The Spacelike and Entanglement Legacy of Mike Manthey

ANPA 44 Annual Meeting
Thurs Aug 10, 2023

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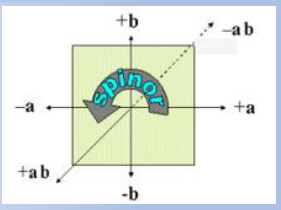
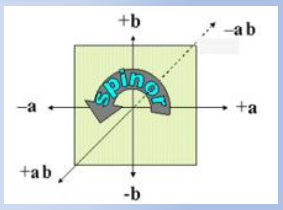
Abstract



This talk is a retrospective legacy summary of some of the work that Mike Manthey and Doug Matzke worked on together since 1994. We choose Geometric Algebra (GALG) as the mathematical representation in order to integrate computer science and physics in a common representation. This GALG approach we took is to create a GALG tool that supported trinary valued bit with coefficients of +1/-1 and 0 (for void) as bit-vectors that are anticommutative using geometric product to produce imaginary numbers, bivectors, trivectors, quaternions, tauquernions and other multivectors. With this GALG tool, we showed how to bootstrap quantum computing qubits and ebits plus a proposal for how to bootstrap the standard model using nilpotent and idempotent multivectors. See my previous ANPA talks about the details.

This talk will focus on why this GALG approach is so fundamental, since GALG bit-vectors are intrinsically orthogonal and spacelike, which naturally constructs the entire system as naturally concurrent and massively parallel, sufficient to support the quantum bit-physics simulation infrastructure for the universe. This representation is naturally and heavily entangled and has its own built-in operating system (see separate Topsy Talk).

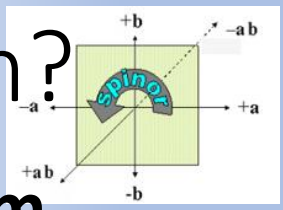
History of our collaboration



- 1994: Special ANPA session at PhysComp'94 - Met Mike & ANPA
  - https://www.matzkefamily.net/PhysComp/PhysComp94/
  - https://www.matzkefamily.net/PhysComp/PhysComp92/
- 1997: Started working with Mike on Ph.D.
- 1998: Visited Mike in Crestone, Colorado – GALG tool idea emerged
- 2001 Spring: Defended Ph.D. Topic
  "Quantum Computing using Geometric Algebra"
- 2002 Spring: Graduated with Ph.D. at UT Dallas (Perl GALG tool)
- 2002 Fall: Attended ANPA Conference in Cambridge
- 2005: Built python version of interactive GALG tool (2000 lines)
- 2012: Standard model and Higgs Boson joint paper using GALG
  "Quantum Entanglement Defines the Higgs Boson"
- 2013: My UT Dallas talk on pervasive entanglement
- 2019:My book www.DeepRealityBook.com was released on Amazon
- 2020 Summer: Presented 3 talks at ANPA 41
- 2023 March: Mike passed away

All my talks and papers at www.QuantumDoug.com

What is below classical and quantum?



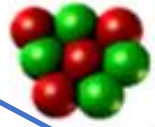
logarithmic scale

1 metre	10^{0} m
1 millimetre	10^{-3} m
1 micrometre	10^{-6} m
1 nanometre	10^{-9} m
1 picometre	10^{-12} m
1 femtometre	10^{-15} m
1 attometre	10^{-18} m
1 zeptometre	10^{-21} m
1 yoctometre	10^{-24} m
	10^{-27} m
	10^{-30} m
	10^{-33} m
	10^{-36} m

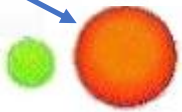

Person


Blood Cell


Atom


Atomic nucleus

Proton/Neutron


Electron/Quark

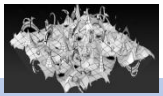
classical realm

quantum realm

Nature isn't classical, dammit, its quantum mechanical

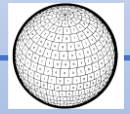
Planck Scale

spacetime metrics


Quantum foam

String/ brane

It from bit



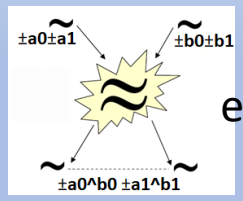
matter energy

8

No space
No time
No metrics

hyperspace

qubits
bits



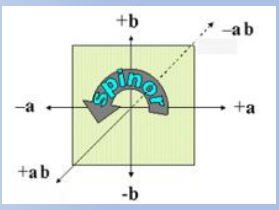
ebits

protophysics

ebits
qubits
bits

8

Protophysics - emergence of Primitive Space and Time



$a + b = b + a$

$c - d \longleftrightarrow d - c$

$c - d \mid d - c$

$c - d + d - c = 0$

(or cannot occur)

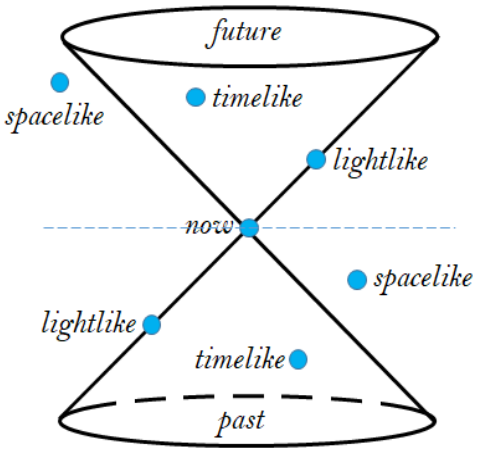
Abstract Space

Abstract Time

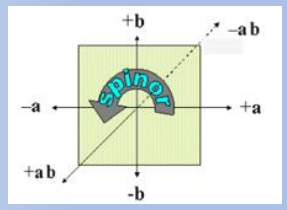
Co-occurrence means states exist simultaneously/concurrent: proto-**Space-like** via "**+**" operator

Co-exclusion means a change occurred due to an operator: proto-**Time-like** via "*****" operator

Built-in concurrency and change, No light cone yet

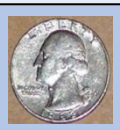


Energy of Big Bang from Bits: Coin Demo: Act I



Setup:

A person stands with both hands behind back

Act I part A: 

Person shows hand containing a coin then hides it again

Act I part B: 

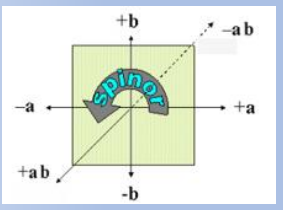
Person again shows a coin (indistinguishable from 1st)

Act I part C:

Person asks: “How many coins do I have?”

This represents one bit: either has 1 coin or has >1 coin

Coin Demo (continued)



Act II:

Person now holds out hand showing two identical coins

We receive one bit since ambiguity is resolved!

Act III: co-occurrence

Asks: "*Where* did the bit of information come from?"

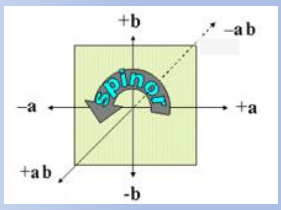
Answer: *Simultaneous* presence of the 2 coins!

Landauer Principle: info creation = effective Energy

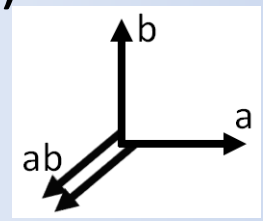
Non-Shannon space-like information derives from simultaneity!

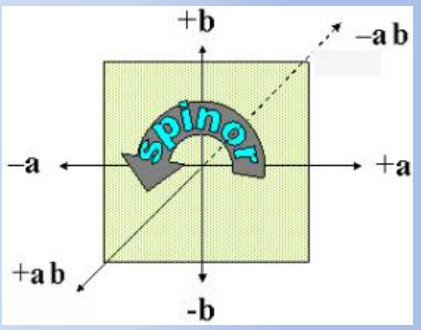
This is the bit-bang driving the energy of the big-bang

Geometric Algebra Introduction



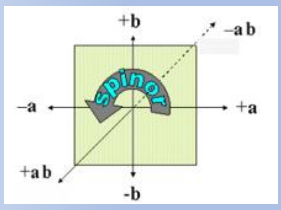
- Vectors, bivector, trivectors, n-vectors, multivectors
- Multivector Spaces (for G_n size is $3^{(2**n)}$)
  - G_0 is size 3: {0, ±1}
  - G_1 is size 9: {0, ±1, ±**a**} **bits**
  - G_2 is size 81: {0, ±1, ±**a**, ±**b**, ±**ab**} **qubits**
  - G_3 is size 6,561: {0, ±1, ±**a**, ±**b**, ±**c**, ±**ab**, ±**ac**, ±**bc**, ±**abc**} **photons**
  - G_4 is size 43,046,721: {0, ±1, ±**a**, ±**b**, ±**c**, ±**d**, …, ±**bcd**, ±**abcd**} **ebits**





- Anti-commuting vector space
  - **ab** = –**ba** → (**ab**)^2 = **abab** = –1 so any bivector **xy** = $\sqrt{-1}$ is spinor *i*
- Arithmetic Operators over Z_3 = {±1=T/F, 0=does not exist}
  - +, * (geometric ~ ⊗), outer (**a^a**=0,**a^b**=**ab**), inner (**a•a**=1,**a•b**=0)
- Co-occurrence (+) & co-exclusion: (**a**-**b**)+(-**a**+**b**)=0 implies **ab**
- Row vector truth table duality (e.g. ±(1+**a**)(1+**b**)=[0 0 0 **±**]).

Geometric Algebra Tools



Custom symbolic math tools in Python (operator overloading):

C:\python -i qubits.py

>>> a+a ← **Mod3 addition for change based logic (xor)**

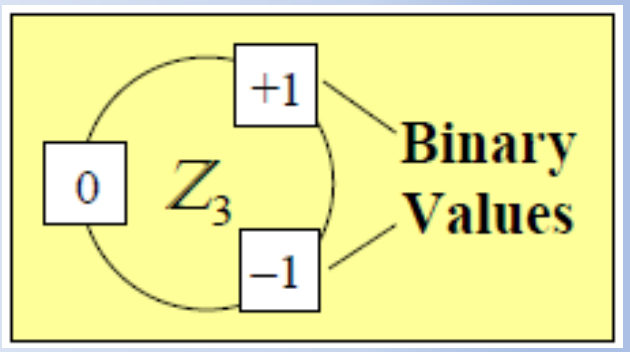
- a

>>> b^a ← **anticommutative bivectors**

- (a^b)

>>> c^b^a ← **anticommutative trivectors**

- (a^b^c)



>>> (1+a)(1+b)(1+c) ← **Smallest vector state contains all algebraic terms**

+ 1 + a + b + c + (a^b) + (a^c) + (b^c) + (a^b^c) ← **Row vector state equivalent [0000 000+]**

>>> a0 ← **Single Qubit State**

+ a0

>>> A ← **Classical Qubit A**

+ a0 - a1

>>> Sa ← **Qubit Spinor**

+ (a0^a1)

>>> Sa*Sa ← **so Spinor = sqrt(-1)**

-1

>>> A*Sa ← **Superposition**

+ a0 + a1

```
>>> gastates(ab)
<table for + (a^b)>
INPUTS: a b ¦ OUTPUT
--------------------
ROW 00: - - ¦ +
ROW 01: - + ¦ -
ROW 02: + - ¦ -
ROW 03: + + ¦ +
--------------------
Counts for outputs of ZERO=0, PLUS=2, MINUS=2 for TOTAL=4 rows
>>> report2(ab)
2.170 ((0, 2, 2), 1) [+ - - +] = + (a^b)
>>> report2((1+a)(1+b))
1.755 ((0, 1, 3), 3) [0 0 0 +] = + 1 + a + b + (a^b)
>>> report2((1+a)(1+b)+(1-a)(1-b))
2.170 ((0, 2, 2), 1) [+ 0 0 +] = - 1 - (a^b)
>>>
```

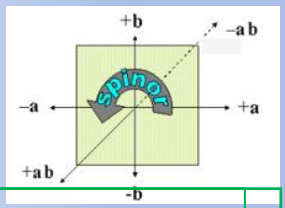
← **Truth Table of row vector output states**

← **Bits, sig, vector, = expr**

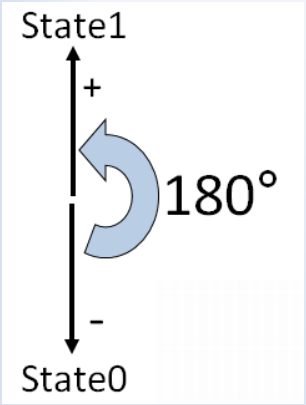
>>> A*B ← **Quantum Register (**where **B = + b0 - b1**)

+ (a0^b0) - (a0^b1) - (a1^b0) + (a1^b1)

Bit Vectors are the Source of Quantum States

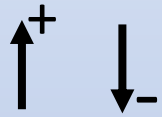


Bit – 1 dim



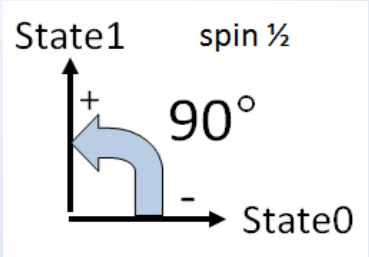
3 orientations ±1, 0

Orthonormal vectors **a**, **b**, …

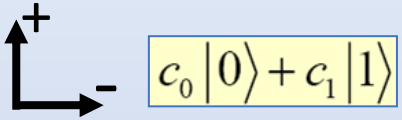


bit-vectors are protodimensions and distinctions

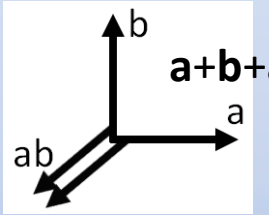
Qubit - 2 dims



bivectors **a^b**

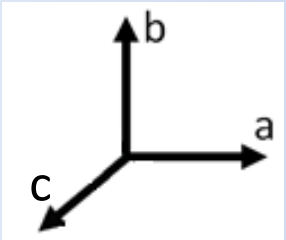


oriented spinors

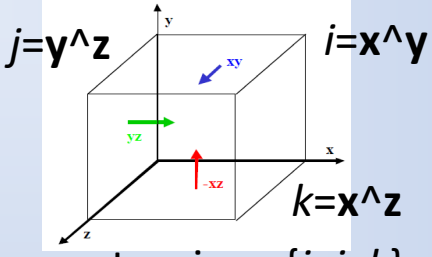


qubits, neutrinos and W/Z bosons

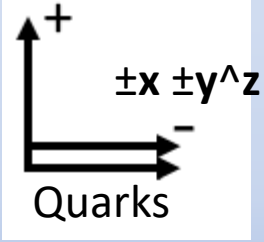
Qutrit - 3 dims



trivectors **a^b^c**



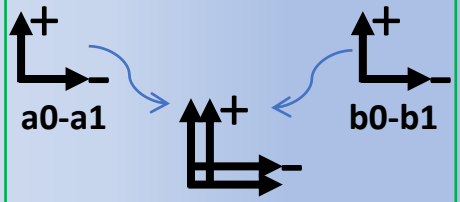
quaternions {*i*, *j*, *k*}



photons, gluons, quarks, mesons, electrons, neutrinos

Ebit – 4 dims

A*B = + a0^b0 - a0^b1 - a1^b0 + a1^b1



spacelike

Bell Operator
$\mathbb{B}$ = **S_A + S_B = a0^a1 + b0^b1**

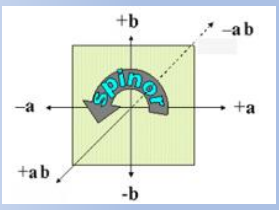
Magic Operator
$\mathbb{M}$ = **S_A - S_B = a0^a1 - b0^b1**

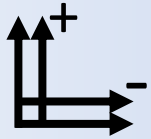
A*B*$\mathbb{B}$ = -a0^b0 +a1^b1
A*B*$\mathbb{M}$ = a0^b1 -a1^b0

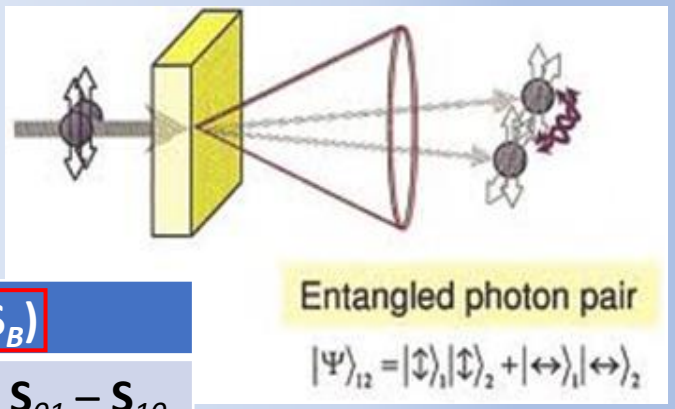
Entangled States $\mathbb{B}_i$
Entangled States $\mathbb{M}_i$

Hyperdimensional spaces can be formed from infinite sets of orthonormal bit vectors

Ebits: Entangled Qubits







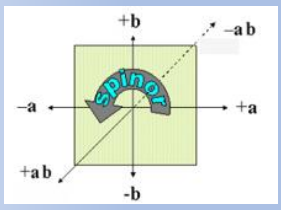
- Bell/Magic Operators (in $\mathbb{G}_4$):
  - **Bell** operator = $S_A + S_B$ = **a0 a1 + b0 b1**
  - **Magic** operator = $S_A - S_B$ = **a0 a1 – b0 b1**
- Bell/Magic States B_i and M_i form rings:

$B_{(i+1)mod4} = B_i (S_A + S_B)$	$M_{(i+1)mod4} = M_i (S_A - S_B)$
B_0 = **A_0 B_0 Bell** = $-S_{00} + S_{11} = \Phi^+$	M_0 = **A_0 B_0 Magic** = $+S_{01} - S_{10}$
$B_1 = B_0$ **Bell** = $+S_{01} + S_{10} = \Psi^+$	$M_1 = M_0$ **Magic** = $-S_{00} - S_{11}$
$B_2 = B_1$ **Bell** = $+S_{00} - S_{11} = \Phi^-$	$M_2 = M_1$ **Magic** = $-S_{01} + S_{10}$
$B_3 = B_2$ **Bell** = $-S_{01} - S_{10} = \Psi^-$	$M_3 = M_2$ **Magic** = $+S_{00} + S_{11}$
$B_0 = B_3$ **Bell** = $-S_{00} + S_{11} = \Phi^+$	$M_0 = M_3$ **Magic** = $+S_{01} - S_{10}$

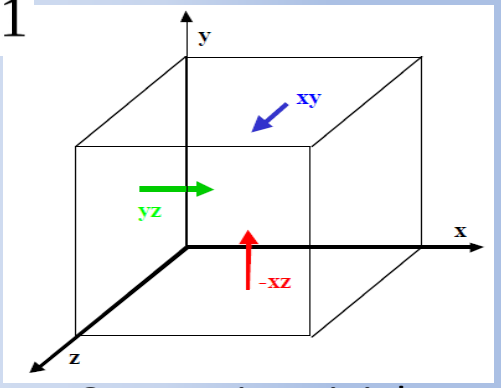
$$\Phi^{\pm} = |00\rangle \pm |11\rangle$$
$$\Psi^{\pm} = |01\rangle \pm |10\rangle$$

- Cannot factor: – **a0 b0** + **a1 b1** (Inseparable)
- **Bell** and **Magic** operators are irreversible in $\mathbb{G}_4$ (different than Hilbert spaces)
  - See proof that $1/(S_A \pm S_B)$ does not exist for Bell (or Magic) operators
- Multiplicative Cancellation – *Information erasure is irreversible*
  - **Qubits A_0 B_0** = + **a0 b0** – **a0 b1** – **a1 b0** + **a1 b1** = $B_3 + M_3$
  - 0 = **Bell** * **Magic** = **Bell** * M_j = **Magic** * B_i = B_i * M_j

TauQuernions: Entangled Quaternions



- **TauQuernions ($\mathcal{T}_i$, $\mathcal{T}_j$, $\mathcal{T}_k$ & conjugate set $\mathcal{T}_i'$, $\mathcal{T}_j'$, $\mathcal{T}_k'$):**
  - Entangled Quaternion isomorphs $i^2 = j^2 = k^2 = ijk = -1$
  - $\mathcal{T}_i$ = **ab – cd**, $\mathcal{T}_j$ = **ac + bd** and $\mathcal{T}_k$ = **ad – bc**
  - $\mathcal{T}_i'$= **ab + cd**, $\mathcal{T}_j'$= **ac – bd** and $\mathcal{T}_k'$= **ad + bc**
  - Anti-Commutative: $\mathcal{T}_x \mathcal{T}_y = -\mathcal{T}_x \mathcal{T}_y$
  - $\mathcal{T}_i \mathcal{T}_j \mathcal{T}_k$ = 1 + **abcd** = "–1" (sparse –1)
  - ("–1")^2 = "+1" = –1 ±**abcd** (sparse +1:idempotent)



Quaternions i, j, k: {xy, yz, xz}

```
>>> report4(1-abcd)
18.868 ((0, 8, 8), 1) [0 - - 0 - 0 0 - - 0 0 - 0 - - 0] = + 1 - (a^b^c^d)
>>> report4(-1-abcd)
18.868 ((0, 8, 8), 1) [+ 0 0 + 0 + + 0 0 + + 0 + 0 0 +] = - 1 - (a^b^c^d)
```

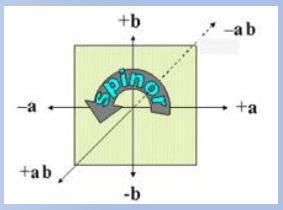
*	$\mathcal{T}_i$	$\mathcal{T}_j$	$\mathcal{T}_k$
$\mathcal{T}_i$	1 + **abcd**	–**ad** + **bc**	**ac** + **bd**
$\mathcal{T}_j$	**ad** – **bc**	1 + **abcd**	–**ab** + **cd**
$\mathcal{T}_k$	–**ac** – **bd**	**ab** – **cd**	1 + **abcd**

*	$\mathcal{T}_i$	$\mathcal{T}_y$	$\mathcal{T}_k$
$\mathcal{T}_i$	"–1"	$-\mathcal{T}_k$	$\mathcal{T}_j$
$\mathcal{T}_j$	$\mathcal{T}_k$	"–1"	$-\mathcal{T}_i$
$\mathcal{T}_k$	$-\mathcal{T}_j$	$\mathcal{T}_i$	"–1"

$\mathcal{T}_i$	$\mathcal{T}_j$	$\mathcal{T}_k$
Magic	$\mathbb{M}_3 = -\mathbb{M}_1$	$\mathbb{M}_0 = -\mathbb{M}_2$
Magic	$\mathbb{M}_3 = -\mathbb{M}_1$	$\mathbb{M}_2 = -\mathbb{M}_0$
Magic	$\mathbb{M}_1 = -\mathbb{M}_3$	$\mathbb{M}_0 = -\mathbb{M}_2$
Magic	$\mathbb{M}_1 = -\mathbb{M}_3$	$\mathbb{M}_2 = -\mathbb{M}_0$

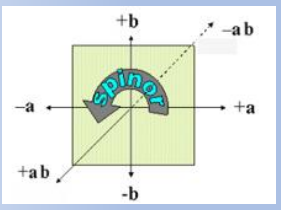
$\mathcal{T}_i'$	$\mathcal{T}_j'$	$\mathcal{T}_k'$
Bell	$\mathbb{B}_2 = -\mathbb{B}_0$	$\mathbb{B}_1 = -\mathbb{B}_3$
Bell	$\mathbb{B}_2 = -\mathbb{B}_0$	$\mathbb{B}_3 = -\mathbb{B}_1$
Bell	$\mathbb{B}_0 = -\mathbb{B}_2$	$\mathbb{B}_1 = -\mathbb{B}_3$
Bell	$\mathbb{B}_0 = -\mathbb{B}_2$	$\mathbb{B}_3 = -\mathbb{B}_1$

Higgs Bosons are Entangled



- The proposed Higgs Boson in $\mathbb{G}_4$:
  - $\mathcal{H} = \mathcal{T}_i + \mathcal{T}_j + \mathcal{T}_k$ (where $\mathcal{H}^2 = 0$)
  - Eight triples: $\pm\mathcal{T}_i\pm\mathcal{T}_j\pm\mathcal{T}_k$ (and 8 more for $\pm\mathcal{T}_i'\pm\mathcal{T}_j'\pm\mathcal{T}_k'$)
- Also various factorizations:
  - $\mathcal{H}$ = (±1 ±**abcd**)(**ab** + **ac** + **bc**) Time-like mass acts on Space
  - $\mathcal{H}$ = (**a** + **b** – **c**)**d** + **ab** + **ac** – **bc** Light and space
- The Higgs $\mathcal{H}$ and proto-mass $\mathcal{M}$ cover even subalgebra:
  - $\mathcal{H}$ = {**X** = ± **ab** ±**ac** ±**bc** ±**ad** ±**bd** ±**cd** | $\mathbf{X}^2 = 0$} (16)
    For X = $\mathcal{H}$ then **X abcd** = **abcd X** = ± **X**
  - $\mathcal{M}$ = {**X** = ±**ab** ±**ac** ±**bc** ±**ad** ±**bd** ±**cd** | $\mathbf{X}^2 = \pm\mathbf{abcd}$} (48)
    For X = $\mathcal{M}$ then only **X abcd** = **abcd X**
    sig ((4, 6, 6), 6) = 32 and sig ((0, 6, 10), 6) = 16

Bit Grades of Primitive “Particles”

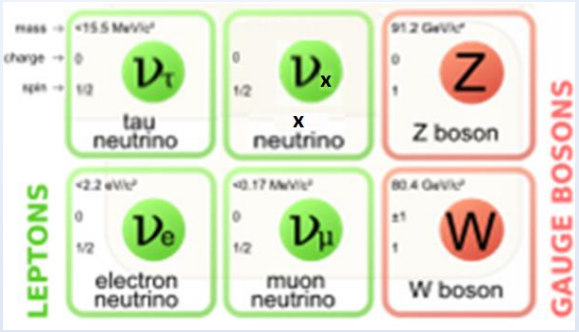


Non-Standard Topological Model (from Manthey and Matzke - ANPA)

Bit in G_1

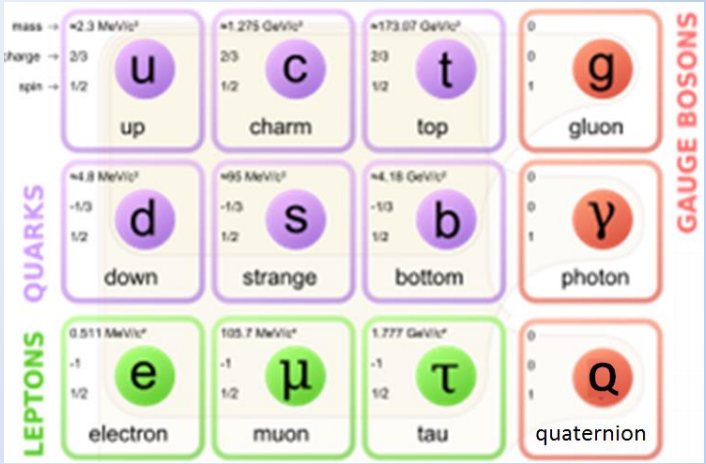
9 states

primitives in G_2 plus qubit



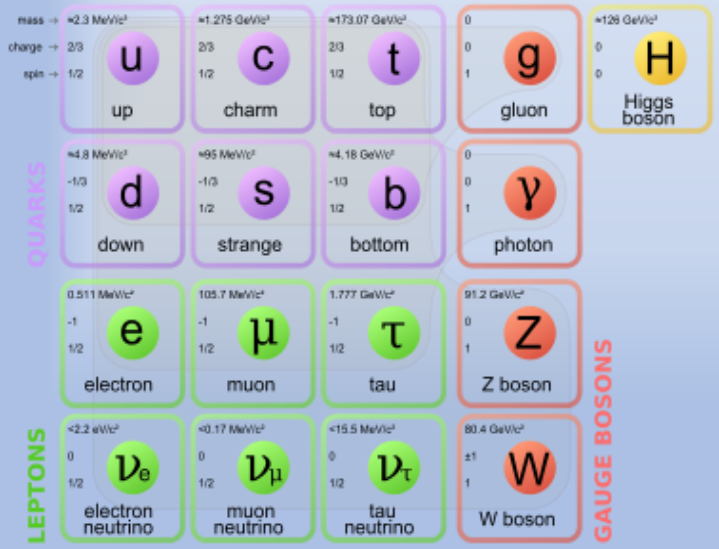
81 states

primitives in G_3

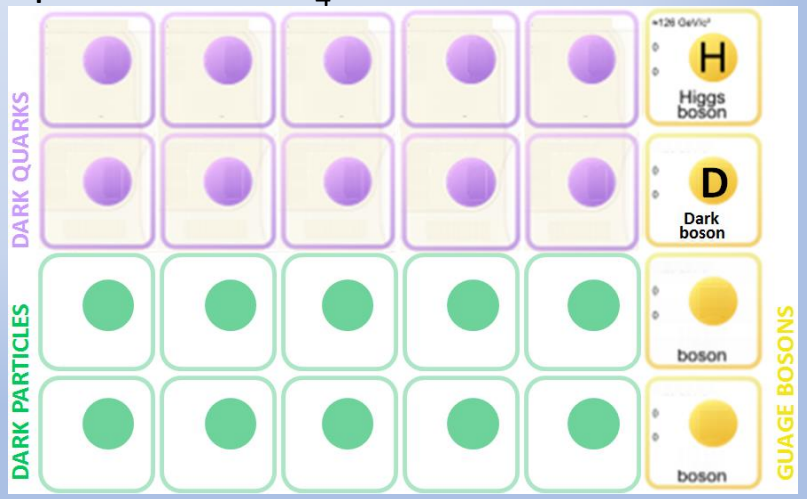


6561 states

Standard Model (from Wikipedia - SU3 symmetry)



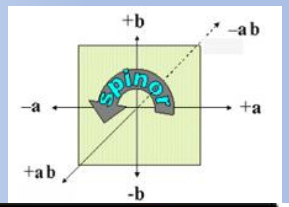
primitives in G_4

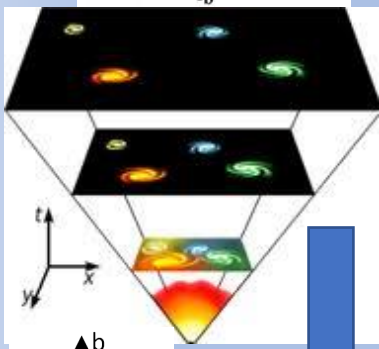


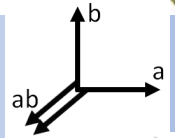
>43 million states 17 particles and 30 bosons

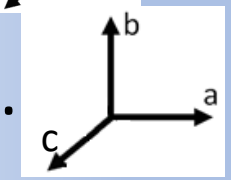
Summary: How to Bootstrap the universe

As spacelike bits coalesce in the bit matrix, they form qubits, bosons, particles, ebits, S/T based on the bit state likely hood

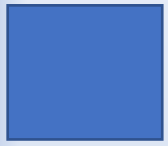






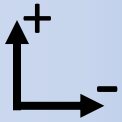


Complexity

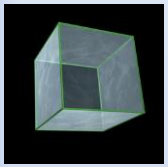


$\mathbb{G}_1$ Space like Bits $\uparrow^+ \downarrow_- \uparrow^+ \downarrow_- \uparrow^+ \downarrow_- \uparrow^+ \downarrow_-$

0.58 bits

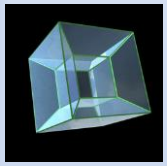
$\mathbb{G}_2$ qubits, W/Z, Neutrinos, coin demo 

2.17 bits



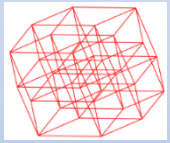
$\mathbb{G}_3$ Quaternions (Space), photons, mesons …

7.29 bits

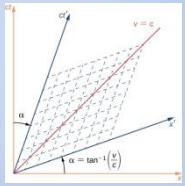


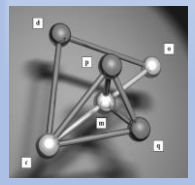
$\mathbb{G}_4$ Tauquernions, entanglement, Higgs, Dark M/E

18.9 bits



$\mathbb{G}_5$ Tauquinions, spacetime emerges?



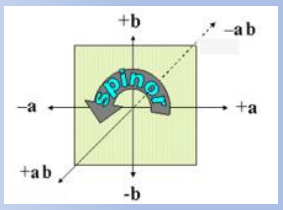


…

$\mathbb{G}_n$ Spacelike Correlithms, Thought

< Standard distance is information

Hyperdimensional Bit-vectors & N-vectors

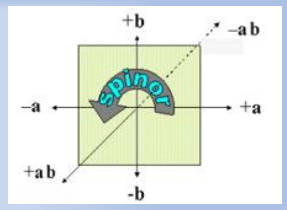


Bits and math are physical: ala Landauer's Principle

- **Bit-vectors** are **protophysical** and **orthogonal** (GALG)
- Infinite supply of bit-vectors, since are mathematical
- Hyperdimensional bit-vectors creates **n-vectors**, hierarchy
- **Bivectors** are equivalent to imaginary numbers (i)
- **N-vectors** are fundamental and are missing from Hilbert spaces
- **Geometric product** & **anticommutative** vectors are built-in
- Multiplicative cancelation in GALG is fundamental to entanglement
- All **multivectors** are states as well as operators (**verbnoun** balanced)
- Hyperdimensional **bit-vectors** & change precede normal spacetime
- **Co-occurrence** (**spacelike**) and **co-exclusion** precede spacetime
- Spacelike simultaneity of bit-vectors is built-in and fundamental
- Infinite computational concurrency since no spacetime metrics/limits
- **Coin Demo** (non-Shannon information & bit-bang)

See my book at www.DeepRealityBook.com and purchase on Amazon

Hyperdimensional Complexity

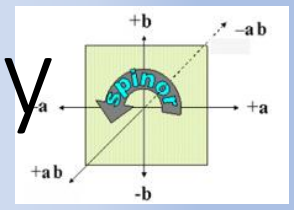


Hyperdimensional complexity emerges from bits

- N-vectors, multivectors emerge from bit-vectors $\mathbb{G}_N$
- Imaginary numbers (***i***), **qubits**, **ebits** & quantum operators
- **Quaternions**, **Tauquernions**, and **Tauquinions** multivectors
- $\mathbb{G}_3$ is equivalent to Pauli Algebra and $\mathbb{G}_4$ contains Dirac Algebra
- Multiplicative cancelation is fundamental to entanglement
- **Idempotent** ($\mathbf{I}^2=\mathbf{I}$), **unitary** ($\mathbf{U}^2=1$), **nilpotent** ($\mathbf{X}^2=0$) multivectors*
- Particles are unitary and bosons are nilpotent
- Standard model, **Higgs Boson**, Dark matter/energy forms
- Majorana analysis made
- **Wait/Signal** emerge from idempotent/unitary
- Multivectors, hierarchy and operating system (Topsy).

*For $\mathbf{X}^2 = \mathbf{X}$ (Idempotent) and $\mathbf{U}^2 = 1$ (Unitary) then $\mathbf{X} = -1 \pm \mathbf{U}$ (proof $\mathbf{X}^2 = (-1 \pm \mathbf{U})^2 = \mathbf{X}$)

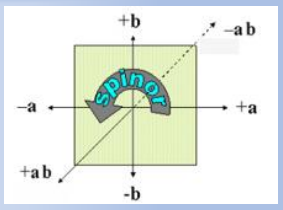
Statements about Mike's Legacy



GALG Predictions:

- Bit-physics is **protophysical**: bit-vectors, n-vectors, multivectors
- **Coin Demo** creates the energy of the bit bang
- **Neutrinos** are 2 dimensional
- **Neutrinos** have 4 variations (not just 3)
- Electrons have 2X chirality variations
- Entanglement operators (Bell/Magic) are **irreversible in GALG**
- Entanglement is connected to built-in spacelike mechanisms
- Higgs-boson is **entangled** (using tauquernions)
- Proposed dark-energy and dark matter are entangled in 4 dim odd algebras
- Complexity and hierarchy is **emergent due to graded n-vectors**

Proposed Source Science Research



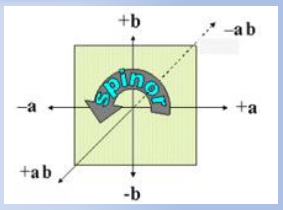
Protophysics themes (based on GALG)

- Explore foundational bit-vectors and & N-vectors
- Explore foundations of built-in spacelike concurrency & change
- Research how space & time emerges from bit-physics
- Explore if neutrinos are 2 dimensional.
- Explore if 4 neutrinos/antineutrino pairs exist
- Explore if photons/quaternions are related (X17 boson)
- Confirm if entanglement is irreversible
- Explore Higgs Boson 4D even-algebra structure
- Explore Dark Quarks/Matter/Energy 4D odd-algebra structure
- Topsy development and research

Metaphysics themes

- Qiskit tool for qubits vs intention experiments
- Qiskit tool for ebits vs intention experiments
- WISH thought coherence research

ANPA Challenge of Mike legacy



- My general experience about acceptance of GALG:
  - GALG combines math, physics, computer, quantum & metaphysics
  - GALG is different enough, that people don't invest learning
  - General science community has ignored the GALG work
  - Likewise, ANPA group members have also mostly ignored GALG

- My Challenge to ANPA members to honor Mike's work:
  - The GALG approach is totally aligned with ANPA goals

> The primary purpose of ANPA is to consider coherent models based on a minimal number of assumptions in order to bring together major areas of thought and experience within a Natural Philosophy including Physics and a continuing investigation of the Combinatorial Hierarchy of Parker-Rhodes and others (the original foundation of the organisation). Such models are often alternative to prevailing scientific attitude.

  - Research includes both GALG hyperspace math and Topsy areas
  - Give feedback regarding approach, problems & predictions
  - Get involved with further GALG research and papers

2007 Photos of Mike and Doug