Outline of E8 Physics:

1 – Start with the Cl(16) real Clifford algebra which
has 120-dimensional bosonic bivectors
and a 256-dimensional spinor space that decomposes
into two 128-dimensional half-spinor spaces

2 – The 120-dimensional bosonic bivectors decompose, with respect to factoring
Cl(16) into the tensor product Cl(8) x Cl(8) allowed by 8-periodicity,
into 1x28 + 8x8 + 28x1

3 – Let the 1x28 bosonic bivectors represent Gravity by a MacDowell-Mansouri mechanism
for the Conformal Group Spin(2,4) = SU(2,2)

4 – Let the 8x8 represent a matrix of an 8-dimensional octonionic spacetime
in terms of an 8-dimensional quaternionic M4xCP2 Kaluza-Klein in which
8-dimensional spacetime breaks down into 4-dim physical M4 spacetime
and 4-dim internal symmetry space CP2 = SU(3)/U(2)
(note that working with 8-dim Kaluza-Klein also gives a natural solution
to the Coleman-Mandula problem – see
Weinberg's book Quantum Theory of Fields, Vol. III, pages 12ff, 382–384, etc)

5 – Let the 28x1 bosonic bivectors represent the 12-dim Standard Model

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

7 – Construct 248-dim E8 out of the 120-dim bosonic Cl(16) bivectors
plus the 128-dim half-spinor representation of one generation
without using the anti-generation Cl(16) half-spinor.

8 – Decompose, with respect to factoring Cl(16) into Cl(8) x Cl(8),
the 128-dim fermion one-generation representation
into two 64-dim fermion representations:

one 64 = 8x8 representing 8 fundamental left-handed fermion particles in terms
of their 8 covariant components with respect to 8-dim spacetime

the other 64 = 8x8 representing 8 fundamental right-handed fermion antiparticles
in terms of their 8 covariant components with respect to 8-dim spacetime

9 – let the right-handed massive fermion particles and
the left-handed massive fermion antiparticles emerge dynamically
by Lorentz symmetry

10 – Let the second and third generations of fermions emerge from the geometry
of breaking uniform 8-dim spacetime into 4+4 = 8-dim M4 x CP2 Kaluza-Klein

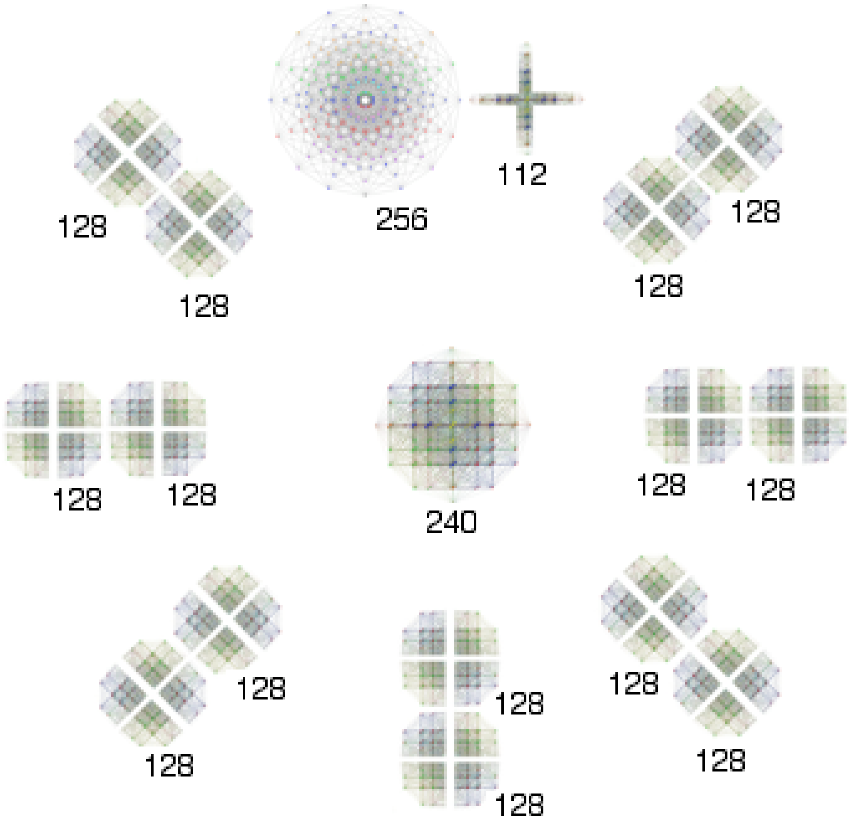
11 – Let the Higgs mechanism emerge naturally (see the work of Meinhard Mayer based
on the math of Kobayashi-Nomizu) from the geometry
of breaking uniform 8-dim spacetime into 4+4 = 8-dim M4 x CP2 Kaluza-Klein

NOTE THAT MY E8 CONSTRUCTION AT THE FUNDAMENTAL LEVEL CONTAINS ONLY ONE FERMION GENERATION,
AND NO ANTIGENERATION so that it has NO CHIRALITY PROBLEM
because
the antigeneration halfspinor of Cl(16) is not included in construction of E8,
which is a physical reason
that E8 is constructed of the Cl(16) bivector plus only one of the half-spinor,
and that if you try to
build a Lie algebra out of the Cl(16) bivector plus both half-spinors it does not work.

Frank Dodd (Tony) Smith, Jr. – 2010

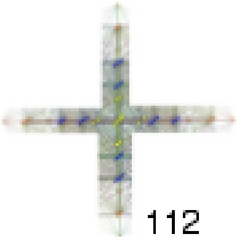
E8 Physics

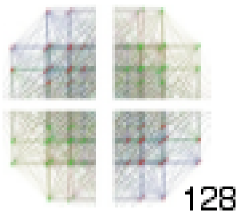
by Frank D. (Tony) Smith, Jr. – September 2009



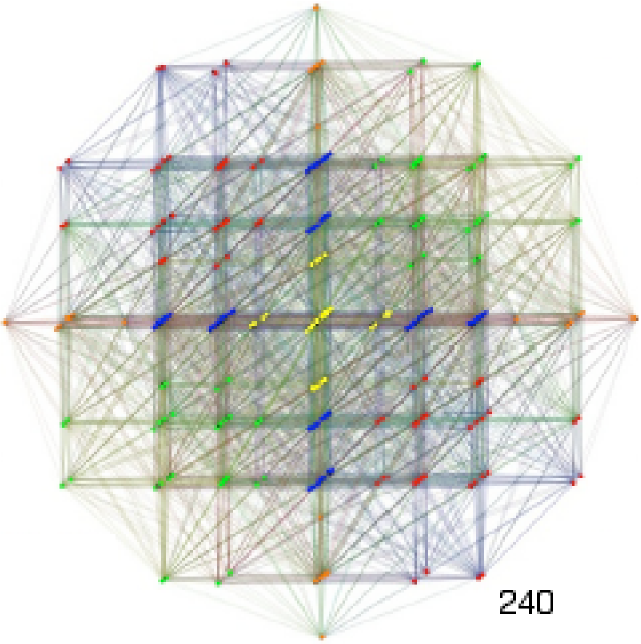
The First and Second shells of an E8 lattice have 240 and 2160 = 112 + 256 + 7(128+128) vertices.
The 256 is an 8-HyperCube with vertices
(+/-1, +/-1, +/-1, +/-1, +/-1, +/-1, +/-1, +/-1) of which
one checkerboard half represents the 128 +half-spinors of D8 and the other mirror image checkerboard half represents the 128 -half-spinors of

D8.
The 112 represents the 112 root vectors of 120-dim D8.
Each of the 7 pairs of 128 are also representations of the 128 +half-spinors and 128 -half-spinors of D8.
The 112 can be combined with any of the 128





to form the 240 of the First Shell of an E8 latttice



that represents the 112 + 128 = 240 root vectors of E8.
There are 7 pairs of 128 in the Second Shell. Each choice of a pair from which to get a 128 to combine with the 112 produces one of the 7 independent E8 lattices.

You can also choose half of the 256 to combine with the 112 to form an 8^{th} E8 lattice. Although the 8^{th} E8 lattice is not independent of the 7, it is useful in constructing a physics model based on 8-Brane spacetime that in the continuum limit at low (compared to Planck) energies has M4 x CP2 Kaluza-Klein structure. Denote the 7 independent E8 lattices by 1E8, 2E8, 3E8, 4E8, 5E8, 6E8, and 7E8 and the 8^{th} E8 lattice by 8E8.

Note that each of the 8 E8 lattices uses only one of the 128 of a pair (or one half of the 256), and that it corresponds to one of the D8 half-spinor spaces. Physically, the chosen 128 represents Fermion Particles and AntiParticles of one generation, so the E8 contains one generation of Fermion Particles and AntiParticles (the second and third generations emerge at low energies). The 128 not chosen represents one antigeneration of Fermion Particles and AntiParticles, so the E8 does not contain a Fermion antigeneration. Therefore, the E8 model has realistic chirality properties. The 128 spinors can represent space spinors and be anticommuting with the E8 Lie algebra commutation relations still preserved, as Pierre Ramond pointed out in hep-th/0112261 (pages 13,14) with respect to F4 and Spin(9).

My goal in this paper is to explain how this E8 model is realistic and overcomes the acknowledged shortcomings of Garrett Lisi's E8 model of arXiv 0711.0770 which model was the motivation for me to work on this E8 model. I think that Garrett Lisi should get full credit for doing the basic ground-work for the E8 model.
I hope that this paper shows to its readers that the E8 model and its AQFT constitute a complete realistic theory that satisfies Einstein's criteria (quoted by Wilczek in the winter 2002 issue of Deadalus) :
"… a theorem which at present can not be based upon anything more than upon a faith in the simplicity, i.e., intelligibility, of nature: there are no arbitrary constants … that is to say,
nature is so constituted that it is possible logically to lay down such strongly determined laws that within these laws only rationally completely determined constants occcur …".

The remainder of this paper consists of the following sections:

10 spacetime Dimensions of 26-dim Bosonic Strings
16 Fermionic Dimensions of 26-dim Bosonic Strings
Closed Bosonic String World-Lines
Quaternionic M4 x CP2 Kaluza-Klein
Calculations of Masses, Force Strengths, etc
-for detailed results of the calculations etc, see web book at
http://www.tony5m17h.net/E8physicsbook.pdf and
www.valdostamuseum.org/hamsmith/E8physicsbook.pdf
AQFT
EPR Entanglement

10 spacetime Dimensions of 26-dim Bosonic Strings:

An 8-Brane is constructed as a superposition of all of the 8 E8 lattices.
Each 8-Brane represents a local neighborhood of spacetime.
Global spacetime is a collection of 8-Branes parameterized by two real variables a , b that are analagous to the conformal dimensions (1,1) that extend (1,3) Minkowski physical spacetime of Spin(1,3) to the (2,4) Conformal spacetime of Spin(2,4) = SU(2,2).
Physical Gauge Bosons link an 8-Brane to a successor 8-Brane along the World Line of that Gauge Boson as follows:
A Gauge Boson emanating from only the 8E8 lattice in the 8-Brane is a U(1) Electromagnetic Photon;
A Gauge Boson emanating from only the 8E8 and the 4E8 lattice in the 8-Brane is a U(2) Weak Boson (note that their common 8E8 unifies the Electromagnetic Photon with the Weak Bosons);
A Gauge Boson emanating from only the 5E8, 6E8, and 7E8 lattices in the 8-Brane is a U(3) Gluon;
A Gauge Boson emanating from only only the 8E8 lattice and the 1E8, 2E8, and 3E8 lattices in the 8-Brane is a U(2,2) = U(1)xSU(2,2) = U(1)xSpin(2,4) Conformal Gauge Boson that gives Gravity by the MacDowell-Mansouri mechanism.

16 Fermionic Dimensions of 26-dim Bosonic Strings:

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

To describe the one fundamental generation of Fermion Particles and AntiParticles of the E8 model add, to the 10 dimensions we already have, a 16-dimensional space that is discretized by Orbifolding it with respect to the 16-element discrete Octonionic multiplicative group
{+/-1,+/-i,+/-j,+/-k,+/-E,+/-I,+/-J,+/-K}
to reduce the 16-dim Fermionic representation space to 16 points {-1,-i,-j,-k,-E,-I,-J,-K;+1,+i,+j,+k,+E,+I,+J,+K}
for which Fermion Particles (nu, ru, gu, bu, e, rd, gd, bu)
are represented by {-1,-i,-j,-k,-E,-I,-J,-K}
and the corresponding Fermion AntiParticles
are represented by {+1,+i,+j,+k,+E,+I,+J,+K}.

Now our E8 model has realistic first-generation Fermions as well as a base manifold with the Standard Model plus Gravity (M4 x CP2 Kaluza-Klein spacetime, with its 4-dim physical spacetime, and the second and third generations of Fermions, emerge at low temperatures when a preferred Quaternionic substructure freezes out from the high-temperature Octonionic structure).

Closed Bosonic String World-Lines:

Interaction of Closed Bosonic Strings as World-Lines looks like Andrew Gray's idea in quant-ph/9712037
"… probabilities are … assigned to entire fine-grained histories … this new formulation makes the same experimental predictions as quantum

field theory …"
so it seems that physical results of Bosonic String Theory can be interpreted as:

String Tachyons can be physically interpreted as describing the virtual particle-antiparticle clouds that dress the orbifold Fermion particles (As Lubos Motl said in his on 13 July 2005: "... closed string tachyons ... can be localized if they appear in a twisted sector of an orbifold ... tachyons condense near the tip which smears out the tip of the cone which makes the tip nice and round. ..." and as Bert Schroer said in hep-th/9908021: "... any compactly localized operator applied to the vacuum generates clouds of pairs of particle/antiparticles ...").

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

The 128 in the 240 of the E8 model breaks up into two 64-element things.
One 64 = 8x8 represents the 8 Dirac gamma covariant components (with respect to high-energy 8-dim spacetime) of each of the 8 fundamental first-generation Fermion Particles;
the other 64 = 8x8 represents the 8 Dirac gamma covariant components (with respect to high-energy 8-dim spacetime) of each of the 8 fundamental first-generation Fermion AntiParticles.

The 112 in the 240 of the E8 model breaks up into three parts: a 64 plus a 24 plus a dual 24.
The 64 = 8x8 in the 112 represents 8 Dirac gammas for the 8 dimensions of high-energy spacetime;
the 24 represents the 24 root vectors of a 28-dim D4 Lie algebra whose generators include those of the Standard Model Gauge Bosons;
the dual 24 represents the 24 root vectors of a second 28-dim D4 Lie algebra whose generators include those of the conformal U(2,2) that

produces Gravity.

Quaternionic M4 x CP2 Kaluza-Klein:

At this stage, the E8 model differs from conventional Gravity plus Standard Model in four respects:
1 - 8-dimensional spacetime
2 – two Spin(8) gauge groups from the two D4 in 112
3 - no Higgs
4 - 1 generation of fermions

These differences can be reconciled as follows:

Introduce (freezing out at lower-than-Planck energies) a preferred Quaternionic 4-dim subspace of the original (high-energy) 8-dim spacetime,
thus forming an 8-dim Kaluza-Klein spacetime M4xCP2
where M4 is 4-dim physical spacetime and CP2 is a 4-dim intrernal symmetry space.

Let the first Spin(8) gauge group act on the M4 physical spacetime through the SU(3) subgroup of its U(4) subgroup. As 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 M4] to which is attached the homogeneous space G / H [SU(3) / U(2) = CP2] … 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 [M4])
…
the Yang-Mills action reduces to a Yang-Mills action for the h-components [U(2) components] of the curvature over M [M4]
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. …".

So, freezing out of a Kaluza-Klein M4xCP2 spacetime plus internal symmetry space produces a classical Lagrangian for the SU(3)xU(2) = SU(3)xSU(2)xU(1) Standard Model including a BEHK Higgs mechanism.

Let the second Spin(8) gauge group act on the M4 physical spacetime through its Conformal Subgroup U(2,2) = Spin(2,4). As Rabindra Mohapatra said (section 14.6 of Unification and Supersymmetry, 2nd edition, Springer-Verlag 1992): "… gravitational theory can emerge from the gauging of conformal symmetry … we start with a Lagrangian invariant under full local conformal symmetry and fix conformal and scale gauge to obtain the usual action for gravity. …".
At this stage, we have reconciled the first 3 of the 4 differences between our E8 Physics Model and conventional Gravity plus the Standard Model.
As to the fourth, the existence of 3 generations of fermions, note that the 8 first generation fermion particles and the 8 first generation antiparticles can each be represented by the 8 basis elements of the Octonions O, and that the second and third generations can be represented by
Pairs of Octonions OxO and
Triples of Octonions OxOxO, respectively.
When the unitary Octonionic 8-dim spacetime is reduced to the Kaluza-Klein M4 x CP2, 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.

Therefore, all four differences have been reconciled, and
our classical Lagrangian E8 Physics Model describes Gravity as well as the Standard Model with a BEHK Higgs mechanism.

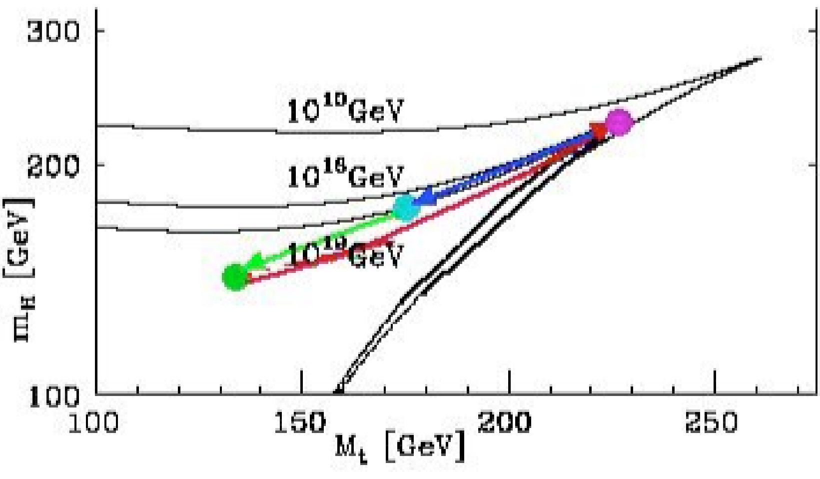
Calculations of Masses, Force Strengths, etc:

However, for our classical Lagrangian E8 Physics Model to be said to be complete and realistic, it must allow us to calculate such things as Force Strengths and Particle Masses that are consistent with experimental and observational results. To do that, we use the results of Hua in his book "Harmonic Analysis of Functions of Several Complex Variables in the Classical Domains". (Similar use of the work of Hua was made years ago by Armand Wyler, and recently by a few others, such as Carlos Castro.)

Hua's calculated volumes related to kernels and Shilov boundaries are the key to calculation of Force Strengths and Particle Masses. For example, the Lagrangian term for each of the Forces is integrated over the M4 physical spacetime base manifold, but each of the Four Forces sees M4 in terms of its own symmetry, consequently with its own measure which measure is proportional to Hua-calculated volumes. Since M4 was formed by a freezing out of a Quaternionic structure, M4 is a 4-dimensional manifold with Quaternionic structure and therefore can be seen as one of Joseph Wolf's 4 equivalence classes:
for Electromagnetism: T4 = U(1)^4
for Weak Force: S2 x S2 = SU(2) / U(1) x SU(2) / U(1)
for Color Force: CP2 = SU(3) / U(2)
for Gravity: S4 = Spin(5) / Spin(4) = Sp(2) / Sp(1)xSp(1)
When we also take into account the relevant volumes related to the curvature term in the Lagrangian for each force,
and the masses involved for forces with gauge bosons related to mass,
the calculations produce results that are reasonably close to experimental observation:

Force Strengths:
Gravity = 5 x 10^-39
Electromagnetic = 1 / 137.03608
Weak = 1.05 x 10^-5
Color at 245 MeV = 0.6286
Renormalization gives Color at 91 GeV = 0.106
and including other effects gives Color at 91 Gev = 0.125

Tree-level fermion masses (Quark masses are constituent masses due to a Bohmian version of Many-Worlds Quantum Theory applied to a confined fermion, in which the fermion is at rest because its kinetic energy is transformed into Bohmian PSI-field potential energy.):
Neutrinos: Me-neutrino = Mmu-neutrino = Mtau-neutrino = 0 at tree-level (first order corrected masses are given below)
Electron/Positron Me = 0.5110 MeV
Up and Down Quarks Md = Mu = 312.8 MeV
Muon Mmu = 104.8 MeV
Strange Quark Ms = 625 MeV
Charm Quark Mc = 2.09 GeV
Tauon Mtau = 1.88 GeV
Beauty Quark Mb = 5.63 GeV
Truth Quark Mt = 130 GeV ground state - 8-dimensional Kaluza-Klein spacetime with Truth-Quark condensate Higgs gives a 3-state system with a renormalization line connecting the 3 states:



(see hep-ph/0307138 for background for chart immediately above)
Low ground state:
Higgs = 146 GeV and T-quark = 130 GeV
Medium Triviality Bound state:
Higgs = 176-188 GeV and T-quark = 172- 175 GeV
High Critical Point state:
Higgs = 239 +/- 3 GeV and T-quark = 218 +/- 3 GeV

Weak Boson Masses (based on a ground state Higgs mass of 146 GeV):
M_W+ = M_W- = 80.326 GeV;
M_Z0 = 80.326 + 11.536 = 91.862 GeV

Kobayashi-Maskawa parameter calculations use phase angle d13 =
= 1 radian (unit length on a phase circumference) to get the K-M matrix:

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

Corrections to the tree-level neutrino calculations give neutrino masses
nu_1 = 0
nu_2 = 9 x 10^(-3)eV
nu_3 = 5.4 x 10^(-2) eV
and
the neutrino mixing matrix:

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

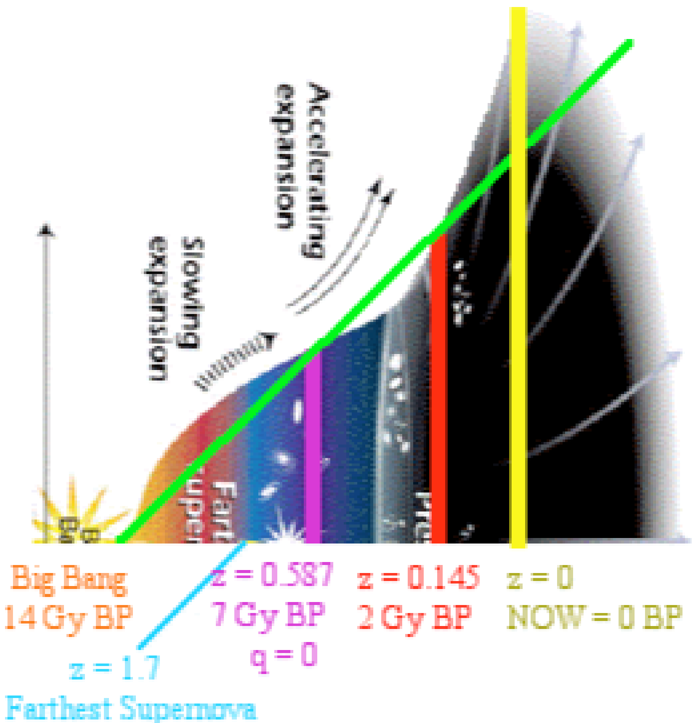
The mass of the charged pion is calculated to be 139 MeV
based on a Kerr-Newman Black Hole model of the pion and its constituent quark-antiquark pair. The pair of Black Holes form a Toroidal Black Hole for which the Torus is an Event Horizon that is (1+1)-dimensional with a timelike dimension which carries a Sine-Gordon Breather whose soliton and antisoliton are the quark and antiquark. The physically relevant Sine-Gordon solution for which the first-order weak coupling expansion is exact gives the ratio of quark constituent mass to the pion mass.

The Neutron-Proton mass difference is calculated to be 1.1 Mev
based on the down quark having virtual states related to the strange quark and the up quark having virtual states related to the charm quark, and the higher probability of strange quark states emerging from the nucleon sea.

The ratio Dark Energy : Dark Matter : Ordinary Matter
for our Universe at the present time is calculated to be:

0.75 : 0.21 : 0.04

based on the Conformal Gravity model of Irving Ezra Segal
and the 15 generators of the Conformal Group Spin(2,4) = SU(2,2)
10 = 6 Lorentz plus 4 Special Conformal = Dark Energy
4 Translations = Dark Matter Primordial Black Holes
1 Dilation = Ordinary Matter mass from Higgs
and the evolution of that basic ratio 10 : 4 : 1 = 0.67 : 0.27 : 0.06
as our universe has expanded



Details of calculations and discussion of some things that here are oversimplified can be found in my free pdf book "E8 and Cl(16) = Cl(8) x Cl(8)" which is available at
http://www.tony5m17h.net/E8physicsbook.pdf and
http://www.valdostamuseum.org/hamsmith/E8physicsbook.pdf

AQFT:

Since the E8 classical Lagrangian is Local, it is necessary to patch together Local Lagrangian Regions to form a Global Structure describing a Global E8 Algebraic Quantum Field Theory (AQFT). Mathematically, this is done by using Clifford Algebras (others now using Clifford algebras in related ways include Carlos Castro and David Finkelstein) to embed E8 into Cl(16) and using a copy of Cl(16) to represent each Local Lagrangian Region. A Global Structure is then formed by taking the tensor products of the copies of Cl(16). Due to Real Clifford Algebra 8-periodicity, Cl(16) = Cl(8)xCl(8) and any Real Clifford Algebra, no matter how large, can be embedded in a tensor product of factors of Cl(8), and therefore of Cl(8)xCl(8) = Cl(16). Just as the completion of the union of all tensor products of 2x2 complex Clifford algebra matrices produces the usual Hyperfinite II1 von Neumann factor that describes creation and annihilation operators on the fermionic Fock space over C^(2n) (see John Baez's Week 175), we can take the completion of the union of all tensor products of Cl(16) = Cl(8)xCl(8) to produce a generalized Hyperfinite II1 von Neumann factor that gives a natural Algebraic Quantum Field Theory structure to the E8 model.

EPR Entanglement:

For the E8 model AQFT to be realistic, it must be consistent with EPR entanglement relations. Joy Christian in arXiv 0904.4259 "Disproofs of Bell, GHZ, and Hardy Type Theorems and the Illusion of Entanglement" said: "… a [geometrically] correct local-realistic framework … provides exact, deterministic, and local underpinnings for at least the Bell, GHZ-3, GHZ-4, and Hardy states. … The alleged non-localities of these states … result from misidentified [geometries] of the EPR elements of reality. … The correlations are … the classical correlations among the points of a 3 or 7-sphere … S3 and S7 … are … parallelizable …
The correlations … can be seen most transparently in the elegant language of Clifford algebra …". The E8 model AQFT is based on the parallelizable Lie group E8 and related Clifford algebras,
so the E8 model seems consistent with EPR.

From Nesti/Percacci 0909.4537 to Lisi 1006.4908

and Beyond to My E8 Physics Model

i.e., N/P using D7 to Lisi E8 and then to my E8 Physics

Frank Dodd (Tony) Smith, Jr. - July 2010

Using compact signature for simplified exposition:

N/P = D7 = adjoint(Spin(14)) + halfspinor(Spin(14)) = 91 + 64 = 169

Lisi = E8 = adjoint(Spin(16)) + halfspinor(Spin(16)) = 120 + 128 = 248

AS TO THE ADJOINT PART:

Spin(16) / Spin(14) x Spin(2) = 28-real-dim 14-complex-dim domain
with 14-real-dim Shilov boundary

Identify 14-dim Shilov boundary with 14-dim vector space of Percacci Spin(14).

14-dim vector space of Percacci Spin(14) breaks down into:
4-dim M4 Minkowski spacetime
plus
an explicit the 10-dim vector space of GUT SO(10) which gives
4-dim CP2 Internal Symmetry Space plus 6-dim Conformal Group Spacetime.

I have problems with using SO(10) GUT because it predicts particles beyond those needed for the Standard Model. Also, it seems to me that the Nesti/ Percacci model may have problems with signature and at this point I will try to discuss signature:

> Nesti/Percaci say that they use SO(3,11) "which uses Majorana-Weyl spinors" and Nesti/Percacci explicitly say in 0909.4537 in the Appendix on page 6: "... signature (3,11) (3 negative, 11 positive eigenvalues) ...". They also say that SO(3,11) breaks down into SO(3,1) x SO(10) so it seems that they use SO(10) = SO(0,10) and again it seems that (x,y) in their notation is x time and y space coordinates.

Therefore they have 3 time and 11 space coordinates even though that gives
the result of using 3 time and 1 space coordinates for their SO(3,1) gravity.
Maybe they realized that when they said at the end of their paper
"... A twist was also adopted to reach a standard basis in signature (3,1) ...".
By periodicity Cl(3,11) = Cl(3,3) is real matrix algebra and so is Cl(3,1)
and
Cl(1,13) = Cl(1,5) is quaternionic matrix algebra and so is Cl(1,3)
so it seems that Nesti/Percacci are using for gravity
SO(3,1) with Clifford 4x4 real matrices
instead of SO(1,3) with Clifford 2x2 quaternion matrices
Therefore,
what Nesti/Percacci seem to want for Gravity
is real matrix algebra to get Majorana-Weyl spinors,
which is not what I would like,
as my model uses quaternionic Cl(1,3) which gives Spin(1,3) which is a
subgroup of the conformal group Spin(2,4) = SU(2,2) for Gravity.

The 6-dim Conformal Group Spacetime can be identified with Minkowski M4
so that the Adjoint effect of going from Nesti/Percacci D7 to Lisi E8 is to
go from using D7 with an external spacetime
to using E8 with a self-contained 8-dim Kaluza-Klein M4xCP2 spacetime.

AS TO THE HALF-SPINOR PART:

Lisi E8 128-dim half-spinor(Spin(16)) = 2 x N/P D7 64-dim half-spinor (Spin(14))

One of the N/P D7 64-dim half-spinors is one generation of fermions,
32-dim for particles and 32-dim for antiparticles.

The second N/P D7 64-dim half-spinors is not used physically in Nesti/Percacci,

so only 64 of the Lisi E8 128 half-spinor(Spin(16)) correspond
to embedding the Nesti/Percacci model in Lisi E8.

The physical interpretation of the second 64 is not clear.

Circumstances such as

SO(10) particles beyond the Standard Model
and
signature problems with Nesti/Percacci
and
E8 generators with no clear physics interpretation in Lisi E8 with embedded Nesti/Percacci

are why I do not use either Nesti/Percacci nor Lisi models.

Here, on the following pages, is what I do:

Percacci/Nesti, Lisi and E8 Physics Models

Frank Dodd (Tony) Smith, Jr. - August 2010

(sometimes I use compact signature for simplified exposition)

Lisi embeds Percacci/Nesti = adjoint(Spin(14)) + halfspinor(Spin(14)) =

= 91 + 64 = 169 dimensions

into

E8 = adjoint(Spin(16)) + halfspinor(Spin(16)) = 120 + 128 = 248 dimensions

AS TO THE ADJOINT PART:

Lisi in 1006.4908 notes that the Percacci/Nesti Spin(3,11) model has the following bosonic-type generators:
6 for gravitational Spin(1,3)
12 for Standard Model color and electroweak gauge bosons
plus
3 for unobserved W' and Z' weak-type gauge bosons
30 unobserved X bosons

My biggest objection to the Percacci/Nesti SO(3,11) model is to the 3 + 30 unobserved W', Z' and X gauge bosons. My effort to make an E8 model (described later in this paper) will not have those 33 unobserved W', Z' and X gauge bosons.

Lisi notes that when the Percacci/Nesti Spin(3,11) model is embedded into E8, there are 120 - 91 = 29 more bosonic-type generators, which Lisi describes as:
20 more unobserved X bosons
8 for frame-Higgs including two axions
1 Peccei-Quinn boson for Spin(1,1)

I am not happy with the 20 unobserved X bosons or the 8 generators giving complicated Higgs sector with two axions,
and
I am not happy with the fact that the Percacci/Nesti and Lisi models have their gauge groups (Spin(3,11) and E8) acting on an external ad hoc 4-dimensional spacetime,
so
I propose that those 20 + 8 = 28 generators of E8 represent the spacetime structures on which the gauge groups operate,
meaning that I would like for **E8 to contain in itself**
not only the gauge bosons and fermion particles on which the gauge forces act, but also the spacetime itself in which the gauge bosons and fermions live and interact.
In other words,
my view of E8 is that **E8 contains in itself all three of the ingredients of a physics Lagrangian:**
(1) a gauge boson force term and (2) a fermion term both of which are integrated over (3) a spacetime base manifold.

My proposed E8 spacetime structure is constructed in terms of symmetric spaces:

Spin(4,12) / Spin(3,11) x Spin(1,1) = 28-real-dim 14-complex-dim domain
with 14-real-dim Shilov boundary
Identify 14-dim Shilov boundary with 14-dim vector space of Percacci Spin(14).
14-dim vector space of Percacci Spin(14) breaks down into:
4-dim M4 Minkowski spacetime for the Lorents Spin(1,3)
plus
an explicit 10-dim vector space of GUT SO(10)

As to the Spin(1,1), Lisi states that it represents 1 Peccei-Quinn boson, which in a non-supersymmetric context is used to enforce CP invariance of the SU(3) color force (see Weinberg's book "Cosmology" (Oxford 2008) pp. 197-200).

AS TO THE HALF-SPINOR PART:

Percacci and Nesti say in 0909.453 that the 64-dim SO(14) half-spinors "... describe precisely the 32 complex components of a chiral spinor of Lorentz and chiral spinor of SO(10), i.e. the representation (2,16) ..."

As to the 128 - 64 = 64 spinor-type generators remaining in E8, Lisi says in 1006.4908 "... the other sixty-four are those of mirror fermions ...".

My biggest objection to the Lisi embedding of Percacci/Nesti Spin(3,11) into E8 (aside from my above remarks that lead to an E8 model which includes spacetime in itself) **is the existence of unobserved mirror fermions**.

Here are my suggestions about how to build an E8 model that satisfies my above-stated objections:

Construction of my E8 Physics Model starts with real Clifford algebra Cl(16) and proceed to interpret it in terms of **Geoffrey Dixon's C x H x O**
which is the tensor product of the Complex Numbers, the Quaternions and the Octonions. Let
the basis for C= Complex numbers correspond to
{ 1 , E } = { neutrino-up quark states , electron-down quark states }
and
the basis for H = Quaternions correspond to
{ 1 , i , j , k } = { lepton , red quark , green quark , blue quark }
and
the basis for O = Octonions correspond to
{ 1 , i , j , k , E , I , J , K } = { t , x1 , x2 , x3 , y1 , y2 , y3 , y4 }
where
t corresponds to 1 time dimension in 8-dim spacetime
xi and yi correspond to 7 spatial dimensions in 8-dim spacetime
and,
after freezing out a preferred quaternionic spacetime subspace at low energies where we do our experiments, thus creating 8-dim M4 x CP2 Kaluza-Klein,
{ t , x1 , x2 , x3 } = 4-dim M4 Minkowski physical spacetime
{ y1 , y2 , y3 , y4 } = 4-dim CP2 = SU(3)/U(2) Batakis Internal Symmetry Space

The real Clifford algebra Cl(16) has 120 bivectors
and 256 spinors = 128 +half-spinors plus 128 -half-spinors.

The two 128-dim half-spinors are physically interpreted as
one 128-dim for one generation of fermion particles and antiparticles
and
the other 128-dim for one antigeneration of fermion particles and antiparticles.

248-dim E8 is constructed by
combining the 120-dim bivector with the 128-dim generation of fermions
and
rejecting the 128-dim antigeneration of fermions.

The 128 fermion generation contains
64 for fermion particles and 64 for fermion antiparticles.

In terms of the 64-dim division algebra structure C x H x O of Geoffrey Dixon

the 64 fermion particles are represented in this way:

From the basis elements of the C x H part of C x H x O:

```
1 x 1 = neutrino
1 x i = red up quark
1 x j = green up quark
1 x k = blue up quark
E x 1 = electron
E x i = red down quark
E x j = green down quark
E x k = blue down quark
```

Adding the O part of C x H x O gives each Particle 8 Octonionic components representing
each Particle's 8 covariant components in 8-dim Kaluza-Klein M4xCP2 spacetime.

The 64 fermion antiparticles are represented similarly.

As to the 120 bivectors of Cl(16) they decompose under the 8-periodicity tensor product Cl(16) = Cl(8) x Cl(8) as
120 = 1x28 + 8x8 + 28x1 = **28 + 64 + 28**

The bivector 64 is related by Triality
to the fermion paticle 64 and the fermion antiparticle 64,
so
bivector 64 = 8x8 = 2x4x8
where in terms of C x H x O:
8 = Octonionic basis elements for 8-dim spacetime
4 = Quaternionic { 1 , i , j , k } = 4 basis elements for 4-dim M4 and for 4-dim CP2
2 = Complex { 1 , E } = 2 basis elements to distinguish between M4 and CP2

Note that with respect to the 120 = 1x28 + 8x8 + 28x1 part of Cl(16) = Cl(8)xCl(8)
the 8 elements 8 of O and one of the 28 come from one Cl(8) factor of Cl(16)
and
the 8 elements 2x4 of CxH and the second of the 28 come from the second Cl (8) factor of Cl(16)
So,
the first 28 bivector generators represent a D4 Lie algebra that acts geometrically on the Octonion 8 that represents 8-dim Octonion spacetime.
After quaternionic subspace freezing to M4xCP2 Kaluza-Klein,
the first D4 is seen to contain a Conformal subalgebra U(2,2) = Spin(2,4)xU(1) which produces Gravity by a generalized MacDowell-Mansouri mechanism
and
the second 28 bivector generators represent a D4 Lie algebra that acts on the 8-dim CxH space corresponding to M4 x CP2
and contains a 15-dim SU(4) subalgebra that includes
the 8-dim SU(3) color force of CP2 = SU(3) / SU(2) x U(1)
A **generalized Batakis** (Class. Quantum Grav. 3 (1986) L99-105) **mechanism produces the 12 = 8+3+1 generators of the Standard Model Lie algebras**:
SU(3) for color force, SU(2) for weak force, and U(1) for electromagnetism.

When the 8-dim spacetime is broken to M4 x CP2 Kaluza-Klein,
that geometric process produces the Higgs by a Mayer-Trautman mechanism
and also
produces the second and third generations of fermions.

Neutrino masses occur by processes beyond tree level,
and
by seeing the Higgs as corresponding to a Tquark condensate you can predict some states that I think are consistent with experimental observations.

Note that the only generators in my E8 model that are not given a direct physical interpretation in terms of the Standard Model + Gravity are:

28 - 16 = 12 generators of the first 28 D4 used for Gravity
and
28 - 12 = 16 generators of the second 28 D4 used for the Standard Model.

My opinion is that
the 12 extra Gravity generators serve as links to the 12 Standard Model generators
and
the 16 extra Standard Model generators serve as links to the 16 Gravity generators,
and
that their role is to enforce mutual compatibility of their actions on the 8-dim Kaluza-Klein M4xCP2 spacetime of my E8 model.

Note further that symmetric space substructures of E8 allow the application of the basic ideas of Armand Wyler with respect to calculation of force strengths, particle masses, etc.

Construction of my E8 Physics Model starts with real Clifford algebra Cl(16)
and proceed to interpret it in terms of Geoffrey Dixon's C x H x O :

In the 64-dim division algebra structure C x H x O of Geoffrey Dixon
now being studied by Cohl Furey 1002.1497 at Perimeter
let
the basis for C= Complex numbers correspond to
{ 1 , E } = { neutrino-up quark states , electron-down quark states }
and
the basis for H = Quaternions correspond to
{ 1 , i , j , k } = { lepton , red quark , green quark , blue quark }
and
the basis for O = Octonions correspond to
{ 1 , i , j , k , E , I , J , K } = { t , x1 , x2 , x3 , y1 , y2 , y3 , y4 }
where
t corresponds to 1 time dimension in 8-dim spacetime
xi and yi correspond to 7 spatial dimensions in 8-dim spacetime
and,
after freezing out a preferred quaternionic spacetime subspace at low energies
where we do our experiments, thus creating 8-dim M4 x CP2 Kaluza-Klein,
{ t , x1 , x2 , x3 } = 4-dim M4 Minkowski physical spacetime
{ y1 , y2 , y3 , y4 } = 4-dim CP2 = SU(3)/U(2) Batakis Internal Symmetry Space

The real Clifford algebra Cl(16) has 120 bivectors
and 256 spinors = 128 +half-spinors plus 128 -half-spinors.

The two 128-dim half-spinors are physically interpreted as
one 128-dim for one generations fermion particles and antiparticles
and
the other 128-dim for one antigeneration of fermion particles and antiparticles.

248-dim E8 is constructed by
combining the 120-dim bivector and the 128-dim generation of fermions
and
rejecting the 128-dim antigeneration of fermions.

The 128 fermion generation contains
64 for fermion particles and 64 for fermion antiparticles.

In terms of the 64-dim division algebra structure C x H x O of Geoffrey Dixon

the 64 fermion particles are represented in this way:

From the basis elements of the C x H part of C x H x O:

```
1 x 1 = neutrino
1 x i = red up quark
1 x j = green up quark
1 x k = blue up quark
E x 1 = electron
E x i = red down quark
E x j = green down quark
E x k = blue down quark
```

Adding the O part of C x H x O gives each Particle 8 Octonionic components representing
each Particle's 8 covariant components in 8-dim Kaluza-Klein M4xCP2 spacetime.

The 64 fermion antiparticles are represented similarly.

As to the 120 bivectors of Cl(16) they decompose under the 8-periodicity tensor product Cl(16) = Cl(8) x Cl(8) as
120 = 1x28 + 8x8 + 28x1 = 28 + 64 + 28

The bivector 64 is related by Triality
to the fermion paticle 64 and the fermion antiparticle 64,
so
bivector 64 = 8x8 = 2x4x8
where in terms of C x H x O:
8 = Octonionic basis elements for 8-dim spacetime
4 = Quaternionic { 1 , i , j , k } = 4 basis elements for 4-dim M4 and for 4-dim CP2
2 = Complex { 1 , E } = 2 basis elements to distinguish between M4 and CP2

Note that with respect to 120 = 1x28 + 8x8 + 28x1

the 8 elements 8 of O and one of the 28 come from one Cl(8) factor of Cl(16)
and
the 8 elements 2x4 of CxH and the second of the 28 come from the second Cl(8) factor of Cl(16)
So,
the first 28 bivector generators represent a D4 Lie algebra that acts geometrically on the Octonion 8 that represents 8-dim Octonion spacetime.
After quaternionic subspace freezing to M4xCP2 Kaluza-Klein,
D4 is seen to contain the Conformal subalgebra U(2,2) = Spin(2,4)xU(1)
which produces Gravity by a generalized MacDowell Mansouri mechanism
and
the second 28 bivector generators represent a D4 Lie algebra that acts
on the 8-dim CxH space corresponding to M4 x CP2
and contains a 15-dim SU(4) subalgebra that includes
the 8-dim SU(3) color force of CP2 = SU(3) / SU(2) x U(1)
A generalized Batakis mechanism produces the 12 = 8+3+1 generators of the Standard Model Lie algebras:
SU(3 for color force, SU(2) for weak force, and U(1) for electromagnetism.

When the 8-dim spacetime is broken to M4 x CP2 Kaluza-Klein,
that geometric process produces the Higgs by a Mayer-Trautman mechanism
and also produces the second and third generations of fermions.
Neutrino masses occur by processes beyond tree level,
and
by seeing the Higgs as corresponding to a Tquark condensate you can predict some states that I think are consistent with experimental observations.

Note that the only generators in my E8 Physics Model that are not given
physical interpretation directly corresponding to Standard Model + Gravity are:

28 - 16 = 12 generators of the first 28 D4 used for Gravity
and
28 - 12 = 16 generators of the second 28 D4 used for the Standard Model.

My opinion is that
the 12 extra Gravity generators serve as links to the 12 Standard Model generators
and
the 16 extra Standard Model generators serve as links to the 16 Gravity generators.

The resulting **Structure of my E8 Physics model** is:

E8 = 120-dim bivector D8 of Cl(16) + 128-dim half-spinor of Cl(16)

By periodicity, Cl(16) = tensor product Cl(8) x Cl(8)
Cl(8) graded structure is 1 8 28 56 70 56 28 8 1
Cl(16) bivectors are 120 which decomposes under that tensor product as
120 = (1 8 28 ...) x (1 8 28 ...) = 1x28 + 8x8 + 28x1

Each 28 was a D4 bivector Lie algebra in Cl(8),
and so preserves that structure in the 120 of Cl(16).
Each 28 D4 acts, at the Cl(8) level, on the vector 8 of Cl(8) in a way
that is effectively 28-dim rotations of 8-dim spacetime.

The 8x8 is tensor product of two vectorial 8 in the two Cl(8),
and so each 8 has the same octonionic spacetime character as
the 8 vectors acted on by the D4 = Spin(8) from bivectors of Cl(8).

The 128 half-spinor of Cl(16) decomposes as:
64+64 of the Cl(14) subalgebra
Each of the 64 then decomposes as

C: (32+32) of the Cl(12) subalgebra, which in turn decomposes as
H: (16+16+16+16) of the Cl(10) subalgebra, which in turn decomposes as
O: (8+8+8+8+8+8+8+8) of the Cl(8) where each 8 has the structure of
a half-spinor of Spin(8) and Cl(8)

By Cl(8) Spin(8) Triality,
the vector 8 is isomorphic to each of the two half-spinor 8,
and
those isomorphisms extends in the E8 Cl(16) structure to a Triality whereby
bivector 64 isomorphic to each of the two 64 in the 128 of E8 and Cl(16).

Note that, in addition to Lattice and Lie Algebra structures, Lie Group Manifold
structures are needed to calculate force strengths, particle masses, etc. using
the geometric point of view of Armand Wyler and L. K. Hua,
and that on the Lie Group Manifold level:
E8 / D8 = 128-dim rank 8 symmetric space (OxO)P2
D8 / D4xD4 = 64-dim rank 8 symmetric space set of RP7 in RP15
D4 / U(4) = 12-dim rank 2 set of fibrations S1 -> RP7 -> CP3 = SU(4) / U(3)

Some Speculative Rough Notes About
Heisenberg Group and E8 Physics - Frank Dodd (Tony) Smith Jr 2010

Consider the grading (grades 0 to 16 inclusive)
of the 256-dim Cl(16) Clifford algebra:

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

The 120 grade-2 bivectors form a Lie algebra that acts as rotations on the 16-dim grade-vector space and represent the 120-dim Spin(16) D8 Lie algebra
so
in that sense they act like gauge bosons.

The 256 = 128 + 128 Cl(16) spinors, being spinors, act like fermions.

If you try to make a big Lie algebra out of the 120-dim D8 Spin(16) plus the 256 Cl(16) spinors, you get a 376-dim mess that does NOT form a Lie algebra,
so
split the 256 spinors into 128 +half-spinors and 128 - half-spinors
and
give them physical interpretation:
128 +half-spinors of Cl(16) = one generation of fermion particles and antiparticles
128 -half-spinors of Cl(16) = one anti-generation of mirror-fermion particles and antiparticles.

Then,
if you throw away the unphysical (because of the need for chirality) anti-generation of mirror-fermions,
you CAN build a big Lie algebra out of the 120-dim D8 Spin(16) plus the 128 Cl(16) +half-spinors of one generation of fermion particles and antiparticles,
which is the 120 + 128 = 248-dim E8 Lie algebra.

As to physical interpretation of the E8 so constructed:

The 128 fermions of one generation split into
64 particle elements plus 64 antiparticle elements.

The 120 bosonic elements are interpreted by using the 8-periodicity tensor product factorization of real Clifford algebras,
whereby Cl(16) = Cl(8) x Cl(8).
Since the graded structure of 256-dim Cl(8) is

1 + 8 + 28 + 56 + 70 + 56 + 28 + 8 + 1

it is clear that the 120 grade-2 bivectors of Cl(16) are identified with

120 = 1x28 + 8x8 + 28x1 = 28 + 64 + 28

where
1 is the grade-0 scalar of Cl(8)
8 is the grade-1 vectors of Cl(8)
28 is the grade-2 bivectors of Cl(8)

When you look at Thomas Larsson's 7-grading of E8
8 + 28 + 56 + 64 + 56 + 28 + 8
and look at its even and odd parts
you see that

Even grades of E8 28 + 64 + 28 correspond to

28 + 28 which is two copies of the 28-dim D4 Lie algebra Spin(8) so that
one 28-dim D4 contains 16-dim U(2,2) which gives Conformal Gravity acting on M4 4-dim physical spacetime
and
the other 28-dim D4 contains 8-dim color SU(3)
which with little group SU(2)xU(1)
gives SU(3) / SU(2)xU(1) = CP2
internal symmetry space of an 8-dim M4xCP2 Kaluza-Klein spacetime

plus

64 = R(64) represents 8-dim spacetime
the 8x8 real matrix algebra R(64) diagonal represents the 8 spacetime dimensions
and the total R(64) represents matrix transformations of 8-dim spacetime.
R(64) can be decomposed into symmetric and skew-symmetric parts.

Symmetric R(64) = 8+28 = 36-dim C4 symplectic Lie algebra Sp(4)
Sp(4) corresponds to the grade-2 part of the Weyl(4) algebra whose
grade-0 and grade-1 parts correspond to the 9-dim Heisenberg algebra H(4).
H(4) corresponds to creation-annihilation operators for
the 4 fermion types (lepton, red quark, green quark, blue quark).

Skew-symmetric R(64) = 28-dim Quaternionic Jordan algebra J4(Q)
B. N. Allison and J. R. Faulkner in their paper "A Cayley-Dickson Process for a Class of Structurable Algebras" (Trans. AMS 283 (1984) 185-210) say
"... [There] are linear bijections ...[between]...
the vector space of all skew-symmetric 8x8 matrices
and
a central simple Jordan algebra of degree 4 ...".
Ranee Brylinski and Bertram Kostant in their paper "Minimal Representations of E6, E7, and E8 and the Generalized Capelli Identity" (Proc. Nat. Acad. Sci. 91 (1994) 2469-2472) say "... there are exactly three simple Jordan algebras ... of degree 4 ... 10-dim J4(R) ... 16-dim J4(c) ... 28-dim Quaternionic J4(Q) ...".

27-dim traceless J4(Q)o <=> 27-dim J3(O) => 26-dim J3(O)o

The 4x28 = 112-dim Quaternification of J4(Q) can be represented as the Symmetric Space E8 / E7 x SU(2) which the book "Einstein Manifolds" (Arthur L. Besse, Springer 1987) describes as "... Set of the (QxO)P2 in (OxO)P2 ...".

Odd grades of E8
8 + 56 + 56 + 8 = 64 + 64
correspond to

8 fermion particle creation operators in 8-dim Kaluza-Klein spacetime
with each of the 8 particles having 8 covariant components

plus

8 fermion antiparticle creation operators in 8-dim Kaluza-Klein spacetime
with each of the 8 particles having 8 covariant components. These 8 can equivalently be seen as 8 fermion particle annihilation operators.

8 fermion particle creation operators and 8 fermion particle annihilation operators form 16 of the 17 dimensions of the Heisenberg algebra H(8).

H(8) can be represented by the 0-grade and 1-grade part of the Weyl(8) algebra in a gradation that is isomorphic to the symmetric algebra of 8-dim space Sym(8), so
H(8) can be said to generate the Weyl(8) algebra whose grade-2 part is
the adjoint representation of the 136-dimensional C8 Lie algebra Sp(8).

If you combine the 112-dim (from Even E8) Quaternification of J4(Q)
with the 136-dim (from Odd E8) C8 Lie algebra Sp(8)
then
you get a 112+136 = 248-dim Symplectic-Heisenberg type algebra
that might be combined
with the E8 Lie algebra itself to produce the 496-dim Ternary Sedenions
(see www.valdostamuseum.org/hamsmith/TernarySedenion.html)

Some References:

Hans Tilgner in his paper "A class of solvable Lie groups and their relation to the canonical formalism" (Ann. I.H.P. A t13 n2 (1970) 103-127) said:
"... the Lie algebra of all bilinear polynomials of the position and momentum operators qi and pi ...[is]... isomorphi[c to the]... Lie algebra spl(2n,R,E) ...[of]... the symplectic matrix group Spl(2n,R,E)
...
for every Hamilton operator which is bilinear in the qi and pi ...[there is]...
a 2n + 2 -dimensional solvable group,
each containing the Heisenberg group as a subgroup.
Their Lie algebras are isomorphic to the Lie algebras formed by
the identity element,
the linear combinations of the qi and pi,
and the chosen Hamilton operatoor in the infinite dimensional associative algebra weyl(E,s), which is a certain modification of the universal enveloping algebra of (Heisenberg) Lie algebra of the canonical commutation operations.
...
it is hard to say which covering group of the infinitely connected group U(n,C) is the invariance group of the n dimensional harmonic oscillator
...
the symplectic group Spl(2n,R,E) ... consists of all invertible 2nx2n matrices which [leave] invariant the [symplectic] bilinear form s
...[of the symplectic vector space E]
...
The ... symplectic group is a 2(2n + 1) -dimensional, noncompact, simple, infinitely connected, connected Lie group
...
The maximal compact subgroup of Spl(2n,R,E) is ...
the unitary group in n dimensions U(n,R,E) ...
and U(n,R,E) = Spl(2n,R,E) intersection SO(2n,R,E)
...
Every R in spl(2n,R,E) can be decomposed uniquely

$$R = \begin{pmatrix} L & K \\ -K & L \end{pmatrix} + \begin{pmatrix} A & B \\ B & -A \end{pmatrix}$$

where K, A and B are symmetric nxn matrices , and L is antisymmetric.
The first part is in u(n,R,E) , the second not.

According to this decomposition we have
spl(2n,R,E) = u(n,R,E) + p
where the vector space p is the intersection of spl(2n,R,E)
with the (Jordan algebra of) symmetric matrices in 2n dimensions.
It is not a Lie algebra but a so-called Lie triple system ...
[There is] a bijection of spl(2n,R,E) onto
the n(2n + 1) -dimensional Jordan algebra of symmetric 2nx2n matrices.
...
[The] Heisenberg group Heis(2n) ... is a 2n + 1 -dimensional Lie group
on the manifold ExR ...
Heis(2n) is nilpotent but not commutative ...[and is]... noncompact
...[and]... connected and simply connected
...
Let ten(heis(2n)) be the tensor algebra of the vector space E + Rc of heis(2n),
x the tensor multiplication,
and ([a,b]- - (axb - bxa)) the two-sided ideal of ten(heis(2n)) ,
which is generated by all elements of the form [a,b]- - (axb - bxa)
with a,b in heis(2n) in ten(heis(2n)) .

Then the infinite dimensional associative algebra
u(heis(2n)): = ten(heis(2n)) / (s(X,Y) c - (XxY - YxX))
is called the universal enveloping algebra of heis(2n).
...
A basis of u(heis(2n)) is given by the identity element and the standard monomials
of the basis elements of inj(heis(2n)) ... embedded injectively in u(heis(2n)).
...
we cannot identify the element inj(c) of inj(heis(2n)) with the identity element
of u(heis(2n) ...
Therefore we consider instead of u(heis(2n))
a different noncommutative associative infinite dimensional algebra
which identifies c and the identity element.
Let (c-1) be the two-sided ideal of u(heis(2n))
which is generated by the elements c-1 in u(heis(2n)) .
Then the algebra weyl(E,s): = u(heis(2n)) / (c-1)
is identical with the algebra ten(E) / (s(X,Y) 1 - (XxY - YxX))
where ten(E) is the tensor algebra over the vector space E,
1 the identity element of ten(E),
and X,Y in E in ten(E).
We call this algebra Weyl algebra of (E,x) ...
heis(2n) is embedded injectively in weyl(E,s).

A basis of weyl(E,x) is given by the standard monomials of the basis element of E in weyl((E,s) and 1.
One should compare ... with
the definition of the Clifford algebra over an orthogonal vector space
...[ten(E) / (XxX - Q(X)1)
where Q(X) is the quadratic form of the vector space of the Clifford algebra]...
...

We get a direct decomposition of weyl(E,s)
if we consider the vector spaces /\Wi ,
defined as linearly generated by the symmetrized standard monomials ...
weyl(E,s) = R1 + E + /\W2 + /\W3 + ...
...
this decomposition weyl(E,s) is not graded, i.e. /\Wi /\Wj is not in /\W(i+j)
... for instance we have /\x /\y = /\xy + (1/2)s(x,y)1
... Instead we have a filtration on weyl(E,s) from which
we can construct a graduation ... but ...
the resulting algebra is commutative ... in fact it is isomorphic to sym(E) ...
...
the Lie algebra R1 + W1 + /\W2 is isomorphic to heis(2n) + spl(2n,R)
...
the restrictions of the linear transformations ad( ) of the vector space weyl(E,s) to the finite-dimensional vector spaces /\Wi are representations of spl(2n,R) ...
the ... one in /\W2 [is] the adjoint representation of spl(2n,R). ...".

R. Hermann in his book "Lie Groups for Physicists" (Benjamin, N. Y. 1966) said:
"... the set of all observables that are at most quadratic in p and q
forms a Lie algebra in p and q.
Those that are precisely quadratic form a subalgebra ... the Lie algebra of the real symplectic group ... a real form of the simple Lie algebra of type Cn ...
The observables that are of degree 0 or 1 in p and q (the Heisenberg algebra) form an ideal in this algebra. ...[We can]... construct a unitary representation of this Lie algebra which extends the representation of the Heisenberg algebra ...
we may extend the representation of the Heisenberg algebra to a representation of the whole algebra of polynomals of degree at most 2 in the variables p and q. We obtain in this way a skew-Hermitan representation of the Lie algebra of the real symplectic group. ...".

Sundaram Thangavelu in his book "Harmonic Analysis on the Heisenberg Group" (Birkhauser 1998) said:
"... The Heisenberg group ... can be realised as a group of unitary operators generated by the exponentials of the position and momentum operators in quantum mechanics.
On the other hand it can be identified with the group of translations of the Siegel upper half space in C(n+1) and plays an important role in our understanding of ... the complex function theory of the unit ball. ...
we can make Rn x Rn x R into a group ... called the Heisenberg group ... denoted by Hn ...
Hn can be realised as groups of upper triangular ... (n+2) x (n+2) ... matrices ... of the form

```
                                     0    y   t+(1/2)x.y
m( x, y, t+(1/2)x.y ) =  I  +   0    0     x
                                     0    0     0
```

...[with]... x,y in Rn, t in R ...
The set of all matrices of the form M(x,y,t) = m(x,y,t) - I is a ... nilpotent ...
Lie algebra with the usual Lie bracket ...
isomorphic to ... Rn x Rn x R ...[with]...
Lie bracket [(x,y,t),(u,v,s)] = (0, 0, u.y - v.x) ...
the Heisenberg group is the image of the above Lie algebra under the exponential map ...
Identifying Rn x Rn with Cn the symplectic form (u.y - v.x) can be written as Im(z.w*) where = z = x + iy and w = u + iv [and * denotes conjugate].
Thus we can define Hn = Cn x R with the group law given by
(z,t)(w,s) = (z + w , t + s + (1/2)Im(z.w*))
... z.w* ... is standard Hermitian form on Cn ...
Now we will see how the Heisenberg group arises in several complex variables. ...
Let B(n+1) denote the unit ball ... in C(n+1)
and let SG(n+1) be the Siegel upper half space ...[in]... C(n+1)
... defined by ... Im(z_(n+1)) > |z|^2 ...
The two domains are biholomorphically equivalent. Indeed, the fractional linear transformation ... maps B(n+1) onto SG(n+1) ...[and]... also preserves boundaries
... SG(n+1) is invariant under ... dilations, rotations and translations ...
dilations ... d_r(z,z_(n+1)) = (r z , r^2 z_(n+1) ...
For each unitary map s of Cn, we have the rotation (z,z_(n+1)) -> (sz , z_(n+1))
...

the translations of SG(n+1) are given by the Heisenberg group ... this enables us to identify Hn with the boundary bSG(n+1) of the Siegel upper half space ...
the Heisenberg group acts on itself and the action is ... the left translation on the Heisenberg group ... the Cauchy-Riemann operators on SG(n+1) ... can be realized as convolution operators on the Heisenberg group ...
...
the sublaplacian ... on the Heisenberg group ... is a unique left invariant, rotation invariant differential operator that is homogeneous of degree 2 ... Though the sublaplacian fails to be elliptic, it satisfies ... subelliptic estimates ...[and]... is closely related to the boundary-Neumann problem on the Siegel upper half space.
...
...
Gn ... the Heisenberg motion group ... is the group of isometries for the natural Heisenberg geometry for which L is the Laplacian. ... this group is the semidirect product of U(n) and Hn .
Thus Gn = U(n) x Hn as a set. ...
for each s in U(n) the map (z , t) -> (sz , t) is an automorphism of ... Hn ...
The Heisenberg motion group acts on Hn by
P(s , z , t) (w , x) = (z , t) (sw , x)
and the group law of Gn is given by
(s , z , t) (r , w , x) = (sr , z+sw , t + x - (1/2) Im sw.z*)
The Heisenberg group Hn and the unitary group U(n) are subgroups
of the Heisenberg motion group Gn .
Moreover,
U(n) is a normal subgroup of Gn
and Hn can be identified as the quotient group Gn / U(n).
...
given a Lie group G and a compact Lie subgroup K of Aut(G) ... There is a natural action of K on the convolution algebra L1(G) ... denote by L1(G/K) the subalgebra of those elements of L1(G) that are invariant under the action of K. The pair (G,K) is said to be a Gelfand pair if the algebra L1(G/K) is commutative.
...
Associated to each Gelfand pair are ... K-spherical functions ...
complex homomorphisms of the commutative Banach algebra L1(G/K) ...
The unitary group U(n) gives rise to a ... compact ... subgroup
of the automorphism group Aut(Hn)
...
There are many subgroups K of U(n) for which (Hn,K) is a Gelfand pair. ...
When K = U(n) we are led to the Heisenberg motion group Gn ...”.

Elias M. Stein in his book “Harmonic Analysis” (Princeton 1993) said:
“... the Heisenberg group ... Hn ... arises in two fundamental but different settings in analysis.

On the one hand, it can be realized as the boundary of the unit ball in several complex variables ... the domain Un is holomorphically equivalent to the unit ball in C(n+1) and it stands in the same relation to that ball as does the upper half-plane to the unit disc in C1. The Heisenberg group arises as the group of translations of Un ; this leads to its identification with the boundary bUn ... the Cauchy-Szego projection can be realized as a convolution operator on Hn with a simple and explicitly given kernel ... the tangential Cauchy-Riemann operators on Un ...[are identified with]... (complex) elements of the Lie algebra of Hn ...

On the other hand, there is its genesis in the context of quantum mechanics, which emphasizes its “symplectic” role ... Regarding phase space and symplectic invariance: ... When ... Qj = xj , Pj = (2 pi i)^(-1) (d / dxj) ...
then the functions a(Q , P) formed in a symplectically-invariant manner are variants of the pseudo-differential operators with symbols a(x , Z) .
This determines the Weyl correspondence a -> Op(a) ...

The Cauchy-Szego integral may be viewed as the othogonal projection of L2(Hn) onto its subspace of boundary values of holomorphic functions. ...
the Cauchy-Szego kernel S(z,w) for the domain Un ... is holomorphic ... symmetric ...[and]... satisfies the reproducing property ...[and]... is unique ...

The underlying complex structure of ... our basic half-space Un in C(n+1) ... leads us to consider the tangential Cauchy-Riemann operators ... complex vector fields on bUn that are ... tangential at bUn ...[and are].... precisely the class of first-order differential operators that annihilate holomorphic functions ...

Fractional linear transformations and the Cauchy-Szego kernel ... Consider the group Go = SU(n+1 , 1) of complex linear transformations of C(n+2) having determinant 1 that preserve ... the Hermitian quadratic form
H(z) = | z(n+2) |^2 - SUM(| zi |^2 for z ... in C(n+2) ...
each element of Go induces a fractional linear transformation of the unit ball to itself ... the induced fractional linear transformation is

$$g(w) = \frac{Aw + B}{Cw + D}$$

where the vector w is thought of as an (n+1) x 1 matrix. ...
Go acts transitively on the unit ball. ...
an... important subgroup of G consists of the affine-linear mappings in G ... it is a product of three ... subgroups A, M, and N. Here A is the subgroup of "dilations", M is the subgroup of "rotations" and N is the Heisenberg group ...

The intimate connection between Sp(n,R) and the Heisenberg group is due to the fact that the ... nodegenerate antisymmetric bilinear ... symplectic ... form ... arises in the group law ... hence the mapping [z , t] -> [s(z) , t] is an automorphism of the Heisenberg group whenever s is in Sp(n,R). ...
for each s in Sp(n,R) there is a unitary operator Us ...

$$\text{If } s = \begin{pmatrix} 0 & I \\ -I & 0 \end{pmatrix} \quad \text{then Us is the Fourier transform} \quad \text{Us f = f\^{}(tilde) ...}$$

$$\text{If } s = \begin{pmatrix} I & 0 \\ C & I \end{pmatrix} \quad \text{then C is symmetric and} \quad \text{(Usf)(x) = exp(pi i Cx.x) f(x) ...}$$

$$\text{If } s = \begin{pmatrix} A & 0 \\ 0 & (At)^{(-1)} \end{pmatrix} \quad \text{then} \quad (Usf)(x) = f(A^{(-1)}x)|\det A|^{(-1/2)}$$

[we can].. choose ... constants so that Us1 Us2 = +/- Us1.s2
This permits us to lift s -> Us to a single-valued representation of
the double covering of Sp(n,R) giving the "metaplectic representation". ...

The special domain Un with is boundary Hn provides a useful model in the study of more general domains in C(n+1) ...
The nilpotent groups that arise as "boundaries" of rank-one symmetric spaces of Cartan are ... direct generalizations of the Heisenberg group ... referred to as H-type groups ...".