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viXra:1508.0065

## High Energy Particle Physics

### E8 Root Vectors - Physical Interpretation

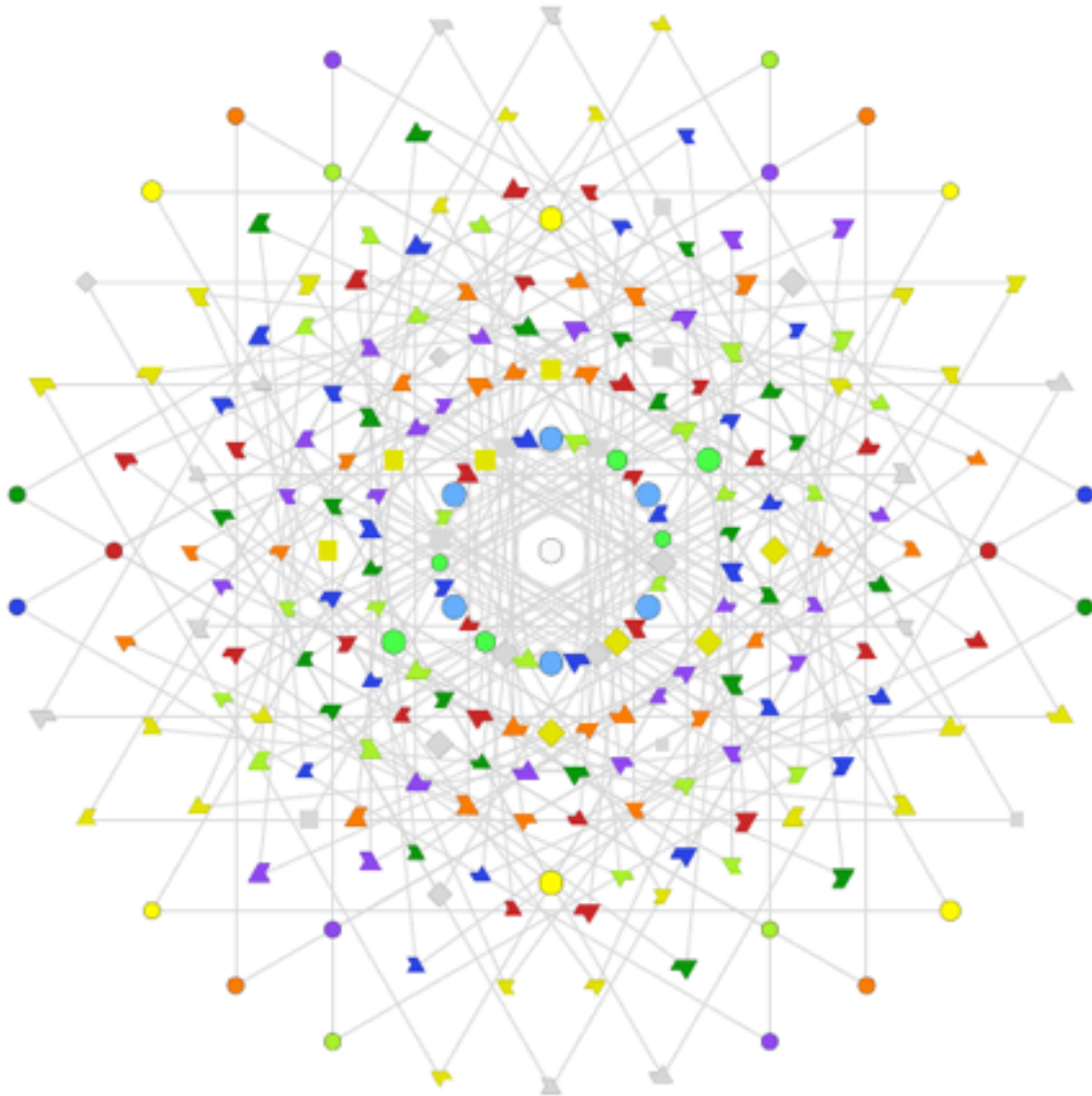
**Authors:** [Frank Dodd Tony Smith Jr](#)

Physical interpretations of the 240 Root Vectors of E8 are given by Garrett Lisi (arXiv 1506.08073) and by Tony Smith (viXra 1405.0030) using, respectively, an 8-circle x 30 vertex projection to 2-dim and a square/cube vertex projection to 2-dim. This paper compares the two interpretations and their projections and gives a graphical view of the physical interpretations of viXra 1405.0030 using the square/cube projection.

# E8 Root Vectors - Physical Interpretation

Frank Dodd (Tony) Smith, Jr. - 2015 - viXra 1508.0065

Garrett Lisi has proposed ( arXiv 1506.08073 ) that the 240 Root Vectors of E8 have a Physical Interpretation, saying "... Spacetime is ... part of the Lie group ... When all fields and particles of General Relativity and the Standard Model, including three generations of fermions, are described ... as excitations of the ... Lie group E8(-24), having 248 dimensions ...

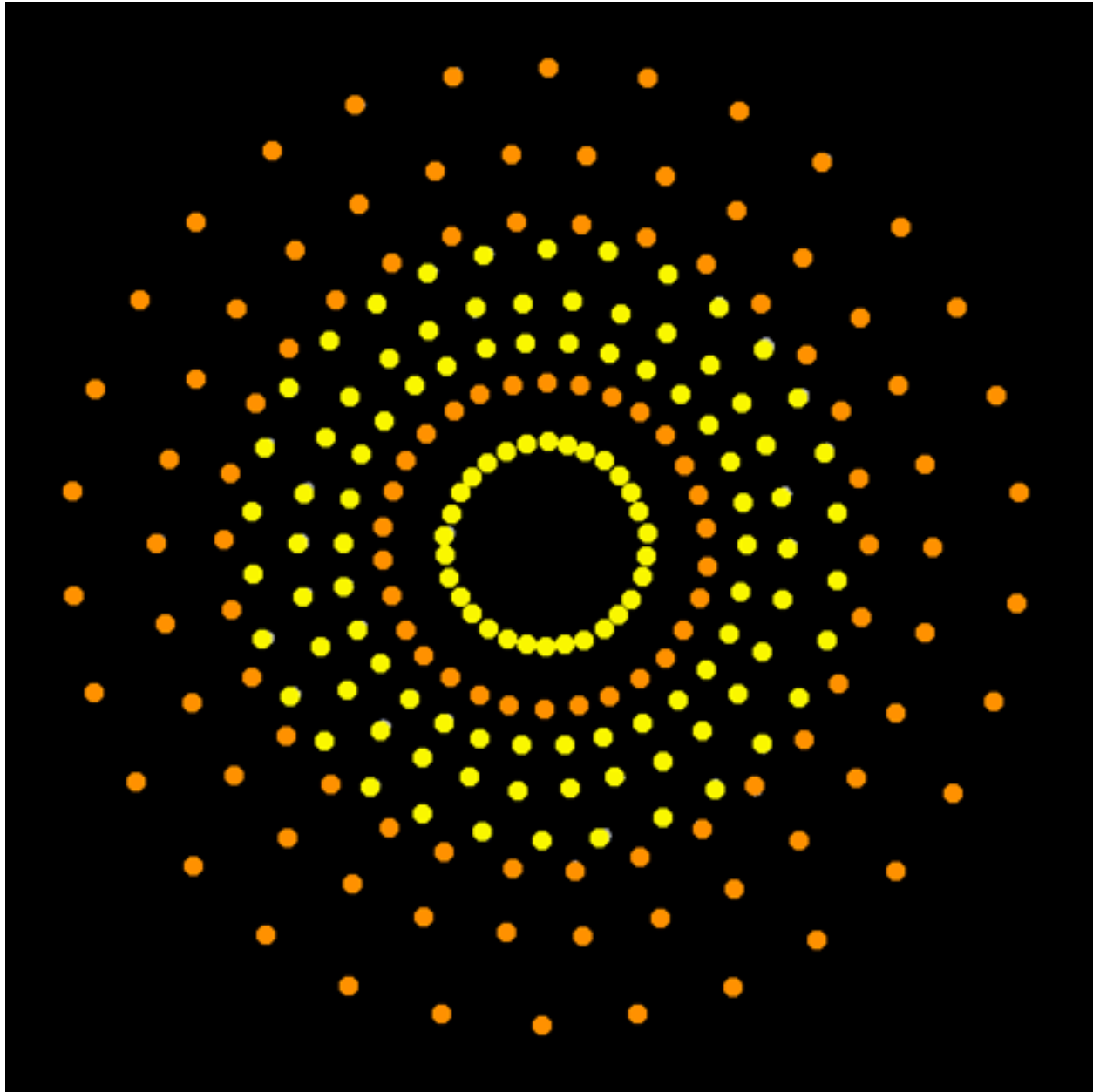


**Figure 1.** The  $E_8$  root system, with three generations of particles related by triality. These particle states are meant to be suggestive rather than definitive. The detailed assignments of elementary particle states to  $E_8$  roots, views of other rotations, and other unification models, are available at the Elementary Particle Explorer: <http://differentialgeometry.org/epe/>

... there is one new, colored gauge boson and its antiparticle ...”.

Garrett Lisi represents the 240 Root Vectors of E8 as projected from 8-dim to 2-dim in the form of 8 concentric circles of 30 Root Vectors each, and attempts to interpret the 240 Root Vectors as directly representing all 3 generations of Fermions.

I prefer a different interpretation of the 240 Root Vectors, based on 8-dim Octonionic spacetime being seen as 4+4 -dim Quaternionic M4 x CP2 Kaluza-Klein Spacetime:

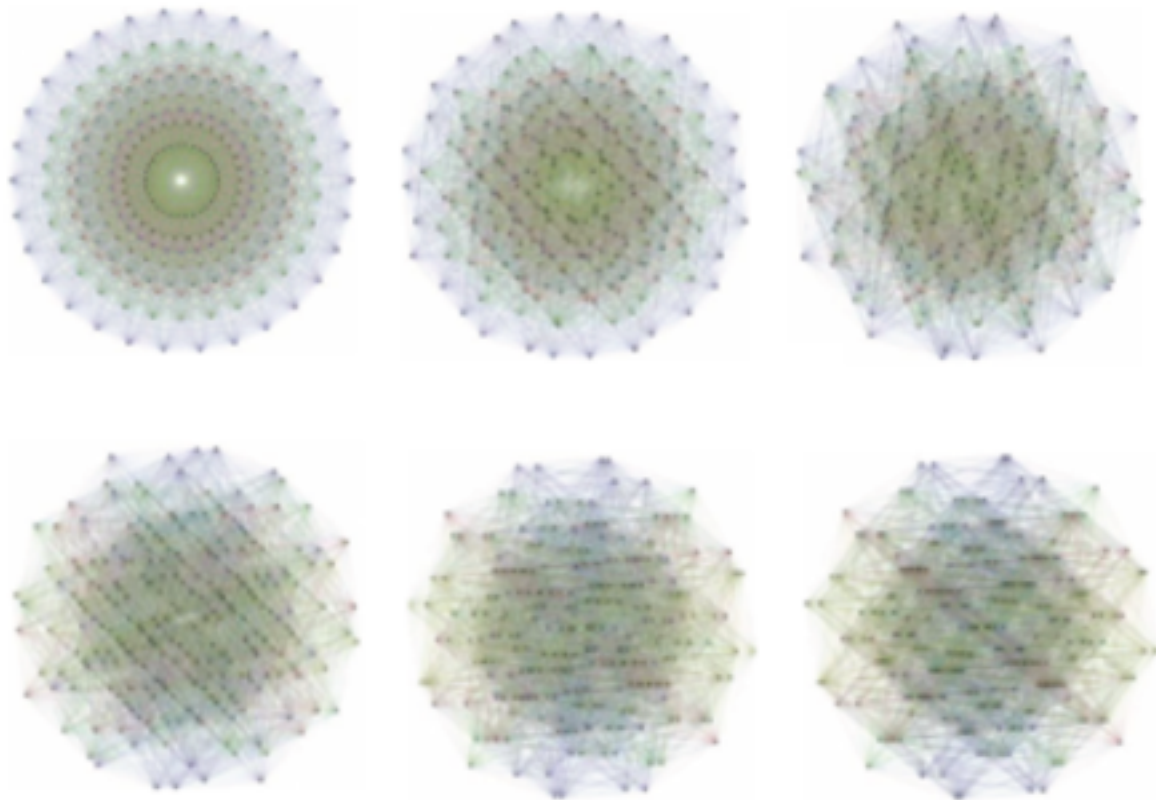


120 of the 240 (yellow dots) represent aspects of First-Generation Fermions, Gauge Bosons and Ghosts, and Position and Momentum related to M4 Physical Spacetime. 120 of the 240 (orange dots) represent aspects of First-Generation Fermions, Gauge Bosons and Ghosts, and Position and Momentum related to CP2 = SU(3) / SU(2)xU(1) Internal Symmetry Space. ( for details see viXra 1405.0030 )

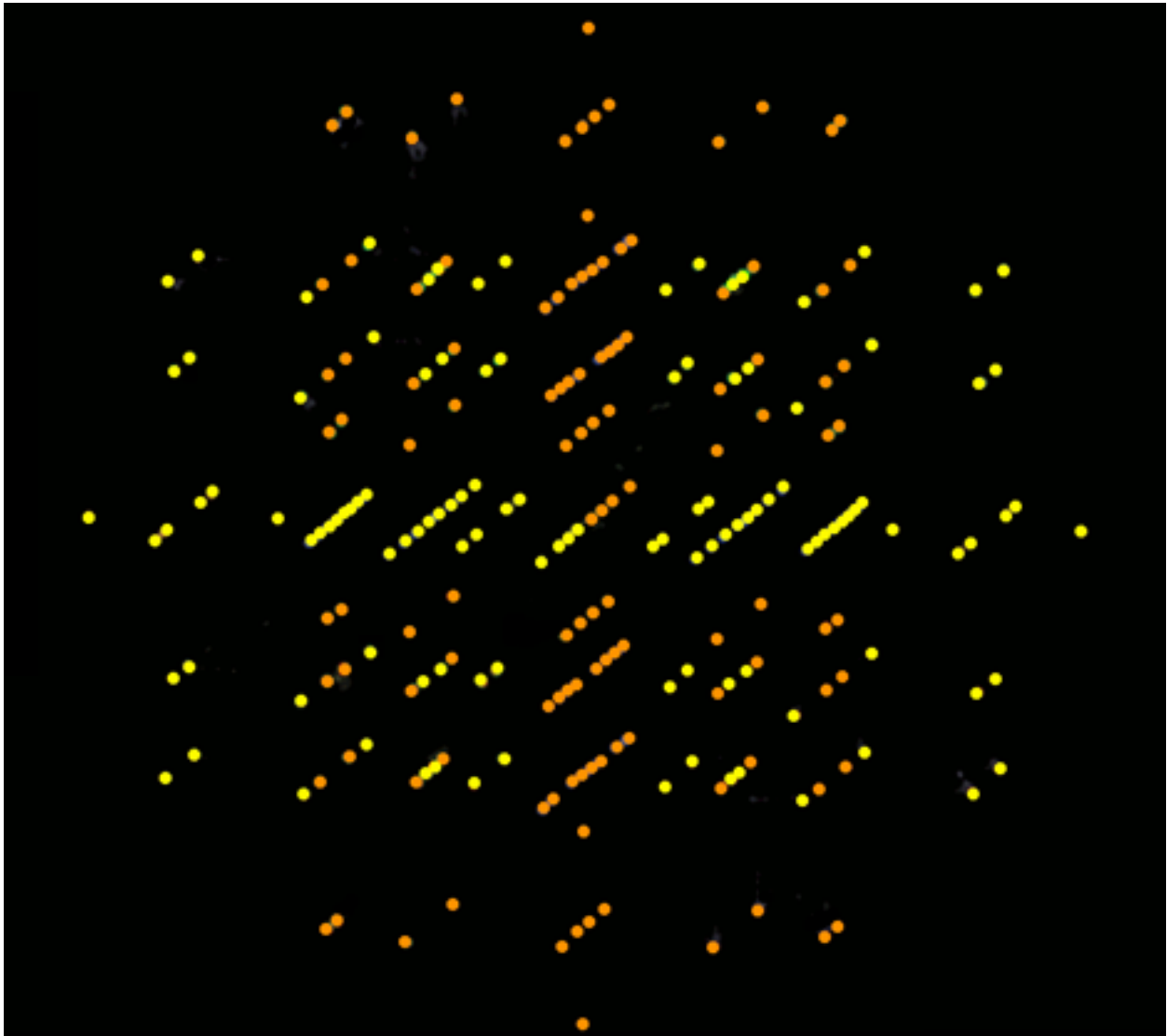
The 120 Root Vectors (yellow dots) related to M4 Physical Spacetime form 4 circles of 30 Root Vectors each, corresponding 120 vertices of a Quaternionic 600-cell.

The 120 Root Vectors (orange dots) related to CP2 Internal Symmetry Space form the remaining 4 circles of 30 Root Vectors each, corresponding 120 vertices of a second Quaternionic 600-cell whose radii are larger than those of the 4 M4 circles by the Golden Ratio  $( 1 + \sqrt{5} ) / 2$ .

Garrett Lisi ( around 2007 ) produced a video from mathematica code that shows a transformation from the 2-dim projection 8 Circles of 30 Root Vectors to another 2-dim projection with Square Geometry related to Cube Geometry. Here is a sequence of images from that video:



Here is a Square/Cube Geometry version of the 4 + 4 circles of 120 + 120 Root Vectors:



At this stage, it looks more confusing and complicated than the 4+4 Circle Geometry,

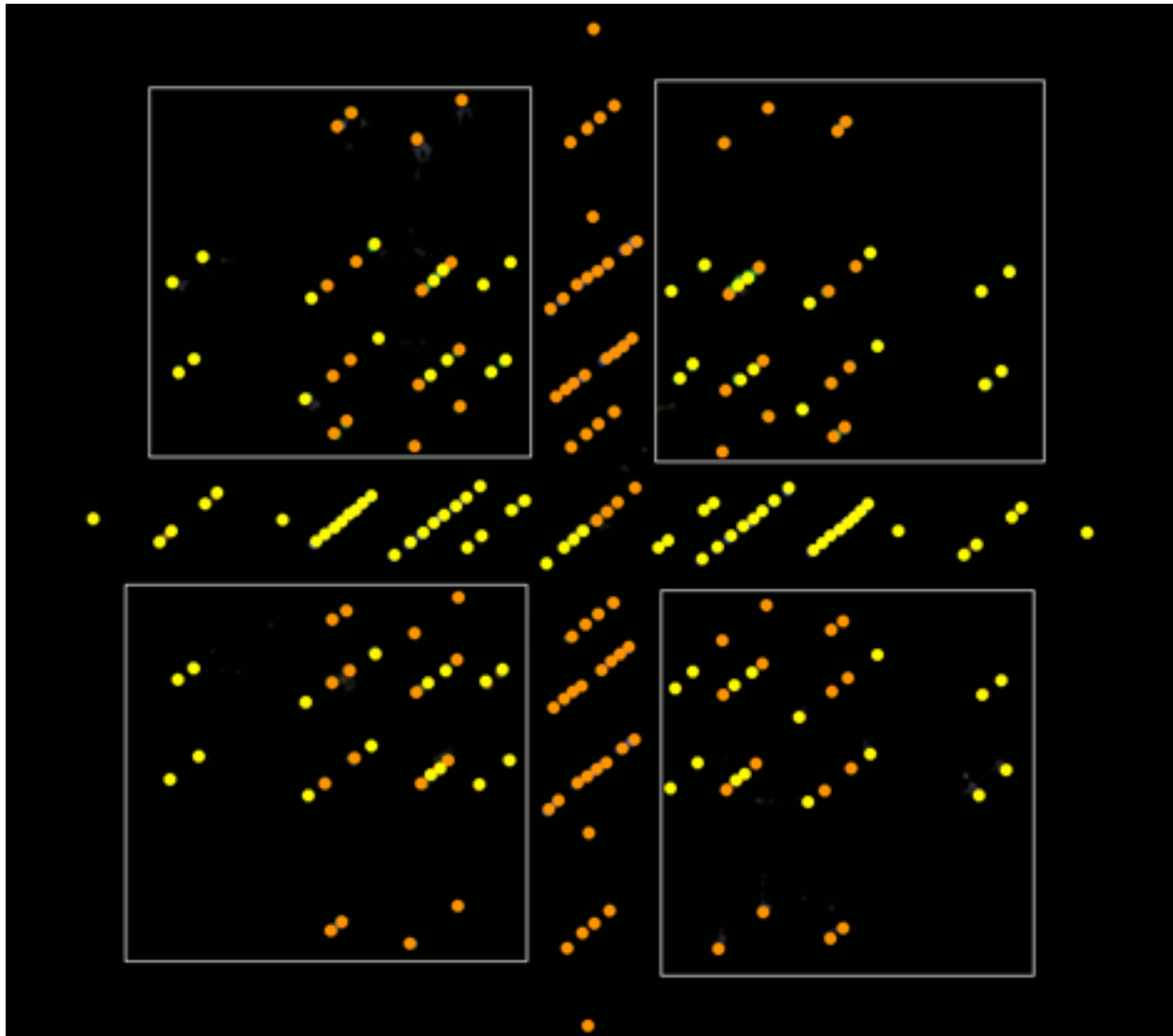
but

if you separate

the Horizontal Axis and Vertical Axis Root Vectors (  $56 + 56 = 112$  of them )

from

the 4 Off-Axis Quadrant Root Vectors (  $4 \times 32 = 128$  of them )



you see that the 112 Horizontal Axis and Vertical Axis Root Vectors represent the Root Vectors of a 120-dim D8 subalgebra of the 248-dim E8 Lie algebra and

the 128 Off-Axis Quadrant Root Vectors represent the Symmetric Space

$$E8 / D8 = (OxO)P2 \text{ representing}$$

64 = 8 Octonionic Components of 8 First-Generation Fermion Particles  
and

64 = 8 Octonionic Components of 8 First-Generation Fermion Anti-Particles

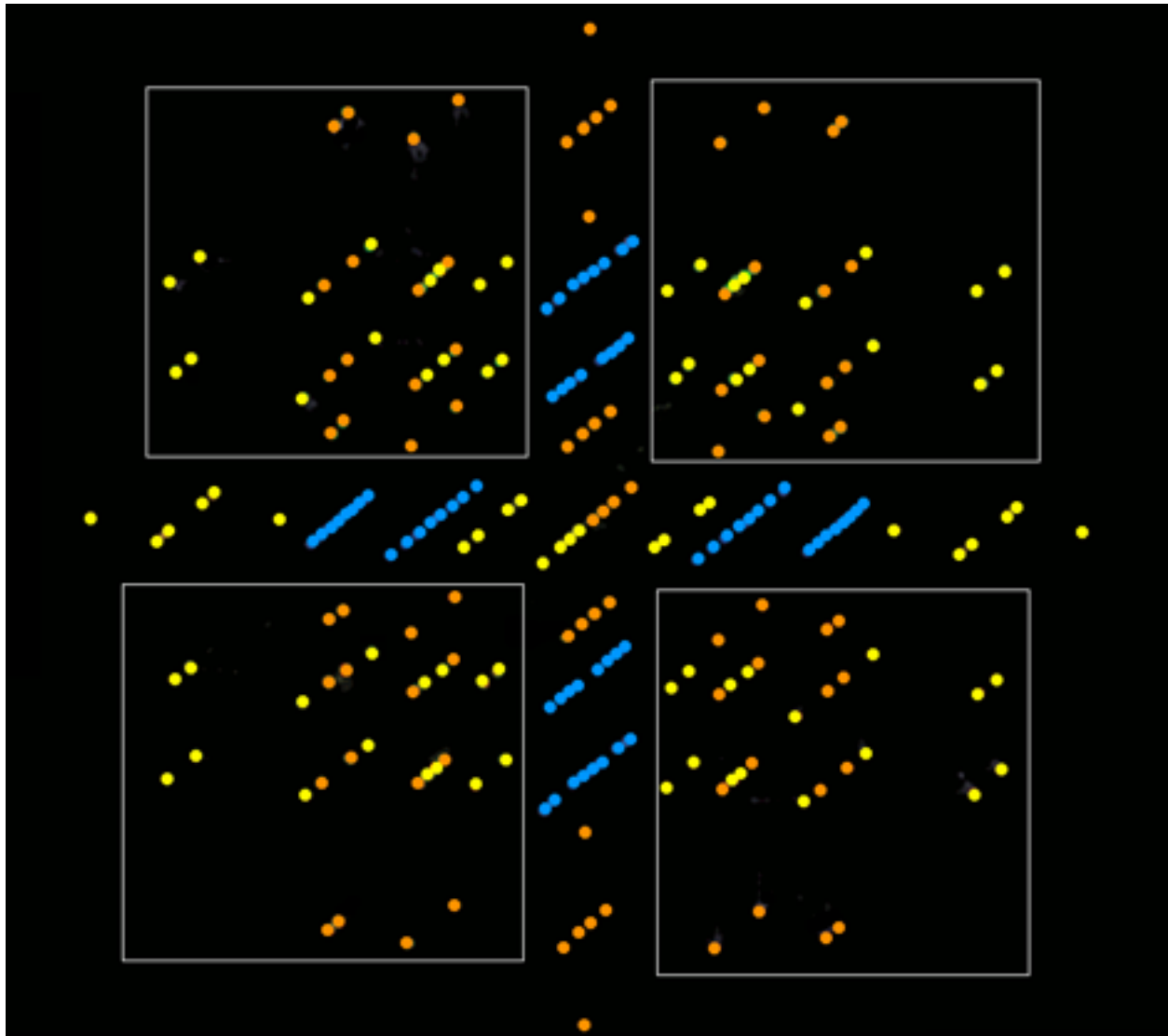
D8 contains a  $28+28 = 56$ -dim  $D4 \times D4$  subalgebra and the Symmetric Space

$$D8 / D4 \times D4 = Gr(8,16) = 64\text{-dim Octonionic Subspaces of } R16$$

( Gr = Grassmanian and R16 = Vectors of Clifford  $Cl(16)$  Matrix Algebra for D8 )

( 8-dim Octonionic spacetime  $\Rightarrow$  Quaternionic 4+4 Kaluza-Klein  $M4 \times CP2$  spacetime which symmetry breaking produces second and third generation fermions and Higgs )

The 64 (blue dots) represent 8 Position x 8 Momentum of Octonionic Spacetime



The 56-dim  $D_4 \times D_4$  on the Horizontal Axis (orange dots) and Vertical Axis (yellow dots) represents Gauge Bosons and Ghosts.

Each 28-dim  $D_4$  is represented by 24 Root Vectors + 4  $E_8$  Cartan Subalgebra Elements

The yellow dot D4 represents Conformal Gravity + Dark Energy

$D4 / D3 \times U(1) = 12$  Standard Model Gauge Boson Ghosts ( 8 Root Vector + 4 Cartan )  
 $U(1) = 1$  Cartan Element

$D3 = A3 = Spin(2,4) = SU(2,2)$  Conformal Gravity + Dark Energy with 12 Root Vectors  
and 3 Cartan Elements

The orange dot D4 represents Standard Model Gauge Bosons

$D4 / A3 \times U(1) = 12$  Gravity+DE Root Vector Ghosts

$U(1) = 1$  Gravity+DE Cartan Ghost

$A3 / A2 \times U(1) = 6 = 4$   $SU(2) \times U(1)$  Gauge Bosons + 2 Gravity+DE Cartan Ghosts

$U(1) = 1$  Gravity+DE Cartan Ghost

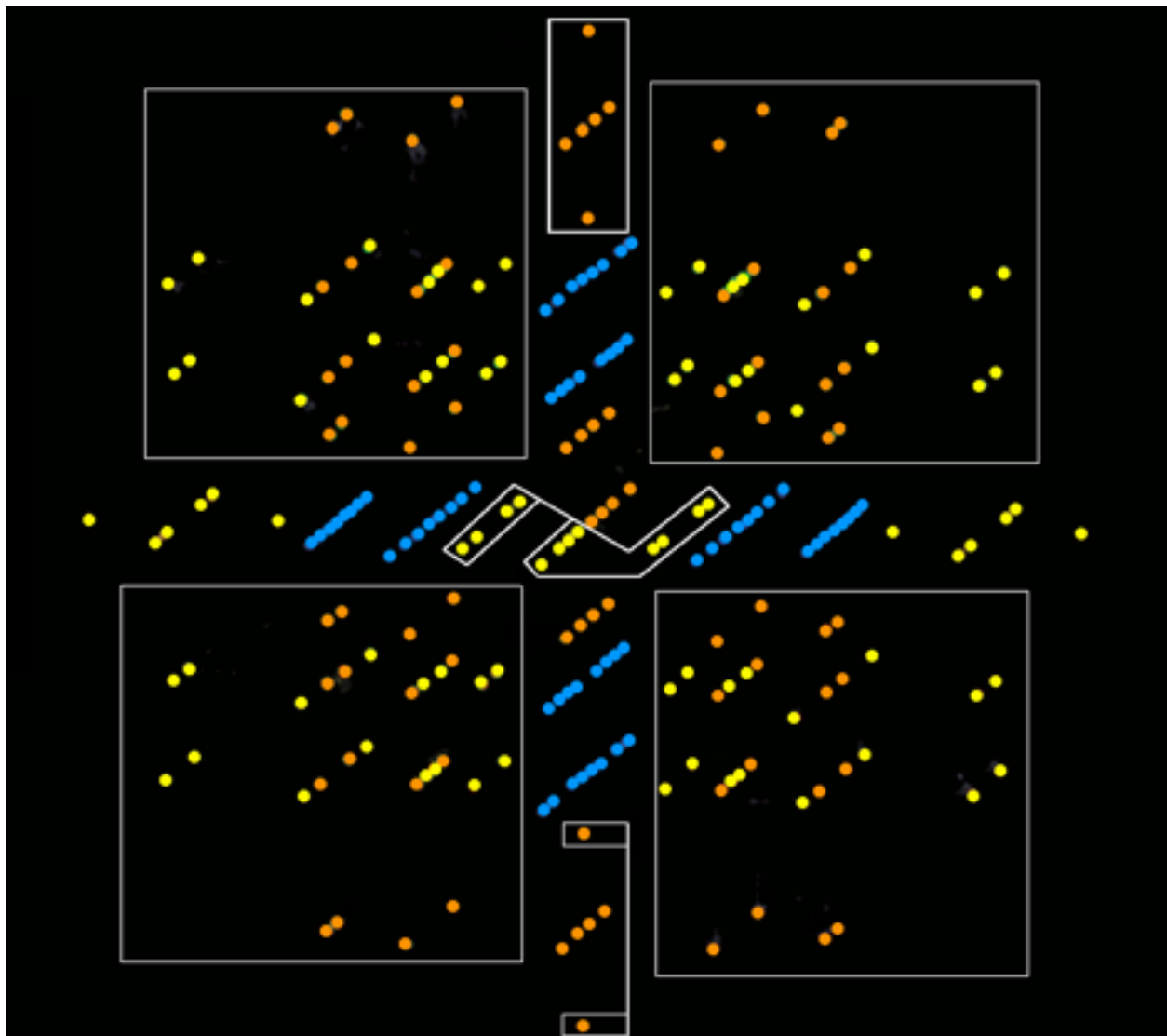
$A2 = 8$   $SU(3)$  Color Gauge Bosons with 6 Root Vectors and 2 Cartan Elements

$SU(2) = 3$  Weak Gauge Bosons with 2 Root Vectors and 1 Cartan Element

$U(1) =$  Photon with 1 Cartan Element

Gauge Bosons and Fermions are enclosed in white boundaries.

Ghosts and Spacetime are not so enclosed.

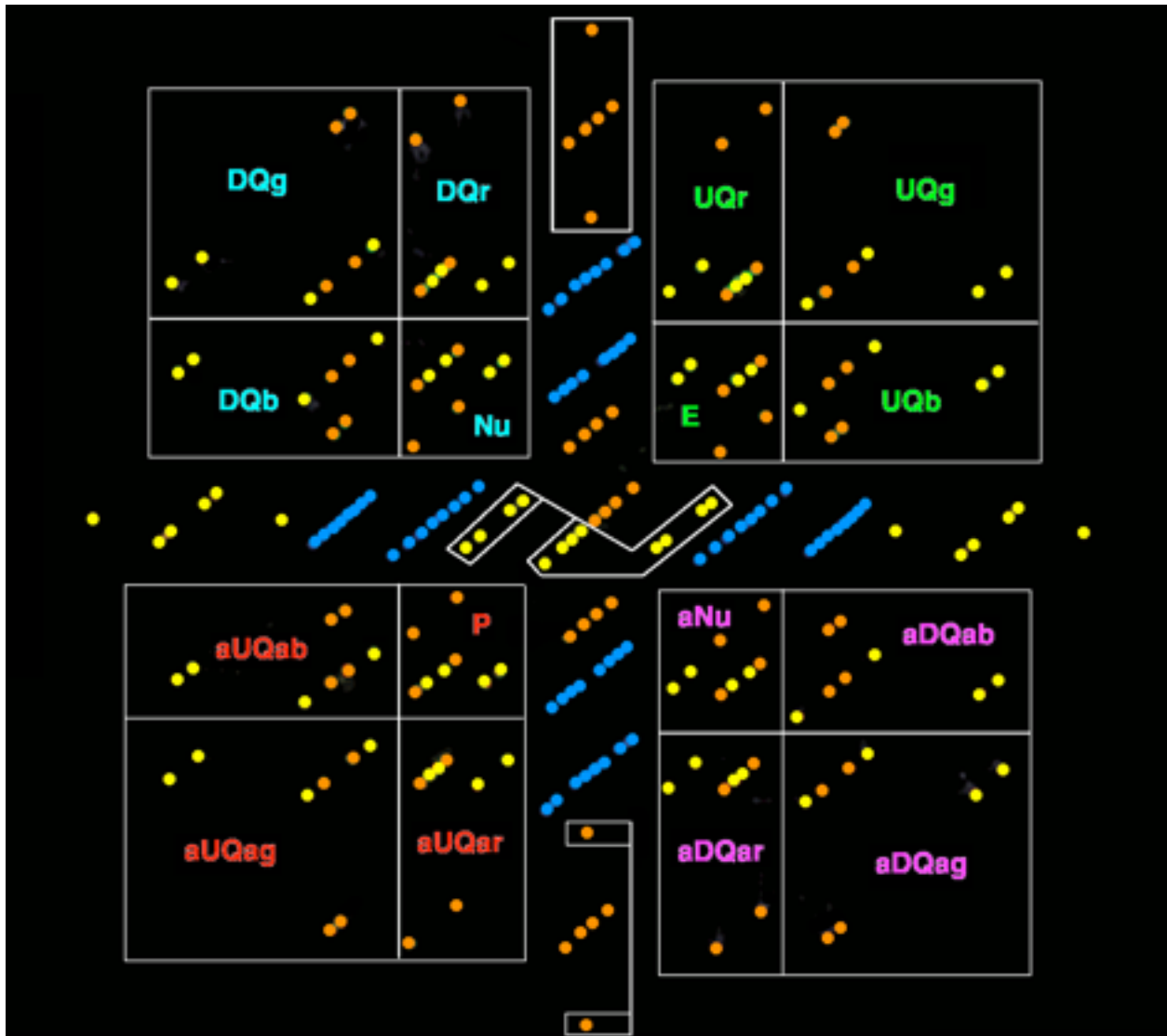




The 128 Off-Axis Quadrant Root Vectors represent the Symmetric Space  
 $E_8 / D_8 = (OxO)P_2$  representing  
 64 = 8 Octonionic Components of 8 First-Generation Fermion Particles  
 and  
 64 = 8 Octonionic Components of 8 First-Generation Fermion Anti-Particles

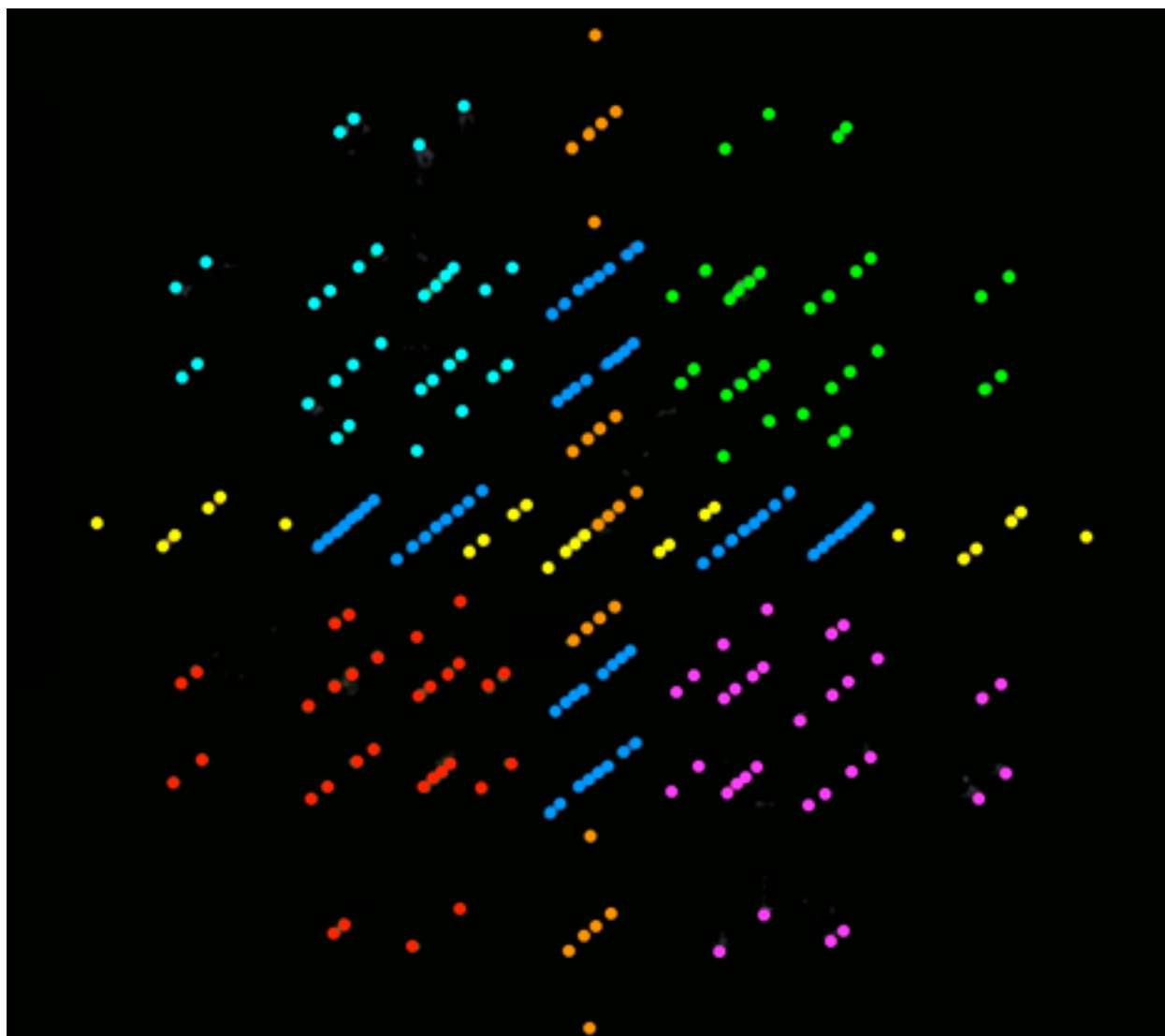
Leptons and Quarks are:

Electron, U Quark red, U Quark green, U Quark blue  
 Neutrino, D Quark red, D Quark green, D Quark blue  
 Positron, U antiQuark antired, U antiQuark antigreen, U antiQuark antiblue  
 antiNeutrino, D antiQuark antired, D antiQuark antigreen, D antiQuark antiblue



Each Fermion has 8 Octonionic Components,  
 4 for M4 (yellow dots) and 4 for CP2 (orange dots)  
 of Quaternionic M4 x CP2 Kaluza-Klein

If you color the Fermions **green**, **cyan**, **red**, **magenta** for types E, Nu, P, and anti-Nu  
then  
the Square/Cube Geometry of the 240 E8 Root Vectors is

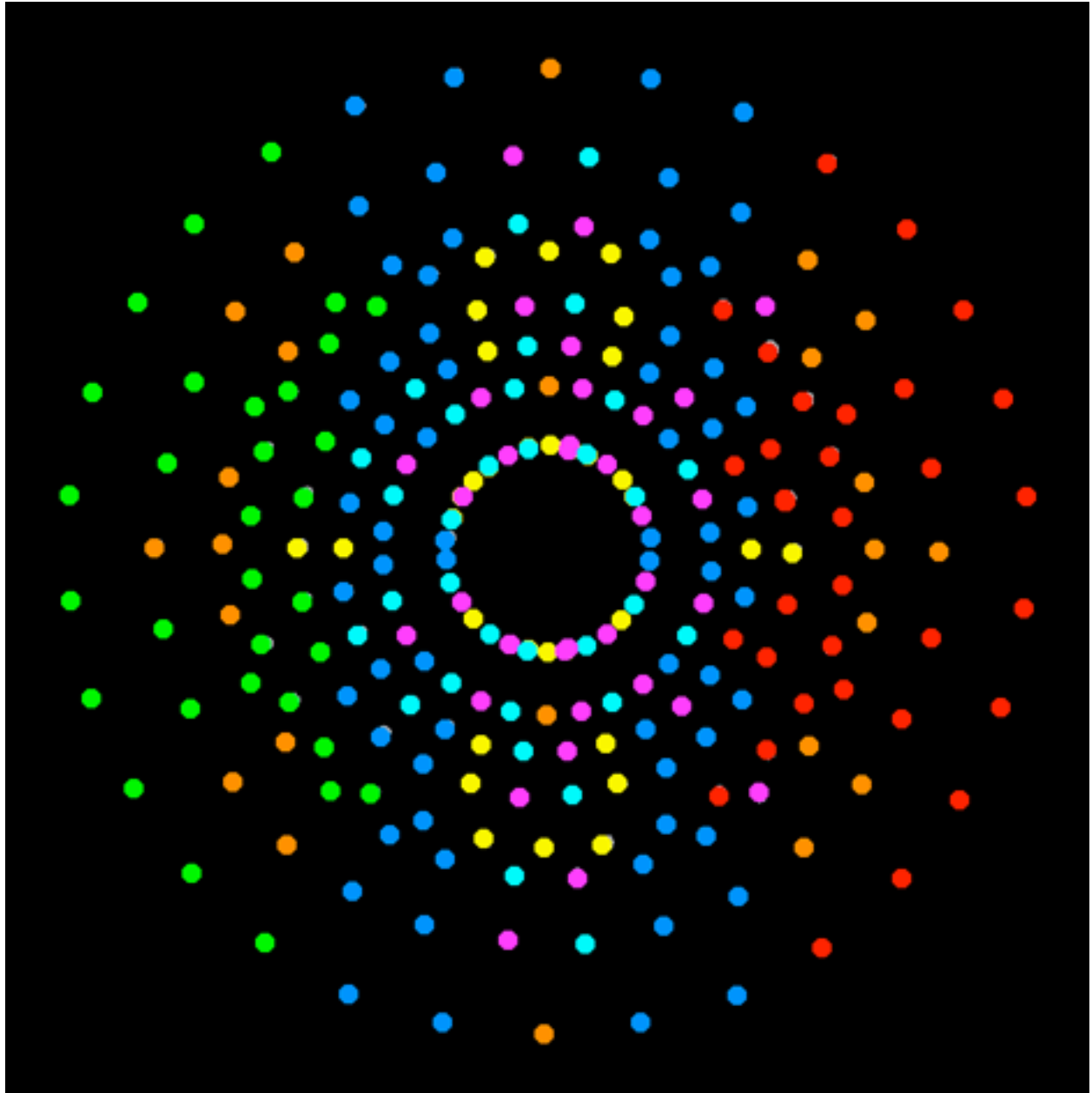


This is consistent with the full unprojected 8-dim picture of the 240 Root Vectors:

1 at North Pole  
56 nearest neighbors of North Pole  
126 next-to-nearest neighbors of North Pole  
56 next-to-next-to-nearest neighbors of North Pole (nearest neighbors to South Pole)  
1 at South Pole

If the 4+4 Cartan Subalgebra elements of E8 are added to the 56 and 56  
you get a 1 + 60 + 126 + 60 + 1 grading of 248-dim E8 in which  
60 + 60 = D8 and 1 + 126 + 1 = E8 / D8 = (OxO)P2

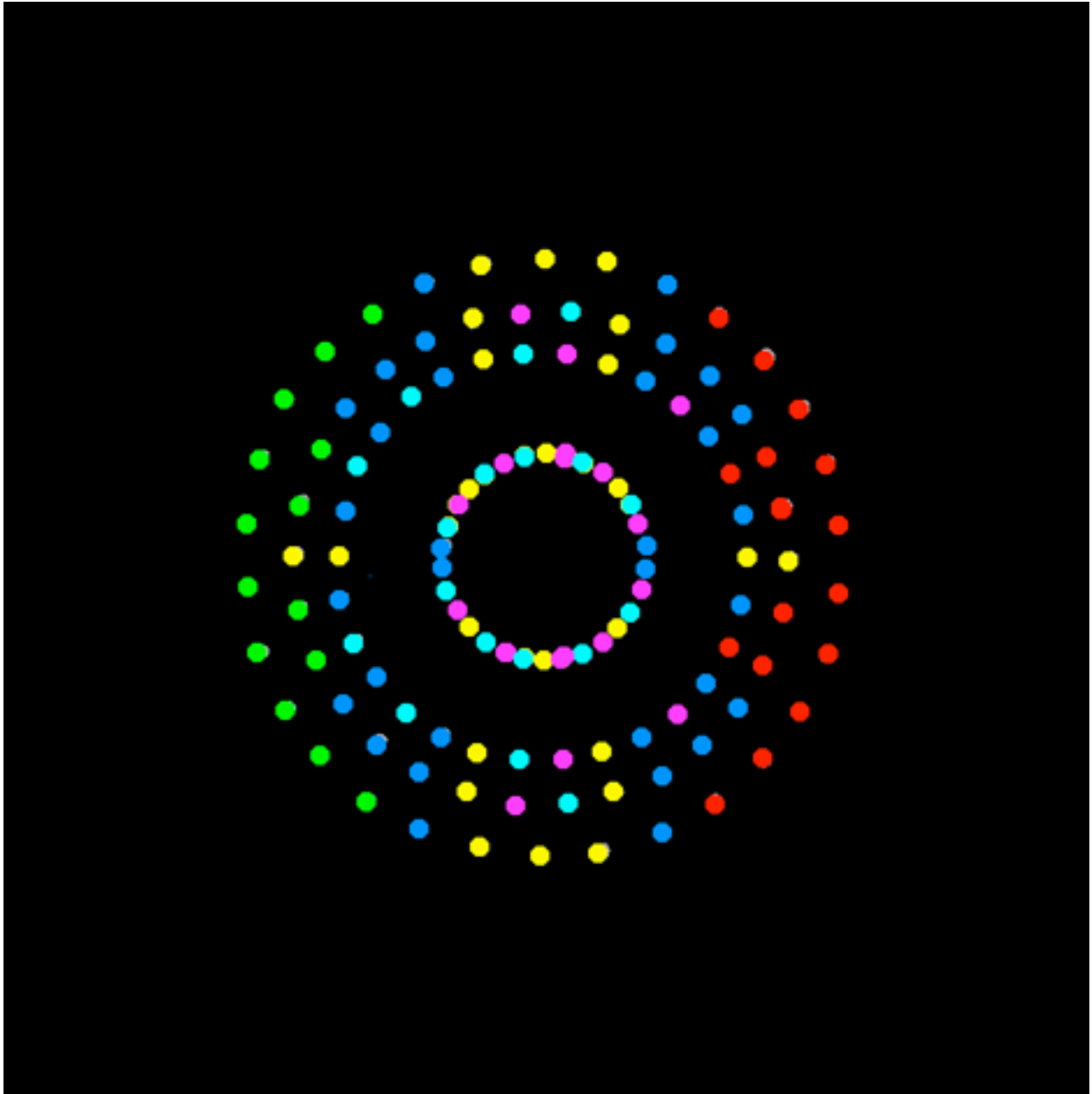
In the 8 Circles of 30 Geometry, the 240 E8 Root Vectors with Fermion Color-Coding  
green, cyan, red, magenta for types E, Nu, P, and anti-Nu  
look more confusing and complicated



which is why I prefer the Square/Cube Geometry for visualizing E8 Physics.

However, the 8 Circles of 30 Geometry is equivalent to the Square/Cube Geometry so that it gives the same E8 Physics, and is useful for some visualizations, such as

the breakdown of 240 E8 Root Vectors into 120 for Gravity+Dark Energy represented by the 120 vertices of a 600-cell



and

120 for the Standard Model  
represented by the 120 vertices of a 600-cell (larger by factor of the Golden Ratio)

