoto, Tanabashi, and Yamawaki. As to the cross-section of the Middle-Mass Higgs



consider that the entire Ground State cross-section lives only in 4-dim $M4$ spacetime (left white circle)

while the Middle-Mass Higgs cross-section lives in full $4+4 = 8$ -dim Kaluza-Klein (right circle with red area only in $CP2$ ISS and white area partly in $CP2$ ISS with only green area effectively living in 4-dim $M4$ spacetime)


so that

our 4-dim $M4$ Physical Spacetime experiments only see for the Middle-Mass Higgs a cross-section that is 25% of the full Ground State cross-section.

The 25% may also be visualized in terms of 8-dim coordinates $\{1,i,j,k,E,I,J,K\}$

	1	i	j	k	E	I	J	K
1	11	1i	1j	1k	1E	1I	1J	1K
i	i1	ii	ij	ik	iE	iI	iJ	iK
j	j1	ji	jj	jk	jE	jI	jJ	jK
k	k1	ki	kj	kk	kE	kI	kJ	kK
E	E1	Ei	Ej	EK	EE	EI	EJ	EK
I	I1	Ii	Ij	Ik	IE	II	IJ	IK
J	J1	Ji	Jj	Jk	JE	JI	JJ	JK
K	K1	Ki	Kj	Kk	KE	KI	KJ	KK

in which $\{1,i,j,k\}$ represent M4 and $\{E,I,J,K\}$ represent CP2.

The Magenta Dot  at the end of the White Line is the high-mass state of a 220 GeV Truth Quark and a 240 GeV Higgs. It is at the critical point of the Higgs-Tquark System with respect to Vacuum Instability and Triviality. It corresponds to the description in hep-ph/9603293 by Koichi Yamawaki of the Bardeen-Hill-Lindner model: "... 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 Λ ...[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 $m_t = m_t(\text{BHL}) = \dots = 1/(\text{sqrt}(2)) \text{ybar}_t v$ within 1-2%, where ybar_t is the quasi-infrared fixed point given by $\text{Beta}(\text{ybar}_t) = 0$ in ... the one-loop RG equation ...

The composite Higgs loop changes ybar_t^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 $m_t = 218 \pm 3$ GeV, at $\Lambda = 10^{19}$ 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.

Its mass was also calculated by BHL through the full RG equation ... the result being ... $M_H / m_t = 1.1$) at $\Lambda = 10^{19}$ GeV ...

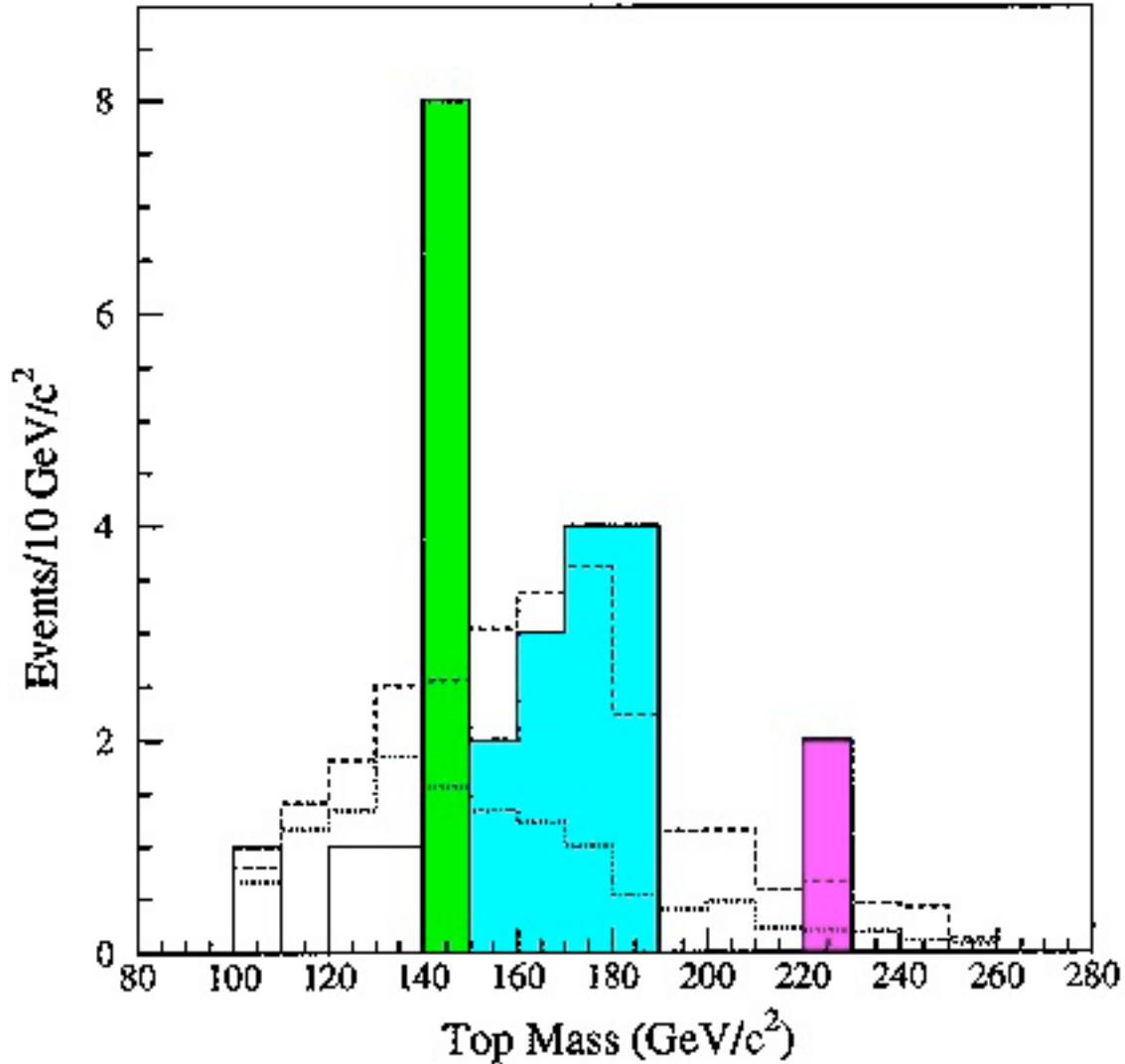
... the top quark condensate proposed by Miransky, Tanabashi and Yamawaki (MTY) and by Nambu independently ... entirely replaces the standard Higgs doublet by a composite one formed by a strongly coupled short range dynamics (four-fermion interaction) which triggers the top quark condensate. The Higgs 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 ...".

High Mass State Cross Section:

As with the Middle-Mass Higgs,
the High-Mass Higgs lives in all $4+4 = 8$ Kaluza-Klein dimensions
so
its cross-section is also about 25% of the Higgs Ground State cross-section.

Three T-quark mass states

The 174 GeV Tquark mass state (cyan dot) is not controversial. It has been observed at Fermilab since 1994, when a semileptonic histogram from CDF (FERMILAB-PUB-94/097-E)

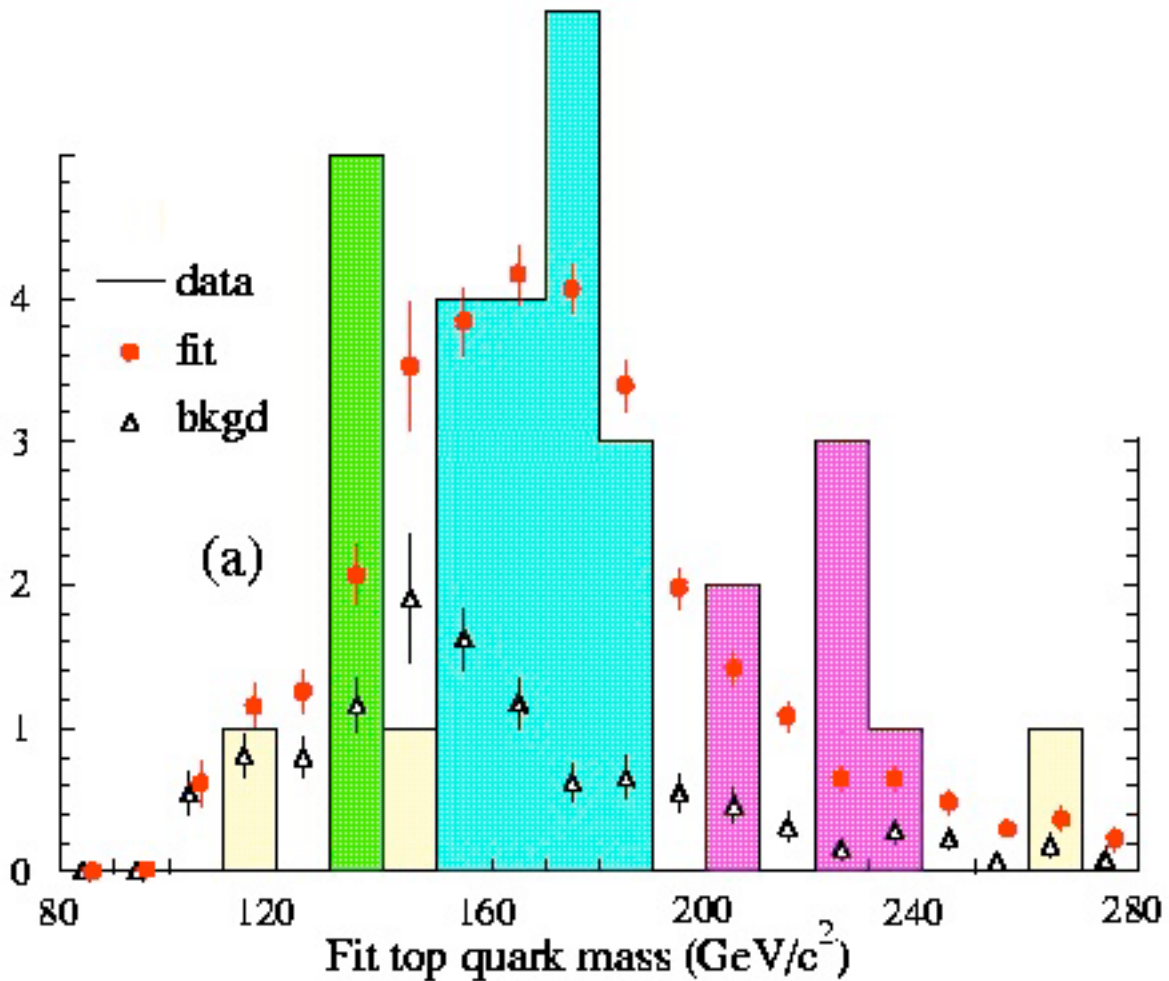


showed all three states of the T-quark.

In particular, the green bar represents a bin in the 140-150 GeV range containing Semileptonic events considered by me to represent the Truth Quark, but as to which CDF said "... We assume the mass combinations in the 140 to 150 GeV/c² bin represent a statistical fluctuation since their width is narrower than expected for a top signal. ...". I strongly disagree with CDF's "statistical fluctuation" interpretation, based on my interpretations of much Fermilab T-quark data.

The same three Tquark mass states were seen in 1997 by D0 (hep-ex/9703008)

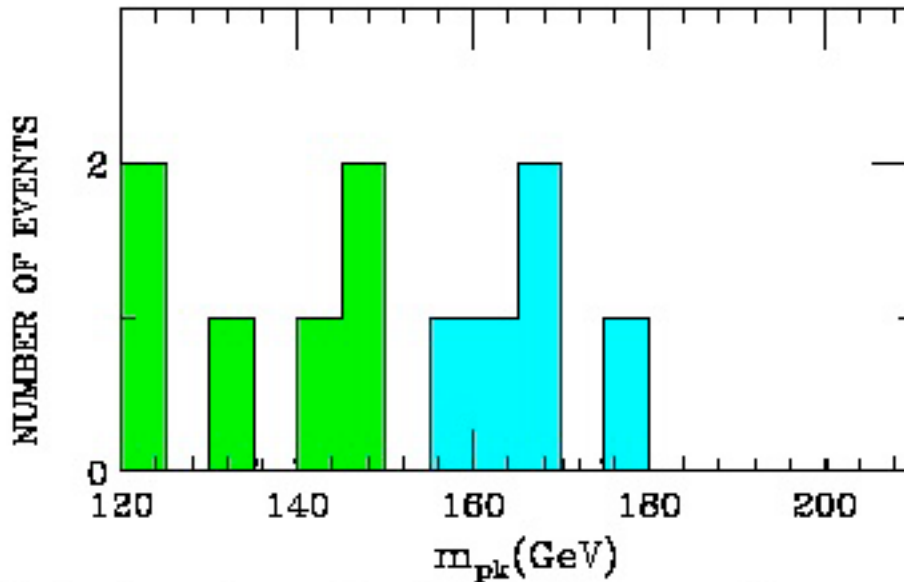
in this semileptonic histogram:



The fact that the low (green) state showed up in both independent detectors indicates a significance of 4 sigma.

**My opinion is that the middle (cyan) state is 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 is narrow because it is in the usual non-trivial region
where the T-quark acts more nearly as a single individual particle.**

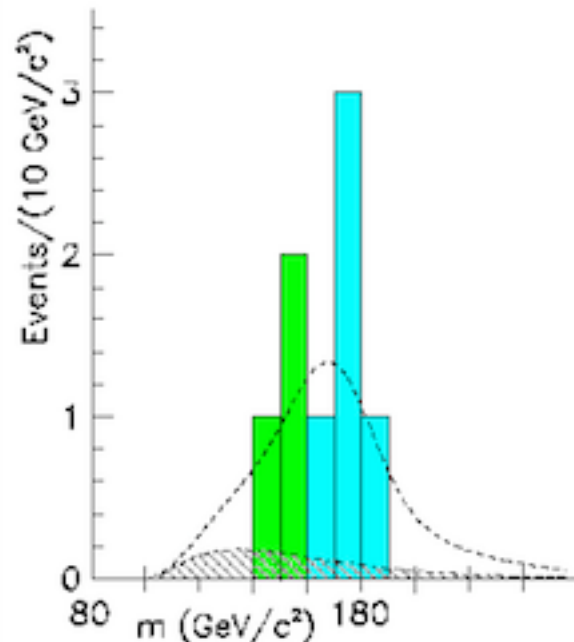
Further, in February 1998 a dilepton histogram of 11 events from CDF (hep-ex/9802017)



The distribution of $m_{p\ell}$ values determined from 11 CDF dilepton events available empirically.

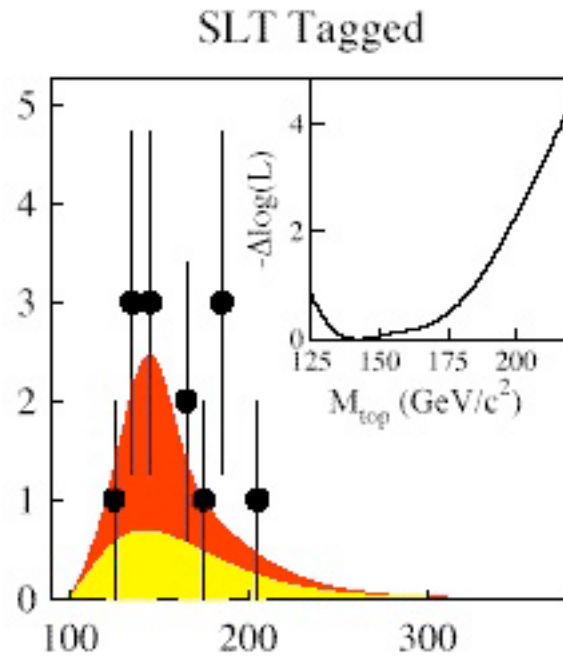
shows both the low (green) state and the middle (cyan) T-quark state but

in October 1998 CDF revised their analysis using 8 Dilepton CDF events (hep-ex/9810029)



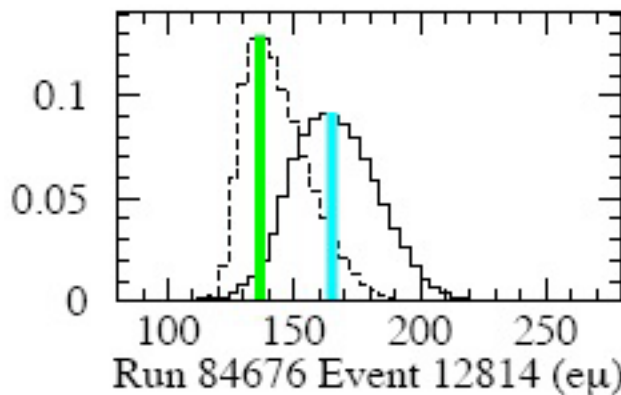
shows that CDF kept the 8 highest-mass dilepton events, and threw away the 3 lowest-mass dilepton events that were indicated to be in the 120-135 GeV range, and shifted the mass scale upward by about 10 GeV, indicating to me that Fermilab was attempting to discredit the low-mass T-quark state by use of cuts etc on its T-quark data.

In 1998 an analysis of 14 SLT tagged lepton + 4 jet events by CDF (hep-ex/9801014)



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 his 1997 Ph.D. thesis 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 corresponds to the 2-jet (dashed curve) event at the low (green) energy level.

As to the T-quark width for the 174 GeV mass state, which appears in the 1994 CDF and 1997 D0 semileptonic histograms to be about 40 GeV, which is 4 of the 10 GeV histogram bins,

Mark Thomson, in “Modern Particle Physics” (Cambridge 2013) says:

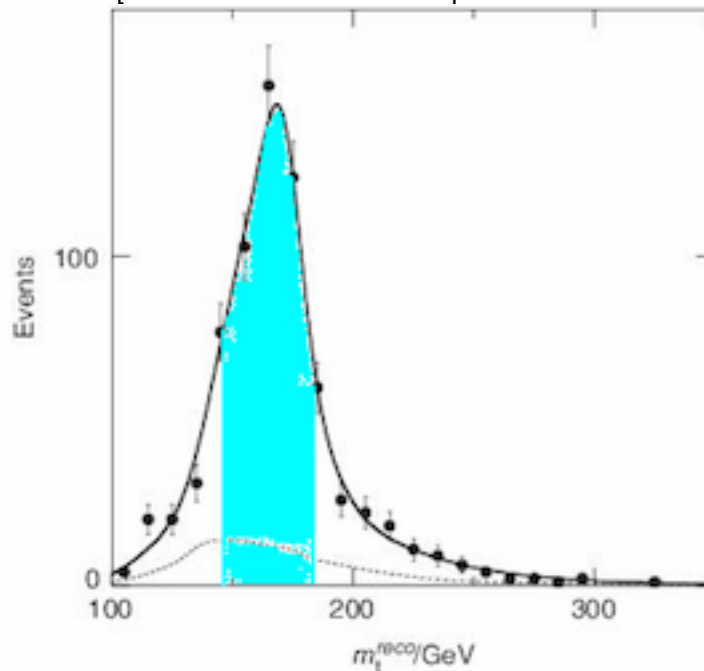
“... Decay of the top quark ... The total decay rate is ...

$$\Gamma(t \rightarrow bW^+) = \frac{G_F m_t^3}{8 \sqrt{2} \pi} \left(1 - \frac{m_W^2}{m_t^2}\right)^2 \left(1 + \frac{2m_W^2}{m_t^2}\right),$$

... For ... $m_t = 173 \text{ GeV}$... the lowest-order calculation of the total decay width of the top quark gives $\Gamma_t = 1.5 \text{ GeV}$...

The total width of the top quark is measured to be $\Gamma_t = 2.0 \pm 0.6 \text{ GeV}$.

The top width is determined much less precisely than the top quark mass because the width of the distribution ... [color added to show correspondence to CDF and D0 histograms] ...



... is dominated by the experimental resolution. ...”.

The T-quark total width $\Gamma_t = 2 \text{ GeV}$ is much smaller than the 40 GeV width experimentally observed at Fermilab and would, except for experimental resolution, fit well within one single bin in the 1994 CDF and 1997 D0 semileptonic histograms.

As to the T-quark width for the 130 GeV mass state, which appears in the 1994 CDF and 1997 D0 semileptonic histograms to be less than the 10 GeV histogram bin width, using the total width formula from Mark Thomson's book and paraphrasing:

“... For $m_t = 130$ GeV ... the lowest-order calculation of the total decay width of the top quark gives $\Gamma_t = \text{about } 0.5 \text{ GeV ...}$ ”.

I think that the CDF explanation for the low mass T-quark peak in a single 10 GeV bin

"... We assume the mass combinations in the ... bin represent a statistical fluctuation since their width is narrower than expected for a top signal. ..."

is highly unlikely since a similar low mass single 10 GeV bin T-quark mass peak was observed by the independent D0 detector.

The $m_t = 130$ GeV width of 0.5 GeV is only 1/20 of the 10 GeV bin width of that peak. The 20:1 = 10 : 0.5 observed width : actual width ratio for $m_t = 130$ GeV is the same as the 20:1 = 40 : 2.0 observed width : actual width ratio for $m_t = 173$ GeV.

What differences between the $m_t = 130$ GeV and $m_t = 173$ GeV states might affect their relative experimental resolutions ?

The $m_t = 130$ GeV peak is in the normal Stable region in which the T-quark is represented by a Schwinger Source in M4 Physical Spacetime which Schwinger Source has Green's Function structure based on Kernel Functions of Bounded Symmetric Domains whose symmetry is that of the T-quark. Since it is a simple Schwinger Source it has simple W - b - 2 jet decay.

The $m_t = 173$ GeV peak is on the boundary of the Non-Perturbativity region where the composite nature of Higgs as T-quark Condensate becomes manifest, as does the 8-dim nature of Kaluza-Klein spacetime $M4 \times CP2$ with M4 Physical Spacetime and CP2 Internal Symmetry Space where $CP2 = SU(3) / SU(2) \times U(1)$ has symmetries of the Standard Model Gauge Groups. Its decay scheme is more complicated, with 2 stages:

175 to 130 GeV, a process of the Higgs - T-quark condensate system of E8 Physics and simple W - b - 2 jet decay of the 130 GeV intermediate state.

The wider width of the 173 GeV decay peak is due to the Higgs - T-quark condensate process.

The 1997 UC Berkeley PhD thesis of Erich Ward Varnes gives details of some D0 events and analysis, based on the Standard Model view of one T-quark mass state: "... the leptonic decays of the t tbar events are divided into two broad categories: the lepton plus jets and dilepton channels.

The former has the advantage of a large branching ratio, accounting for about 30% of all t tbar decays, with the disadvantage that electroweak processes or detector misidentification of final-state particles can mimic the t tbar signal relatively frequently.

Conversely,

the dilepton channels have lower backgrounds, but account for only 5% of all decays.

...

The kinematic selection of dilepton events is summarized in Table 5.2 ...

	$e\bar{e}$	$e\mu$	$\mu\mu$
Leptons	$E_T > 20 \text{ GeV}$ $ \eta < 2.5$	$E_T(e) > 15 \text{ GeV}$, $p_T(\mu) > 15 \text{ GeV}/c$ $ \eta(e) < 2.5$	$p_T(\mu) > 15 \text{ GeV}/c$
Jets	≥ 2 with $E_T > 20 \text{ GeV}$ and $ \eta < 2.5$		
\cancel{E}_T	$> 25 \text{ GeV}$	$\cancel{E}_T > 20 \text{ GeV}$ $\cancel{E}_T^{\text{cal}} > 10 \text{ GeV}$	N/A
H_T^c	$> 120 \text{ GeV}$	$> 120 \text{ GeV}$	$> 100 \text{ GeV}$

Table 5.2: Kinematic cuts for the dilepton event selection. The cut used in place of \cancel{E}_T to reject $Z \rightarrow \mu\mu$ events is described in the text, as is the H_T^c variable. Also, the muon η cut is run-dependent, as detailed in Chapter 4.

...

In the dilepton channels, one expects the final state to consist of two charged leptons, two neutrinos, and two b jets (see Fig. 6.1)

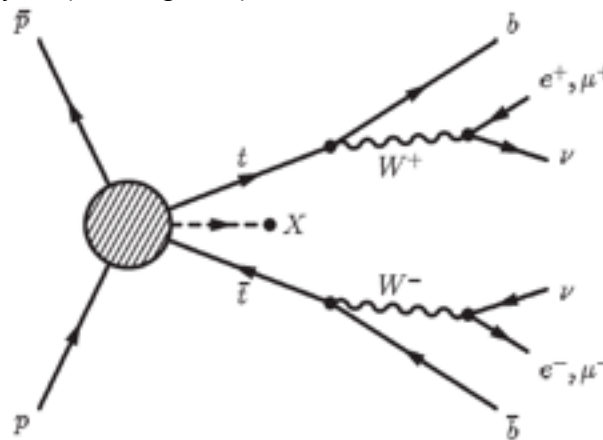


Figure 6.1: Schematic representation of $t\bar{t}$ production and decay in the dilepton channels.

so that the final state is completely specified by knowledge of the energy four-vectors of these six particles ... there are ... kinematic constraints:

The invariant mass of each lepton and neutrino pair is equal to the W mass.

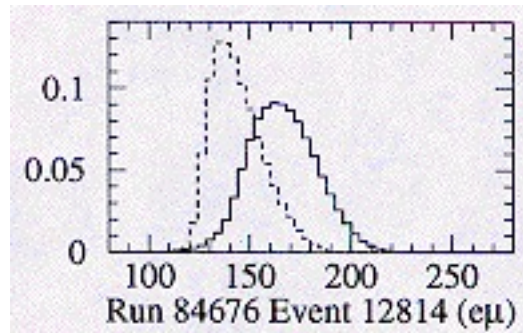
The masses of the reconstructed t and tbar in the event are equal.

...

The result of reconstructing the top quark mass for a dilepton event is the distribution $W(m_t)$, which is evaluated for 50 values of the top quark mass ... the intrinsic resolution of the dilepton mass reconstruction is much broader than the 4 GeV/c² interval between assumed top quark masses ... the RMS of the typical $W(m_t)$ distribution ... typically lies between 35 and 40 GeV/c² ...

...

Figure 8.1: $W(m_t)$ 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 ...



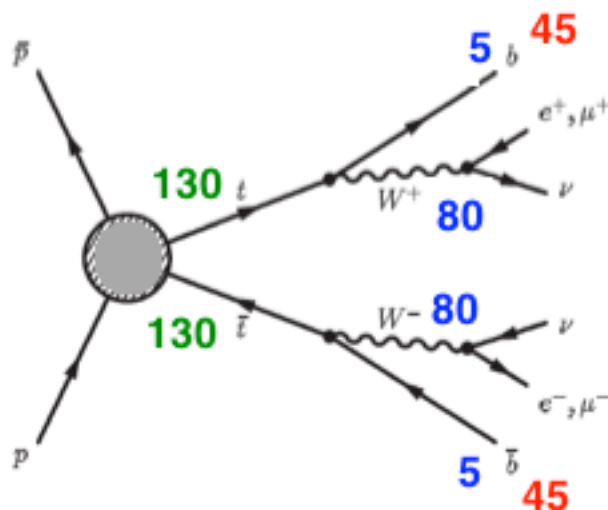
Run 84676 Event 12814					z vertex: -6.17 cm		
Object	E	E_x	E_y	E_z	E_T	η	ϕ
Electron	81.3	-75.4	-1.1	-30.2	74.5	-0.39	3.16
Muon	30.2	-25.2	10.6	-12.8	27.4	-0.45	2.75
E_T	-	62.0	5.2	-	62.3	-	0.08
Jet 1	93.8	38.0	-83.7	-15.6	91.9	-0.17	5.14
	(95.9)	(38.9)	(-85.6)	(-16.0)	(94.0)		
Jet 2	37.8	13.9	32.3	-11.2	35.2	-0.31	1.17
	(38.8)	(14.2)	(33.1)	(-11.4)	(36.0)		
Jet 3	31.4	-1.6	28.6	11.6	28.7	0.39	1.63
	(32.2)	(-1.6)	(29.3)	(11.9)	(29.4)		

...”

In E8 Physics (viXra 1508.0157) there are, as stated above, three T-quark mass states, so in order to keep the kinematic constraint

“The masses of the reconstructed t and tbar in the event are equal”
 the t and tbar must be in the same mass state, which is physically realistic because the t and tbar are created together in the same collider collision event.

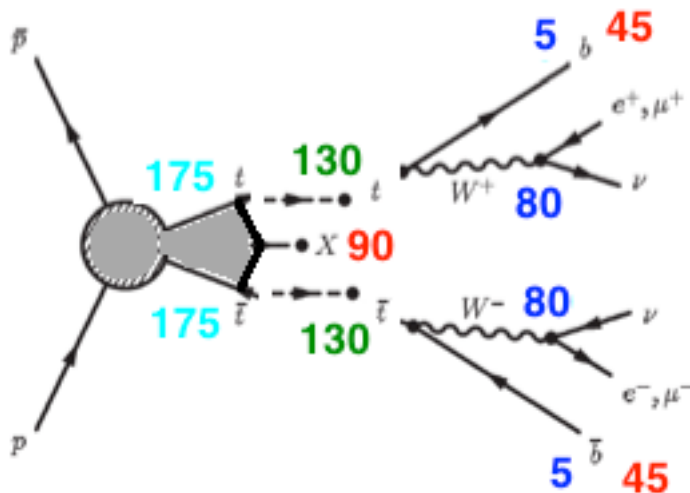
If the t and tbar are both in the 130 GeV mass state then the decay is simple with 2 jets:



and both jets are highly constrained as being related to the W - b decay process so it is reasonable to expect that the 130 GeV decay events would fall in the narrow width of a single 10 GeV histogram bin.

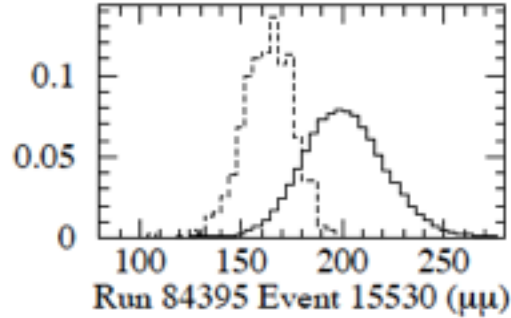
(In these two diagrams I have indicated energies only approximately for t and tbar mass states (cyan and green) and W and b-quark (blue) and jets (red). Actual kinematic data may vary from the idealized numbers on the diagrams, but they should give similar physics results.)

If the t and tbar are both in the 173 GeV mass state (as, for example, in Run 84676 Event 12814 (e mu) described above) the decay has two stages and 3 jets:



First, the 175 GeV t and tbar both decay to the 130 GeV state, emitting a jet. Then, the 130 GeV t and tbar decay by the simple 2-jet process. The first jet is a process of the Higgs - T-quark condensate system of E8 Physics and is not a W -b decay process so it is not so highly constrained and it is reasonable to expect that the 175 GeV decay events would appear to have a larger (on the order of 40 GeV) width.

As to t and $tbar$ being the high T -quark mass state (around 225 GeV) there would be a third stage for decay from 225 GeV to 175 GeV with a fourth jet carrying around 100 GeV of decay energy. In the Varnes thesis there is one dilepton event



Run 84395 Event 15530					z vertex: 5.9 cm		
Object	E	E_x	E_y	E_z	E_T	η	ϕ
Muon 1	68.6	-63.9	12.7	-21.4	65.1	-0.32	2.91
Muon 2	34.9	-16.0	31.0	1.9	34.9	0.05	2.05
\cancel{E}_T	-	71.2	53.2	-	88.9	-	0.61
Jet 1	146.1 (153.5)	32.1 (33.8)	-98.2 (-103.1)	-102.4 (-107.6)	103.3 (108.5)	-0.88	5.03
Jet 2	35.1 (37.2)	-8.6 (-9.1)	21.4 (22.7)	26.2 (27.7)	23.1 (24.5)	0.97	1.95
Jet 3	47.1 (52.3)	-7.6 (-8.4)	-16.8 (-18.6)	43.0 (47.8)	18.4 (20.5)	1.58	4.29

that seems me to represent that third stage of decay from 225 GeV to 175 GeV. Since it is described as a 3-jet event and not a 4-jet event as I would have expected, my guess is that the third and fourth jets of my model were not distinguished by the experiment so that they appeared to be one third jet.

What Does E8 Physics Do ?

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 quark	312.8 MeV	charged pion = 139 MeV
up quark	312.8 MeV	proton = 938.25 MeV
		neutron - proton = 1.1 MeV
muon	104.8 MeV	106.2 MeV
strange quark	625 MeV	
charm quark	2090 MeV	

tauon	1.88 GeV	
beauty quark	5.63 GeV	
truth quark (low state)	130 GeV	(middle state) 174 GeV (high state) 218 GeV

W+	80.326 GeV	
W-	80.326 GeV	
W0	98.379 GeV	Z0 = 91.862 GeV

Mplanck 1.217x10¹⁹ GeV

Higgs VEV (assumed)	252.5 GeV	
Higgs (low state)	126 GeV	(middle state) 182 GeV (high state) 239 GeV

Gravity Gg (assumed)	1	
(Gg)(Mproton ² / Mplanck ²)		$5 \times 10^{(-39)}$
EM fine structure	1/137.03608	
Weak Gw	0.2535	
Gw(Mproton ² / (Mw+ ² + Mw- ² + Mz0 ²))		$1.05 \times 10^{(-5)}$
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.

How Does E8 Physics Work ?

Mathematical Prerequisites:

In my opinion, the best text / reference for the mathematics used in E8 Physics is the Princeton University Advanced Calculus text by H. K. Nickerson, D. C. Spencer, and N. E. Steenrod.

However, it is over 50 years old, so I have added some Supplementary Material to produce a 21 MB pdf file on the web at

<http://www.valdostamuseum.com/hamsmith/NSS6313.pdf>

TABLE OF CONTENTS OF THE SUPPLEMENTED TEXT:

Supplementary Material in Red

I. THE ALGEBRA OF VECTOR SPACES

II. LINEAR TRANSFORMATIONS OF VECTOR SPACES

Lie Groups and Symmetric Spaces

III. THE SCALAR PRODUCT

IV. VECTOR PRODUCTS IN R^3

Vector Products in R^7

V. ENDOMORPHISMS

VI. VECTOR-VALUED FUNCTIONS OF A SCALAR

VII. SCALAR-VALUED FUNCTIONS OF A VECTOR

VIII. VECTOR-VALUED FUNCTIONS OF A VECTOR

IX. TENSOR PRODUCTS AND THE STANDARD ALGEBRAS

Clifford Algebra and Spinors

X. TOPOLOGY AND ANALYSIS

XI. DIFFERENTIAL CALCULUS OF FORMS

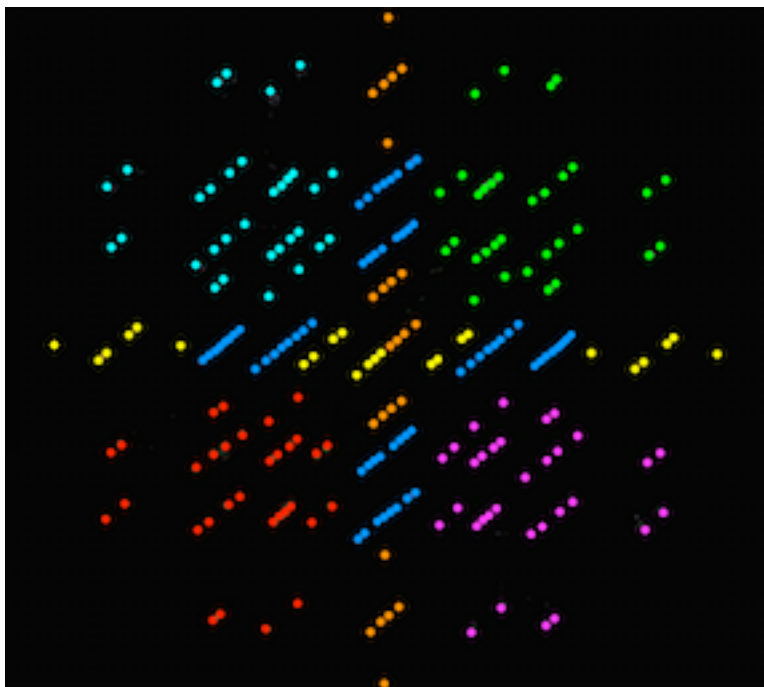
XII. INTEGRAL CALCULUS OF FORMS

XIII. COMPLEX STRUCTURE

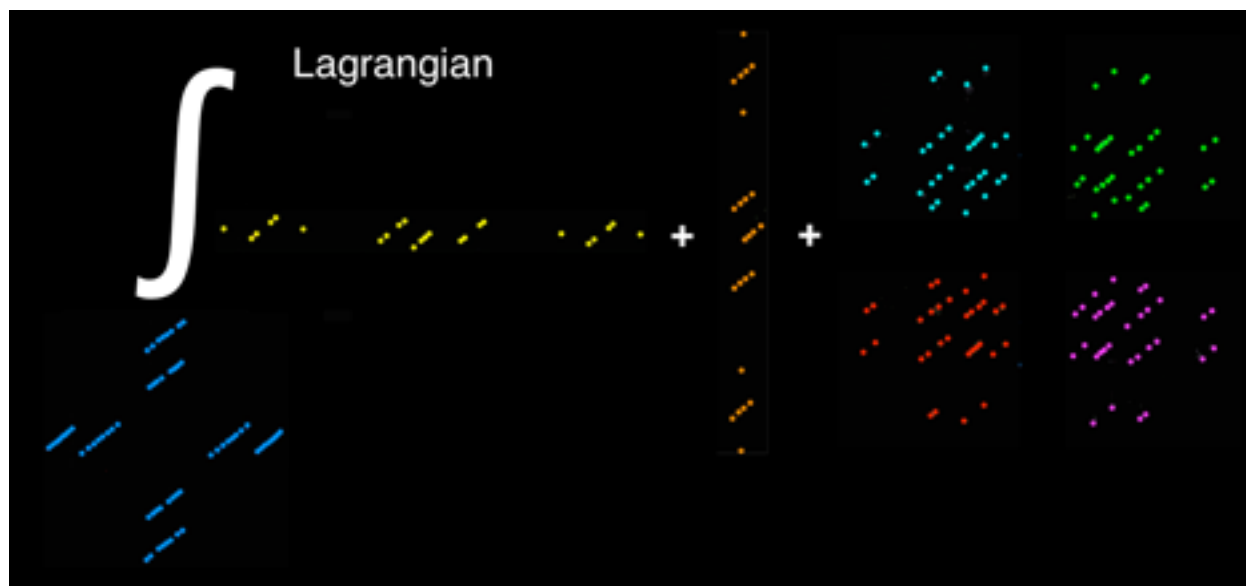
Potential Theory, Green's Functions, Bergman Kernels, Schwinger Sources

Lagrangian Structure

E8 Physics is based on Lagrangian integral of gauge boson and fermion terms integrated over spacetime, all of which are represented by the 240 E8 root vectors (this visualization uses a square/cubel type of projection of the 240 E8 root vectors to 2-dim)

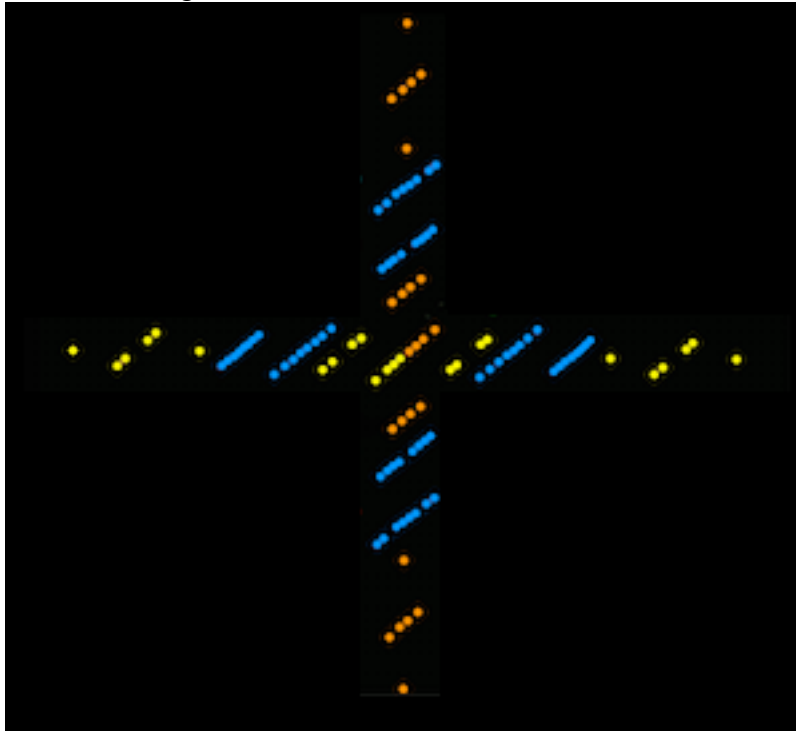


organized to produce this Lagrangian

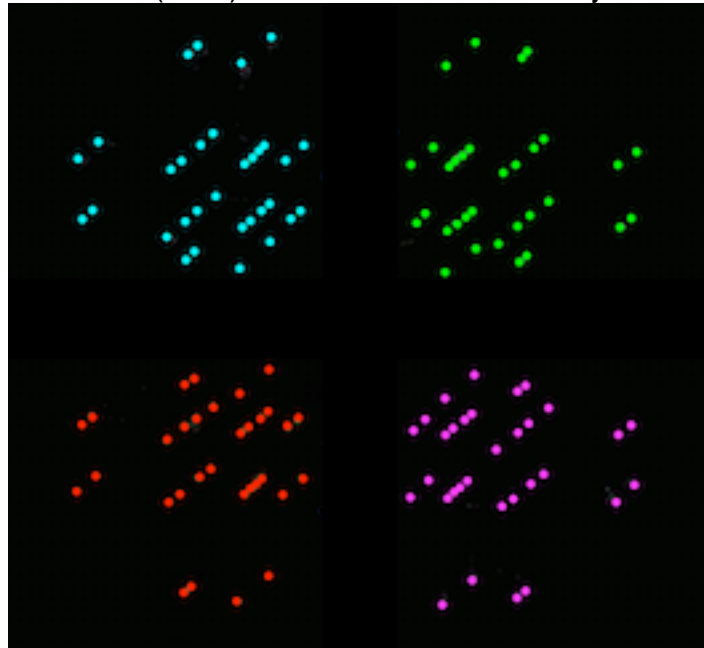


based on these E8 structures:

112 root vectors of D8 subalgebra of E8



128 root vectors of $E8 / D8 = (OxO)P2 = \text{OctoOctonionic Projective Plane}$



24 root vectors of D4 with D3 subalgebra representing Conformal Gravity + Dark Energy



24 root vectors of D4 with A3 subalgebra containing A2 of Standard Model Color Force



64 root vectors of D8 / D4xD4 = Gr(8,16) = 64-dim Octonionic Subspaces of R16
(Gr = Grassmanian and R16 = Vectors of Clifford Cl(16) Matrix Algebra for D8)

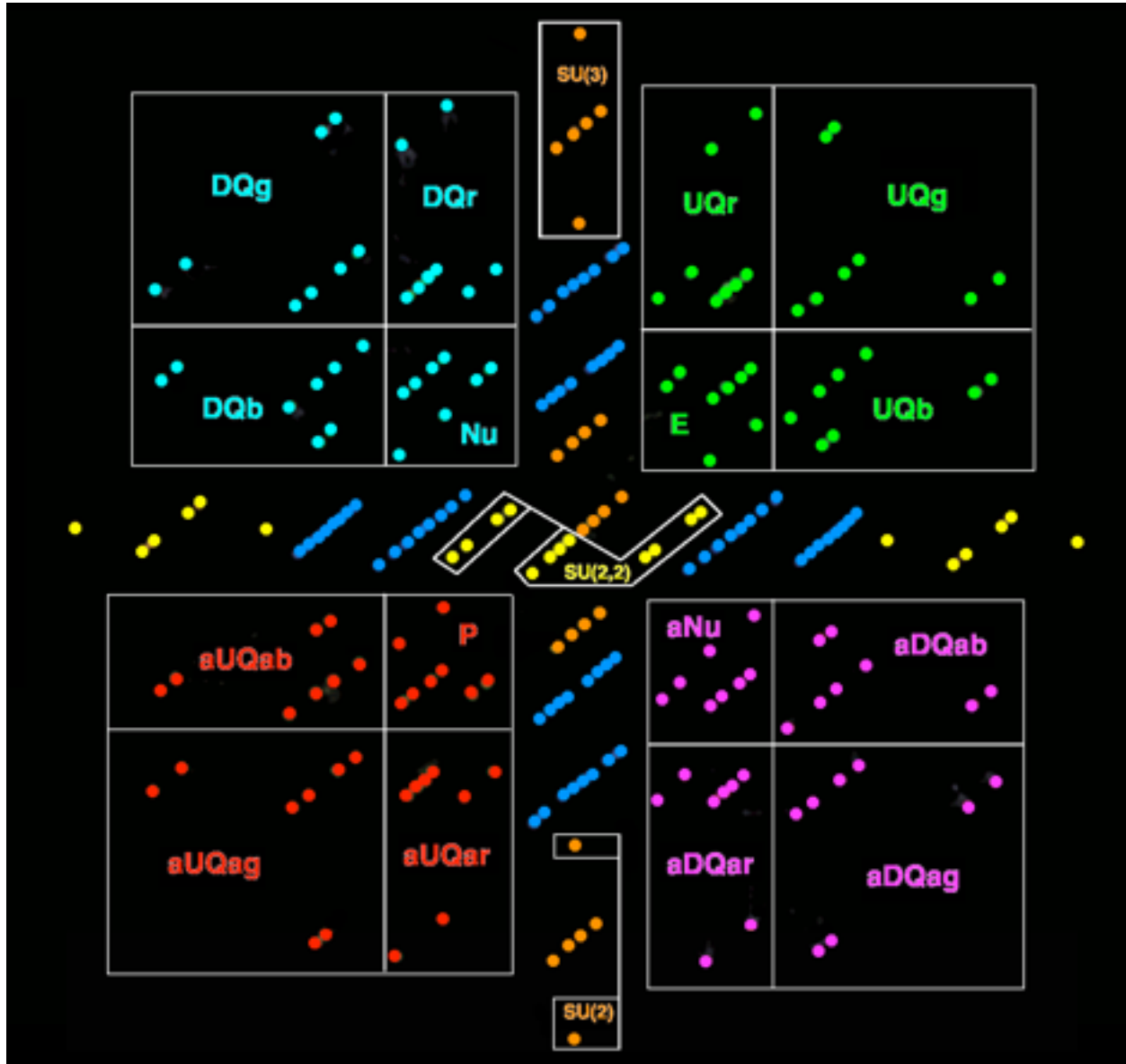


representing 8-dim Octonionic spacetime which, upon freezing out of a preferred Quaternionic structure, produces 4+4 dim Kaluza-Klein M4 x CP2

M4 being the Horizontal 16+16 corresponding to Gravity+Dark Energy

CP2 = SU(3)/SU(2)xU(1) being the vertical 16+16 corresponding to the Standard Model.

The physical interpretations of the 240 E8 root vectors are:



E = electron, UQr = red up quark, UQg = green up quark, UQb = blue up quark
 Nu = neutrino, DQr = red down quark, DQg = green down quark, DQb = blue down quark
 P = positron, aUQar = anti-red up antiquark,
 aUQag = anti-green up antiquark, aUQab = anti-blue up antiquark
 aNu = antineutrino, aDQar = anti-red down antiquark,
 aDQag = anti-green down antiquark, aDQab = anti-blue down antiquark
 Each Lepton and Quark has 8 components with respect to 4+4 dim Kaluza-Klein
 6 orange SU(3) and 2 orange SU(2) represent Standard Model root vectors
 $24 - 6 - 2 = 16$ orange represent U(2,2) Conformal Gravity Ghosts
 12 yellow SU(2,2) represent Conformal Gravity SU(2,2) root vectors
 $24 - 12 = 12$ yellow represent Standard Model Ghosts
 $32 + 32 = 64$ blue represent 4+4 dim Kaluza-Klein spacetime position and momentum

Gauge Gravity and Standard Model terms of Lagrangian have total weight $28 \times 1 = 28$
 12 generators for SU(3) and U(2) Standard Model +
 + 16 generators for U(2,2) of Conformal Gravity =
 = 28 D4 Gauge Bosons each with 8-dim Lagrangian weight = 1

Fermion Particle-AntiParticle term also has total weight $8 \times (7/2) = 28$
 8 Fermion Particle/Antiparticle types each with 8-dim Lagrangian weight = 7/2

Since Boson Weight 28 = Fermion Weight 28
the CI(16)-E8 model has a Subtle SuperSymmetry and is UltraViolet Finite.

The CI(16)-E8 model has 8-dim Lorentz structure satisfying Coleman-Mandula because its fermionic fundamental spinor representations are built with respect to spinor representations for 8-dim Spin(1,7) spacetime.

(See pages 382-384 of Steven Weinberg's book "The Quantum Theory of Fields" Vol. III)

The CI(16)-E8 model is Chiral because
 E8 contains CI(16) half-spinors (64+64) for a Fermion Generation
 but does not contain CI(16) Fermion AntiGeneration half-spinors (64+64).
 Fermion +half-spinor Particles with high enough velocity are seen as left-handed.
 Fermion -half-spinor AntiParticles with high enough velocity are seen as right-handed.

The CI(16)-E8 model obeys Spin-Statistics because
 the CP2 part of M4xCP2 Kaluza-Klein has index structure Euler number $2+1 = 3$ and
 Atiyah-Singer index $-1/8$ which is not the net number of generations because
CP2 has no spin structure but you can use a generalized spin structure
 (Hawking and Pope (Phys. Lett. 73B (1978) 42-44))
 to get (for integral m) the generalized CP2 index $n_R - n_L = (1/2) m (m+1)$
 Prior to Dimensional Reduction: $m = 1$, $n_R - n_L = (1/2) \times 1 \times 2 = 1$ for 1 generation
 After Reduction to 4+4 Kaluza-Klein: $m = 2$, $n_R - n_L = (1/2) \times 2 \times 3 = 1$ for 3 generations
 (second and third generations emerge as effective composites of the first)

Hawking and Pope say: "Generalized Spin Structures in Quantum Gravity ...what happens in CP2 ... is a two-surface K which cannot be shrunk to zero. ... However, one could replace the electromagnetic field by a Yang-Mills field whose group G had a double covering $G\sim$. The fermion field would have to occur in representations which changed sign under the non-trivial element of the kernel of the projection ... $G\sim \rightarrow G$ while the bosons would have to occur in representations which did not change sign ...".
 For CI(16)-E8 model gauge bosons are in the $28+28=56$ -dim D4 + D4 subalgebra of E8.
 D4 = SO(8) is the Hawking-Pope G which has double covering $G\sim = \text{Spin}(8)$.
 The 8 fermion particles / antiparticles are D4 half-spinors represented within E8
 by anti-commutators and so do change sign while
 the 28 gauge bosons are D4 adjoint represented within E8 by commutators
 and so do not change sign.

**E8 inherits from F4 the property whereby
 its Spinor Part need not be written as Commutators
 but can also be written in terms of Fermionic AntiCommutators. (vixra 1208.0145)**

Fundamental Spinor - Clifford Algebra Origin of E8

Where does the E8 of E8 Physics come from ?
Based on David Finkelstein's view of Fundamental Physics:

In the beginning there was $Cl(0)$ spinor fermion void



from which emerged $2 = \sqrt{2^2} = 1+1$ $Cl(2)$ half-spinor fermions/antifermions



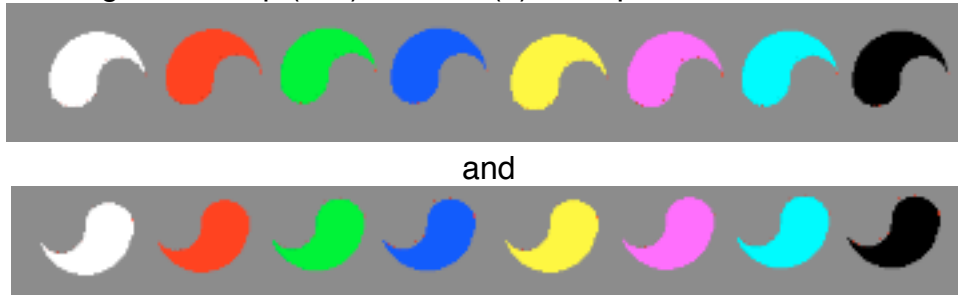
from which emerged $4 = \sqrt{2^4} = 2+2$ $Cl(4)$ half-spinor fermions/antifermions



from which emerged $8 = \sqrt{2^6} = 4+4$ $Cl(6)$ half-spinor fermions/antifermions



from which emerged $16 = \sqrt{2^8} = 8+8$ $Cl(8)$ half-spinor fermions/antifermions



8 half-spinor fermions and 8 half-spinor antifermions are isomorphic by $Cl(8)$ Triality to each other and to the 8 $Cl(8)$ vectors

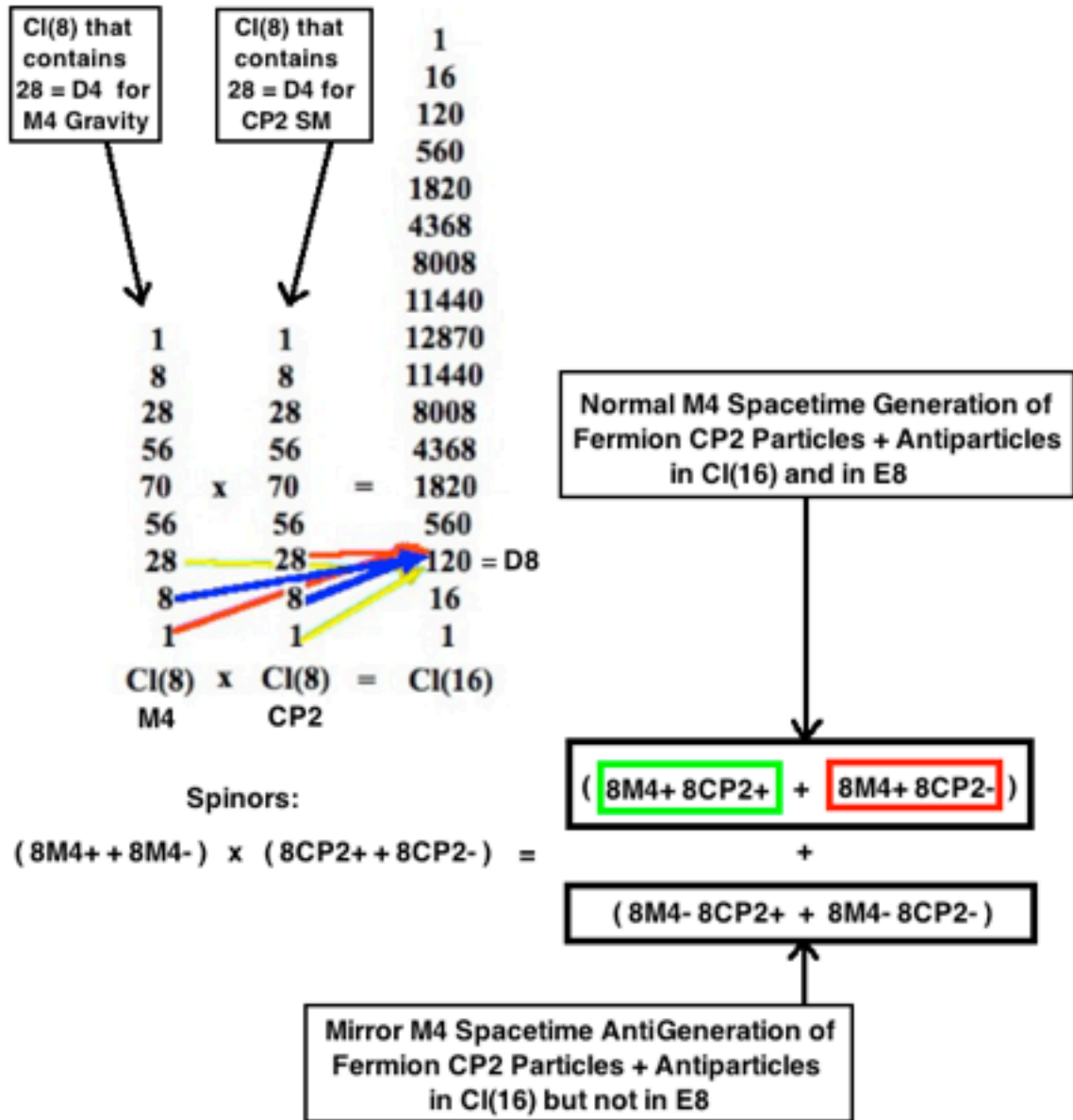


8-Periodicity of Real Clifford Algebras

$Cl(8) \times \dots (N \text{ times tensor product}) \dots \times Cl(8) = Cl(8N)$

shows that $Cl(8)$ (or any tensor multiple it) is the basic building block of ALL Real Clifford Algebras, no matter how large they may be.

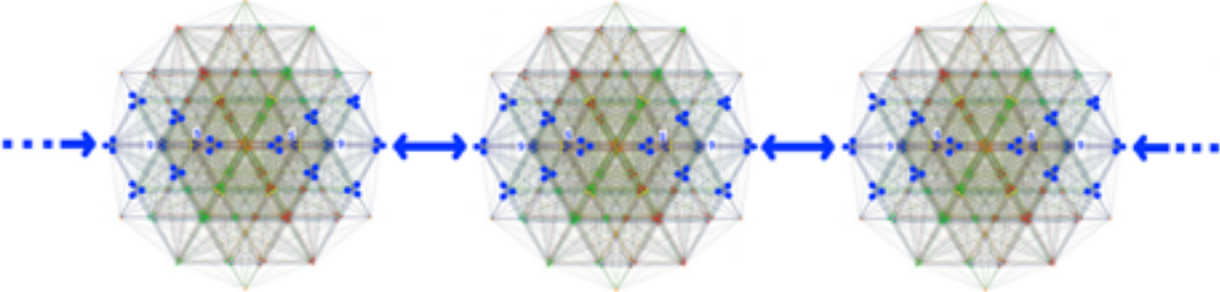
In particular, the tensor product $Cl(8) \times Cl(8) = Cl(16)$



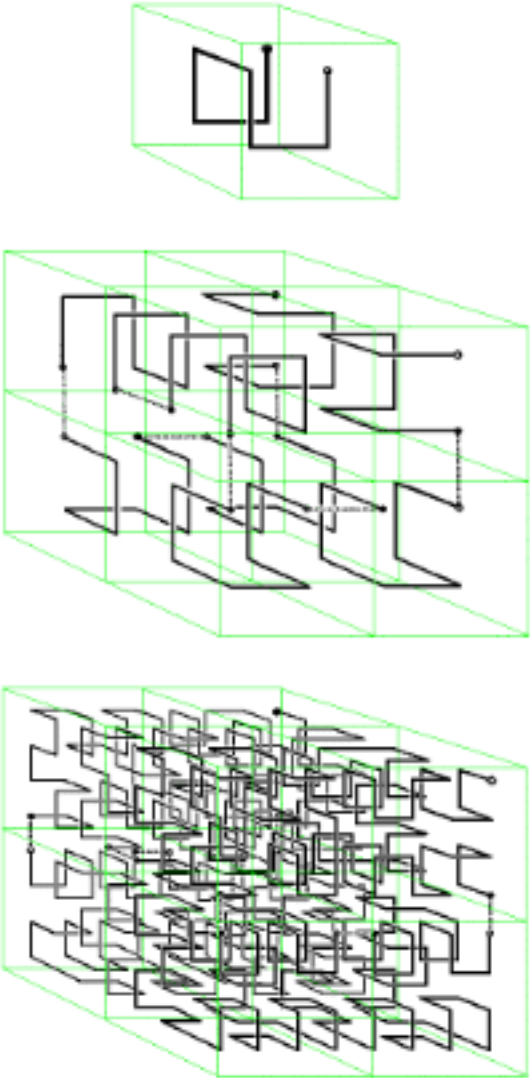
$256 = \sqrt{2^{16}} = 128 + 128$ $Cl(16)$ spinors
 128 $Cl(16)$ half-spinors = $64 + 64$ fermions + antifermions
 $120 = Cl(16)$ bivectors = D8 root vectors
 $120 + 64 + 64 = E_8$ root vectors
 $E_8 / D_8 = 128$ -dim $(OxO)P_2$ OctoOctonionic Projective Plane
 $D_8 / D_4 \times D_4 = Gr(8,16) = 64$ -dim Octonionic Subspaces of R_{16}
 (Gr = Grassmanian and R_{16} = Vectors of Clifford $Cl(16)$ Matrix Algebra for D_8)
 one D_4 contains D_3 of Conformal Gravity+Dark Energy
 other D_4 contains A_3 of Standard Model Color Force $SU(3)$
 ($CP_2 = SU(3) / SU(2) \times U(1)$ of Kaluza-Klein contains $SU(2) \times U(1)$ of Electroweak Forces)

One $Cl(16)$ containing one E_8 gives a Lagrangian description of one local spacetime neighborhood. To get a realistic global spacetime structure, take the tensor product $Cl(16) \times \dots \times Cl(16)$ with all E_8 local 8-dim Octonionic spacetimes consistently aligned as described by 64-dim $D_8 / D_4 \times D_4$ (blue dots)

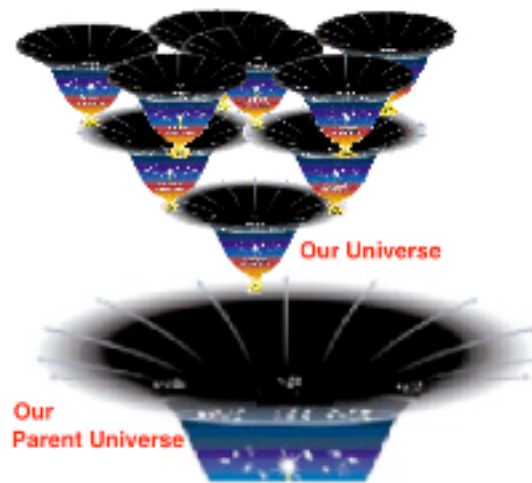
(this visualization uses a hexagonal type of projection of the 240 E_8 root vectors to 2-dim)



which then fill up spacetime according to Gray Code Hilbert's curves:



Our Universe emerged from its parent in Octonionic Inflation



As Our Parent Universe expanded to a Cold Thin State Quantum Fluctuations occurred. Most of them just appeared and disappeared as Virtual Fluctuations, but at least one Quantum Fluctuation had enough energy to produce 64 Unfoldings and reach Paola Zizzi's State of Decoherence thus making it a Real Fluctuation that became Our Universe.

As Our Universe expands to a Cold Thin State, it will probably give birth to Our Child, GrandChild, etc, Universes.

Unlike "the inflationary multiverse" described by Andrei Linde in arXiv 1402.0526 as "a scientific justification of the anthropic principle", in the $Cl(16)$ -E8 model ALL Universes (Ours, Ancestors, Descendants) have the SAME Physics Structure as E8 Physics (viXra 1312.0036 and 1310.0182)

In the $Cl(16)$ -E8 model, our SpaceTime remains Octonionic 8-dimensional throughout inflation.

Stephen L. Adler in his book Quaternionic Quantum Mechanics and Quantum Fields (1995) said 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 NonAssociativity and Non-Unitarity of Octonions accounts for particle creation without the need for a conventional inflaton field.

E8 Physics has Representation space for 8 Fermion Particles + 8 Fermion Antiparticles on the original Cl(16) E8 Local Lagrangian Region



where a Fermion Representation slot _ of the 8+8 = 16 slots can be filled

by Real Fermion Particles ■ or Real Fermion Antiparticles ■

IF the Quantum Fluctuation(QF) has enough Energy to produce them as Real and

IF the Cl(16) E8 Local Lagrangian Region has an Effective Path from its QF Energy to that Particular slot.

Let Cl(16) = Cl(8) x Cl(8) where

the first Cl(8) contains the D4 of Conformal Gravity with actions on M4 physical spacetime whose CPT symmetry determines the property matter - antimatter.

Consider, following basic ideas of Geoffrey Dixon related to his characterization of 64-dimensional spinor spaces as C x H x O (C = complex, H = quaternion, O = octonion),

64-dim 64s₊₊ = 8s₊ x 8s₊ of Cl(8) x Cl(8) = Cl(16)

and

64-dim 64s₊₋ = 8s₊ x 8s₋ of Cl(8) x Cl(8) = Cl(16)

so that

64s₊₊ + 64s₊₋ = 128s₊ are +half-spinors of Cl(16) which is in E8

Then Cl(16) contains

128-dim +half-spinor space 64s₊₊ + 64s₊₋ of Cl(16) in E8 = Fermion Generation

and

128-dim -half-spinor space 64s₋₊ + 64s₋₋ of Cl(16) not in E8 = Fermion AntiGeneration

Since E8 contains only the 128 +half-spinors and none of the 128 -half-spinors of Cl(16)

and

since, due to their +half-spinor property with respect to the first Cl(8),

the 128s₊ = 64s₊₊ + 64s₊₋ have only Effective Paths of QF Energy that go

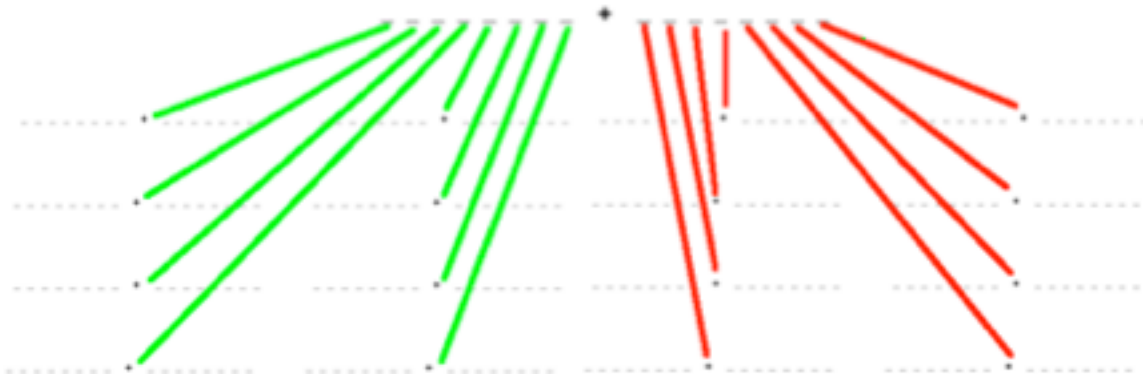
to the Fermion Particle slots that are also of type +

that is, to the 8 Fermion Particle Representation slots

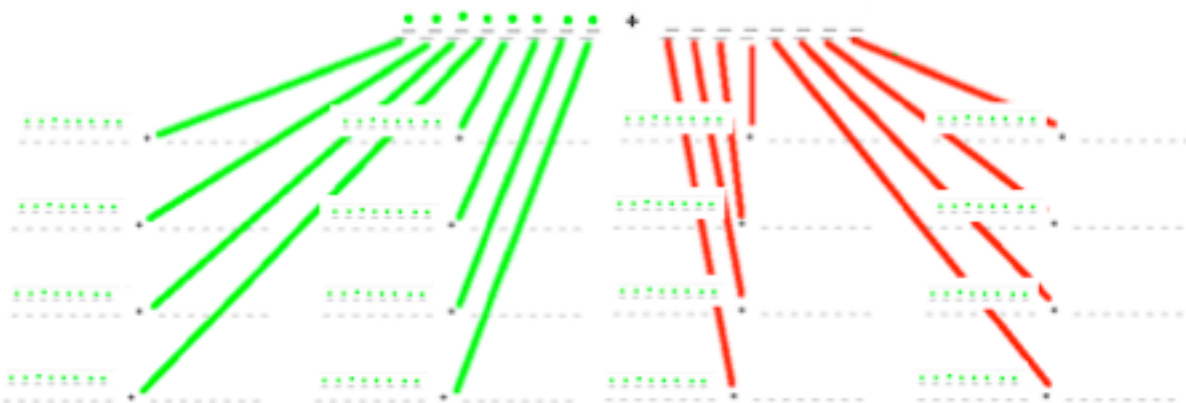


Next, consider **the first Unfolding step of Octonionic Inflation**. It is based on all 16 = 8 Fermion Particle slots + 8 Fermion Antiparticle Representation slots whether or not they have been filled by QF Energy.

7 of the 8 Fermion Particle slots correspond to the 7 Imaginary Octonions and therefore to the 7 Independent E8 Integral Domain Lattices and therefore to 7 New Cl(16) E8 Local Lagrangian Regions.
 The 8th Fermion Particle slot corresponds to the 1 Real Octonion and therefore to the 8th E8 Integral Domain Lattice (not independent - see Kirmse's mistake) and therefore to the 8th New Cl(16) E8 Local Lagrangian Region.
 Similarly, the 8 Fermion Antiparticle slots Unfold into 8 more New New Cl(16) E8 Local Lagrangian Regions, so that one Unfolding Step is a 16-fold multiplication of Cl(16) E8 Local Lagrangian Regions:



If the QF Energy is sufficient, the Fermion Particle content after the first Unfolding is is



so it is clear that **the Octonionic Inflation Unfolding Process creates Fermion Particles with no Antiparticles, thus explaining the dominance of Matter over AntiMatter in Our Universe.**

Each Unfolding has duration of the Planck Time T_{Planck} and none of the components of the Unfolding Process Components are simultaneous, so that **the total duration of N Unfoldings is $2^N T_{\text{Planck}}$.**

Paola Zizzi in gr-qc/0007006 said: "... 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 ... [$T_{\text{decoh}} = 10^9 T_{\text{Planck}} = 10^{(-34)} \text{ sec}$] ... and corresponds to a superposed state of ... [$10^{19} = 2^{64}$ qubits]. ...".

Why decoherence at 64 Unfoldings = 2^{64} qubits ?

2^{64} qubits corresponds to the Clifford algebra $Cl(64) = Cl(8 \times 8)$.

By the periodicity-8 theorem of Real Clifford algebras, $Cl(64)$ is the smallest Real Clifford algebra for which we can reflexively identify each component $Cl(8)$

with a vector in the $Cl(8)$ vector space. This reflexive identification/reduction causes our universe to decohere at $N = 2^{64} = 10^{19}$

which is roughly the number of Quantum Consciousness Tubulins in the Human Brain.

The Real Clifford Algebra $Cl(8)$ is the basic building block of Real Clifford Algebras due to 8-Periodicity whereby $Cl(8N) = Cl(8) \times \dots (N \text{ times tensor product}) \dots \times Cl(8)$

An Octonionic basis for the $Cl(8)$ 8-dim vector space is $\{1, i, j, k, E, I, J, K\}$

NonAssociativity, NonUnitarity, and Reflexivity of Octonions is exemplified by

the 1-1 correspondence between Octonion Basis Elements and $E8$ Integral Domains

$$1 \Leftrightarrow 0E8$$

$$i \Leftrightarrow 1E8$$

$$j \Leftrightarrow 2E8$$

$$k \Leftrightarrow 3E8$$

$$E \Leftrightarrow 4E8$$

$$I \Leftrightarrow 5E8$$

$$J \Leftrightarrow 6E8$$

$$K \Leftrightarrow 7E8$$

where $1E8, 2E8, 3E8, 4E8, 5E8, 6E8, 7E8$ are 7 independent Integral Domain $E8$ Lattices and $0E8$ is an 8th $E8$ Lattice (Kirmse's mistake) not closed as an Integral Domain.

Using that correspondence expands the basis $\{1, i, j, k, E, I, J, K\}$ to

$$\{0E8, 1E8, 2E8, 3E8, 4E8, 5E8, 6E8, 7E8\}$$

Each of the $E8$ Lattices has 240 nearest neighbor vectors so the total dimension of the Expanded Space is $240 \times 240 \times 240 \times 240 \times 240 \times 240 \times 240 \times 240$

Everything in the Expanded Space comes directly from the original $Cl(8)$ 8-dim space so all Quantum States in the Expanded Space can be held in Coherent Superposition.

However,

if further expansion is attempted, there is no direct connection to original $Cl(8)$ space and any Quantum Superposition undergoes Decoherence.

If each 240 is embedded reflexively into the 256 elements of $Cl(8)$ the total dimension is

$$256 \times 256 \times 256 \times 256 \times 256 \times 256 \times 256 \times 256 = 256^8 = 2^{(8 \times 8)} = 2^{64} = \\ = Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) = Cl(8 \times 8) = Cl(64)$$

so the largest Clifford Algebra that can maintain Coherent Superposition is $Cl(64)$

which is why Zizzi Quantum Inflation ends at the $Cl(64)$ level.

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

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

and

the size of our Universe was then about $10^{(-24)}$ cm

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

(see viXra 1311.0088)

End of Inflation and Low Initial Entropy in Our Universe:

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.** ...".

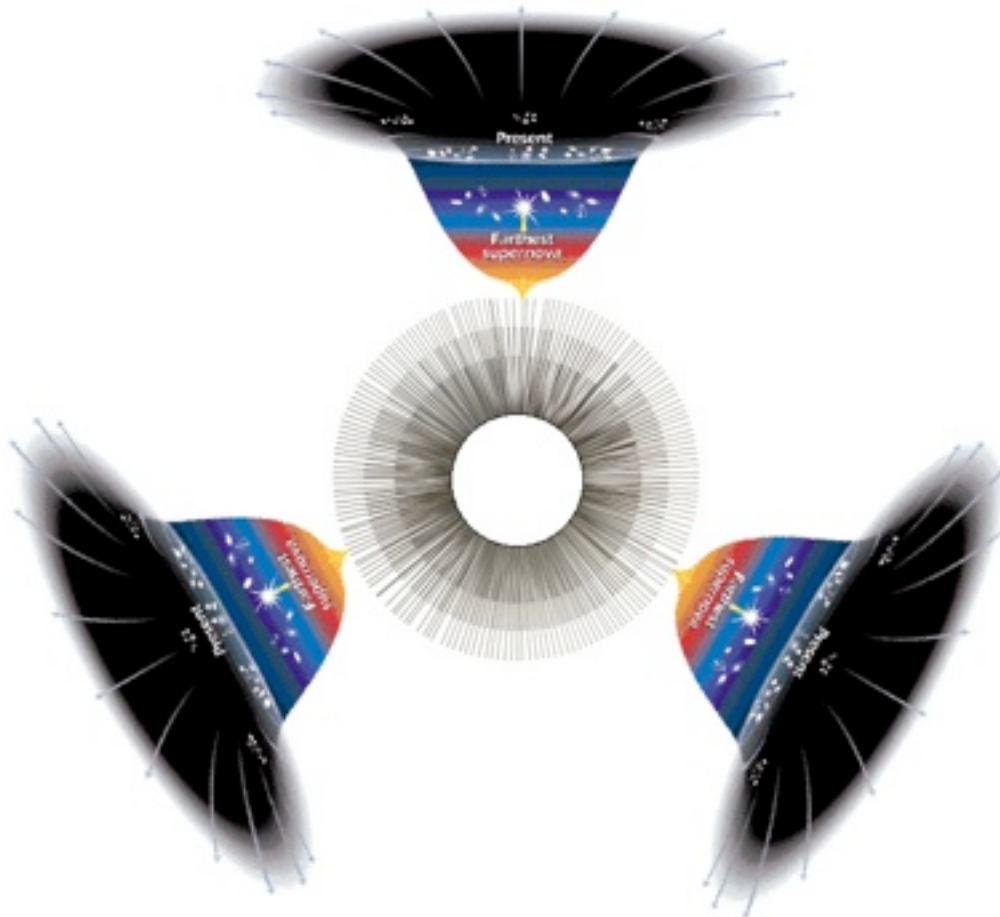
The key to solving Penrose's Puzzle is given by Paola Zizzi in gr-qc/0007006:

"... **The self-reduction of the superposed quantum state is ... reached at the end of inflation ...[at]... the decoherence time ... [$T_{\text{decoh}} = 10^9 T_{\text{planck}} = 10(-34) \text{ sec}$] ... 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 Zizzi Inflation phase of our universe ends with decoherence "collapse" of the 2^{64} Superposition Inflated Universe into Many Worlds of Quantum Theory,

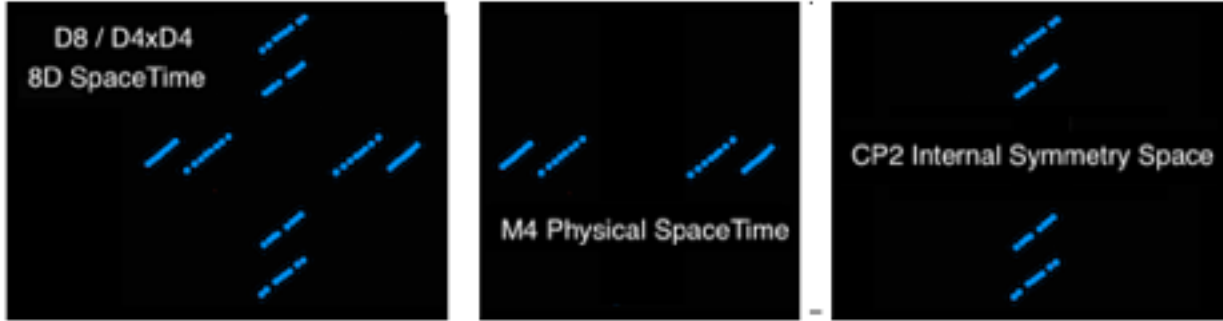


only one of which Worlds is our World. The central white circle is the Inflation Era in which everything is in Superposition; the boundary of the central circle marks the decoherence/collapse at the End of Inflation; and each line radiating from the central circle corresponds to one decohered/collapsed 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.

End of Inflation and Quaternionic Structure

In Cl(16)-E8 Physics (vixra 1405.0030) Octonionic symmetry of 8-dim spacetime is broken at the End of Non-Unitary Octonionic Inflation to Quaternionic symmetry of (4+4)-dim Kaluza-Klein M4 x CP2 physical spacetime x internal symmetry space.



Here are some details about that transition:

The basic local entity of Cl(16)-E8 Physics is
 $Cl(0,16) = Cl(1,15) = Cl(4,12) = Cl(5,11) = Cl(8,8) = M(R,256) = 256 \times 256$ Real Matrices
 which contains E8 with 8-dim Octonionic spacetime
 and is the tensor product $Cl(0,8) \times Cl(0,8) = Cl(1,7) \times Cl(1,7)$
 where $Cl(0,8) = Cl(1,7) = M(R,16)$ is the Clifford Algebra of the 8-dim spacetime.

Non-Unitary Octonionic Inflation is based on Octonionic spacetime structure with superposition of E8 integral domain lattices. At the End of Inflation the superposition ends and Octonionic 8-dim structure is replaced by Quaternionic (4+4)-dim structure.

Since $M(R,16) = M(Q,2) \times M(Q,2)$ and $M(Q,2) = Cl(1,3) = Cl(0,4)$
 $Cl(0,8) = Cl(1,7)$ can be represented as $Cl(1,3) \times Cl(0,4)$
 where
 $Cl(1,3)$ is the Clifford Algebra for M4 physical spacetime
 and
 $Cl(0,4)$ is the Clifford Algebra for $CP2 = SU(3) / U(2)$ internal symmetry space
 thus
 making explicit the Quaternionic structure of (4+4)-dim M4 x CP2 Kaluza-Klein.

Quaternionic structure similar to that of $Cl(1,3) = Cl(0,4) = M(Q,2)$ is seen in
 $Cl(2,4) = M(Q,4) = 4 \times 4$ Quaternion matrices with grading based on $4 \times 4 = 1 \quad 4 \quad 6 \quad 4 \quad 1$

$$\begin{array}{cccc}
 1 & 2 & 1 & \\
 & 4 & 8 & 4 \\
 & & 6 & 12 & 6 \\
 & & & 4 & 8 & 4 \\
 \hline
 & & & & 1 & 2 & 1 \\
 1 & 6 & 15 & 20 & 15 & 6 & 1
 \end{array}$$

Batakis Standard Model Gauge Groups and Mayer-Trautman Higgs

The Mayer-Trautman Mechanism reduces the Lagrangian integral over the 8-dim SpaceTime whose 8-Position x 8-Momentum is represented by 64-dim D8 / $D4 \times D4$ where D8 is the Adjoint part of E8.

$$\int_{\text{8-dim SpaceTime}} \text{Gauge Gravity} + \text{Standard Model} + \text{Fermion Particle-AntiParticle}$$

to

a Lagrangian integral over the 4-dim M4 Minkowski Physical SpaceTime part of Kaluza-Klein $M4 \times CP2$

$$\int_{\text{4-dim M4}} \text{GG} + \text{SM} + \text{Fermion Particle-AntiParticle} + \text{Higgs}$$

by integrating out the Lagrangian Density over the $CP2$ Internal Symmetry Space and so creating a new Higgs term in the Lagrangian Density integrated only over $M4$.

Since the $D4 = U(2,2)$ of Gauge Gravity acts on the $M4$, there is no problem with it.

As to the $D4 = U(4)$ of the Standard Model, $U(4)$ contains as a subgroup color $SU(3)$ which is also the global symmetry group of the $CP2 = SU(3) / SU(2) \times U(1)$ Internal Symmetry Space of $M4 \times CP2$ Kaluza-Klein SpaceTime.

A. Batakis in Class. Quantum Grav. 3 (1986) L99-L105 said:

“... In a standard Kaluza-Klein framework, $M4 \times CP2$ allows the classical unified description of an $SU(3)$ gauge field with gravity ...

[and]

the possibility of an additional $SU(2) \times U(1)$ gauge field structure is uncovered. ...”.

Since the $CP2 = SU(3) / U(2)$ has global $SU(3)$ action, the $SU(3)$ can be considered as a local gauge group acting on the $M4$, so there is no problem with it.

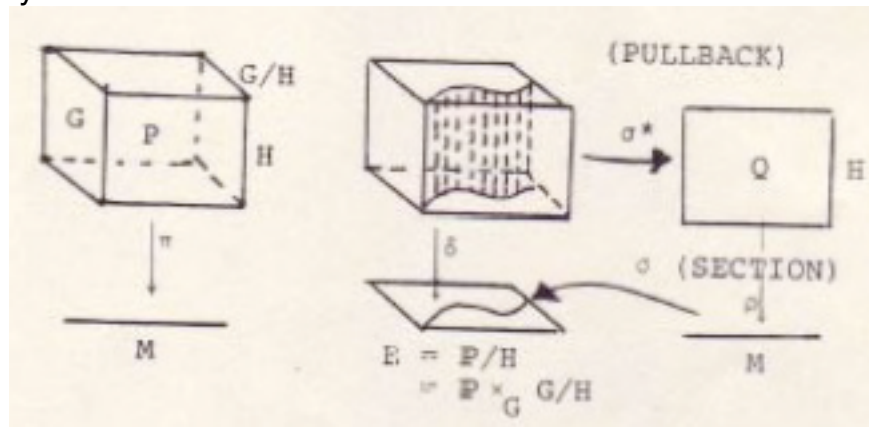
However, the $U(2)$ acts on the $CP2 = SU(3) / U(2)$ as little group, and so has local action on $CP2$ and then on $M4$, so **the local action of $U(2)$ on $CP2$ must be integrated out to get the desired $U(2) = SU(2) \times U(1)$ local action directly on $M4$.**

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 [M^4] with values in H [$SU(2)$] ... the remaining components will be subjected to symmetry and gauge transformations, thus reducing the Yang-Mills action ...[on $M^4 \times CP^2$]... to a Yang-Mills-Ginzburg-Landau action on M [M^4] ... 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 [M^4] (spacetime) and those along directions tangent to G/H [CP^2] .

We denote the former components by $F_{!!}$ and the latter by $F_{??}$, whereas the mixed components (one along M , the other along G/H) will be denoted by $F_{!?$...

Then the integrand ... becomes

$$\text{Tr} (F_{!!} F^{!!} + 2 F_{! ?} F^{! ?} + F_{??} F^{??})$$

...

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

...

the middle term .. becomes, symbolically,
 $\text{Tr} \sum D_{\mu} \Phi D^{\mu} \Phi$

where Φ is the Lie-algebra-valued 0-form corresponding to the invariance of A with respect to the vector field ξ , 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]

$$2 F_{\mu\nu} = [\Phi_{,\mu}, \Phi_{,\nu}] - \Phi_{,[\mu, \nu]}$$

... Thus,

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

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

...

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 ...

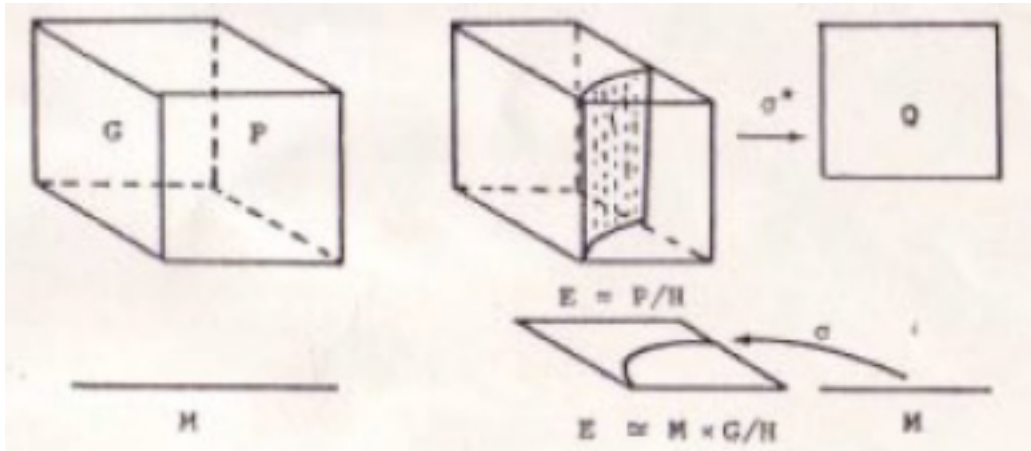
The curvature form Ω of the K -invariant connection defined by $\Lambda_{\mathfrak{m}}$ satisfies the following condition:

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

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. ...”.

Fock - Hua - Wolf - Schwinger - Wyler Quantum Theory

Fock (1931) showed that Fundamental Quantum Theory requires Linear Operators “... represented by a definite integral [of a]... kernel ... function ...”.

Hua (1958) showed Kernel Functions for Complex Classical Domains.

Schwinger (1951 - see Schweber, PNAS 102, 7783-7788) “... introduced a description in terms of Green’s functions, what Feynman had called propagators ... The Green’s functions are vacuum expectation values of time-ordered Heisenberg operators, and the field theory can be defined non-perturbatively in terms of these functions ...[which]... gave deep structural insights into QFTs; in particular ... the structure of the Green’s functions when their variables are analytically continued to complex values ...”.

Wolf (J. Math. Mech 14 (1965) 1033-1047) showed that the Classical Domains (complete simply connected Riemannian symmetric spaces) representing 4-dim Spacetime with Quaternionic Structure are:

$S^1 \times S^1 \times S^1 \times S^1 = 4$ copies of $U(1)$

$S^2 \times S^2 = 2$ copies of $SU(2)$

$CP^2 = SU(3) / SU(2) \times U(1)$

$S^4 = Spin(5) / Spin(4) =$ Euclidean version of $Spin(2,3) / Spin(1,3)$

Armand Wyler (1971 - C. R. Acad. Sc. Paris, t. 271, 186-188) showed how to use **Green’s Functions = Kernel Functions** of Classical Domain structures characterizing **Sources = Leptons, Quarks, and Gauge Bosons,** to calculate Particle Masses and Force Strengths (see also viXra 1405.0030).

Schwinger (1969 - see physics/0610054) said: “... operator field theory ... replace[s] the particle with ... properties ... distributed throughout ... small volumes of three-dimensional space ... particles ... must be created ... even though we vary a number of experimental parameters ... The properties of the particle ... remain the same ... We introduce a quantitative description of the particle source in terms of a source function ... we do not have to claim that we can make the source arbitrarily small ... the experimenter... must detect the particles ...[by]... collision that annihilates the particle ... the source ... can be ... an abstraction of an annihilation collision, with the source acting negatively, as a sink ... The basic things are ... the source functions ... describing the intermediate propagation of the particle ...”.

Creation and Annihilation operators indicate a Clifford Algebra, and 8-Periodicity shows that the basic Clifford Algebra is formed by tensor products of 256-dim $Cl(8)$ such as $Cl(8) \times Cl(8) = Cl(16)$ containing 248-dim $E_8 = 120$ -dim $D_8 + 128$ -dim D_8 half-spinor whose maximal contraction is a realistic generalized Heisenberg Algebra

$$h_{92} \times A_7 = 5\text{-graded } 28 + 64 + ((SL(8,R)+1) + 64 + 28$$

(see viXra 1507.0069 and 1405.0030)

**Schwinger Sources with inherited Monster Group Symmetry
have
Kerr-Newman Black Hole structure size about $10^{(-24)}$ cm
and
Geometry of Bounded Complex Domains and Shilov boundaries**

The $CI(16)$ -E8 model Lagrangian over 4-dim Minkowski SpaceTime M4 is

$$\int_{4\text{-dim M4}} GG + SM + \text{Fermion Particle-AntiParticle} + \text{Higgs}$$

Consider the **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. 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.

The $CI(16)$ -E8 model does not put in the mass m in an ad hoc way, but constructs the Lagrangian integral such that the mass m emerges naturally from the geometry of the spinor fermions by setting the spinor fermion mass term as the volume of the Schwinger Source Fermions.

Effectively the integral over the Schwinger Source spacetime region of its Kerr-Newman cloud of virtual particle/antiparticle pairs plus the valence fermion gives the volume of the Schwinger Source fermion and defines its mass, which, since it is dressed with the particle/antiparticle pair cloud, gives quark mass as constituent mass.

The $CI(16)$ -E8 model constructs the Lagrangian integral such that the mass m emerges as the integral over the Schwinger Source spacetime region of its Kerr-Newman cloud of virtual particle/antiparticle pairs plus the valence fermion so that the volume of the Schwinger Source fermion defines its mass, which, being dressed with the particle/antiparticle pair cloud, gives quark mass as constituent mass.

Fermion Schwinger Sources correspond to the Lie Sphere Symmetric space
 $Spin(10) / Spin(8) \times U(1)$
 which has local symmetry of the $Spin(8)$ gauge group
 from which the first generation spinor fermions are formed as **+half-spinor** and **-half-spinor** spaces
 and
 Bounded Complex Domain D8 of type IV8 and Shilov Boundary Q8 = $RP^1 \times S^7$

Consider the **GG + SM term** from Gauge Gravity and Standard Model Gauge Bosons. The process of breaking Octonionic 8-dim SpaceTime down to Quaternionic (4+4)-dim M4 x CP2 Kaluza-Klein creates differences in the way gauge bosons "see" 4-dim Physical SpaceTime

There 4 equivalence classes of 4-dimensional Riemannian Symmetric Spaces with Quaternionic structure consistent with 4-dim Physical SpaceTime:

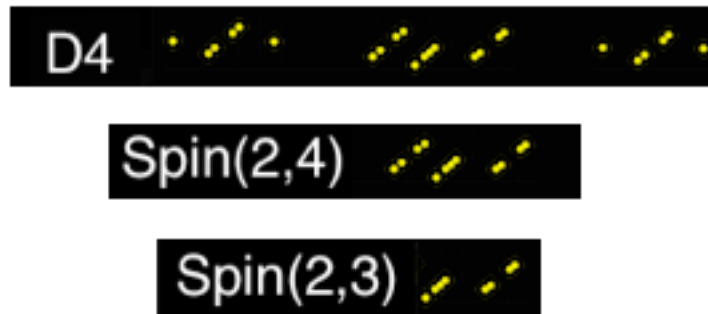
S4 = 4-sphere = Spin(5) / Spin(4) where Spin(5) = Schwinger-Euclidean version of the Anti-DeSitter subgroup of the Conformal Group that gives **MacDowell-Mansouiri Gravity**

CP2 = complex projective 2-space = SU(3) / U(2) with **the SU(3) of the Color Force**

S2 x S2 = SU(2)/U(1) x SU(2)/U(1) with two copies of **the SU(2) of the Weak Force**

S1 x S1 x S1 x S1 = U(1) x U(1) x U(1) x U(1) = 4 copies of **the U(1) of the EM Photon**
(1 copy for each of the 4 covariant components of the Photon)

The Gravity Gauge Bosons (Schwinger-Euclidean versions) live in a Spin(5) subalgebra of the Spin(6) Conformal subalgebra of D4 = Spin(8).



They "see" M4 Physical spacetime as the 4-sphere S4 so that their part of the Physical Lagrangian is

$$\int_{S4} \text{Gravity Gauge Boson Term}$$

an integral over SpaceTime S4.

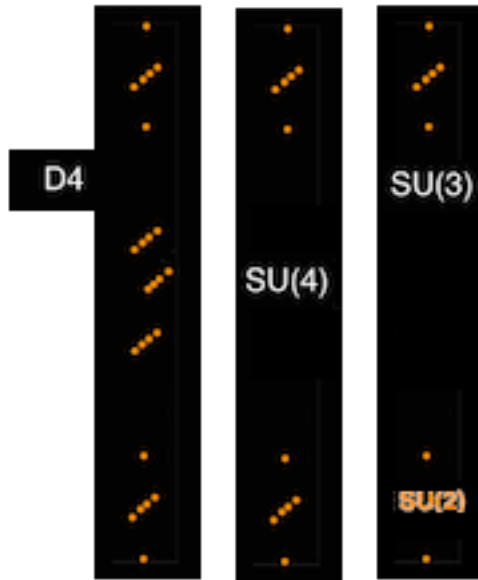
The Schwinger Sources for GRb bosons are the Complex Bounded Domains and Shilov Boundaries for Spin(5) MacDowell-Mansouri Gravity bosons.

However, due to Stabilization of Condensate SpaceTime by virtual Planck Mass Gravitational Black Holes,

for Gravity, the effective force strength that we see in our experiments is not just composed of the S4 volume and the Spin(5) Schwinger Source volume, but is suppressed by the square of the Planck Mass.

The unsuppressed Gravity force strength is the Geometric Part of the force strength.

The Standard Model SU(3) Color Force bosons live in a SU(3) subalgebra of the SU(4) subalgebra of D4 = Spin(8).



They "see" M4 Physical spacetime as the complex projective plane CP2 so that their part of the Physical Lagrangian is

$$\int_{\text{CP2}} \text{SU(3) Color Force Gauge Boson Term}$$

an integral over SpaceTime CP2.

The Schwinger Sources for SU(3) bosons are the Complex Bounded Domains and Shilov Boundaries for SU(3) Color Force bosons.

The Color Force Strength is given by the SpaceTime CP2 volume and the SU(3) Schwinger Source volume.

Note that since the Schwinger Source volume is dressed with the particle/antiparticle pair cloud, the calculated force strength is for the characteristic energy level of the Color Force (about 245 MeV).

The Standard Model SU(2) Weak Force bosons live in a SU(2) subalgebra of the U(2) local group of CP2 = SU(3) / U(2). They "see" M4 Physical spacetime as two 2-spheres S2 x S2 so that their part of the Physical Lagrangian is

$$\int_{S^2 \times S^2} \text{SU(2) Weak Force Gauge Boson Term}$$

an integral over SpaceTime S2xS2.

The Schwinger Sources for SU(2) bosons are the Complex Bounded Domains and Shilov Boundaries for SU(2) Weak Force bosons.

However, due to the action of the Higgs mechanism, for the Weak Force, the effective force strength that we see in our experiments is not just composed of the S2xS2 volume and the SU(2) Schwinger Source volume, but is suppressed by the square of the Weak Boson masses.

The unsuppressed Weak Force strength is the Geometric Part of the force strength.

The Standard Model U(1) Electromagnetic Force bosons (photons) live in a U(1) subalgebra of the U(2) local group of CP2 = SU(3) / U(2). They "see" M4 Physical spacetime as four 1-sphere circles S1xS1xS1xS1 = T4 (T4 = 4-torus) so that their part of the Physical Lagrangian is

$$\int_{T^4} \text{(U(1) Electromagnetism Gauge Boson Term)}$$

an integral over SpaceTime T4.

The Schwinger Sources for U(1) photons

are the Complex Bounded Domains and Shilov Boundaries for U(1) photons.

The Electromagnetic Force Strength is given by

the SpaceTime T4 volume and the U(1) Schwinger Source volume.

Schwinger Sources as described above are continuous manifold structures of Bounded Complex Domains and their Shilov Boundaries but

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

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

When a fermion particle/antiparticle appears in E8 spacetime it does not remain a single Planck-scale entity because Tachyons create a cloud of particles/antiparticles. The cloud is one Planck-scale Fundamental Fermion Valence Particle plus an effectively neutral cloud of particle/antiparticle pairs forming a Kerr-Newman black hole.

That cloud constitutes the Schwinger Source.

Its structure comes from the 24-dim Leech lattice part of the Monster Group which is $2^{(1+24)}$ times the double cover of Co_1 , for a total order of about 10^{26} .

(Since a Leech lattice is based on copies of an E8 lattice and since there are 7 distinct E8 integral domain lattices there are 7 (or 8 if you include a non-integral domain E8 lattice) distinct Leech lattices. The physical Leech lattice is a superposition of them, effectively adding a factor of 8 to the order.)

The volume of the Kerr-Newman Cloud is on the order of 10^{27} x Planck scale, so the Kerr-Newman Cloud should contain about 10^{27} particle/antiparticle pairs and its size should be about $10^{(27/3)} \times 1.6 \times 10^{(-33)}$ cm =
= roughly $10^{(-24)}$ cm.

Force Strength and Boson Mass Calculation

Cl(8) bivector Spin(8) is the D4 Lie algebra two copies of which are in the Cl(16)-E8 model Lagrangian (as the D4xD4 subalgebra of the D8 subalgebra of E8)

$$\int_{4\text{-dim } M4} GG + SM + \text{Fermion Particle-AntiParticle} + \text{Higgs}$$

with the Higgs term coming from integrating over the CP2 Internal Symmetry Space of M4 x CP2 Kaluza-Klein by the Mayer-Trautman Mechanism

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.

The 4-dim spacetime Lagrangian **GG SM** 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) subgroup of Conformal Spin(2,4) for gravity by the MacDowell-Mansouri mechanism.

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.

The Cl(16)-E8 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 strengths.

Each gauge group is the global symmetry of a symmetric space

S^1 for U(1)
 $S^2 = SU(2)/U(1) = Spin(3)/Spin(2)$ for SU(2)
 $CP^2 = SU(3)/SU(2) \times U(1)$ for SU(3)
 $S^4 = Spin(5)/Spin(4)$ for Spin(5)

Each gauge group is the local symmetry of a symmetric space

U(1) for itself
SU(2) for Spin(5) / $SU(2) \times U(1)$
SU(3) for SU(4) / $SU(3) \times U(1)$
Spin(5) for Spin(7) / $Spin(5) \times U(1)$

The nontrivial local symmetry symmetric spaces correspond to bounded complex domains

SU(2) for Spin(5) / $SU(2) \times U(1)$ corresponds to IV3
SU(3) for SU(4) / $SU(3) \times U(1)$ corresponds to B^6 (ball)
Spin(5) for Spin(7) / $Spin(5) \times U(1)$ corresponds to IV5

The nontrivial bounded complex domains have Shilov boundaries

SU(2) for Spin(5) / $SU(2) \times U(1)$ corresponds to IV3 Shilov = $RP^1 \times S^2$
SU(3) for SU(4) / $SU(3) \times U(1)$ corresponds to B^6 (ball) Shilov = S^5
Spin(5) for Spin(7) / $Spin(5) \times U(1)$ corresponds to IV5 Shilov = $RP^1 \times S^4$

Very roughly, think of the force strength as
integral over global symmetry space of physical (ie Shilov Boundary) volume =
= strength of the force.

That is:

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
the gravity Volume product is normalized to be 1, and so (approximately):

$$\begin{aligned}\text{Volume product for gravity} &= 1 \\ \text{Volume product for color} &= 2/3 \\ \text{Volume product for weak} &= 1/4 \\ \text{Volume product for electromagnetism} &= 1/137\end{aligned}$$

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:

Gravity as curvature deformation of SpaceTime, with SpaceTime as a condensate of
Planck-Mass Black Holes, must be carried by virtual Planck-mass black holes,
so that the geometric strength of gravity should be reduced by $1/M_p^2$

The weak force is carried by weak bosons,
so that the geometric strength of the weak force should be reduced by $1/M_W^2$

That gives the result (approximate):

$$\begin{aligned}\text{gravity strength} &= G \text{ (Newton's } G\text{)} \\ \text{color strength} &= 2/3 \\ \text{weak strength} &= G_F \text{ (Fermi's weak force } G\text{)} \\ \text{electromagnetism} &= 1/137\end{aligned}$$

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 less approximate more detailed force strength calculations:

The force strength of a given force is

$$\text{alphaforce} = (1 / \text{Mforce}^2) (\text{Vol}(\text{MISforce})) (\text{Vol}(\text{Qforce}) / \text{Vol}(\text{Dforce})^{(1 / \text{mforce})})$$

where:

alphaforce represents the force strength;

Mforce represents the effective mass;

MISforce represents the relevant part of the target Internal Symmetry Space;

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

Qforce represents the link from the origin to the relevant target for the gauge boson;

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 SpaceTime),

1 for Electromagnetism (which therefore is considered to have four copies of QE for SpaceTime)

$\text{Vol}(\text{Dforce})^{(1 / \text{mforce})}$ 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:

Spin(5)	Spin(7) / Spin(5)xU(1)	IV5	4	RP ¹ xS ⁴
SU(3)	SU(4) / SU(3)xU(1)	B ⁶ (ball)	4	S ⁵
SU(2)	Spin(5) / SU(2)xU(1)	IV3	2	RP ¹ xS ²
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 [unit radius scale].

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

Note (thanks to Carlos Castro for noticing this) also that the volume listed for CP^2 is unconventional, but physically justified by noting that S^4 and CP^2 can be seen as having the same physical volume, with the only difference being structure at infinity.

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	$8\pi^2/3$	$RP^1 \times S^4$	$8\pi^3/3$	IV_5	$\pi^5/2^4 5!$
color	CP^2	$8\pi^2/3$	S^5	$4\pi^3$	$B^6(\text{ball})$	$\pi^3/6$
Weak	$S^2 \times S^2$	$2 \times 4\pi$	$RP^1 \times S^2$	$4\pi^2$	IV_3	$\pi^3/24$
e-mag	T^4	$4 \times 2\pi$	-	-	-	-

Note (thanks to Carlos Castro for noticing this) that the volume listed for S^5 is for a squashed S^5 , a Shilov boundary of the complex domain corresponding to the symmetric space $SU(4) / SU(3) \times U(1)$.

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

Spin(5)	gravity	approx 10^{19} GeV	1	$G G m_{\text{proton}}^2$ approx 5×10^{-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 1.05×10^{-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

Higgs:

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 Cl(16)-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 therefore the electron mass will 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, i

n the notation of quant-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 λ in the Lagrangian is not the coupling constant, the latter will change after quantization ... The invariant meaning of λ 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 that $\lambda = (\cos(\pi / 6))^2 = 0.866^2$ (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

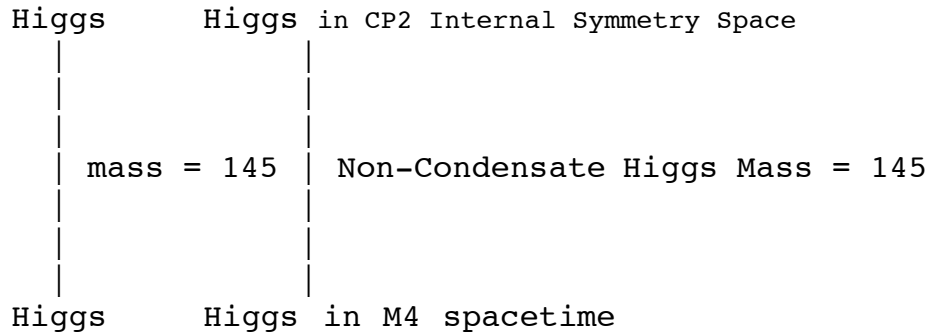
$$M_H^2 / v^2 = (\cos(\pi / 6))^2 / 3$$

In the Cl(16)-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 is set to be 252.514 GeV so that

$$M_H = v \cos(\pi / 6) / \sqrt{3} = 126.257 \text{ GeV}$$

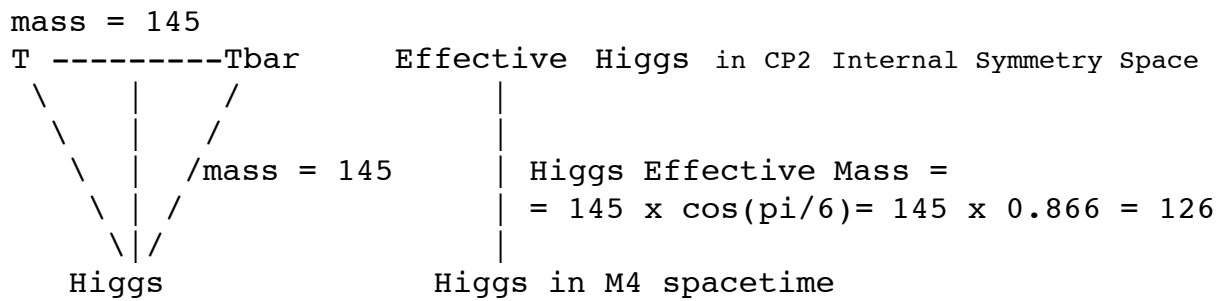
This is the value of the Low Mass State of the Higgs observed by the LHC. Middle and High Mass States come from a Higgs-Tquark Condensate System. The Middle and High Mass States may have been observed by the LHC at 20% of the Low Mass State cross section, and that may be confirmed by the LHC 2015-1016 run.

A Non-Condensate Higgs is represented by a Higgs at a point in M4 that is connected to a Higgs representation in CP2 ISS by a line whose length represents the Higgs mass



and the value of lambda is $1 = 1^2$
 so that the Higgs mass would be $M_H = v / \sqrt{3} = 145.789 \text{ GeV}$

However, in the $Cl(16)$ -E8 model, the Higgs has structure of a Tquark condensate



in which the Higgs at a point in M4 is connected to a T and Tbar in CP2 ISS so that the vertices of the Higgs-T-Tbar system are connected by lines forming an equilateral triangle composed of 2 right triangles (one from the CP2 origin to the T and to the M4 Higgs and another from the CP2 origin to the Tbar and to the M4 Higgs).

In the T-quark condensate picture
 $\lambda = 1^2 = \lambda(T) + \lambda(H) = (\sin(\pi / 6))^2 + (\cos(\pi / 6))^2$
 and
 $\lambda(H) = (\cos(\pi / 6))^2$

Therefore the Effective Higgs mass observed by LHC is:

$$\text{Higgs Mass} = 145.789 \times \cos(\pi/6) = 126.257 \text{ GeV.}$$

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

$$M_{W_+} = M_{W_-} = 80.326 \text{ GeV and } M_{W_0} = 98.379 \text{ GeV.}$$

The charged W_{\pm} neutrino-electron interchange must be symmetric
 with the electron-neutrino interchange, so that the tree-level absence
 of right-handed neutrino particles requires that

the charged W_{\pm} 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_{\pm} 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_{\pm} 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_{\pm} .

Since the mass of the W_0 is greater than the mass of the W_{\pm} , 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 $(M_{W_{\pm}}^2 / M_{W_0}^2)$ acting on left-handed fermions and $(1 - (M_{W_{\pm}}^2 / M_{W_0}^2))$ acting on both types of fermions.

If $(1 - (M_{W_{\pm}}^2 / M_{W_0}^2))$ is defined to be $\sin(\theta_w)^2$ and denoted by K , and if the strength of the W_{\pm} 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 $W_0LR = K$.

Since the W_0 acts as W_0L with respect to the parity violating $SU(2)$ weak force and as W_0LR with respect to the parity conserving $U(1)$ electromagnetic force, the W_0 mass m_{W_0} has two components: the parity violating $SU(2)$ part m_{W_0L} that is equal to $M_{W_{\pm}}$ and the parity conserving part M_{W_0LR} that acts like a heavy photon.

As $M_{W_0} = 98.379 \text{ GeV} = M_{W_0L} + M_{W_0LR}$, and as $M_{W_0L} = M_{W_{\pm}} = 80.326 \text{ GeV}$, we have $M_{W_0LR} = 18.053 \text{ GeV}$.

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 α_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 α_E force.

Therefore

$$\begin{aligned} *alphaE &= alphaE (\sqrt{ 2 } / \sqrt{ 3 })(2 / 4) = alphaE / \sqrt{ 6 } , \\ *e &= e / (4th \text{ root of } 6) = e / 1.565 , \end{aligned}$$

and

the mass mW0LR must be reduced to an effective value

$$M_W0LReff = M_W0LR / 1.565 = 18.053/1.565 = 11.536 \text{ GeV}$$

for the *alphaE force to act like an electromagnetic force in the E8 model:

$$*e M_W0LR = e (1/5.65) M_W0LR = e M_Z0,$$

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

Therefore, the correct Cl(16)-E8 model values for weak boson masses and the Weinberg angle theta_w are:

$$M_W+ = M_W- = 80.326 \text{ GeV};$$

$$M_Z0 = 80.326 + 11.536 = 91.862 \text{ GeV};$$

$$\text{Sin}(\text{theta}_w)^2 = 1 - (M_W+/- / M_Z0)^2 = 1 - (6452.2663 / 8438.6270) = 0.235.$$

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

2nd and 3rd Generation Fermions

The 8 First Generation Fermion Particles

can each be represented by the 8 basis elements $\{1,i,j,k,E,I,J,K\}$ of the Octonions O

$1 \Leftrightarrow$ e-neutrino

$i \Leftrightarrow$ red down quark

$j \Leftrightarrow$ green down quark

$k \Leftrightarrow$ blue down quark

$E \Leftrightarrow$ electron

$I \Leftrightarrow$ red up quark

$J \Leftrightarrow$ green up quark

$K \Leftrightarrow$ blue up quark

with AntiParticles being represented similarly.

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 $OxOxO$.

Combinatorics contributes to Fermion mass ratios. For example:

Blue Down Quark is 1 out of 8 and Blue Up Quark is 1 out of 8
so the Down Quark : Up Quark mass ratio is 1 : 1

Blue Strange Quark is 3 out of $8 \times 8 = 64$ and Blue Charm Quark is 17 out of $8 \times 8 = 64$
so the Strange Quark : Charm Quark mass ratio is 3 : 17

Blue Beauty Quark is 7 out of $8 \times 8 \times 8 = 512$ and Blue Truth Quark is 161 out of $8 \times 8 \times 8 = 512$
so the Beauty Quark : Truth Quark mass ratio is 7 : 161

Fermion Mass Calculations

In the Cl(16)-E8 model, the first generation spinor fermions are seen as +half-spinor and -half-spinor spaces of $Cl(1,7) = Cl(8)$. 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.

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 $Spin(10) / Spin(8) \times U(1)$ corresponding to a bounded domain of type IV8 whose Shilov boundary is $RP^1 \times S^7$

Since all 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. Cl(16)-E8 model fermions correspond to Schwinger Source Kerr-Newman Black Holes, so the quark mass in the Cl(16)-E8 model is a constituent mass.

Fermion masses are calculated as a product of four factors:

$$V(Qfermion) \times N(Graviton) \times N(octonion) \times Sym$$

$V(Qfermion)$ is the volume of the part of the half-spinor fermion particle manifold $S^7 \times RP^1$ related to the fermion particle by photon, weak boson, or gluon interactions.

$N(Graviton)$ is the number of types of Spin(0,5) graviton related to the fermion. The 10 gravitons correspond to the 10 infinitesimal generators of $Spin(0,5) = Sp(2)$. 2 of them are in the Cartan subalgebra.

6 of them carry color charge, and therefore correspond 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 $6/1 = 6$.

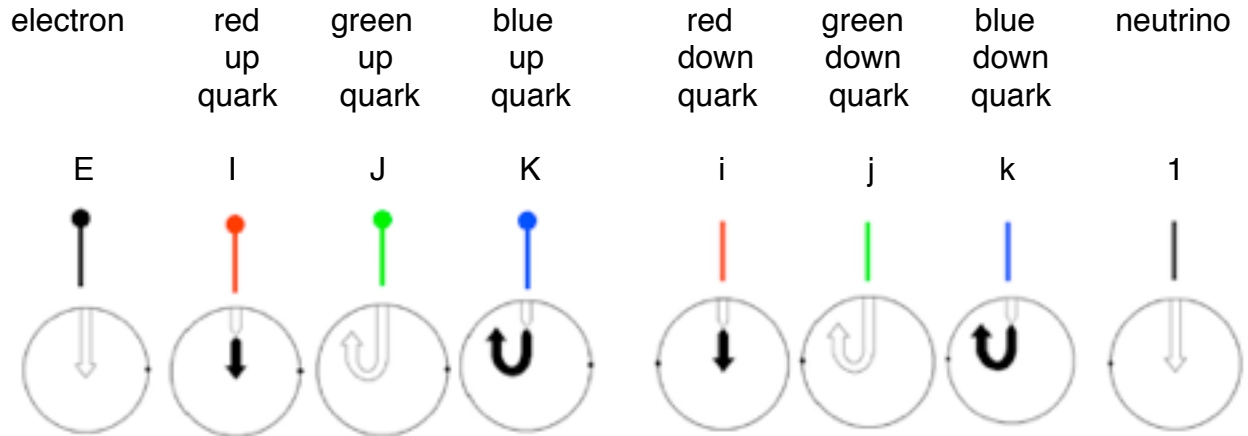
$N(octonion)$ is an octonion number factor relating up-type quark masses to down-type quark masses in each generation.

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.

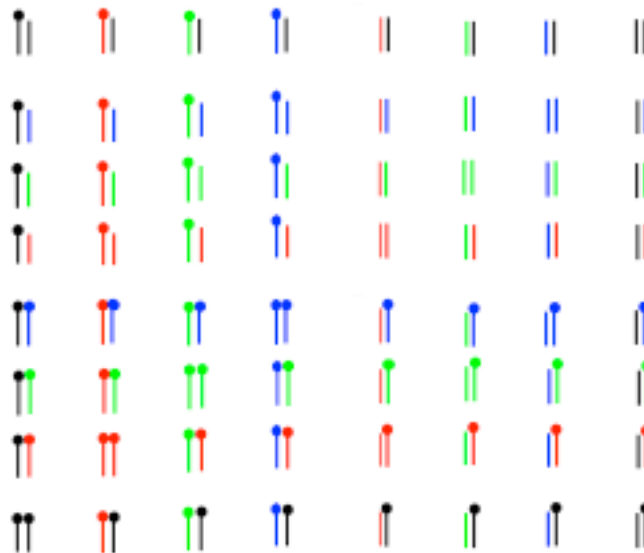
3 Generation Fermion Combinatorics

First Generation (8)

(geometric representation of Octonions is from arXiv 1010.2979)



Second Generation (64)



Mu Neutrino (1)

Rule: a Pair belongs to the Mu Neutrino if:
 All elements are Colorless (black)
 and all elements are Associative

(that is, is 1 which is the only Colorless Associative element) .

Muon (3)

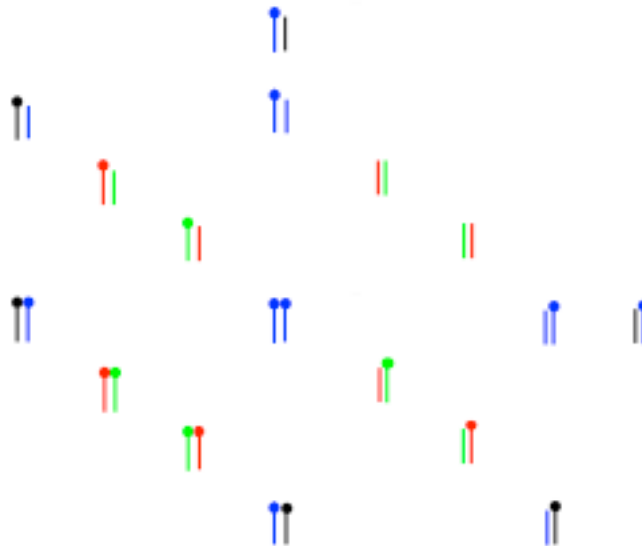
Rule: a Pair belongs to the Muon if:
All elements are Colorless (black)
and at least one element is NonAssociative
(that is, is E which is the only Colorless NonAssociative element).

Blue Strange Quark (3)

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

Blue Charm Quark (17)

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



(Red and Green Strange and Charm Quarks follow similar rules)

Third Generation (512)

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Tau Neutrino (1)

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

Tauon (7)

Rule: a Triple belongs to the Tauon if:
 All elements are Colorless (black)
 and at least one element is NonAssociative (that is, is E which is the only Colorless NonAssociative element)

Blue Beauty Quark (7)

Rule: a Triple belongs to the Blue Beauty Quark if:

There is at least one Blue element and all other elements are Blue or Colorless (black) and all elements are Associative (that is, is either 1 or i or j or k).

Blue Truth Quark (161)

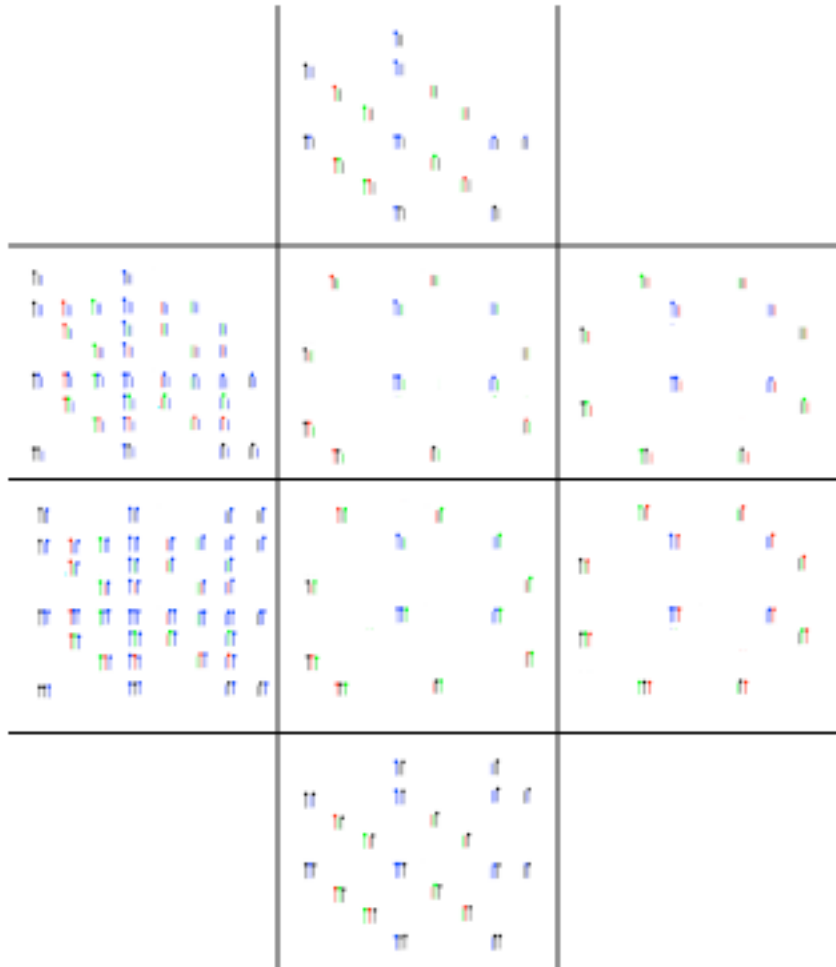
Rules: a Triple belongs to the Blue Truth Quark if:

1 - There is at least one Blue element and all other elements are Blue or Colorless (black)

and at least one element is NonAssociative (that is, is either E or I or J or K)

2 - There is one Red element and one Green element and the other element is Colorless (Red x Green = Blue)

3 - The Triple has one element each that is Red, Green, or Blue, in which case the color of the Third element (for Third Generation) is determinative and must be Blue.



(Red and Green Beauty and Truth Quarks follow similar rules)

The first generation down quark constituent mass : electron mass ratio is:

The electron, E, can only be taken into the tree-level-massless neutrino, 1, by photon, weak boson, and gluon interactions.

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 i.

By gluon interactions, i can be taken into j and k, the blue and green down quarks.

By also using weak boson interactions,

it can also be taken into l, 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 all parts of $S^7 \times RP^1$,

the compact manifold corresponding to $\{ 1, i, j, k, E, l, J, K \}$

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

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

Since the first generation graviton factor is 6,

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

As the up quarks correspond to l, J, and K, which are the octonion transforms under E of i, j, and k 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:

$$\Sigma_{\text{maf1}} = 1.877 \text{ GeV}$$

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

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

which 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:

$\{ E, E, E \}$
 $\{ E, E, 1 \}$
 $\{ E, 1, E \}$
 $\{ 1, E, E \}$
 $\{ 1, 1, E \}$
 $\{ 1, E, 1 \}$
 $\{ E, 1, 1 \}$

The symmetry of the 7 tauon triples is the same as the symmetry of the first generation tree-level-massive fermions, 3 down, quarks, the 3 up quarks, and the electron, so by the Sym factor the tauon mass should be the same as the sum of the masses of the first generation massive fermion particles.

Therefore the tauon mass is calculated at tree level as 1.877 GeV.

The 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 at which 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.

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 involving 1 and E,
but for 1 and I, 1 and J, and 1 and K,
which correspond to the red, green, and blue beauty quarks,
respectively.

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

The red beauty quark constituent mass should be the tauon mass times
the third generation graviton factor $6/2 = 3$,
so the red beauty quark mass is $m_b = 5.63111$ GeV.

The blue and green beauty quarks are similarly determined to also be 5.63111 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 α_s is known.
The conventional value of α_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 ± 0.25 (stat) ± 0.34 (frag) ± 0.27 (theo).

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 α_s at about 5 GeV is about 0.166, while the conventional value of the color force strength constant α_s at about 5 GeV is about 0.216, and the theoretical model calculated value of the color force strength constant α_s at about 90 GeV is about 0.106, while the conventional value of the color force strength constant α_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 α_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.

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

The blue and green truth quarks are similarly determined to also be 129.5155 GeV.

This is the value of the Low Mass State of the Truth calculated in the Cl(16)_E8 model. The Middle Mass State of the Truth Quark has been observed by Fermilab since 1994. The Low and High Mass States of the Truth Quark have, in my opinion, also been observed by Fermilab (see Chapter 17 of this paper) but the Fermilab and CERN establishments disagree.

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 $v = 252.514$ GeV), including the Higgs scalar mass and Truth quark mass, are calculated (not assumed) masses in the Cl(16)-E8 model. These results when added up give a total mass of third generation fermion particles:

$$\mathbf{\Sigma_{maf3} = 1,629 \text{ GeV}}$$

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.

For the Sym factor, 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, $m_{\mu} = 104.76$ MeV .

According to the 1998 Review of Particle Physics of the Particle Data Group, the experimental muon mass is about 105.66 MeV which may be consistent with radiative corrections for the calculated tree-level $m_{\mu} = 104.76$ MeV as Bailin and Love, in "Introduction to Gauge Field Theory", IOP (rev ed 1993), say: "... considering the order alpha radiative corrections to muon decay ... Numerical details are contained in Sirlin ... 1980 Phys. Rev. D 22 971 ... who concludes that the order alpha corrections have the effect of increasing the decay rate about 7% compared with the tree graph prediction ...". Since the decay rate is proportional to m_{μ}^5 the corresponding effective increase in muon mass would be about 1.36%, which would bring 104.8 MeV up to about 106.2 MeV.

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 i, j, or k.

The red strange quark is defined as the three pairs $\{ 1, i \}$, $\{ i, 1 \}$, $\{ i, i \}$ 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 $6/2 = 3$.

So 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 similarly determined to also be 625.5 MeV.

The charm quark corresponds to the remaining $64 - 1 - 3 - 9 = 51$ 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 similarly determined to also be 2.085 GeV.

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 MSbar mass if the color force strength constant α_s is known.

The conventional value of α_s at about 2 GeV is about 0.39, which is somewhat lower than the theoretical model value.

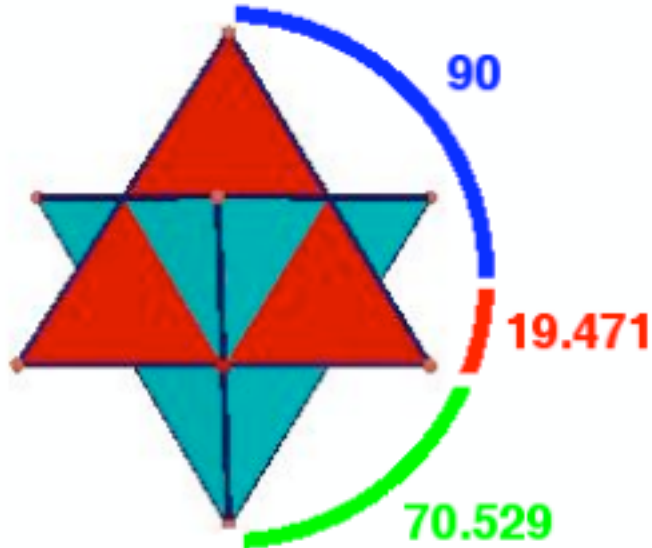
Using $\alpha_s(2 \text{ GeV}) = 0.39$, a pole mass of 1.9 GeV gives an MSbar 1-loop mass of 1.6 GeV, evaluated at about 2 GeV.

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

$$\mathbf{\Sigma_{mf2} = 32.9 \text{ GeV}}$$

Kobayashi-Maskawa Parameters

In E8 Physics the KM Unitarity Triangle angles can be seen on the Stella Octangula



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

$$S_{mf2} = 32.94504 \text{ GeV} \text{ and } S_{mf3} = 1,629.2675 \text{ GeV}.$$

The resulting KM matrix is:

	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

**Below the energy level of ElectroWeak Symmetry Breaking
the Higgs mechanism gives mass to particles.**

According to a Review on the Kobayashi-Maskawa mixing matrix by Ceccucci, Ligeti, and Sakai in the 2010 Review of Particle Physics (note that I have changed their terminology of CKM matrix to the KM terminology that I prefer because I feel that it was Kobayashi and Maskawa, not Cabibbo, who saw that 3x3 was the proper matrix structure): "... the charged-current W_{\pm} interactions couple to the ... quarks with couplings given by ...

$$\begin{matrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{matrix}$$

This Kobayashi-Maskawa (KM) matrix is a 3x3 unitary matrix. It can be parameterized by three mixing angles and the CP-violating KM phase ... The most commonly used unitarity triangle arises from $V_{ud} V_{ub}^* + V_{cd} V_{cb}^* + V_{td} V_{tb}^* = 0$, by dividing each side by the best-known one, $V_{cd} V_{cb}^*$

... $\bar{\rho} + i\bar{\eta} = -(V_{ud} V_{ub}^*)/(V_{cd} V_{cb}^*)$ is phase-convention-independent ...

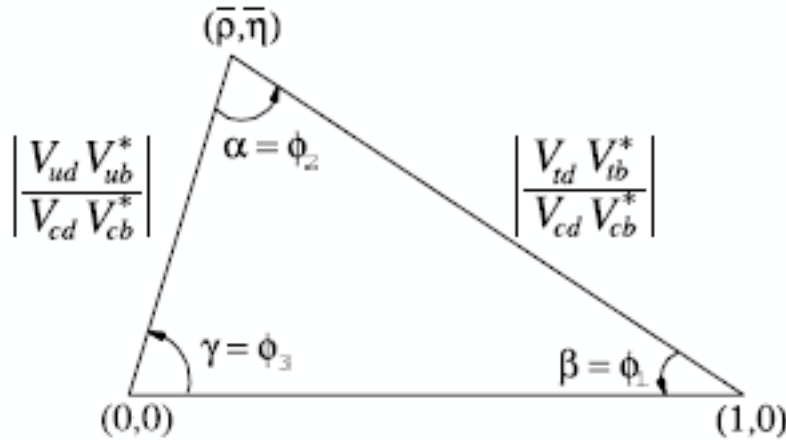


Figure 11.1: Sketch of the unitarity triangle.

... $\sin 2\beta = 0.673 \pm 0.023$... $\alpha = 89.0 +4.4 -4.2$ degrees ... $\gamma = 73 +22 -25$ degrees ... The sum of the three angles of the unitarity triangle, $\alpha + \beta + \gamma = (183 +22 -25)$ degrees, is ... consistent with the SM expectation. ...

The area... of ...[the]... triangle...[is]... half of the Jarlskog invariant, J , which is a phase-convention-independent measure of CP violation, defined by $\text{Im } V_{ij} V_{kl} V_{il}^* V_{kj}^* = J \sum_{(m,n)} \epsilon_{ikm} \epsilon_{jln}$

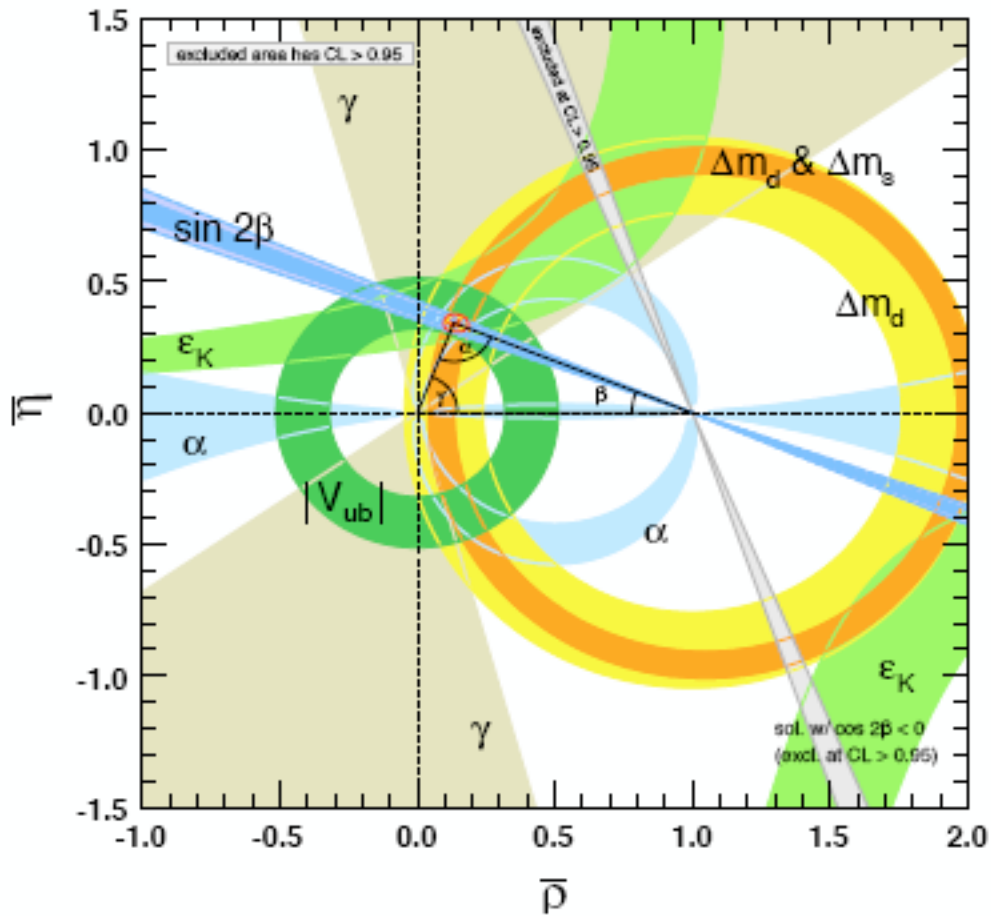


Figure 11.2: Constraints on the $\bar{\rho}, \bar{\eta}$ plane.
The shaded areas have 95% CL.

The fit results for the magnitudes of all nine KM elements are ...

0.97428 ± 0.00015	0.2253 ± 0.0007	$0.00347 +0.00016 -0.00012$
0.2252 ± 0.0007	$0.97345 +0.00015 -0.00016$	$0.0410 +0.0011 -0.0007$
$0.00862 +0.00026 -0.00020$	$0.0403 +0.0011 -0.0007$	$0.999152 +0.000030 -0.000045$

and the Jarlskog invariant is $J = (2.91 +0.19 -0.11) \times 10^{-5}$".

**Above the energy level of ElectroWeak Symmetry Breaking
particles are massless.**

Kea (Marni Sheppeard) proposed
that in the Massless Realm the mixing matrix might be democratic.
In Z. Phys. C - Particles and Fields 45, 39-41 (1989) Koide said: "...
the mass matrix ... MD ... of the type ... $1/3 \times m \times$

$$\begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$$

... has name... "democratic" family mixing ...
the ... democratic ... mass matrix can be diagonalized by the transformation matrix A ...

$$\begin{matrix} 1/\sqrt{2} & -1/\sqrt{2} & 0 \\ 1/\sqrt{6} & 1/\sqrt{6} & -2/\sqrt{6} \\ 1/\sqrt{3} & 1/\sqrt{3} & 1/\sqrt{3} \end{matrix}$$

as $A M D A^t =$

$$\begin{matrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & m \end{matrix}$$

...".

Up in the Massless Realm you might just say that there is no mass matrix,
just a democratic mixing matrix of the form $1/3 \times$

$$\begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$$

with no complex stuff and no CP violation in the Massless Realm.

When go down to our Massive Realm by ElectroWeak Symmetry Breaking
then you might as a first approximation use $m = 1$
so that all the mass first goes to the third generation as

$$\begin{matrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{matrix}$$

which is physically like the Higgs being a T-Tbar quark condensate.

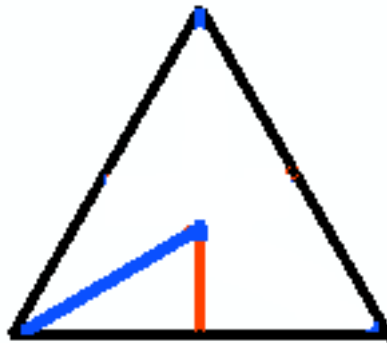
Consider a 3-dim Euclidean space of generations:

The case of mass only going to one generation
can be represented as a line or 1-dimensional simplex

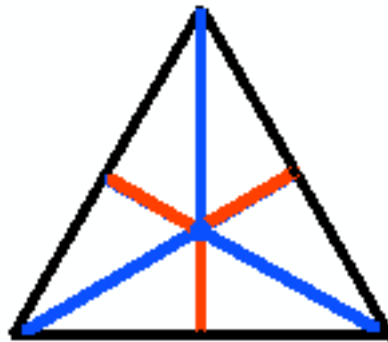


in which the blue mass-line covers the entire black simplex line.

If mass only goes to one other generation
that can be represented by a red line extending to a second dimension
forming a small blue-red-black triangle



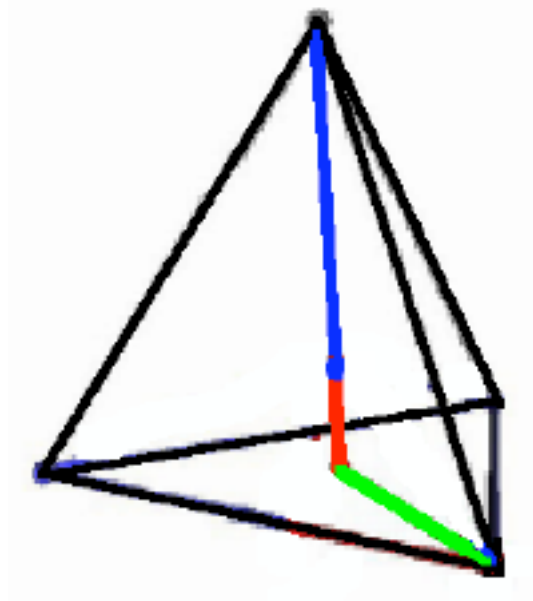
that can be extended by reflection to form six small triangles making up a large triangle



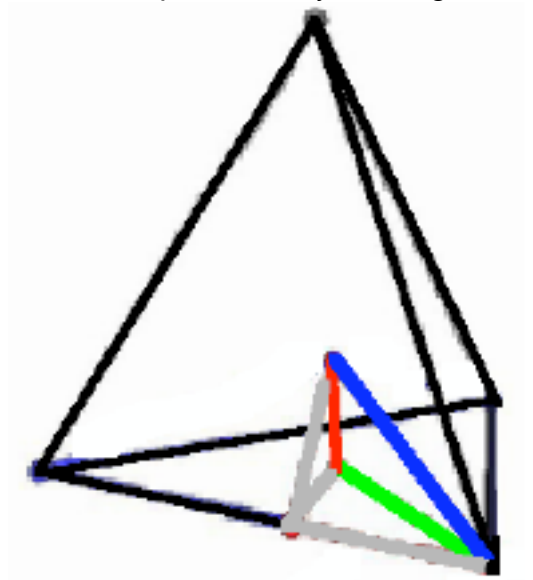
Each of the six component triangles has 30-60-90 angle structure:



If mass goes on further to all three generations that can be represented by a green line extending to a third dimension



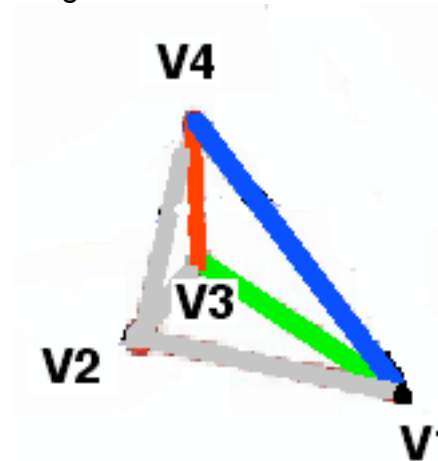
If you move the blue line from the top vertex to join the green vertex



you get a small blue-red-green-gray-gray-gray tetrahedron that can be extended by reflection to form 24 small tetrahedra making up a large tetrahedron.

Reflection among the 24 small tetrahedra corresponds to the $12+12 = 24$ elements of the Binary Tetrahedral Group.

The basic blue-red-green triangle of the basic small tetrahedron



has the angle structure of the K-M Unitary Triangle.

Using data from R. W. Gray's "Encyclopedia Polyhedra: A Quantum Module" with lengths

$V1.V2 = (1/2) EL \cong$ Half of the regular Tetrahedron's edge length.

$V1.V3 = (1 / \sqrt{3}) EL \cong 0.577\ 350\ 269\ EL$

$V1.V4 = 3 / (2 \sqrt{6}) EL \cong 0.612\ 372\ 436\ EL$

$V2.V3 = 1 / (2 \sqrt{3}) EL \cong 0.288\ 675\ 135\ EL$

$V2.V4 = 1 / (2 \sqrt{2}) EL \cong 0.353\ 553\ 391\ EL$

$V3.V4 = 1 / (2 \sqrt{6}) EL \cong 0.204\ 124\ 145\ EL$

the Unitarity Triangle angles are:

$\beta = V3.V1.V4 = \arccos(2 \sqrt{2} / 3) \cong 19.471\ 220\ 634\ \text{degrees}$ so $\sin 2\beta = 0.6285$

$\alpha = V1.V3.V4 = 90\ \text{degrees}$

$\gamma = V1.V4.V3 = \arcsin(2 \sqrt{2} / 3) \cong 70.528\ 779\ 366\ \text{degrees}$

which is substantially consistent with the 2010 Review of Particle Properties

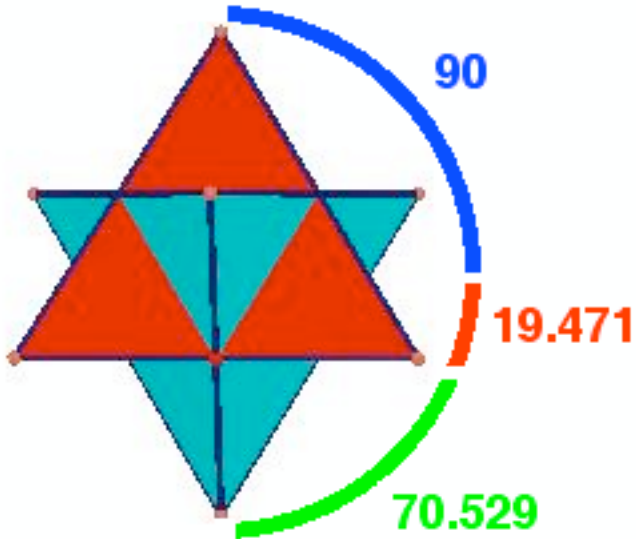
$\sin 2\beta = 0.673 \pm 0.023$ so $\beta = 21.1495\ \text{degrees}$

$\alpha = 89.0\ +4.4\ -4.2\ \text{degrees}$

$\gamma = 73\ +22\ -25\ \text{degrees}$

and so also consistent with the Standard Model expectation.

The constructed Unitarity Triangle angles can be seen on the Stella Octangula configuration of two dual tetrahedra (image from gauss.math.nthu.edu.tw):



In the $Cl(16)$ -E8 model 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 $d_{13} = \gamma = 70.529$ degrees

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

$$\sin(\theta_{13}) = s_{13} = [m_e + 3m_d + 3m_\mu] / \sqrt{[m_e^2 + 3m_d^2 + 3m_\mu^2] + [3m_\nu^2 + 3m_b^2 + 3m_t^2]} = 0.004608$$

$$\sin(\theta_{23}) = [3m_\nu + 3m_s + 3m_c] / \sqrt{[3m_\nu^2 + 3m_b^2 + 3m_t^2] + [3m_\nu^2 + 3m_s^2 + 3m_c^2]}$$

$$\sin(\theta_{23}) = s_{23} = \sin(\theta_{23}) \sqrt{(\Sigma_{f2} / \Sigma_{f1})} = 0.04234886$$

The factor $\sqrt{(\Sigma_{f2} / \Sigma_{f1})}$ 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 $\Sigma_{f2} / \Sigma_{f1}$.

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 $\Sigma_{f2} / \Sigma_{f1}$ the effective magnitude of the s_{23} terms in the KM entries is increased by the factor $\sqrt{(\Sigma_{f2} / \Sigma_{f1})}$.

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:

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta_{23}) & \sin(\theta_{23}) \\ 0 & -\sin(\theta_{23}) & \cos(\theta_{23}) \end{pmatrix}$$

$$\begin{pmatrix} \cos(\theta_{13}) & 0 & \sin(\theta_{13})\exp(-i d_{13}) \\ 0 & 1 & 0 \\ -\sin(\theta_{13})\exp(i d_{13}) & 0 & \cos(\theta_{13}) \end{pmatrix}$$

$$\begin{pmatrix} \cos(\theta_{12}) & \sin(\theta_{12}) & 0 \\ -\sin(\theta_{12}) & \cos(\theta_{12}) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

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.

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 Beyond Tree Level

Consider the three generations of neutrinos:
nu_e (electron neutrino); nu_m (muon neutrino); nu_t
and three neutrino mass states: nu_1 ; nu_2 : nu_3
and
the division of 8-dimensional spacetime into
4-dimensional physical Minkowski spacetime
plus
4-dimensional CP2 internal symmetry space.

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 Cl(16)-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 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

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

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 ν_2 corresponds to a neutrino whose propagation begins or ends in CP2 internal symmetry space and ends or begins in M4 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 Cl(16)-E8 model the mass of ν_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 ν_2 first-order corrections, as opposed to the 36 different possible anchorings for ν_3 first-order corrections, so that the first-order corrected mass of ν_2 is less than the first-order corrected mass of ν_3 by a factor of 6, so

the first-order corrected mass of ν_2 is
$$M_{\nu_2} = M_{\nu_3} / \text{Vol}(\text{CP}2) = 5.4 \times 10^{(-2)} / 6$$
$$= 9 \times 10^{(-3)} \text{eV}.$$

The low mass state ν_1 corresponds to a neutrino whose propagation begins and ends in physical Minkowski spacetime. thus having only one anchoring to CP2 interna symmetry space.

According to the Cl(16)-E8 model the mass of ν_1 is zero at tree-level but it has only 1 possible anchoring to CP2 as opposed to the 36 different possible anchorings for ν_3 first-order corrections or the 6 different possible anchorings for ν_2 first-order corrections so that the first-order corrected mass of ν_1 is less than the first-order corrected mass of ν_2 by a factor of 6, so

the first-order corrected mass of ν_1 is
$$M_{\nu_1} = M_{\nu_2} / \text{Vol}(\text{CP}2) = 9 \times 10^{(-3)} / 6$$
$$= 1.5 \times 10^{(-3)} \text{eV}.$$

Therefore:

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

and

$$\begin{aligned} \text{the mass-squared difference } D(M_{12}^2) &= M_{\nu_2}^2 - M_{\nu_1}^2 = \\ &= (81 - 2) \times 10^{(-6)} \text{ eV}^2 = \\ &= 7.9 \times 10^{(-5)} \text{ eV}^2 \end{aligned}$$

The 3x3 unitary neutrino mixing matrix neutrino mixing matrix U

	nu_1	nu_2	nu_3
nu_e	Ue1	Ue2	Ue3
nu_m	Um1	Um2	Um3
nu_t	Ut1	Ut2	Ut3

can be parameterized (based on the 2010 Particle Data Book)
by 3 angles and 1 Dirac CP violation phase

$$U = \begin{pmatrix} c_{12} c_{13} & s_{12} c_{13} & s_{13} e^{-i\delta} \\ -s_{12} c_{23} - c_{12} s_{23} s_{13} e^{i\delta} & c_{12} c_{23} - s_{12} s_{23} s_{13} e^{i\delta} & s_{23} c_{13} \\ s_{12} s_{23} - c_{12} c_{23} s_{13} e^{i\delta} & -c_{12} s_{23} - s_{12} c_{23} s_{13} e^{i\delta} & c_{23} c_{13} \end{pmatrix}$$

where $c_{ij} = \cos(\theta_{ij})$, $s_{ij} = \sin(\theta_{ij})$

The angles are

$\theta_{23} = \pi/4 = 45$ degrees

because

ν_3 has equal components of ν_m and ν_t so
that $U_{m3} = U_{t3} = 1/\sqrt{2}$ or, in conventional
notation, mixing angle $\theta_{23} = \pi/4$

so that $\cos(\theta_{23}) = 0.707 = \sqrt{2}/2 = \sin(\theta_{23})$

$\theta_{13} = 9.594$ degrees = $\arcsin(1/6)$

and $\cos(\theta_{13}) = 0.986$

because $\sin(\theta_{13}) = 1/6 = 0.167 = |U_{e3}|$ = fraction of ν_3 that is ν_e

$\theta_{12} = \pi/6 = 30$ degrees

because

$\sin(\theta_{12}) = 0.5 = 1/2 = U_{e2}$ = fraction of ν_2 begin/end points
that are in the physical spacetime where massless ν_e lives

so that $\cos(\theta_{12}) = 0.866 = \sqrt{3}/2$

$\delta = 70.529$ degrees is the Dirac CP violation phase

$e^{i(70.529)} = \cos(70.529) + i \sin(70.529) = 0.333 + 0.943 i$

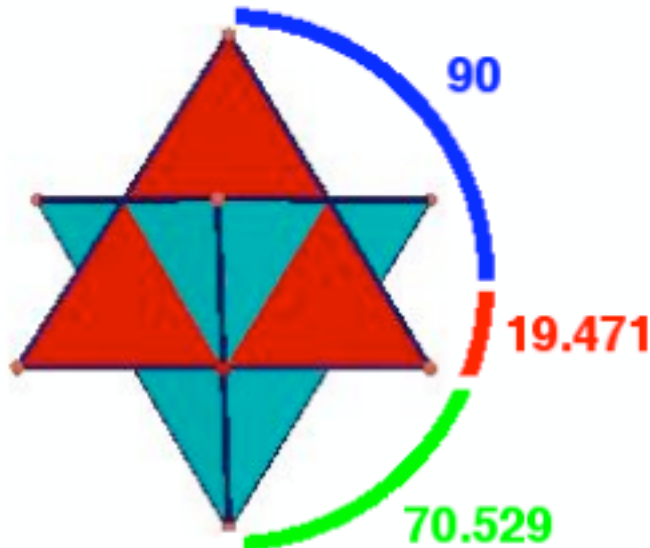
This is because the neutrino mixing matrix has 3-generation structure
and so has the same phase structure as the KM quark mixing matrix
in which the Unitarity Triangle angles are:

$\beta = V_3.V_1.V_4 = \arccos(2 \sqrt{2} / 3) \cong 19.471 220 634$ degrees so $\sin 2\beta = 0.6285$

$\alpha = V_1.V_3.V_4 = 90$ degrees

$\gamma = V_1.V_4.V_3 = \arcsin(2 \sqrt{2} / 3) \cong 70.528 779 366$ degrees

The constructed Unitarity Triangle angles can be seen on the Stella Octangula configuration of two dual tetrahedra (image from gauss.math.nthu.edu.tw):



Then we have for the neutrino mixing matrix:

	nu_1	nu_2	nu_3
nu_e	0.866 x 0.986	0.50 x 0.986	0.167 x e-id
nu_m	-0.5 x 0.707 -0.866 x 0.707 x 0.167 x eid	0.866 x 0.707 -0.5 x 0.707 x 0.167 x eid	0.707 x 0.986
nu_t	0.5 x 0.707 -0.866 x 0.707 x 0.167 x eid	-0.866 x 0.707 -0.5 x 0.707 x 0.167 x eid	0.707 x 0.986

	nu_1	nu_2	nu_3
nu_e	0.853	0.493	0.167 e-id
nu_m	-0.354 -0.102 eid	0.612 -0.059 eid	0.697
nu_t	0.354 -0.102 eid	-0.612 -0.059 eid	0.697

Since $e^{i(70.529)} = \cos(70.529) + i \sin(70.529) = 0.333 + 0.943 i$
and $.333e^{-i(70.529)} = \cos(70.529) - i \sin(70.529) = 0.333 - 0.943 i$

	nu_1	nu_2	nu_3
nu_e	0.853	0.493	0.056 - 0.157 i
nu_m	-0.354 -0.034 - 0.096 i	0.612 -0.020 - 0.056 i	0.697
nu_t	0.354 -0.034 - 0.096 i	-0.612 -0.020 - 0.056 i	0.697

for a result of

	nu_1	nu_2	nu_3
nu_e	0.853	0.493	0.056 - 0.157 i
nu_m	-0.388 - 0.096 i	0.592 - 0.056 i	0.697
nu_t	0.320 - 0.096 i	0.632 - 0.056 i	0.697

which is consistent with the approximate experimental values of mixing angles shown in the Michaelmas Term 2010 Particle Physics handout of Prof Mark Thomson if the matrix is modified by taking into account the March 2012 results from Daya Bay observing non-zero $\theta_{13} = 9.54$ degrees.

Proton-Neutron Mass Difference

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 comparable to the experimental value of 1.3 Mev.

Pion as Sine-Gordon Breather

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.

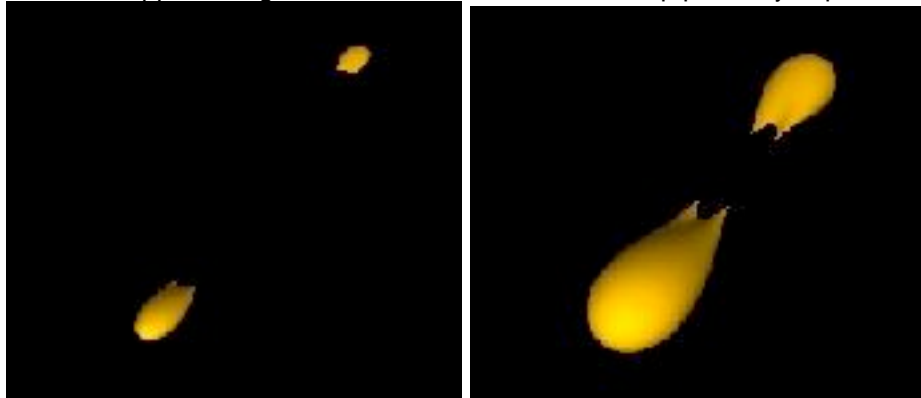
The quark is a Schwinger Source Kerr-Newman Black Hole with constituent mass M 312 MeV.

The antiquark is also a Schwinger Source Kerr-Newman Black Hole, with constituent mass M 312 MeV.

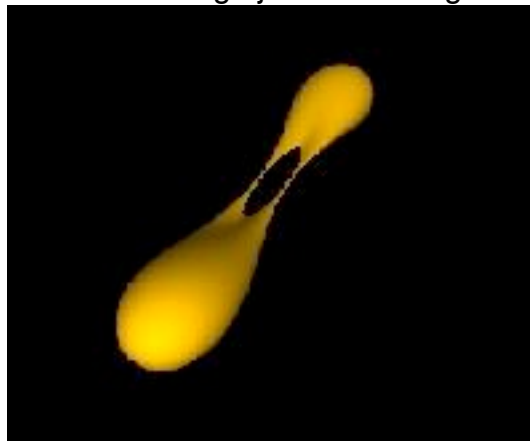
According to section 3.6 of Jeffrey Winicour's 2001 Living Review of the Development of Numerical Evolution Codes for General Relativity (see also a 2005 update):

"... 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. ...".

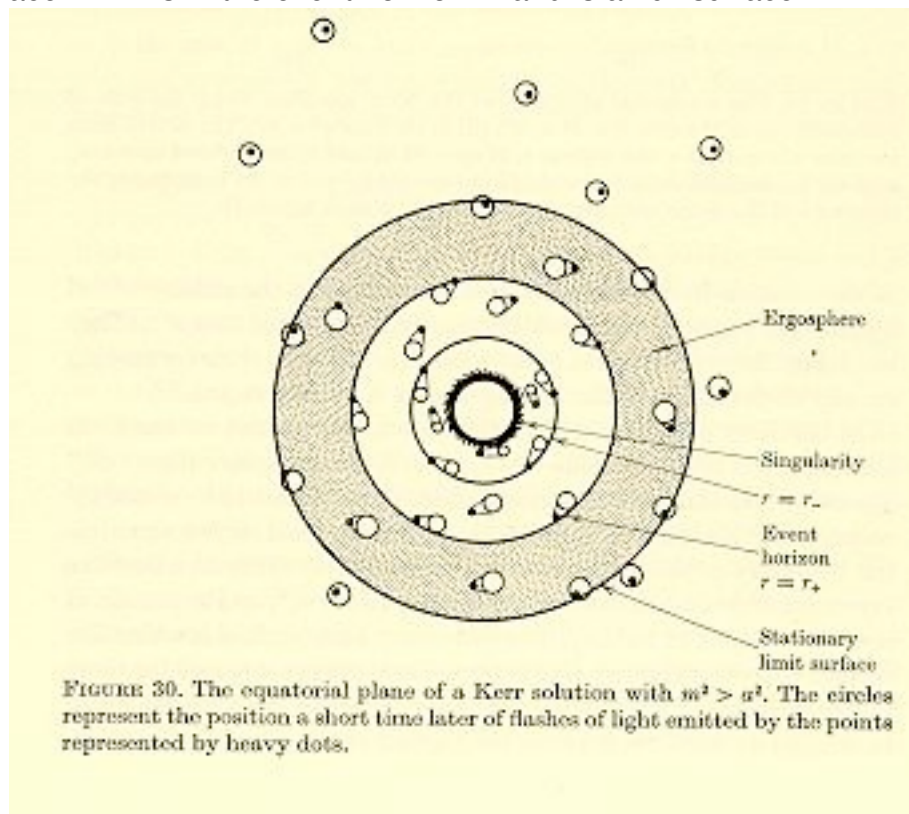
In the physical case of quark and antiquark forming a pion, the toroidal black hole remains a torus.

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. The soliton and antisoliton of a Sine-Gordon Breather correspond to the quark and antiquark that make up the pion, analogous to the Massive Thirring Model.

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 he writes the Lagrangian for the Sine-Gordon equation as (Coleman's eq. 4.3):

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

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 move 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.

... 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).
 ...[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. (4.65), 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]

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

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 4π .

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 : 4π (where the qualitative picture of the soliton as a lump totally breaks down), 2π , and π . At 4π we know the exact answer ... I happen to know the exact answer for 2π , 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 $(8 / B^2) - (1 / \pi)$".

Using the Cl(16)-E8 model 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 close to the experimental value of about 139.57 MeV.

Why is the value $B^2 = \pi$ the special value that gives the pion mass ?

(or, using Coleman's eq. (5.14), the Thirring coupling constant $g = 3\pi$)

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.

Planck Mass as Superposition Fermion Condensate

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 allowed 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.

There are 8 fermion particles and 8 fermion antiparticles for a total of 64 particle-antiparticle pairs. Of the 64 particle-antiparticle pairs, 12 are bosonic pions.

A typical combination should have about 6 pions so it should have a mass of about $.14 \times 6 \text{ GeV} = 0.84 \text{ GeV}$.

Just as the pion mass of .14 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 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 GeV.

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

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

Conformal Gravity ratio Dark Energy : Dark Matter : Ordinary Matter

MacDowell-Mansouri Gravity is described by Rabindra Mohapatra in section 14.6 of his book "Unification and Supersymmetry":

§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_μ^A as follows:

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

Let us denote the parameter associated with X_A by ε^A . The gauge transformations on the fields h_μ^A are given as follows:

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

We can then define a covariant curvature

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

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:

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

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

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

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

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

$$R_{\mu\nu}(M) = \partial_\nu \omega_\mu^{mn} - \partial_\mu \omega_\nu^{mn} - \omega_\nu^{mp} \omega_{\mu,p}^n - \omega_\mu^{mp} \omega_{\nu,p}^n - 4(e_\mu^n f_\nu^n - e_\nu^n f_\mu^n), \quad (14.6.9)$$

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

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

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

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

We also impose the constraint that

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

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

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

Using eqn. (14.6.8) we can rewrite

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

where

$$\delta_P(\xi^\nu)e_\mu^a = \partial_\nu \xi^\mu e_\mu^a + \xi^\nu \omega_\mu^{mn} e_\mu^a + \xi^\nu b_\mu. \quad (14.6.15)$$

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 \bar{P} such that

$$\delta_{\bar{P}}(\xi) = \delta_{GC}(\xi^\nu) - \sum_{A'} \delta_{A'}(\xi^{\nu} h_{\mu}^A), \quad (14.6.16)$$

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

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

We also wish to point out that for fields which carry spin or conformal charge, only the intrinsic parts contribute to D_{μ}^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_μ^a to get an expression for it, i.e.,

$$e_\nu^a f_{\mu a} = -\frac{1}{2}[e_\mu^a e_{\nu a} R_{\lambda\lambda}^{\mu\nu} - \frac{1}{6}g_{\mu\nu}R], \quad (14.6.18)$$

where f_μ^a has been set to zero in R written in the right-hand side.

This eliminates (from the theory the degrees of freedom) ω_μ^{mn} and f_μ^a and we are left with e_μ^a and b_μ . 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 ϕ . 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 ϕ can be assumed to be zero since $K_m = x^2 \partial$ 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

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

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

$$\square^c \phi = \frac{1}{e} \partial_\nu (g^{\mu\nu} e D_\mu^c \phi) + b_\mu D_\mu^c \phi + \frac{1}{2} \phi R. \quad (14.6.22)$$

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 $b_\mu = 0$ 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 ϕ , leads to gravity. We may call ϕ 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).

(Frank Wilczek, in 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 [anti] de Sitter group,** as is described by

Freund in chapter 21 of his book Supersymmetry (Cambridge 1986) (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 $g_{uv} = e^a_u e^b_v n_{ab}$ (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_μ 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 NOT SHOWN IN THIS QUOTE]...

we shall see ...[that]... the action becomes invariant

under all local [anti]de-Sitter transformations ...[and]... we recognize ... t

he 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. ...".

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 $x^u \rightarrow x^u / \sigma^2$. Under such a transformation, the Poincare group P is transformed into the group Q, and the Minkowski space M becomes the conespace N. The points at infinity of M are concentrated in the vertex of the conespace N, and those on the light-cone of M becomes the infinity of N. It is concepts of space isotropy and equivalence between inertial frames in the conespace 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. ..."

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

**3 Rotations
3 Boosts
4 Translations
4 Special Conformal transformations
1 Dilatation**

The **Cosmological Constant / Dark Energy** comes from the **10 Rotation, Boost, and Special Conformal generators** of the Conformal Group Spin(2,4) = SU(2,2), so the fractional part of our Universe of the Cosmological Constant should be **about 10 / 15 = 67% for tree level.**

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 Spin(2,4) = 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% at tree level.**

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

However,
as Our Universe evolves the Dark Energy, Dark Matter, and Ordinary Matter densities evolve at different rates,
so that the differences in evolution must be taken into account from the initial End of Inflation to the Present Time.

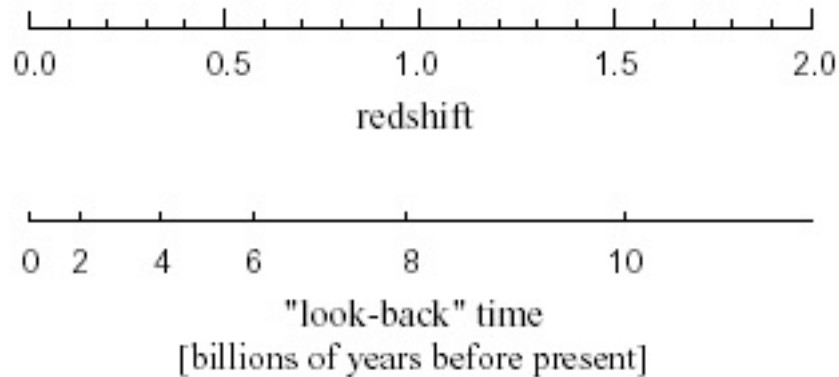
Without taking into account any evolutionary changes with time,
our Flat Expanding Universe should have roughly:

**67% Cosmological Constant
27% Dark Matter - possibly primordial stable Planck mass black holes
6% Ordinary Matter**

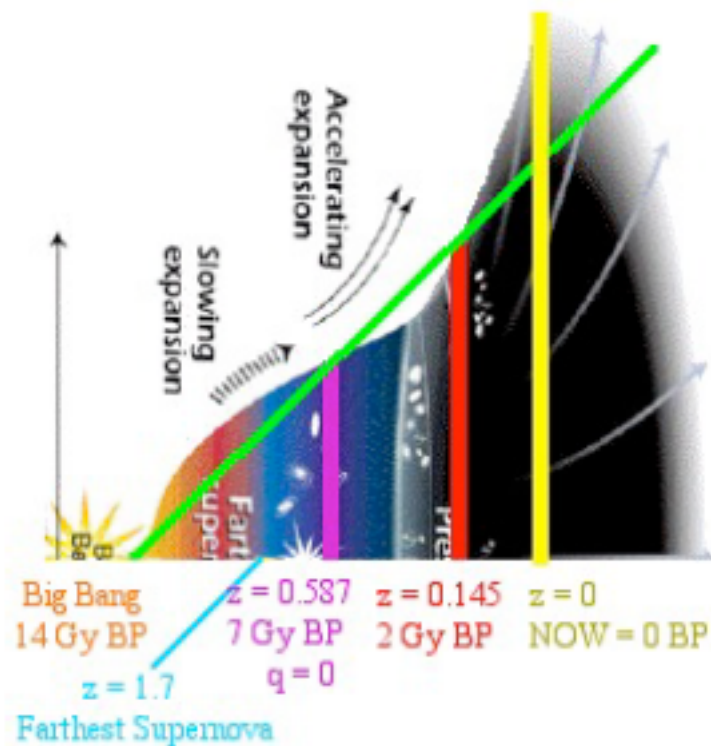
As Dennis Marks pointed out to me,
 since density ρ is proportional to $(1+z)^3(1+w)$ for red-shift factor z
 and a constant equation of state w :
 $w = -1$ for Λ and the average overall density of Λ Dark Energy remains constant
 with time and the expansion of our Universe;
 and
 $w = 0$ for nonrelativistic 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
 $1 / (1+z)^3 = 0.04 / 0.06 = 2/3$, or $(1+z)^3 = 1.5$, or $1+z = 1.145$, 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 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, Fe₂O₃ 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 Λ 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 Λ and Cold Dark Matter terms have evolved during the past 2 Gy, a rough estimate analysis would be:

Λ 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 Λ and CDM factors in their natural ratio $67 : 27$, producing, for NOW after 2 Gy of expansion:

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.

2013 Planck Data (arxiv 1303.5062) showed "... anomalies ... previously observed in the WMAP data ... alignment between the quadrupole and octopole moments ... asymmetry of power between two ... hemispheres ... Cold Spot ... are now confirmed at ... 3 sigma ... but a higher level of confidence ...".

E8 model rough evolution calculation is: DE : DM : OM = 75 : 20 : 05

WMAP: DE : DM : OM = 73 : 23 : 04

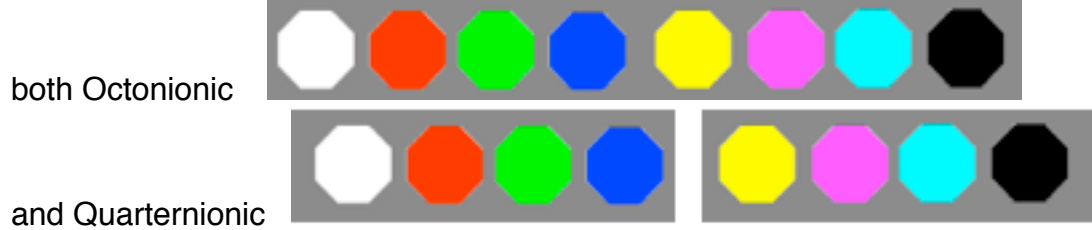
Planck: DE : DM : OM = 69 : 26 : 05

basic unevolved E8 Conformal calculation: DE : DM : OM = 67 : 27 : 06

Since uncertainties are substantial, I think that there is reasonable consistency.

Strong CP Problem

In the $Cl(16)$ -E8 model, 8-dim SpaceTime,



is represented by the 64-dim Adjoint D8 / D4xD4 part of E8 which is the $A7 \times R$ grade-0 part of the Maximal Contraction $A7 \times h92$ with 5-grading $28 + 64 + (SL(8,R) + 1) + 64 + 28$

In the $Cl(16)$ -E8 model Gravity is most often written as in Chapter 18 of this paper in terms of the MacDowell-Mansouri Conformal Group $Spin(2,4)$ which is the 15-dimensional Conformal BiVector Group of the 64-dim $Cl(2,4)$ Clifford Algebra but

it can also be written in terms of 64-dim grade-0 Maximal Contraction term $SL(8,R) + 1$ in which case it is known as Unimodular $SL(8,R)$ Gravity which effectively describes a generalized checkerboard of 8-dim SpaceTime HyperVolume Elements and, with respect to $Cl(16) = Cl(8) \times Cl(8)$, is the tensor product of the two 8v vector spaces of the two $Cl(8)$ factors of $Cl(16)$. If those two $Cl(8)$ factors are regarded as Fourier Duals, then $8v \times 8v$ describes Position \times Momentum in 8-dim SpaceTime.

Conformal $Spin(2,4) = SU(2,2)$ Gravity and Unimodular $SL(4,R) = Spin(3,3)$ Gravity seem to be effectively equivalent since, as Bradonjic and Stachel in arXiv 1110.2159 said: "... in ... Unimodular relativity ... the symmetry group of space-time is ... the special linear group $SL(4,R)$... the metric tensor ... break[s up] ... into the conformal structure represented by a conformal metric ... with $\det = -1$ and a four-volume element ... at each point of space-time ...[that]... may be the remnant, in the ... continuum limit, of a more fundamental discrete quantum structure of space-time itself ...". Further,

Frampton, Ng, and Van Dam in J. Math. Phys. 33 (1992) 3881-3882 said: "... Because of the existence of topologically nontrivial solutions, instantons, of the classical field equations associated with quantum chromodynamics (QCD), the quantized theory contains a dimensionless parameter θ ($0 < \theta < 2\pi$) not explicit in the classical lagrangian. Since θ multiplies an expression odd in CP, QCD predicts violation of that symmetry unless the phase θ takes one of the special values ... $0 \pmod{\pi}$... this fine tuning is the strong CP problem ... the quantum dynamics of ... unimodular gravity ... may lead to the relaxation of θ to $\theta = 0 \pmod{\pi}$ without the need ... for a new particle ... such as the axion ...".

Grothendieck Universe Quantum Theory

The First Grothendieck Universe is the Empty Set.

The Second Grothendieck Universe is Hereditarily Finite Sets such as a Generalized Feynman Checkerboard Quantum Theory based on E8 Lattices and Discrete $Cl(16)$ Clifford Algebra.
(viXra 1501.0078)

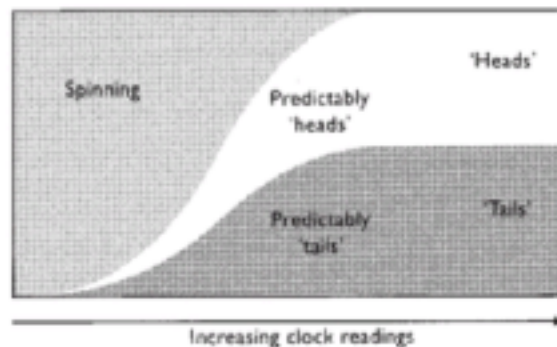
The Third Grothendieck Universe is the Completion of Union of all tensor products of $Cl(16)$ Real Clifford algebra

Since the $Cl(16)$ -E8 Lagrangian is Local and Classical, it is necessary to patch together Local Lagrangian Regions to form a Global Structure describing a Global $Cl(16)$ -E8 Algebraic Quantum Field Theory (AQFT).

The usual Hyperfinite II1 von Neumann factor for creation and annihilation operators on Fermionic Fock Space over $C^{(2n)}$ is constructed by completion of the union of all tensor products of 2×2 Complex Clifford algebra matrices, which have Periodicity 2, so

for the $Cl(16)$ -E8 model based on Real Clifford Algebras with Periodicity 8, whereby any Real Clifford Algebra, no matter how large, can be embedded in a tensor product of factors of $Cl(8)$ and of $Cl(8) \times Cl(8) = Cl(16)$, the completion of the union of all tensor products of $Cl(16) = Cl(8) \times Cl(8)$ produces a generalized Hyperfinite II1 von Neumann factor that gives the $Cl(16)$ -E8 model a natural Algebraic Quantum Field Theory.

The overall structure of $Cl(16)$ -E8 AQFT is similar to the Many-Worlds picture described by David Deutsch in his 1997 book "The Fabric of Reality" said (pages 276-283): "... there is no fundamental demarcation between snapshots of other times and snapshots of other universes ... Other times are just special cases of other universes ... Suppose ... we toss a coin ... Each point in the diagram represents one snapshot



... in the multiverse there are far too many snapshots for clock readings alone to locate a snapshot relative to the others. To do that, we need to consider the intricate detail of which snapshots determine which others. ... in some regions of the multiverse, and in some places in space,

the snapshots of some physical objects do fall, for a period, into chains, each of whose members determines all the others to a good approximation ...".

The Real Clifford Algebra $Cl(16)$ containing $E8$ for the Local Lagrangian of a Region is equivalent to a " snapshot" of the Deutsch "multiverse".

The completion of the union of all tensor products of all $Cl(16)$ - $E8$ Local Lagrangian Regions forms a generalized hyperfinite II1 von Neumann factor AQFT and emergently self-assembles into a structure = Deutsch multiverse.

For the $Cl(16)$ - $E8$ model AQFT to be realistic, it must be consistent with **EPR entanglement relations**. Joy Christian in arXiv 0904.4259 said: "... a [geometrically] correct local-realistic framework ... provides exact, deterministic, and local underpinnings ... The alleged non-localities ... result from misidentified [geometries] of the EPR elements of reality. ... The correlations are ... the classical correlations [such as those] 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 ...". Since $E8$ is a Lie Group and therefore parallelizable and lives in Clifford Algebra $Cl(16)$, **the $Cl(16)$ - $E8$ model is consistent with EPR.**

The Creation-Annihilation Operator structure of $Cl(16)$ - $E8$ AQFT is given by the

Maximal Contraction of $E8$ = semidirect product $A7 \times h92$

where $h92 = 92+1+92 = 185$ -dim Heisenberg algebra and $A7 = 63$ -dim $SL(8)$

The Maximal $E8$ Contraction $A7 \times h92$ can be written as a 5-Graded Lie Algebra

$$28 + 64 + (SL(8,R) + 1) + 64 + 28$$

$$\text{Central Even Grade } 0 = SL(8,R) + 1$$

The 1 is a scalar and $SL(8,R) = Spin(8) + \text{Traceless Symmetric } 8 \times 8 \text{ Matrices}$, so $SL(8,R)$ represents a local 8-dim SpaceTime in Polar Coordinates.

$$\text{Odd Grades } -1 \text{ and } +1 = 64 + 64$$

Each = $64 = 8 \times 8 = \text{Creation/Annihilation Operators for 8 components of 8 Fundamental Fermions.}$

$$\text{Even Grades } -2 \text{ and } +2 = 28 + 28$$

Each = Creation/Annihilation Operators for 28 Gauge Bosons of Gravity + Standard Model.

The $Cl(16)$ - $E8$ AQFT inherits structure from the $Cl(16)$ - $E8$ Local Lagrangian

$$\int_{\text{8-dim SpaceTime}} \text{Gauge Gravity} + \text{Standard Model} + \text{Fermion Particle-AntiParticle}$$

The $Cl(16)$ - $E8$ generalized Hyperfinite II1 von Neumann factor Algebraic Quantum Field Theory is based on the Completion of the Union of all Tensor Products of the form

$$Cl(16) \times \dots (N \text{ times tensor product}) \dots \times Cl(16) = Cl(16N)$$

For $N = 2^8 = 256$ the copies of $Cl(16)$ are on the 256 vertices of the 8-dim HyperCube



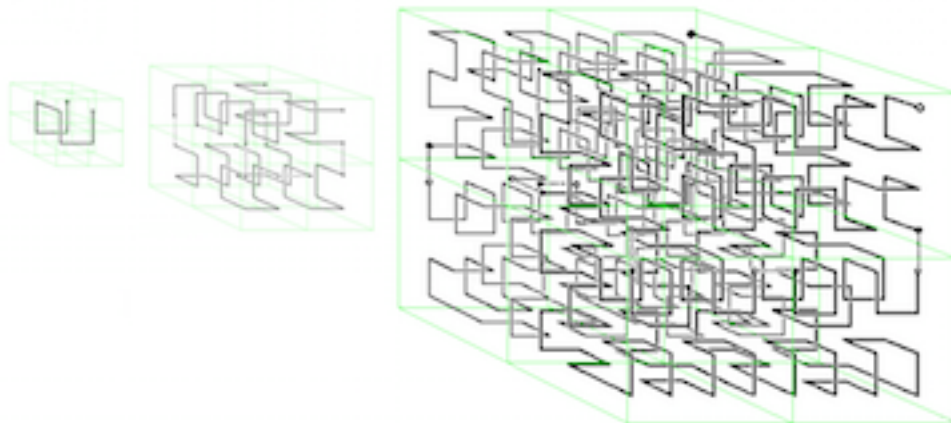
For $N = 2^{16} = 65,536 = 4^8$ the copies of $Cl(16)$ fill in the 8-dim HyperCube as described by William Gilbert's web page: "... The n -bit reflected binary **Gray** code will describe a path on the edges of an n -dimensional cube that can be used as the initial stage of a Hilbert curve that will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

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

As N grows, the copies of $Cl(16)$ continue to fill the 8-dim HyperCube of E_8 SpaceTime using higher Hilbert curve stages from the 8-bit reflected binary Gray code subdividing the initial 8-dim HyperCube into more and more sub-HyperCubes.

If edges of sub-HyperCubes, equal to the distance between adjacent copies of $Cl(16)$, remain constantly at the Planck Length, then the

full 8-dim HyperCube of our Universe expands as N grows to 2^{16} and beyond similarly to the way shown by this 3-HyperCube example for $N = 2^3, 4^3, 8^3$ from William Gilbert's web page:



The Union of all $Cl(16)$ tensor products is the Union of all subdivided 8-HyperCubes and their Completion is a huge superposition of 8-HyperCube Continuous Volumes which Completion belongs to the Third Grothendieck Universe.

World-Line String Bohm Quantum Potential and Consciousness

The Cl(16)-E8 AQFT inherits structure from the Cl(16)-E8 Local Lagrangian

$$\int_{8\text{-dim SpaceTime}} \text{Gauge Gravity} + \text{Standard Model} + \text{Fermion Particle-AntiParticle}$$

whereby World-Lines of Particles are represented by Strings moving in a space whose dimensionality includes $8v = 8\text{-dim SpaceTime Dimensions} + 8s+ = 8 \text{ Fermion Particle Types} + 8s- = 8 \text{ Fermion AntiParticle Types}$ combined in the traceless part $J(3,0)$ of the 3×3 Octonion Hermitian Jordan Algebra

$$\begin{array}{ccc} a & 8s+ & 8v \\ 8s+^* & b & 8s- \\ 8v^* & 8s-^* & -a-b \end{array}$$

which has total dimension $8v + 8s+ + 8s- + 2 = 26$ and is the space of a 26D String Theory with Strings seen as World-Lines.

Slices of $8v \text{ SpaceTime}$ are represented as D8 branes. Each D8 brane has Planck-Scale Lattice Structure superpositions of 8 types of E8 Lattice denoted by $1E8, iE8, jE8, kE8, EE8, IE8, JE8, KE8$

Stack D8 branes to get SpaceTime with Strings = World-Lines
with
a and b representing
ordering of D8 brane stacks and Bohm-type Quantum Potential

Let Oct16 = discrete multiplicative group $\{ +/-1, +/-i, +/-j, +/-k, +/-E, +/-I, +/-J, +/-K\}$.
Orbifold by Oct16 the $8s+$ to get 8 Fermion Particle Types
Orbifold by Oct16 the $8s-$ to get 8 Fermion AntiParticle Types

Gauge Bosons from $1E8$ and $EE8$ parts of a D8 give $U(2)$ Electroweak Force
Gauge Bosons from $IE8, JE8,$ and $KE8$ parts of a D8 give $SU(3)$ Color Force
Gauge Bosons from $1E8, iE8, jE8,$ and $kE8$ parts of a D8 give $U(2,2)$ Conformal Gravity

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

Green, Schwartz, and Witten say in their book "Superstring Theory" vol. 1 (Cambridge 1986)

"... For the ... closed ... bosonic string The first excited level ... consists of ... the ground state ... tachyon ... and ... a scalar ... 'dilaton' ... and ... SO(24) ... little group of a ...[26-dim]... massless particle ... and ... a ... massless ... spin two state ...".

Closed string tachyons localized at orbifolds of fermions produce virtual clouds of particles / antiparticles that dress fermions.

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

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

The massless spin two state is what I call the Bohmion:
 the carrier of the Bohm Force of the Bohm-Sarfatti Quantum Potential.
 Peter R. Holland says in his book "The Quantum Theory of Motion" (Cambridge 1993)
 "... the total force ... from the quantum potential ... does not ... fall off with distance ... because ... the quantum potential ... depends on the form of ...[the quantum state]... rather than ... its ... magnitude ...".

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

The Quantum State Form of a Conscious Brain is determined by the configuration of a subset of its 10^{18} to 10^{19} Tubulin Dimers with math description in terms of a large Real Clifford Algebra.

First consider Superposition of States involving one tubulin with one electron of mass m and two different position states separated by a .

The Superposition Separation Energy Difference is the gravitational energy

$$E_{\text{electron}} = G m^2 / a$$

For any single given tubulin $a = 1$ nanometer $= 10^{-7}$ cm so that for a single Electron

$$T = h / E_{\text{electron}} = (\text{Compton} / \text{Schwarzschild}) (a / c) = 10^{26} \text{ sec} = 10^{19} \text{ years}$$

Now consider the case of N Tubulin Electrons in Coherent Superposition

Jack Sarfatti defines coherence length L by $L^3 = N a^3$ so that the Superposition Energy E_N of N superposed Conformation Electrons is

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

The decoherence time for the system of N Tubulin Electrons is

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

So we have the following rough approximate Decoherence Times T_N

Time T_N	Number of Involved Tubulins
$10^{(-5)}$ sec	10^{18}
$25 \times 10^{(-3)}$ sec (40 Hz)	10^{16}