E8 Root Vectors from 8D to 3D
Frank Dodd (Tony) Smith, Jr. - viXra 1708.xxxx

Abstract:
This paper is an elementary-level attempt at discussing 8D E8 Physics based on the 240 Root Vectors of an E8 lattice and how it compares with physics models based on 4D and 3D structures such as Glotzer Dimer packings in 3D, Elser-Sloane Quasicrystals in 4D, and various 3D Quasicrystals based on slices of 600-cells.

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My E8 Physics model described in viXra 1602.0319 is based on physical interpretation of each of the 240 Root Vectors of E8. The E8 Root Vectors live in 8D but it is hard for me to visualize 8 dimensional space so I like to use projections to 3D and 2D. Bathsheba Grossman makes laser sculptures in 3D glass cubes, including a sculpture of the 240 E8 Root Vectors. In this E8 sculpture by her

where different 2D face projections of her 3D cube projection from full 8D Root Vectors look quite different, although they obviously represent the same 240 of E8.

The 2D projection above on the left I call the square-cube projection. In it there are 112 Root Vector Vertices on the two axes of the square and there are in each of the 4 off-axis quadrants there are 32 vertices for 4x32 = 128 so that the square-cube projection corresponds to E8 / D8 = (OxO)P2 where E8 has 240 Root Vectors and D8 has 112 Root Vectors and (OxO)P2 is Rosenfeld’s Octo-Octonionic Projective Plane with 64+64 = 128 dimensions of half-spinors for 8 components of 8 fermion particles and 8 fermion antiparticles. The D8 axes have structure D8 / D4 x D4 = 64-dim real 4-Grassmannian of R8 which represents 8 spacetime position x 8 spacetime momentum dimensions and one D4 represents gauge bosons of gravity and ghosts of standard model and the other D4 represents gauge bosons of the standard model and ghosts of gravity.

The 2D projection above on the right I call the circle-ball projection. It has 8 concentric circles each with 30 vertices. 4 circles represent E8 Physics of gravity and the M4 part of M4 x CP2 Kaluza-Klein and 4 represent E8 Physics of standard model and CP2 part of M4 x CP2 Kaluza-Klein.

First, look at the 240 E8 Root Vectors in the square-cube projection:
Here is the physical identification of the 128 E8 / D8 fermionic root vector subset:

Here are some more details using the electron as example:
I conjecture that
the 4 vertices of M4 components for 4D H4grav 600-cell form a tetrahedron
with N = 1 tetrahedra (imagea from Wolfram CDF file by Ed Pegg Jr)

and
the 4 vertices of CP2 components for 4D H4stdmod 600-cell form another tetrahedron
which when combined with the H4grav tetrahedron forms an 8-vertex dimer
as described by Chen, Engel, and Glotzer in arXiv 1001.0586
with N = 2 tetrahedra

representing all 8 components of the electron.

The propagation path of each of the two tetrahedra of the electron dimer remains
within its own 4D H4 600-cell inside the E8 Lattice.
Packing densities in 3D for tetrahedral dimer structures are described by Chen, Engel, and Glotzer in arXiv 1001.0586:

<table>
<thead>
<tr>
<th>#Tetra</th>
<th>Maximum Density</th>
<th>Success Rate</th>
<th>Motifs, Structural Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Numerical, $\hat{\phi}$</td>
<td>Analytical, $\phi$</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.367346</td>
<td>18/49</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>0.719486</td>
<td>$\phi_2$</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>0.666665</td>
<td>2/3</td>
<td>21%</td>
</tr>
<tr>
<td>4</td>
<td>0.856347</td>
<td>4000/4671</td>
<td>80%</td>
</tr>
<tr>
<td>5</td>
<td>0.7480966</td>
<td>$\phi_5$</td>
<td>22%</td>
</tr>
<tr>
<td>6</td>
<td>0.754058</td>
<td>$\phi_6$</td>
<td>11%</td>
</tr>
<tr>
<td>7</td>
<td>0.749304</td>
<td>3500/4671</td>
<td>15%</td>
</tr>
<tr>
<td>8</td>
<td>0.856347</td>
<td>4000/4671</td>
<td>44%</td>
</tr>
<tr>
<td>9</td>
<td>0.766081</td>
<td>—</td>
<td>2%</td>
</tr>
<tr>
<td>10</td>
<td>0.829282</td>
<td>$\phi_{10}$</td>
<td>—</td>
</tr>
<tr>
<td>11</td>
<td>0.794604</td>
<td>—</td>
<td>2%</td>
</tr>
<tr>
<td>12</td>
<td>0.856347</td>
<td>4000/4671</td>
<td>3%</td>
</tr>
<tr>
<td>13</td>
<td>0.788728</td>
<td>—</td>
<td>4%</td>
</tr>
<tr>
<td>14</td>
<td>0.816834</td>
<td>—</td>
<td>3%</td>
</tr>
<tr>
<td>15</td>
<td>0.788693</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>16</td>
<td>0.856342</td>
<td>4000/4671</td>
<td>$&lt; 1%$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>8 × 82</td>
<td>0.850267</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

TABLE I: Maximum numerical densities $\hat{\phi}$ for packings with small cells, obtained with numerical compression via Monte Carlo compression starting from a random configuration. The quasicrystal approximant result with $N = 8 \times 82$ is included. Details about the analytical results $\phi_2 = 9/(139 - 40\sqrt{10})$, $\phi_5 = 0.74809657 \ldots$, $\phi_6 = 11228544/(97802181 - 132043\sqrt{396129})$, and $\phi_{10} = 29611698560/(23657426736 + 4919428689\sqrt{6})$

As you increase the number $N$ of tetrahedra you first encounter the maximum at $N = 4$ which represents two dimers = particle-antiparticle pair (electron-positron)
The maximum is encountered at $N = 4, 8, 12, 16 \ldots$ for dimer tetrahedra periodicity 4. A tetrahedron can be seen as a pair of binary binars

so that the dimer binary periodicity is $2 \times 4 = 8$
which is the same 8-periodicity as Real Clifford Algebras with binary structure.

**The tetrahedral $N = 8$** is for 4 dimers corresponding to a lepton and G R B quarks
(electron and green, red, and blue up quarks)

*Diagram of tetrahedral N = 8*

The tetrahedral $N = 12$ is for 6 dimers corresponding to 3 quark-antiquark pairs
(green, red, and blue up quarks and green, red, and blue up antiquarks)

*Diagram of tetrahedral N = 12*

**The tetrahedral $N = 16$** is for 8 dimers (lepton and G R B quarks and their antiparticles)

*Diagram of tetrahedral N = 16*
The tetrahedral \( N = 32 \) is for 16 dimers that represent \( E8 / D8 = (OxO)P2 \)
\[ = \text{all 16 fermions x 8 components} = 128 \text{ Fermionic E8 Root Vectors} \]

The 128 Fermionic E8 Root Vectors are also consistent with Geoffrey Dixon’s
fundamental tensor \( T^2 \) where \( T = RxCxHxO \)
\[ = \text{real x complex x quaternion x octonion.} \]

The tetrahedral \( N = 48 \) adds \( 16 / 2 = 8 \) dimers (magenta)
representing \( (4+4 = 8) \) dimensions of spacetime and \( 8x8 = 64 \) E8 Root Vectors
for a total of \( 128 + 64 = 192 \) Root Vectors or 96 binars or 24 dimers.

There are two tetrahedra = one Glotzer 8-vertex dimer for each dimension of 8D spacetime. The \( 8x8 = 64 \) vertices are

For each dimension of 8D spacetime,
two tetrahedra represent momentum in 4D M4 and in 4D CP2
each propagating in its own H4 600-cell subspace
Therefore, $128 + 64 = 192$ of the 240 representing fermions and spacetime can be represented as tetrahedra.

The spacetime 64 are isomorphic by Triality to the $N = 8$ lepton and G R B quark particle components ($8 \times 8 = 64$) and to their $N = 8$ lepton and G R B quark antiparticle components ($8 \times 8 = 64$)

Consistently with Clifford Periodicity (tetrahedral $N = 48$ is divisible by 4)
Fermions + Spacetime give a packing of the maximum density $4000 / 4671 = 0.8656347$
which is more dense than a dodecagonal quasicrystal (0.8324) and
more dense than a compressed QC approximant at 0.8503
(see Haji-Akbari1, Engel, Keys, Zheng, Petschek, Palffy-Muhoray, and Glotzer in arXiv 1012.5138)

BUT as tetrahedral $N = 54$, equivalent to binary 108, is NOT consistent with periodicity because when you add EITHER 24 vertices of Gravity+Dark Energy OR 24 vertices of Standard Model to $128 + 64 = 192$ Fermion Particles and Antiparticles and Spacetime then you get 216 vertices or 54 tetrahedra or 108 binars and 54 is not a multiple of 4 and 108 is not a multiple of 8.

However, when you add BOTH 24 vertices of Gravity+Dark Energy AND 24 vertices of Standard Model to $128 + 64 = 192$ Fermion Particles and Antiparticles and Spacetime then you get 240 vertices or 30 dimers or 60 tetrahedra or 120 binars (30 8-vertex dimers give the circle-ball 2D projection) so for $N = 60$ the totality of all 240 E8 Root Vectors is consistent with periodicity.
What is the physical reason that you cannot add only one of 24-vertex Gravity-Dark Energy and 24-vertex Standard Model to the 192 vertices of Fermions and Spacetime but must add both?

A non-physical answer is that \(192 + 24 \text{ vertices} = 216 / 4 = 54\) tetrahedra and 54 is not divisible by 4 whereas \(192 + 24 + 24 \text{ vertices} = 240 / 4 = 60\) tetrahedra is divisible by 4 of periodicity.

Physically, the gauge bosons of Gravity+Dark Energy are in M4 (horizontal axis) and their ghosts are in CP2 (vertical axis) so both axes must be used and Standard Model similarly requires both axes to be used.
Now, look at the 240 E8 Root Vectors in the circle-ball projection:

My E8 Physics model Physical Interpretation of the 240 E8 Root Vectors which break down into two sets of 120 each with H4 symmetry that correspond to the M4 gravity and CP2 standard model sectors of M4 x CP2 Kaluza-Klein is:

64 blue = Spacetime
64 green and cyan = Fermion Particles
64 red and magenta = Fermion AntiParticles
24 yellow = D4g Root Vectors = 12 Root Vectors of SU(2,2) Conformal Gravity + 12 Ghosts of Standard Model SU(3)xSU(2)xU(1)
24 orange = D4sm Root Vectors = 8 Root Vectors of Standard Model SU(3)xSU(2)xU(1) + 16 Ghosts of U(2,2) of Conformal Gravity

Here they are shown in the circle-ball 2-dim projection with 8 circles of 30 vertices each:
Here is how the 240 break down into 120 + 120 of H4grav and H4stdmod

Here are 128 Fermionic Root Vectors with the 8 components for the electron dimer that break into two (M4 and CP2) tetrahedra with 4 vertices shown connected by white lines.

If you combine the dimers for the green, red, and blue up quarks with the electron dimer as shown in purple boxes then you get 4 dimers with maximum packing density.
If you then take all 4 Fermion Quadrants

\[ \text{tetrahedral } N = 32 \text{ for 16 dimers that represent } E_8 / D_8 = (O \times O)P_2 \]

\[ = \text{all 16 fermions x 8 components} = 128 \text{ Fermionic E}_8 \text{ Root Vectors} \]

The 128 Fermionic E_8 Root Vectors are also consistent with Geoffrey Dixon’s fundamental tensor \( T^2 \) where \( T = R \times C \times H \times O \)

\[ = \text{real x complex x quaternion x octonion.} \]

The 240 of E_8 = (128 spinor fermionic E_8 / D_8) + 112 of D_8
The Spinor Fermion part = E8 / D8 contains 128 vertices = 64 binars = 16 dimers = 32 tetrahedra so it has tetrahedral $N = 32$

Since $D8 / D4xD4 = 64$-dim $(OxO)P2$
the 112 of $D8 = (8x8 = 64$ spacetime $) + (24+24 = 48$ D4xD4 $)$
The Spacetime part = D8 / D4xD4 contains 64 vertices = 32 binars = 8 dimers = 16 tetrahedra so it has tetrahedral N = 16

and the total Spinors + Spacetime has 192 vertices = 96 binars = 24 dimers = 48 tetrahedra so it has tetrahedral N = 48

The Gauge Boson + Ghosts part = D4xD4 contains 48 vertices = 24 binars = 6 dimers = 12 tetrahedra so it has tetrahedral N = 12

and the total Spinors + Spacetime + Gauge Bosons + Ghosts has 240 vertices = 120 binars = 30 dimers = 60 tetrahedra so the total E8 tetrahedral N = 60
D4g = 24 Root Vectors =
= 12 Root Vectors of SU(2,2) = Spin(2,4) Conformal Gravity + Dark Energy
+ 12 Ghosts for Standard Model SU(3)xSU(2)xU(1)

Neutrino + RGB Down Quarks

Electron + RGB Up Quarks

M4 Minkowski Physical Spacetime

CP2 = SU(3) / SU(2) x U(1)
Internal Symmetry Space

Positron + RGB Up AntiQuarks

AntiNeutrino + RGB Down AntiQuarks

D4sm = 24 Root Vectors =
= 8 Root Vectors of Standard Model SU(3)xSU(2)xU(1)
+ 16 Ghosts for SU(2,2) = Spin(2,4) Conformal Gravity + Dark Energy
Dimer Packing and QuasiCrystals

In arXiv 1106.4765 Haji-Akbari, Engel, and Glotzer said:
“... Phase Diagram of Hard Tetrahedra ...
Two dense phases of regular tetrahedra have been reported recently. The densest known tetrahedron packing is achieved in a crystal of triangular bipyramids (dimers) ... phase DIII ... triclinic ... with packing density $\frac{4000}{4671} = 85.63\%$.
In simulation a dodecagonal quasicrystal is observed; its approximant, with periodic tiling $(3,4,3^2,4)$, can be compressed to a packing fraction of $85.03\%$. ...

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**FIG. 11:** Schematic phase diagram of hard tetrahedra summarizing our findings. In thermodynamic equilibrium the Dimer III crystal and the approximant are stable (Middle panel). In compression simulations the approximant is never observed, and only the quasicrystal forms. If crystallization is suppressed, then a jammed packing with local tetrahedral order forms [29, 36] (Lower panel). The transformation of the approximant or quasicrystal directly to and from the Dimer III crystal is not observed in simulation. Instead, during expansion the Dimer III crystal transforms into the Dimer II crystal, and then the Dimer I phase prior to melting to the fluid (Upper Panel).

... The phase DIII ... triclinic ... is thermodynamically stable, DII ... monoclinic ... and Di ... rhombohedral ... are metastable ...
The transformation of the approximant or quasicrystal directly to and from the Dimer III crystal is not observed ... Instead, during expansion the Dimer III crystal transforms into the Dimer II crystal, and then the Dimer I phase prior to melting ...
Structurally, the quasicrystal is significantly more complicated than the dimer phase; tetrahedra are arranged into rings that are further capped with pentagonal dipyramids (PDs). The rings and PDs are stacked in logs parallel to the ring axis, which in projection form the vertices of a planar tiling of squares and triangles ...

... Additional particles - referred to as interstitials - appear in the space between the neighboring logs. It is noteworthy that the entire structure is a network of interpenetrating PDs spanning all particles in the system.

A periodic approximant of the quasicrystal, i.e. a crystal approximating the structure of the quasicrystal on a local level, with the (3, 4, 3^2, 4) Archimedean tiling and 82 tetrahedra per unit cell compresses up to ... 85.03%, only slightly less dense than the dimer crystal ...

In this paper we demonstrate that the approximant is more stable than the dimer crystal up to very high pressures and that the system prefers the dimer crystal thermodynamically only at packing densities exceeding 84%. ...”.

The quasicrystal QC is a cut-and-projection from a full E8 lattice and so any QC loses by projection some of the full E8 information, and the lost part of the E8 information corresponds to complicated empire-phason structure of the QC, so

the complexity of the QC phase is due to its failure to connect with full E8 information.
For example, consider the Elser-Sloane 4D QuasiCrystal described by them in J. Phys. A: Math. Gen. 20 (1987) 6161-6168 where they say:

"... Let \( V \) be 8D Euclidean space with orthonormal basis \( e_1, \ldots, e_8 \)

... The unit icosians consist of ... 120 quaternions ...
the icosians ... with the Euclidean ... rational number ... norm lie in a real 8D space and form a lattice isomorphic to the \( E_8 \) lattice ...
the Weyl group \( W(E_8) \) ... is ... [t]he point group \( G_0 \) of this lattice ...

There are 240 icosians of Euclidean norm unity, consisting of the unit icosians and sigma \( \sigma = (1/2)( 1 - \sqrt{5} ) \) times the unit icosians, and these correspond to the 240 minimal vectors of the \( E_8 \) lattice ...

the group \( G_1 = [3,3,5] \) ... consists ... of all transformations of the icosians ...
\( G_1 \) has order 14,400 ...[and]... acts on \( V \) as a subgroup of \( G_0 \) ...
There are two 4D subspaces \( X \) and \( Xbar \) of \( V \) that are invariant under the action of \( G_1 \) ...

We note that \( E_8 \) has only the origin in common with either of the spaces \( X \) or \( Xbar \) ...

The Voronoi cell \( W \) of \( E_8 \) is defined by \( W = \{ Q \in V : ||Q|| \leq ||Q - P|| \text{ for all } P \in E_8 \} \)
... The Voronoi cell \( W \) is a convex 8D polytope ...[with]... 19,400 vertices ...
The ... [Elser-Sloane] quasicrystal involves the 4D polytope \( S \) ... obtained by projecting \( W \) onto the subspace \( Xbar \) ...
... The polytope \( S \) is the convex hull of the projection of these ... \( W \) ... vertices onto \( Xbar \) ...
... to project onto \( Xbar \) ... multiply ...

\[ \Phi = \begin{bmatrix} c(I + \sigma H) & c(I + \tau H) \\ c(I - \sigma H) & c(I - \tau H) \end{bmatrix} \]

where \( I = I_4 = \text{diag}(1,1,1,1), \)

\[ c = (4 + 2\sigma)^{-1/2} = 0.602 \ldots \]

\[ H = \frac{1}{2} \begin{bmatrix} -1 & -1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \]

and take the last four coordinates ... \( S \) has 720 vertices ...
120 vertices of a copy of the polytope \( \{3,3,5\} \) ...
600 vertices of a copy of the reciprocal polytope \( \{5,3,3\} \) (the 120-cell) ...
\( S \) is the convex hull of reciprocal (and concentric) polytopes \( \{3,3,5\} \) and \( \{5,3,3\} \), arranged so that the midpoints of the edges of the \( \{5,3,3\} \) pass through the centres of the triangular faces of the \( \{3,3,5\} \) ...
\( S \) is a 4D analogue of the triacontahedron ... convex hull of ... \{3,5\} ... and \{5,3\} ...
arranged so that the midpoints of their edges coincide ...

The 4D quasicrystal $C$ is obtained by projecting the lattice $E_8$ onto the subspace $X$, subject to the requirement that the projection onto $X_{\bar{}}$ lies in the polytope $S$ ...

(i) $C$ is invariant under a point group (fixing the origin) isomorphic to $G_1 = [3,3,5]$ ...
(ii) $C$ is closed under multiplication by $\tau = (1/2)(1 + \sqrt{5})$ [Golden Ratio] ...
(iii) $C$ is a discrete set of points ...
(iv) ... 120 of the 240 minimal vectors of $E_8$ project into $C$ ... forming a copy of $\{3,3,5\}$
    Similarly ... 120 of the 2160 vectors in $E_8$ of length 2 project into $C$ ... forming a ...
    larger $\{3,3,5\}$ concentric with the first ...
(v) $C$ has a cross section which is a 3D quasicrystal with icosahedral symmetry. ...

Boyle and Steinhardt in arXiv1608.08215 and arXiv1604.06426 say:
“... $H_4$ root $QL$ ... corresponds to the icosians ...

then the maximally-symmetric 4D orthogonal projection of the $E_8$ roots may be achieved by taking the eight columns of the $8 \times 8$ matrix

$$
\begin{pmatrix}
  v^+_1 & v^+_2 & v^+_3 & v^+_4 & v^-_1 & v^-_2 & v^-_3 & v^-_4 \\
\end{pmatrix} =
\begin{pmatrix}
  (I + \sigma H) & (I + \tau H) \\
  (I - \sigma H) & (I - \tau H) \\
\end{pmatrix}
$$

as an orthogonal basis in eight dimensions, and choosing $\{v^+_1, v^+_2, v^+_3, v^+_4\}$ as a basis for the $\parallel$ space, while $\{v^-_1, v^-_2, v^-_3, v^-_4\}$ are a basis for the $\perp$ space. With this choice, the 240 $E_8$ roots project onto the parallel space to yield two copies of the 120 $H_4$ roots (an inner copy and an outer copy that is longer by $\tau$).

...”.

Physically, 8D $E_8$ gives two 4D 600-cells, one in $X = v\parallel$ and the other in $X_{\bar{}} = v\perp$
which in $E_8$ physics represent $M4$ and $CP2$ of 8-dim Kaluza-Klein spacetime $M4 \times CP2$
Therefore, in terms of $E_8$ Physics based on physical interpretation of Root Vectors, each of the two 600-cells contains one $D4$ of $D4xD4$ in $D8$ / $D4xD4$ of $E8$
and the 600-cell with $D4_{grav}$ represents $M4$ spacetime and Gravity+DarkEnergy and the 600-cell with $D4_{stdmod}$ represents CP2 symmetry space and Standard Model.

An Elser-Sloane 4D QC is based on either one or the other of those two 600-cells each of which has 120 vertices corresponding to 120 of the 240 $E_8$ Root Vectors so an

**Elser-Sloane 4D QC cannot describe more than $120 / 240 = \frac{1}{2}$ of $E8$ Physics.**
A 3D QC based on 4D 600-cells is even more limited in the parts of E8 Physics that it can describe, being based on a cross section of the 600-cell of Elser-Sloane 4D QC which cross sections have only a subset of the 120 vertices of the 600-cell.

Here are some cross section slices of a 600-cell
(see “Geometrical Frustration” (Cambridge 1999, 2006) by Sadoc and Mosseri)

<table>
<thead>
<tr>
<th>vertex first</th>
<th>cell first</th>
<th>rhombic triacontahedra</th>
</tr>
</thead>
<tbody>
<tr>
<td>57G contact neighbors</td>
<td>jitterbugs with truncated octahedra</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram showing cross section slices of a 600-cell]
Vertex-first Tetrahedral Slice Structure:
At Equator is the 30-vertex icosidodecahedron + top and bottom vertices = 32 vertices corresponding to 4 momentum dimensions of 4-dim physical spacetime M4
time 4+4 = 8 dimensions of a M4 x CP2 Kaluza-Klein spacetime
where CP2 = SU(3) / SU(2) x U(1) is a compact internal symmetry space
carrying the symmetry groups of the Standard Model.

Adjacent to the icosadodecahedron on either side are 20+12 vertices of dodecahedron +icosahedron whose convex hull is the 32-vertex Rhombic Triacontahedron (RTH).
The upper 20+12 = 32 vertices represent 4 covariant components of 4-dim M4 Physical Spacetime of 8 first-generation fermion fundamental particles
electron, RGB up quarks; neutrino, RGBdown quarks)
and the lower 12+20 = 32 vertices represent 4 covariant components of 4-dim M4 Physical Spacetime of 8 first-generation fermion fundamental particles
(positron, RGB up antiquarks; antineutrino, RGBdown antiquarks).

The upper and lower 12-vertex icosahedra represent
the 12 Root Vectors of the SU(2,2) = Spin(2,4) Conformal Group
that gives, by a MacDowell-Mansouri mechanism, Gravity+ Dark Energy
and
the ghosts of the 12 gauge bosons of the SU(3)xSU(2)xU(1) Standard Model.

Therefore the

Vertex-first Tetrahedral Slice Structure allows construction of a Realistic Physics Model
IF you can generate
the Standard Model gauge bosons from their ghosts
and
the Gravity+Dark Energy ghosts from their gauge bosons
and
the 4D CP2 components of fermions and spacetime from the existence of M4 x CP2 Kaluza-Klein

The result with Tetrahedral Vertex-first Slicing is very similar to the result with Rhombic Triacontahedra based

on sharp and flat golden rhombohedra
Cell-first Tetrahedral Slice Structure with 57G:
The top and bottom structures are **26-vertex groups of 57 tetrahedra (57G)**
which are the maximal number of tetrahedra in a group
all in contact with each other within the 600-cell.

This configuration most clearly shows how
individual tetrahedra represent individual fermions

but

vertices with similar physical interpretation
are not grouped together as nicely
as in Vertex-first Slicing or as with Rhombic Triacontahedra.
"... The 32-vertex **Rhombic Triacontahedron**, is a combination of the 12-vertex Icosahedron and the 20-vertex Dodecahedron. It "forms the convex hull of ... orthographic projection ... using the Golden ratio in the basis vectors ... of a 6-cube to 3 dimensions." (Wikipedia).

The 32-vertex Rhombic Triacontahedron does not itself tile 3-dim space but it is important in 3-dim QuasiCrystal tiling. Mackay (J. Mic. 146 (1987) 233-243) said "... the basic cluster, to be observed everywhere in the three-dimensional ... Penrose ...tiling ...[is]... a rhombic triacontahedron (RTH) ... The 3-D tiling can be regarded as an assembly of such RTH, party overlapping ...".

To look at tiling 3-dim space by Rhombic Triacontahedra, the first step is to describe the physical interpretation of the Rhombic Triacontahedra, beginning with

which are interpreted as $4 \times 8 = 32$ vertices representing

4 covariant components of 4-dim M4 Physical Spacetime of 8 first-generation fermion fundamental particles (electron, RGB up quarks; neutrino, RGBdown quarks)

and $4 \times 8 = 32$ vertices representing

4 covariant components of 4-dim M4 Physical Spacetime of 8 first-generation fermion fundamental particles (positron, RGB up antiquarks; antineutrino, RGBdown antiquarks)
Since fermion particles are inherently Left-Handed, so their RTH is Left-Handed and fermion antiparticles are inherently Right-Handed, so their RTH is Right-Handed.

The third RTH with no handedness describes Spacetime as $4\times 8 = 32$ vertices representing 4 momentum dimensions of 4-dim physical spacetime $M_4$ time $4+4 = 8$ dimensions of a $M_4 \times CP^2$ Kaluza-Klein spacetime where $CP^2 = SU(3) / SU(2) \times U(1)$ is a compact internal symmetry space carrying the symmetry groups of the Standard Model.

Note that the central RTH of spacetime as a Rhombic Triacontahedron is dual to the equatorial icosadodecahedron of the vertex-first slices of a 600-cell.

The two 12-vertex icosahedra (top and bottom slices of the 600-cell) represent the 12 Root Vectors of the $SU(2,2) = Spin(2,4)$ Conformal Group that gives, by a MacDowell-Mansouri mechanism, Gravity+ Dark Energy and the ghosts of the 12 gauge bosons of the $SU(3)\times SU(2)\times U(1)$ Standard Model.

Note that the cuboctahedron transforms by Jitterbug to an icosahedron which is the top and bottom configuration for Vertex-first projection.
Mackay (J. Mic. 146 (1987) 233-243) said "... a rhombic triacontahedron (RTH) ... can be deformed to ... a truncated octahedron ... [which is] the space-filling polyhedron for body-centered cubic close packing ...

... By a similar process ... a cuboctahedron... can be deformed to an icosahedron ...

Using those Jitterbug transformations the icosahedral / rhombic triacontahedral slicing of the 24-cell goes to cuboctahedral / truncated octahedral structure

The 4x8 = 32 M4 spacetime components of 8 fermion particles (left-hand) and 4x8 = 32 M4 spacetime components of 8 fermion antiparticles (right-hand) are indicated by color codes

- ν: neutrino,
- red down quark,
- green down quark,
- blue down quark;
- blue up quark,
- green up quark,
- red up quark,
- e: electron

With the quarks at vertices of square faces and the leptons at centers of hexagon faces.

For the central configuration representing spacetime the 8 dimensions of spacetime correspond to the 8 fundamental fermions.
Truncated Octahedra tile 3D space
and
the cuboctahedron has a 6-square configuration that is compatible
with the 6-square space-filling configuration of the truncated octahedron
so
the Rhombic Triacontahedra slicing can, by Jitterbug transformation
tile 3D space with transformed Truncated Octahedra
EXCEPT that some of the Truncated Octahedra (marked in cyan in the following image) must be replaced by Cuboctahedra:
(image from apgoucher at cp4space (25 Aug 2013))

The 3D QC Quasicrystal structure of Rhombic Triacontahedra with Icosahedra
is transformed by Jitterbug into
a 3D almost-space-filling structure of Truncated Octahedra with Cuboctahedra.

Instead of the empire - phason structure of vertex-first 600-cell slicing 3D QC
with points, icosahedra, dodedahedra, and an icosidodecahedron
you have
the pattern of cuboctahedra replacements in the overall truncated octahedral 3D tiling.
Therefore the Rhombic Triacontahedra Structure allows construction of a Realistic Physics Model IF you can generate the Standard Model gauge bosons from their ghosts and the Gravity+Dark Enery ghosts from their gauge bosons and the 4D CP2 components of fermions and spacetime from the existence of M4 x CP2 Kaluza-Klein

( That is, IF the 600-cell of H4grav could somehow generate the information of the other 600-cell H4stdmod that it is missing. )