

# B-mode Octonionic Inflation of E8 Physics

Frank Dodd (Tony) Smith, Jr. - 2014

viXra 1403.0300

**BICEP2** in arXiv 1403.3985 said:

"... Inflation predicts ... a primordial background of ... gravitational waves ...[that]... would have imprinted a unique signature upon the CMB. **Gravitational waves induce local quadrupole anisotropies** in the radiation field within the last-scattering surface, **inducing polarization** in the scattered light ... **This polarization pattern will include a "curl" or ... inflationary gravitational wave (IGW) B-mode ... component** at degree angular scales that cannot be generated primordially by density perturbations. The amplitude of this signal depends upon **the tensor-to-scalar ratio ...  $r = 0.20 \pm 0.07 - 0.05$**  ... which itself is a function of the energy scale of inflation. ...".

## In E8 Physics, Inflation is due to Non-Unitarity of Octonion Quantum Processes

that occur in 8-dim SpaceTime before freezing out of a preferred Quaternionic Frame ends Inflation and begins Ordinary Evolution in (4+4)-dim  $M4 \times CP2$  Kaluza-Klein. The unit sphere in the Euclidean version of 8-dim SpaceTime ( see viXra 1311.0088 for Schwinger's "unitary trick" to allow use of Euclidean SpaceTime ) is the 7-sphere  $S7$ .  
( for E8 Physics overview see viXra 1312.0036 and 1310.0182 )

**Curl-type B-modes** (tensor) are Octonionic Quantum Processes on the surface of SpaceTime  $S7$  which is a **7-dim NonAssociative Moufang Loop Malcev Algebra**.

( for Malcev Algebras see Appendix I ) ( image below from Sky and Telescope )

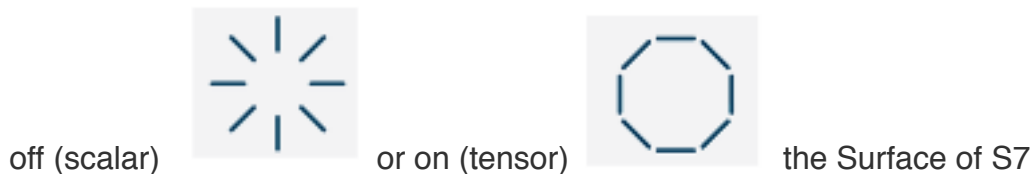


**Divergence-type E modes** (scalar and tensor) are Octonionic Quantum Processes from SpaceTime  $S7$

plus a spinor-type  $S7$  representing Dirac Fermions living in SpaceTime plus a 14-dim  $G2$  Octonionic Derivation Algebra connecting the two  $S7$  spheres all of which is a **28-dim  $D4$  Lie Algebra  $Spin(8)$** .

( image below from Sky and Telescope )

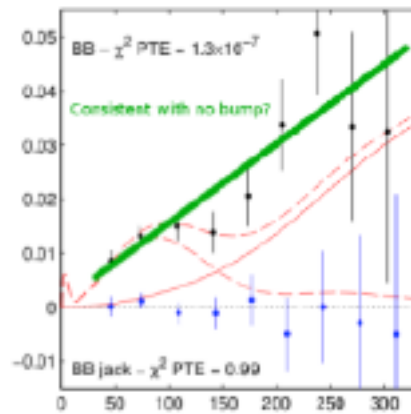
E-modes look like Fermion Pair Creation either



Therefore: for E8 Physics Octonionic Inflation the ratio  $r = 7 / 28 = 0.25$

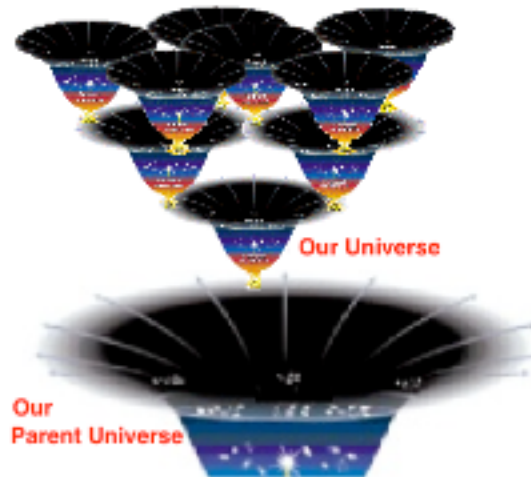
Phil Bull in his Lumps'n' Bumps blog (17 March 2014) said:

"... the blue points in the plot ... are the null tests for the BB power spectrum ... You'd ... expect about a third of the points to have their errorbars not overlapping with zero ...



... a straight line would fit the points quite well (green line; my addition). ...".

**Here is an outline of how Octonionic Inflation works in E8 Physics:**



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

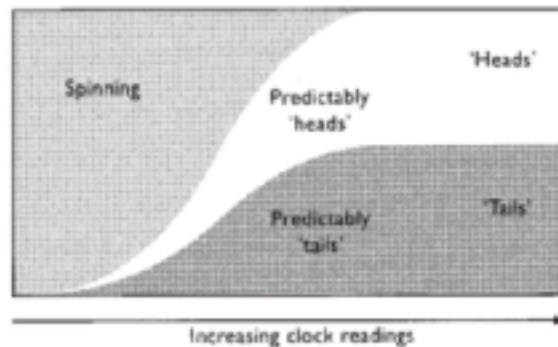
As Our Universe expands to a Cold Thin State, it will probably give birth to Our Child, GrandChild, etc, Universes.

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

**In E8 Physics**, our present 4-dimensional physical spacetime is based on a Quaternionic substructure of an Octonionic 8-dimensional spacetime in which the physics of each Local Region is described by a Local Lagrangian with E8 structure from an E8 Lie Algebra that is embedded in a Cl(16) Real Clifford Algebra. Our spacetime remains Octonionic 8-dimensional throughout inflation.

**How do the Cl(16) E8 Local Lagrangian Regions fit together to describe the Quantum Physics of the MultiVerse ?**

David Deutsch in his 1997 book "The Fabric of Reality" said (pages 276-283):  
 "... there is no fundamental demarcation between snapshots of other times and snapshots of other universes ... Other times are just special cases of other universes ... Suppose ... we toss a coin ... Each point in the diagram represents one snapshot



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

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

Anthony Bonner in his 2007 book "The Art and Logic of Ramon Llull" said:  
 "... Giordano Bruno wrote five commentaries on Llull, four of them on the Art - more attention than he gave to any other thinker ...  
 Giordano Bruno ... saw .... Llull's ... Art ... as a way to explore the connections among his infinity of worlds ...".

If you look at Llull's Art (especially his Quaternary Phase) you see that it is equivalent to E8 Physics ( see viXra 1403.0178 ) with **the Clifford Algebra Cl(16) containing E8 giving the Local Lagrangian of a Region that is equivalent to a " snapshot" of the Deutsch "multiverse".**

**The completion of the union of all tensor products of all Cl(16) E8 Local Lagrangian Regions**

then

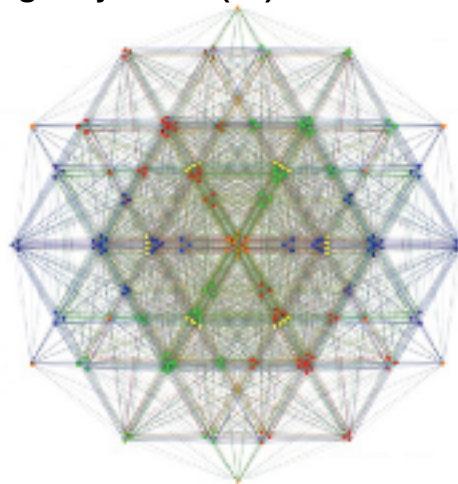
**emergently self-assembles into a structure = Deutsch multiverse forming a generalized hyperfinite II1 von Neumann factor AQFT ( Algebraic Quantum Field Theory ).**

Stephen L. Adler in his book Quaternionic Quantum Mechanics and Quantum Fields (1995) said at pages 50-52, 561:

"... If the multiplication is associative, as in the complex and quaternionic cases, we can remove parentheses in ... Schroedinger equation dynamics ... to conclude that ... the inner product  $\langle f(t) | g(t) \rangle$  ... is invariant ... this proof fails in the octonionic case, and hence one cannot follow the standard procedure to get a unitary dynamics. ...[so there is a]... **failure of unitarity in octonionic quantum mechanics** ...".

**The NonAssociativity and Non-Unitarity of octonions accounts for particle creation without the need for tapping the energy of a conventional inflaton field.**

**Inflation begins in Octonionic E8 Physics with a Quantum Fluctuation initially containing only one Cl(16) E8 Local Lagrangian Region**



The Fermion Representation Space for a Cl(16) E8 Local Lagrangian Region is  $E_8 / D_8 =$  the  $64+64 = 128$ -dim +half-spinor space  $64s_{++} + 64s_{+-}$  of Cl(16)

$64s_{++} = 8$  components of 8 Fermion Particles

$64s_{+-} = 8$  components of 8 Fermion Antiparticles

By 8-Periodicity of Real Clifford Algebras  $Cl(16) =$  tensor product  $Cl(8) \times Cl(8)$

where the two copies of  $Cl(8)$  can be denoted by  $Cl(8)_G$  and  $Cl(8)_{SM}$

( in E8 Physics  $Cl(8)_G$  gives Gravity with Dark Energy and  $Cl(8)_{SM}$  gives the Standard Model )

$Cl(8)_G$  and  $Cl(8)_{SM}$  each have 8-dim half-spinor spaces  $8G_{s+}$   $8G_{s-}$  and  $8SM_{s+}$   $8SM_{s-}$

$8G_{s+}$  and  $8SM_{s+}$  representing 8 Fermion Particles

$8G_{s-}$  and  $8SM_{s-}$  representing 8 Fermion Antiparticles

so that

$64s_{++} = 8G_{s+} \times 8SM_{s+}$  for First Generation Particles of E8 Physics

$64s_{+-} = 8G_{s+} \times 8SM_{s-}$  for First Generation AntiParticles of E8 Physics

$64s_{-+} = 8G_{s-} \times 8SM_{s+}$  for AntiGeneration Particles ( NOT in E8 Physics )

$64s_{--} = 8G_{s-} \times 8SM_{s-}$  for AntiGeneration AntiParticles ( NOT in E8 Physics )

where

+/- half-spinor of  $Cl(8)_G$  determines +/- half-spinor of  $Cl(16)$

and Generation or AntiGeneration ( only +half-spinor Generation is in E8 )

+/- half-spinor of  $Cl(8)_{SM}$  determines Particle or AntiParticle

E8 Physics has Representation space for 8 Fermion Particles + 8 Fermion Antiparticles on the original  $Cl(16)$  E8 Local Lagrangian Region that is  $64s_{++} + 8$  of  $64s_{+-} =$



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

by Real Fermion Particles ■ or Real Fermion Antiparticles ■

IF the Quantum Fluctuation( QF ) has enough Energy to produce them as Real and IF the  $Cl(16)$  E8 Local Lagrangian Region has an Effective Path from its QF Energy to that Particular slot. ( see Appendix III for Geoffrey Dixon's ideas and Effective Path of QF Energy )

Since E8 contains only the 128 +half-spinors and none of the 128 -half-spinors of  $Cl(16)$  the only Effective Path of QF Energy to E8 Fermion Representation slots goes to the only Fermion Particle slots that are also of type + that is, to the 8 Fermion Particle Representation slots

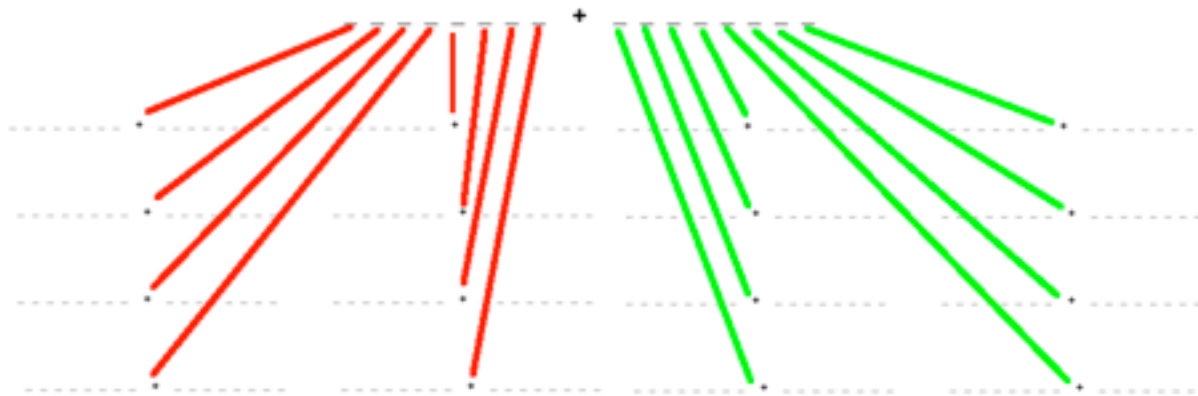


Next, consider **the first Unfolding step of Octonionic Inflation**. It is based on all  $16 = 8$  Fermion Particle slots + 8 Fermion Antiparticle Representation slots whether or not they have been filled by QF Energy.

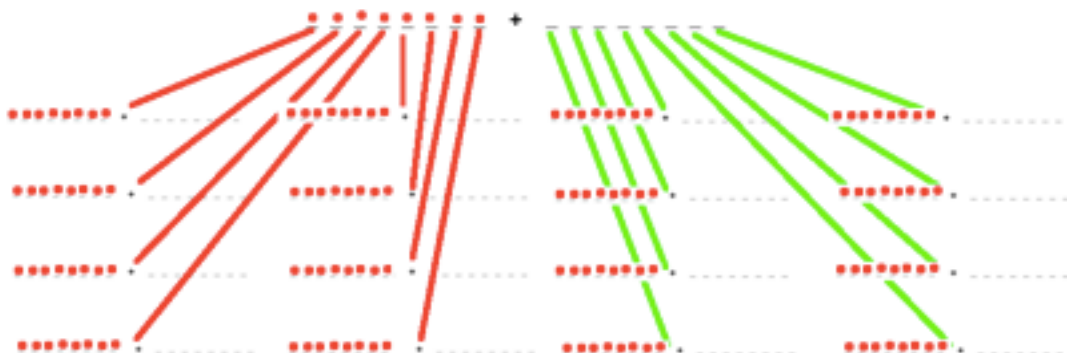
7 of the 8 Fermion Particle slots correspond to the 7 Imaginary Octonions and therefore to the 7 Independent E8 Integral Domain Lattices and therefore to 7 New  $Cl(16)$  E8 Local Lagrangian Regions.

The 8th Fermion Particle slot corresponds to the 1 Real Octonion and therefore to the 8th E8 Integral Domain Lattice ( not independent - see Kirmse's mistake ) and therefore to the 8th New  $Cl(16)$  E8 Local Lagrangian Region.

Similarly, the 8 Fermion Antiparticle slots Unfold into 8 more New New  $Cl(16)$  E8 Local Lagrangian Regions, so that one Unfolding Step is a 16-fold multiplication of  $Cl(16)$  E8 Local Lagrangian Regions:



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



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

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

**Paola Zizzi** in gr-qc/0007006 said: "... during inflation, the universe can be described as a superposed state of quantum ... [ qubits ]. the self-reduction of the superposed quantum state is ... reached at the end of inflation ...[at]... the decoherence time ... [  $T_{\text{decoh}} = 10^9 T_{\text{planck}} = 10^{(-34)} \text{ sec}$  ] ... and corresponds to a superposed state of ... [  $10^{19} = 2^{64}$  qubits ]. ...".

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

$2^{64}$  qubits corresponds to the Clifford algebra  $Cl(64) = Cl(8 \times 8)$ . By the periodicity-8 theorem of Real Clifford algebras,  $Cl(64)$  is the smallest Real Clifford algebra for which we can reflexively identify each component  $Cl(8)$  with a vector in the  $Cl(8)$  vector space. This reflexive identification/reduction causes our universe to decohere at  $N = 2^{64} = 10^{19}$  which is roughly the number of Quantum Consciousness Tubulins in the Human Brain.

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

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

NonAssociativity, NonUnitarity, and Reflexivity of Octonions is exemplified by the 1-1 correspondence between Octonion Basis Elements and  $E_8$  Integral Domains

$$\begin{aligned} 1 &\Leftrightarrow 0E_8 \\ i &\Leftrightarrow 1E_8 \\ j &\Leftrightarrow 2E_8 \\ k &\Leftrightarrow 3E_8 \\ E &\Leftrightarrow 4E_8 \\ I &\Leftrightarrow 5E_8 \\ J &\Leftrightarrow 6E_8 \\ K &\Leftrightarrow 7E_8 \end{aligned}$$

where  $1E_8, 2E_8, 3E_8, 4E_8, 5E_8, 6E_8, 7E_8$  are 7 independent Integral Domain  $E_8$  Lattices and  $0E_8$  is an 8th  $E_8$  Lattice (Kirmse's mistake) not closed as an Integral Domain.

Using that correspondence expands the basis  $\{1, i, j, k, E, I, J, K\}$  to  $\{0E_8, 1E_8, 2E_8, 3E_8, 4E_8, 5E_8, 6E_8, 7E_8\}$

Each of the  $E_8$  Lattices has 240 nearest neighbor vectors so the total dimension of the Expanded Space is  $240 \times 240 \times 240 \times 240 \times 240 \times 240 \times 240 \times 240$

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

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

If each 240 is embedded reflexively into the 256 elements of  $Cl(8)$  the total dimension is  $256 \times 256 \times 256 \times 256 \times 256 \times 256 \times 256 \times 256 = 256^8 = 2^{(8 \times 8)} = 2^{64} = Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) \times Cl(8) = Cl(8 \times 8) = Cl(64)$  so the largest Clifford Algebra that can maintain Coherent Superposition is  $Cl(64)$  which is why Zizzi Quantum Inflation ends at the  $Cl(64)$  level.

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

**The End of Inflation time was at about  $10^{(-34)}$  sec =  $2^{64}$  Tplanck  
and  
the size of our Universe was then about  $10^{(-24)}$  cm  
which is about the size of a Fermion Schwinger Source Kerr-Newman Cloud.  
( see viXra 1311.0088 )**

## End of Inflation and Low Initial Entropy in Our Universe:

Roger Penrose in his book *The Emperor's New Mind* (Oxford 1989, pages 316-317) said:

"... in our universe ... Entropy ... increases ... Something forced the entropy to be low in the past. ... **the low-entropy states in the past are a puzzle.** ...".

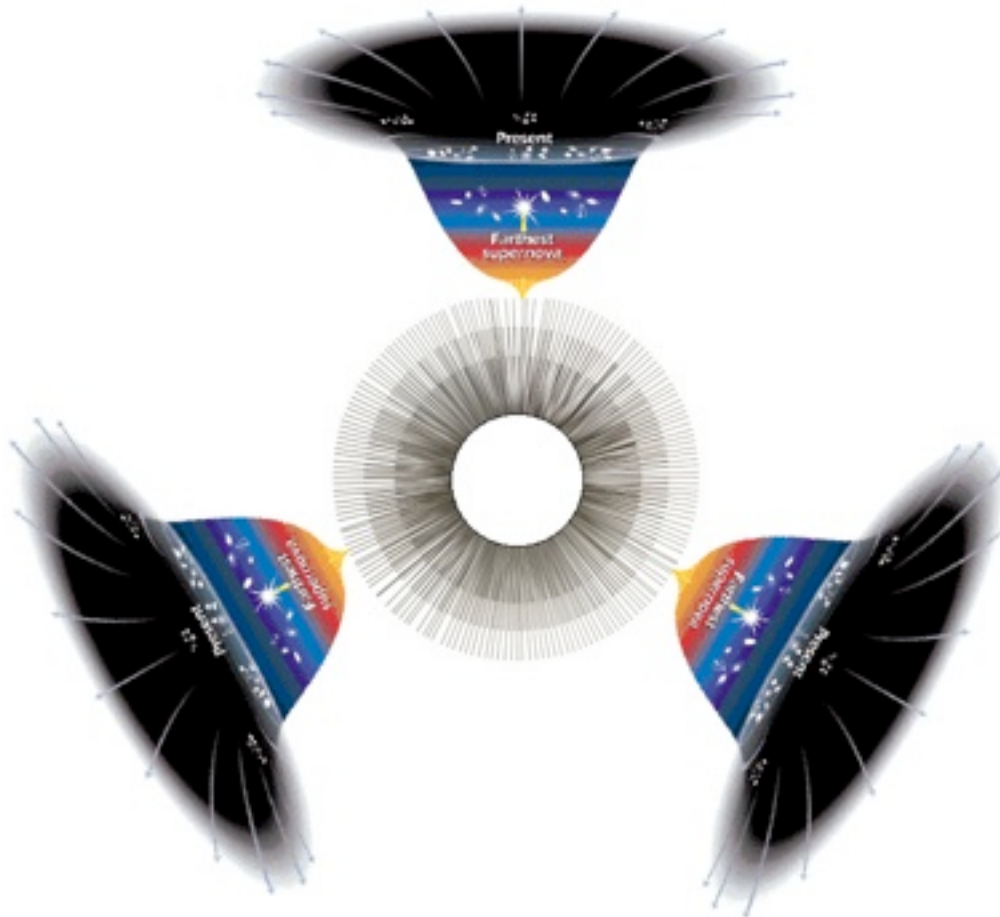
The key to solving Penrose's Puzzle is given by Paola Zizzi in gr-qc/0007006:

"... **The self-reduction of the superposed quantum state is ... reached at the end of inflation ...[at]... the decoherence time ... [  $T_{\text{decoh}} = 10^9 T_{\text{planck}} = 10(-34) \text{ sec}$  ] ... and corresponds to a superposed state of ... [  $10^{19} = 2^{64}$  qubits ]. ...**

... This is also the number of

**superposed tubulins-qubits in our brain ... leading to a conscious event. ...".**

The Zizzi Inflation phase of our universe ends with decoherence "collapse" of the  $2^{64}$  Superposition Inflated Universe into Many Worlds of Quantum Theory,

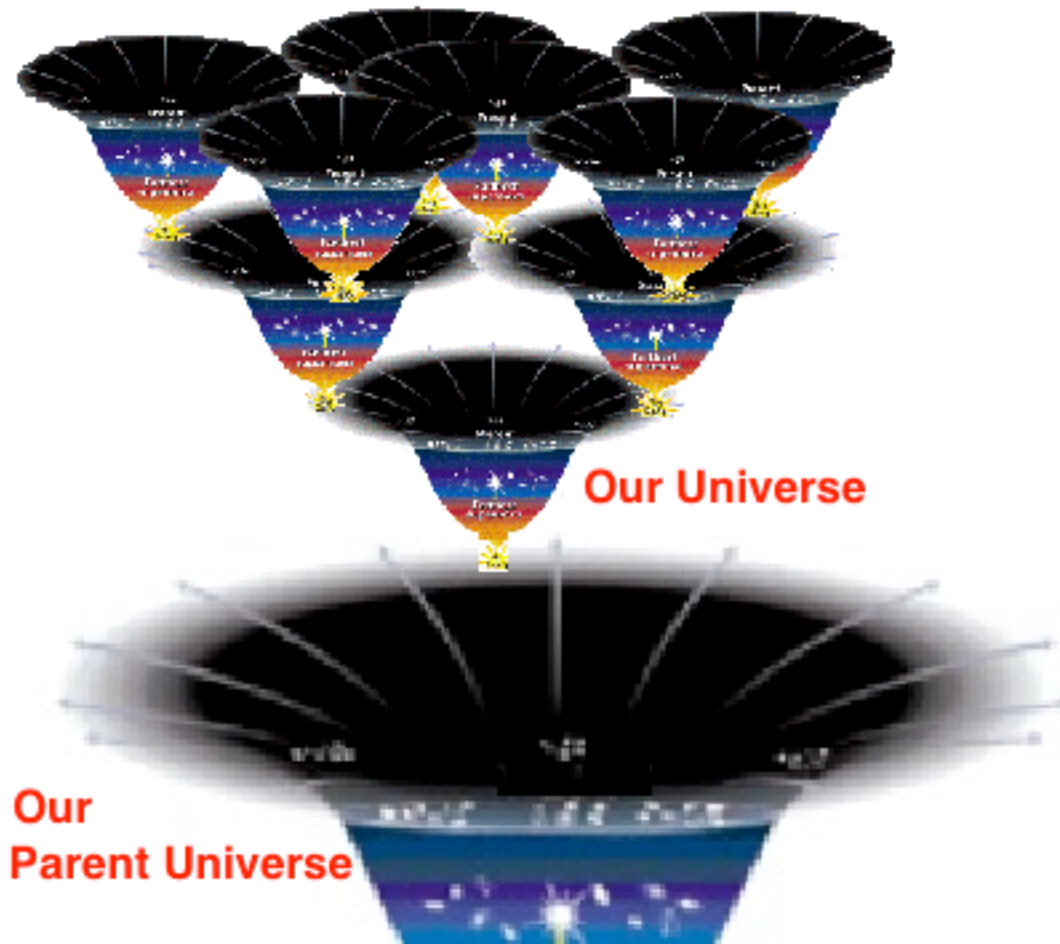


only one of which Worlds is our World. The central white circle is the Inflation Era in which everything is in Superposition; the boundary of the central circle marks the decoherence/collapse at the End of Inflation; and each line radiating from the central circle corresponds to one decohered/collapsed Universe World (of course, there are many more lines than actually shown), only three of which are explicitly indicated in the image, and only one of which is Our Universe World.

**Since our World is only a tiny fraction of all the Worlds, it carries only a tiny fraction of the entropy of the  $2^{64}$  Superposition Inflated Universe, thus solving Penrose's Puzzle.**



## How did Inflation Begin ?



As Our Parent Universe expanded to a Cold Thin State, isolated Quantum Fluctuations occurred. Most of them just appeared and disappeared as Virtual Fluctuations, but

at least one of the Quantum Fluctuations had enough energy to produce 64 Unfoldings and reach Zizzi's State of Decoherence making it a Real Fluctuation that became Our Universe with  $16^{64} = 2^{256} = 10^{77}$  Fermions.

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

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

## AFTER Inflation, how did Structures of Galaxies and their Clusters Emerge ?

Frank Wilczek said, in his Physics Today (May 2006) Reference Frame:

“... The standard models contain ... numerical parameters ... of wide significance for present-day phenomena in the natural world ... the amplitude of the primeval fluctuation spectrum. ...[ is ]... from cosmology ...”.

Max Tegmark and Martin J. Rees said, in astro-ph/9709058 Why is the CMB Fluctuation Level  $10^{-5}$  ?:  
“... Q ... of order  $10^{-5}$  ... is the amplitude that fluctuations in the gravitational potential have when they enter the horizon

... the baryon-to-photon ratio  $n = 10^{-9}$

... the electromagnetic coupling constant  $\alpha = e^2 = 1/137$  ...”.

Given  $N_{\text{baryon}}$  the number of quarks is  $N_{\text{quark}} = 3 \times N_{\text{baryon}}$ .

Given  $N_{\text{photon}}$  the number of geometric gravitons,

unsuppressed by factor of Planck mass squared,

is  $N_{\text{geograv}} = 137 \times N_{\text{photon}}$ .

$$\begin{aligned} N_{\text{quark}} / N_{\text{geograv}} &= 3 \times ( N_{\text{baryon}} / N_{\text{photon}} ) \times 1/137 = \\ &= 3 \times 10^{-9} \times 7 \times 10^{-3} = \\ &= 21 \times 10^{-12} = 0.21 \times 10^{-10} \end{aligned}$$

David Layzer said, in his book Cosmogogenesis (Oxford 1990):

“... random fluctuations obey well-understood statistical laws, among them the “square-root-of-N law”, which says that if the average number ... in a sample is N , then the random fluctuations of this number are likely to be near the square root of N ...”.

Given  $N_{\text{quark}} / N_{\text{geograv}}$  as the number of quarks per geograviton unit of spacetime the amplitude of fluctuations of quark-matter in spacetime gravitational potential is

$$\sqrt{ N_{\text{quark}} / N_{\text{geograv}} } = 0.45 \times 10^{-5}$$

That is consistent with cosmological observation that Q is of the order  $10^{-5}$ .

## Appendix I ( 3 pages ): Malcev Algebras

Jaak Lohmus, Eugene Paal, and Leo Sorgsepp in their book Nonassociative Algebras in Physics (Hadronic Press 1994), said:

"... Moufang loops and Mal'tsev [another transliteration for "Malcev"] algebras ... are ... natural (minimal) generalizations of Lie groups and Lie algebras, respectively. Because of the uniqueness of octonions ... octonionic Moufang loop and the corresponding simple (non-Lie) Mal'tsev algebra are of exceptional importance

...

A Moufang loop is a set  $G$  with a binary operation (multiplication) ... so that ...

- 1) in the equation  $g h = k$ , the knowledge of any two of  $g, h, k$  [in]  $G$  specifies the third one uniquely;
- 2) there is a distinguished unit or identity element  $e$  of  $G$  with the property  $e g = g e = g$ , [for all]  $g$  [in]  $G$ ;
- 3) the Moufang identity holds:  $(g h)(k g) = g((h k)g)$ , [for all]  $g, h, k$  [in]  $G$ .

A set with such a binary operation that only axioms 1/ and 2) are satisfied is called a loop. ... roughly speaking, loops are the "nonassociative groups". ... The most remarkable property of Moufang loops is their diassociativity: the subloop generated by any two elements in a Moufang loop is associative (group). Hence, for any  $g, h$  in a Moufang loop  $G$  ...  $(h g)g = h g^2$ ,  $g(g h) = g^2 h$ ,  $(g h)g = g(h g)$  ... thanks to [which]... the Moufang identity can be written ...  $(g h)(k g) = g(h k) g$ .

... one can define the notion of the inverse element of  $g$  [in]  $G$ . The unique solution of the equation  $g x = e$  ( $x g = e$ ) is called the right (left) inverse element of  $g$  [in]  $G$  and denoted as  $g^{-1}R$  ( $g^{-1}L$ ). From ... diassociativity ...  $g^{-1}R = g^{-1}L = g^{-1}$ ,  $g^{-1}(g h) = (h g)g^{-1} = h$ ,  $(g^{-1})^{-1} = g$ ,  $(g h)^{-1} = h^{-1} g^{-1}$ ; [for all]  $g, h$  [in]  $G$ .

... The Moufang loop  $G$  is said to be analytic if  $G$  is a real analytic manifold so that both the Moufang loop operation  $G \times G \rightarrow G : (g, h) \rightarrow g h$  and the inversion map  $G \rightarrow G : g \rightarrow g^{-1}$  are analytic ... denote the dimension of  $G$  by  $r$  ... introduce the antisymmetric quantities

$c^i_{jk} := a^i_{jk} - a^i_{kj}$  ...  $i, j, k = 1, \dots, r$ ,  
called the structure constants of  $G$ .

...

The tangent algebra  $G$  of  $G$  ...[with]... product

$[X, Y]^i := c^i_{jk} X^j Y^k = -[Y, X]^i$ ;  $i, j, k = 1, 2, \dots, r$ .

...[with the]... Mal'tsev identity ...

$[[X, Y], [Z, X]] + [[[X, Y], Z], X] + [[[Y, Z], X], X] + [[[Z, X], X], Y] = 0$

... is ... the ... Mal'tsev algebra. ... the Jacobi identity ...[may fail] in  $G$

...

... every Lie algebra is a Mal'tsev algebra

...

In a Mal'tsev algebra  $G$  the Yamaguti triple product ... may be defined as ...

$[x, y, z] := [x, [y, z]] - [y, [x, z]] + [[x, y], z]$

...

K. Yamaguti proved ... the possibility of embedding a Mal'tsev algebra into a Lie algebra ...

every Mal'tsev algebra can be realized as a subspace of some Lie algebra so that the Mal'tsev operation is a projection of the Lie algebra operation to this subspace.

....

Every Mal'tsev algebra is also a ... Lie triple system ...

Lie triple systems ... serve as tangent algebras for symmetric spaces ...".

### S7 Moufang Loop

E. K. Loginov in his paper hep-th/0109206 Analytic Loops and Gauge Fields said:

"... simple nonassociative Moufang loops ...[are]... analytically isomorphic to one of the spaces  $S_7$ ,  $S_3 \times R_4$ , or  $S_7 \times R_7$

...

... Suppose  $A$  is a complex (real) Cayley-Dickson algebra,  $M$  is its commutator Malcev algebra, and  $L(A)$  is the enveloping Lie algebra of regular representation of  $A$ .

It is obvious that the algebra  $L(A)$  is generated by the operators  $R_x$  and  $L_x$ , where  $x$  [is in]  $A$ . We select in  $L(A)$  the subspaces  $R(A)$ ,  $S(A)$ ,  $P(A)$  and  $D(A)$  generated by the operators

$R_x$ ,

$L_x$ ,

$S_x = R_x + 2L_x$ ,

$P_x = L_x + 2R_x$  and

$D_{x,y} = [T_x, T_y] + T[x,y]$ ,

where  $T_x = R_x - L_x$ , accordingly. ...

$[R_x, S_y] = R[x,y]$  ...[and]...  $[L_x, P_y] = L[y,x]$ .

... the algebra  $L(A)$  is decomposed into the direct sums

$L(A) = D(A) + S(A) + R(A)$ ,

$L(A) = D(A) + P(A) + L(A)$ ,

of the Lie subalgebras  $D(A) + S(A)$ ,  $D(A) + P(A)$  and the vector spaces  $R(A)$ ,  $L(A)$  ... In addition, the map  $x \rightarrow S_x$  from  $M$  into  $S(A)$  is a linear representation of the algebra  $M$ , which transforms the space  $R(A)$  into  $M$ -module that is isomorphic ... to the regular Malcev  $M$ -module. ...

... the direct summands ... are orthogonal with respect to the scalar product  $\text{tr}\{XY\}$  on  $L(A)$  ...

[ From 7-dim  $S_7$  to 28-dim  $\text{Spin}(8)$  ]

...Let  $A$  be the complex Cayley-Dickson algebra [of Octonions]. Then  $A$  supposes the base  $1, e_1, \dots, e_7$  such that

$$e_i e_j = -\delta_{ij} + c_{ijk} e_k,$$

where the structural constants  $c_{ijk}$  are completely antisymmetric and different from 0 only if

$$c_{123} = c_{145} = c_{167} = c_{246} = c_{257} = c_{374} = c_{365} = 1.$$

It is easy to see that in such base the operators

$$\begin{aligned} R_{ei} &= e_{[i0]} - (1/2) c_{ijk} e_{[jk]}, \\ L_{ei} &= e_{[i0]} + (1/2) c_{ijk} e_{[jk]}, \end{aligned}$$

where  $e_{[uv]}$  are skew-symmetric matrices  $8 \times 8$  with the elements  $(e_{uv})_{ab} = \delta_{ma} \delta_{nb} - \delta_{mb} \delta_{na}$ .

Using the identity

$$c_{ijk} c_{mnk} = \delta_{im} \delta_{jn} - \delta_{in} \delta_{jm} + c_{ijmn},$$

where the completely antisymmetric tensor  $c_{ijkl}$  is defined by the equality

$$(e_i, e_j, e_k) = 2 c_{ijkl} e_l,$$

we have  $D_{ei, ej} = 8 e_{[ij]} + 2 c_{ijmn} e_{[mn]}$  . ...

... Its enveloping Lie algebra  $L(A)$  (in fixed base) consists of real skew-symmetric  $8 \times 8$  matrices. Therefore we can connect every element  $F = F_{mn} e_{[mn]}$  of  $L(A)$  with the 2-form  $F = F_{mn} dx^m \wedge dx^n$  . ... the factors of  $F$  are such that

$$\begin{aligned} \epsilon F_{0i} + (1/2) c_{ijk} F_{jk} &= 0, \\ \text{if } F & \text{ [is in] } S(A) + D(A) \text{ ...[or]... } P(A) + D(A) \end{aligned}$$

$$\begin{aligned} \epsilon F_{0i} &= c_{ijk} F_{jk}, \\ \text{if } F & \text{ [is in] } R(A) \text{ ...[or]... } L(A) \end{aligned}$$

where there is no summing over  $j, k$  in [the second equations],  $c_{ijk} \neq 0$ , and

$$\begin{aligned} \epsilon &= 0, \text{ if } F \text{ [is in] } D(A), \\ \epsilon &= 1, \text{ if } F \text{ [is in] } S(A) + D(A), F \text{ [is not in] } D(A) \text{ or } F \text{ [is in] } R(A), \\ \epsilon &= -1, \text{ if } F \text{ [is in] } P(A) + D(A), F \text{ [is not in] } D(A) \text{ or } F \text{ [is in] } L(A). \end{aligned}$$

For  $\epsilon = -1$  these are precisely the (anti-self-dual) equations of Corrigan et al. ... In addition,  $R(A)$  and  $L(A)$  are not Lie algebras. Therefore the [second] equations, in contrast to [the first equation], are not Yang-Mills equations. Nevertheless, there are a solution of the [second] equations, which generalizes the known (anti-)instanton solution of Belavin et al. ...".

## Appendix II (3 pages): E8 Lattices and Root Vectors

### Correspondence between Imaginary Octonions and E8 Integral Domain Lattices

7-dim S7 EXPANDS TO Spin(8) Lie Algebra containing S7 and S7 and G2

/ \  
| corresponds to  
\ /

7 Imaginary Octonions i j k E I J K

/ \  
| corresponds to  
\ /

7 independent E8 Integral Domain Lattices  
based on the 7 basic Heptavertons / Onarhedra

	Associative Triangle	Coassociative Square	Heptaverton
i	$\begin{array}{c} I \\ / \ \backslash \\ E \text{---} i \end{array}$	$\begin{array}{c} J \text{---} j \\   \ \   \\ K \text{---} k \end{array}$	$\begin{array}{c} k \ J \\   / \\ I \text{---} i \text{---} E \\ /   \\ K \ j \end{array}$
j	$\begin{array}{c} J \\ / \ \backslash \\ E \text{---} j \end{array}$	$\begin{array}{c} K \text{---} k \\   \ \   \\ I \text{---} i \end{array}$	$\begin{array}{c} k \ I \\   / \\ J \text{---} j \text{---} E \\ /   \\ K \ i \end{array}$
k	$\begin{array}{c} K \\ / \ \backslash \\ E \text{---} k \end{array}$	$\begin{array}{c} I \text{---} i \\   \ \   \\ J \text{---} j \end{array}$	$\begin{array}{c} i \ J \\   / \\ K \text{---} k \text{---} E \\ /   \\ I \ j \end{array}$
E	$\begin{array}{c} j \\ / \ \backslash \\ i \text{---} k \end{array}$	$\begin{array}{c} I \text{---} J \\   \ \   \\ K \text{---} E \end{array}$	$\begin{array}{c} I \ k \\   / \\ J \text{---} E \text{---} j \\ /   \\ K \ i \end{array}$
I	$\begin{array}{c} J \\ / \ \backslash \\ i \text{---} K \end{array}$	$\begin{array}{c} I \text{---} j \\   \ \   \\ k \text{---} E \end{array}$	$\begin{array}{c} E \ j \\   / \\ J \text{---} I \text{---} k \\ /   \\ K \ i \end{array}$
J	$\begin{array}{c} j \\ / \ \backslash \\ I \text{---} K \end{array}$	$\begin{array}{c} J \text{---} i \\   \ \   \\ k \text{---} E \end{array}$	$\begin{array}{c} E \ k \\   / \\ K \text{---} J \text{---} i \\ /   \\ I \ i \end{array}$
K	$\begin{array}{c} J \\ / \ \backslash \\ I \text{---} k \end{array}$	$\begin{array}{c} K \text{---} i \\   \ \   \\ j \text{---} E \end{array}$	$\begin{array}{c} E \ i \\   / \\ I \text{---} K \text{---} j \\ /   \\ J \ k \end{array}$

### Kirmse's Mistake:

H. S. M. Coxeter in his paper Integral Cayley Numbers

(Duke Math. J., v. 13, no. 4, December 1946) said:

"... Kirmse ... selects an eight-dimensional module ... which is closed under subtraction and contains eight linearly independent members. ...

a module is called an INTEGRAL DOMAIN if it is closed under multiplication.

A simple instance is the module  $J_0$  consisting of all Cayley numbers ... [that are] integers. ...

[Kirmse] then defines a maximal ... integral domain over  $J_0$  as an extension of  $J_0$  which cannot be further extended without ceasing to be an integral domain.

He states that there are EIGHT such domains, one of which he calls  $J_1$  and describes in detail.

Actually, there are only SEVEN, which presumably are the remaining seven of his eight. ...  $J_1$  itself is not closed under multiplication. ...

Since the 168-group is doubly transitive on the seven [imaginary octonions], ANY transposition [of the imaginary octonions] will serve to rectify  $J_1$  in the desired manner. But there are only seven such domains, since the  $(7!2) = 21$  possible transpositions fall into 7 sets of 3, each set having the same effect.

In each of the seven domains, one of the [imaginary octonions] plays a special role, viz., that one which is not affected by any of the three transpositions.

Comparing Kirmse's multiplication table with Cayley's

... we see that ... Kirmse's  $J_1$  could be used as it stands if we replaced his multiplication table with Cayley's. ..."

H. S. M. Coxeter in his paper Regular and Semi-Regular Polytopes III

(Math. Z. 200, 3-45, 1988) about the 240 units of an  $E_8$  Integral Domain said:

"... "... the 16 + 16 + 16 octaves

$$\begin{aligned} & \pm 1, \pm i, \pm j, \pm k, \pm e, \pm ie, \pm je, \pm ke, \\ & (\pm 1 \pm ie \pm je \pm ke)/2, \\ & (\pm e \pm i \pm j \pm k)/2, \end{aligned}$$

and the 192 others derived from the last two expressions by cyclically permuting the 7 symbols [ i,j,k,e,ie,je,ke ] in the peculiar order

$$e, i, j, ie, ke, k, je$$

... It seems somewhat paradoxical ... that the cyclic permutation

$$(e, i, j, ie, ke, k, je),$$

which preserves the integral domain (and the finite projective [Fano] plane ...)

is not an automorphism of the whole ring of octaves;

it transforms the associative triad  $ijk$  into the anti-associative triad  $jie$ .

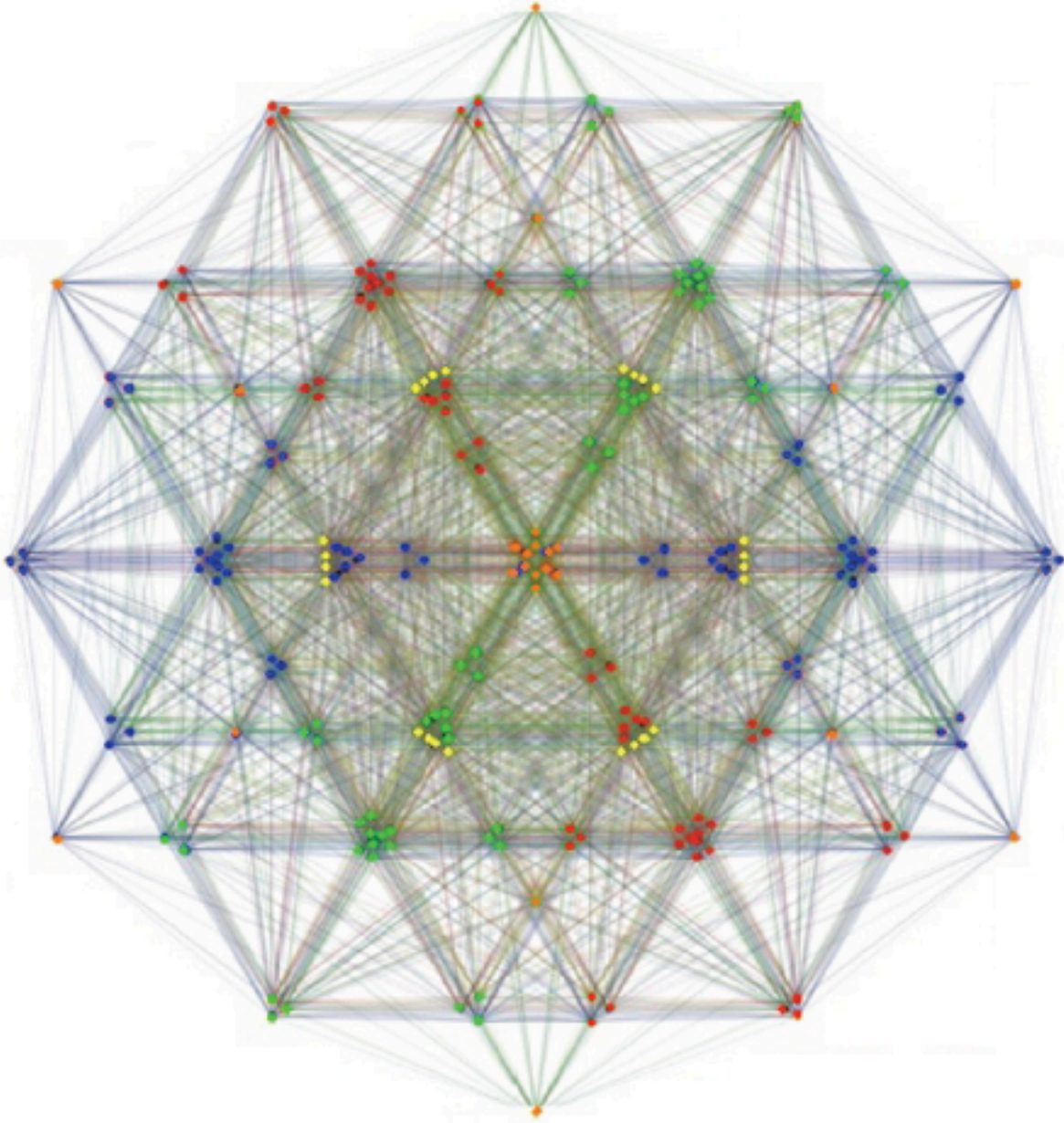
On the other hand, the permutation

$$(e\ ie\ je\ i\ k\ ke\ j),$$

which IS an automorphism of the whole ring of octaves (and of the finite [Fano] plane ...)

transforms this particular integral domain into another one of R. H. Bruck's cyclic of seven such domains. ..."

**240 Root Vectors of 248-dim E8 have physical interpretations in E8 Physics:**



64 Red = 8 components of 8 Fermion Particles

64 Green = 8 components of 8 Fermion Antiparticles

64 Blue = 8 position x 8 momentum of 8-dim SpaceTime

28 Yellow include 12 of the 16 generators of U(2,2)

for Conformal Gravity, Dark Energy, and Propagator Phase

( the other 4 come from 4 of the 248 - 240 = 8 Cartan Subalgebra elements of E8 )

28 Orange include 8 of the 12 generators of Standard Model SU(3)xSU(2)xU(1)

( the other 4 come from 4 of the 248 - 240 = 8 Cartan Subalgebra elements of E8 )



### Appendix III ( 4 pages ): **Effective Path of QF Energy and Dixon CxHxO**

Another ( probably equivalent ) way to see that the Effective Path of QF Energy goes entirely to creation of Real Fermion Particles is to follow the work of **Geoffrey Dixon** who said ( 2012.09.20 ) "... based on **the algebra  $T := CxHxO$**  , an interpretation is developed that **implies the existence of a matter universe, and an anti-matter universe ...**".

Represent both 64-dim  $64s_{++}$  and 64-dim  $64s_{+-}$  as tensor product  $C \times H \times O = T$  where  $C =$  Complex Numbers,  $H =$  Quaternions, and  $O =$  Octonions so that  $T+T =$  128-dim +half-spinor space  $64s_{++} + 64s_{+-}$  of  $Cl(16)$  which is in  $E8$

Dixon says that  $T+T$  corresponds to a 1,9-spacetime and that there are 2 ways to reduce 1,9-spacetime to our physical 1,3-spacetime with one way producing a matter universe and the other producing an antimatter universe.

My view is that those 2 ways correspond to 2 copies of  $T+T$  which represent 128-dim +half-spinor space  $64s_{++} + 64s_{+-}$  of  $Cl(16)$  and in  $E8 =$   
= Dixon's Matter Universe

and 128-dim -half-spinor space  $64s_{-+} + 64s_{--}$  of  $Cl(16)$  and not in  $E8 =$   
= Dixon's AntiMatter Universe

$E8$  Physics uses only the 128 +half-spinors and none of the 128 -half-spinors of  $Cl(16)$  so, using Geoffrey Dixon's ideas,  **$E8$  Physics Octonionic Inflation produces Real Fermion Particles and a Matter Universe**

and the **Effective Path of Quantum Fluctuation Energy is to Creation of Real Fermion Particles consistently with Dixon's reduction of 1,9-spacetime to 1,3-spacetime.**

Here are some details about Geoffrey Dixon's ideas:

Geoffrey Dixon in his book Division Algebras, Lattices, Physics, Windmill Tilting (2011) said:

( in this quote I use  $T+T$  instead of Geoffrey Dixon's notation  $T^2$  )

"...  $T$  inherits noncommutativity from  $H$  and  $O$ , and nonassociativity from  $O$ .

From the combination of  $H$  and  $O$  it also loses alternativity ...

$TL$  uses only  $HL$  , and  $TA$  uses  $HA$  , which includes both  $HL$  ,  $HR$  , and their combined actions.

...

$T$  ... is a Pauli spinor doublet for a 1,9-spacetime

in exactly the same way  $P$  is a Pauli spinor doublet for 1,3-spacetime

...

In the Pauli algebra case, we got Dirac spinors by doubling  $P$  to  $P+P$ , and the associated Clifford algebra is  $PL(2) = C \times Cl(1,3)$

...

To produce Dirac spinors we do for  $T$  what we did for  $P$ :

we double up and use  $T+T$  as our spinor space,

with the associated Clifford algebra  $TL(2) = C \times Cl(1,9)$

...

Note that in both these cases, if we absorb the  $C$  into the Clifford algebra, we expand the dimensionality of the associated spacetime.

This is sometimes done, but not here. ...

As to  $\mathbf{T}$ , there are several ways to resolve its identity into four orthogonal *idempotents* ( $\Delta_m$ ,  $m = 0, 1, 2, 3$ ), but only one way (I believe), up to automorphism, satisfying for all  $y$  in  $\mathbf{T}$ ,

$$\begin{aligned}
 \Delta_0 + \Delta_1 + \Delta_2 + \Delta_3 &= 1, \\
 \Delta_m(\Delta_n y) &= \delta_{mn} \Delta_m y, \\
 (y \Delta_m) \Delta_n &= \delta_{mn} y \Delta_m, \\
 \Delta_m(y \Delta_n) &= (\Delta_m y) \Delta_n,
 \end{aligned} \tag{3.23}$$

these properties ensuring the  $\Delta_m$  can be treated as a set of orthogonal projection operators with which we can consistently decompose the spinor space  $\mathbf{T}$ .

Drawn from [7], we make the assignments:

$$\begin{aligned}
 \Delta_0 &= \frac{1}{4}(1 + i\vec{x})(1 + ie_7) = \left(\frac{1}{2}(1 + i\vec{x})\right)\left(\frac{1}{2}(1 + ie_7)\right) = \lambda_0 \rho_+, \\
 \Delta_1 &= \frac{1}{4}(1 - i\vec{x})(1 + ie_7) = \left(\frac{1}{2}(1 - i\vec{x})\right)\left(\frac{1}{2}(1 + ie_7)\right) = \lambda_1 \rho_+, \\
 \Delta_2 &= \frac{1}{4}(1 + i\vec{y})(1 - ie_7) = \left(\frac{1}{2}(1 + i\vec{y})\right)\left(\frac{1}{2}(1 - ie_7)\right) = \lambda_2 \rho_-, \\
 \Delta_3 &= \frac{1}{4}(1 - i\vec{y})(1 - ie_7) = \left(\frac{1}{2}(1 - i\vec{y})\right)\left(\frac{1}{2}(1 - ie_7)\right) = \lambda_3 \rho_-,
 \end{aligned} \tag{3.24}$$

...  
 the following identifications fall out of the mathematics (at least the way I do it):

$$\begin{aligned} \rho_+ \Psi &: \text{matter} \\ \rho_- \Psi &: \text{antimatter} \end{aligned} \quad (3.25)$$

Going one step further:

$$\begin{aligned} \rho_+ \Psi \rho_+ &: \text{matter - lepton doublet - } SU(3) \text{ singlet} \\ \rho_+ \Psi \rho_- &: \text{matter - quark doublets - } SU(3) \text{ triplet} \\ \rho_- \Psi \rho_- &: \text{antimatter - antilepton doublet - } SU(3) \text{ antisinglet} \\ \rho_- \Psi \rho_+ &: \text{antimatter - antiquark doublets - } SU(3) \text{ antitriplet} \end{aligned} \quad (3.26)$$

And one final step:

$$\begin{aligned} \rho_+ \Psi \Delta_0 &: \text{matter - neutrino - } SU(3) \text{ singlet} \\ \rho_+ \Psi \Delta_1 &: \text{matter - electron - } SU(3) \text{ singlet} \\ \rho_+ \Psi \Delta_2 &: \text{matter - up quark - } SU(3) \text{ triplet} \\ \rho_+ \Psi \Delta_3 &: \text{matter - down quark - } SU(3) \text{ triplet} \\ \rho_- \Psi \Delta_3 &: \text{antimatter - antineutrino - } SU(3) \text{ antisinglet} \\ \rho_- \Psi \Delta_2 &: \text{antimatter - positron - } SU(3) \text{ antisinglet} \\ \rho_- \Psi \Delta_1 &: \text{antimatter - anti-up antiquark - } SU(3) \text{ antitriplet} \\ \rho_- \Psi \Delta_0 &: \text{antimatter - anti-down antiquark - } SU(3) \text{ antitriplet} \end{aligned} \quad (3.27)$$

...".

Geoffrey Dixon in his paper Matter Universe: A Mathematical Solution said:  
 ( in this quote I use T+T instead of Geoffrey Dixon's notation T2 )

"... The algebra  $T := C \times H \times O$  is  $2 \times 4 \times 8 = 64$ -dimensional.  
 It is noncommutative, nonassociative, and nonalternative.

...

In this model ... the foundation is the 128-dimensional ... space T+T  
 (the doubling of T in the spinor space is modeled on the notion  
 that a Dirac spinor is a double Pauli spinor). ...  
 the Dirac algebra ...  $PL := C \times H$  ... is  
 the complexification of the Clifford algebra of 1,3-spacetime

...

T+T is acted upon by the complexification of the Clifford algebra of 1,9-spacetime,  
 represented by  $TL(2)$ , where TL is the algebra of left actions of T on itself,  
 which in the octonion case, due to nonassociativity, requires the nesting of actions.

...

In the T-theory ... the quarks are associated with the octonion units  $e_p$ ,  $p=1, \dots, 6$ .  
 The extra six space dimensions ... also rest on these units

...

An elegant representation of the Clifford algebra  $Cl(1,9)$  represented in  $TL(2)$  that is aligned with the choice of the octonion unit  $e_7$  ... arises from the following set of ten anti-commuting 1-vectors:

$$\beta, \gamma_{QLk}e_{L7}, k = 1, 2, 3, \gamma_{ie_{Lp}}, p = 1, \dots, 6,$$

where

$$\epsilon = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \alpha = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, \beta = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \gamma = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix},$$

...

Our observable spacetime has 3 space dimensions, not 9. There are two (what I would call) canonical ways of reducing the 1-vectors of  $\mathcal{C}\mathcal{L}(1, 9)$ , a mix of observable and unobservable dimensions, to the 1-vectors of observable  $\mathcal{C}\mathcal{L}(1, 3)$ :

$$\begin{aligned} \rho_{L\pm} \{ \beta, \gamma_{QLk}e_{L7}, k = 1, 2, 3, \gamma_{ie_{Lp}}, p = 1, \dots, 6 \} \rho_{L\pm} \\ = \{ \beta, \gamma_{iQLk}, k = 1, 2, 3 \} \rho_{L\pm}. \end{aligned}$$

These two collections of  $\mathcal{C}\mathcal{L}(1, 3)$  1-vectors act on half of the full spinor space  $\mathbf{T}^2$ . In particular, they act respectively on

$$\rho_{L\pm}[\mathbf{T}^2] = \rho_{\pm}\mathbf{T}^2,$$

where the underlying mathematics implies that these are, respectively, the matter and anti-matter halves of  $\mathbf{T}^2$  ( $\rho_+\mathbf{T}^2$  being a full family of lepton and quark Dirac spinors, and  $\rho_-\mathbf{T}^2$  the corresponding anti-family) (see [2][3]).

Our observable universe is a 1,3-spacetime. There are those two ways of reducing the initial 1,9-spacetime above to 1,3-spacetimes, one associated with matter, one anti-matter. It now seems perfectly obvious to me to interpret this to mean that our observable 1,3-spacetime must be one, or the other (since it is ours, we call it matter). That is, the observable (habitable, if you will) spacetime in which we reside must of necessity be a matter universe, with anti-matter arising from secondary interactions - or an anti-matter universe - and that both must exist. ...".

My view is that those 2 ways correspond to 2 copies of T+T which represent 128-dim +half-spinor space  $64s_{++} + 64s_{+-}$  of  $Cl(16)$  = Dixon's Matter Universe and 128-dim -half-spinor space  $64s_{-+} + 64s_{--}$  of  $Cl(16)$  = Dixon's AntiMatter Universe However,

E8 Physics uses only the 128 +half-spinors and none of the 128 -half-spinors of  $Cl(16)$  so **E8 Physics has only a Matter Universe.**