# Bit-Physics: How to bootstrap the universe using topological bits

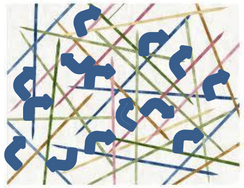
Presented to:

InformationPhysicsInstitute.org invited Lecture

Sat Dec 17, 2022

by Quantum Doug Matzke, Ph.D.
doug@QuantumDoug.com
www.QuantumDoug.com
www.DeepRealityBook.com

# Abstract

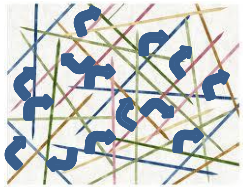


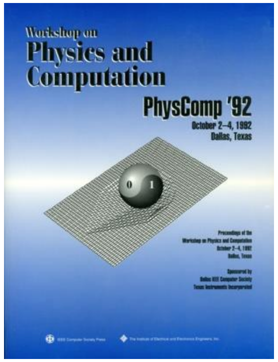
In my 2002 Ph.D. dissertation, I defined bit-physics as a mathematical model using topological bits (geometric algebra) to derive quantum computing (qubits and ebits). Later in my 2020 book Deep Reality, I expanded that approach to include the standard model, neural computing and beyond. Both of these efforts make testable predictions different than the models for quantum computing and standard model. This research gives keen insight into the hyperdimensional nature of the quantum-verse.

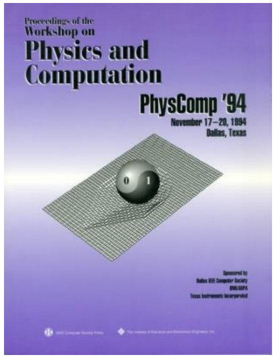
The key to understanding bit-physics are these concepts:

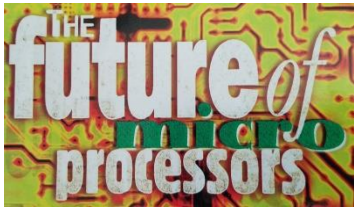
1) **“bits are physical”** (Landauer’s principle) thus effecting the physical universe
2) **“bits are protophysical”** (Matzke’s principle), which means that the topological mathematics supporting hyperdimensional bits is fundamental to the substrate structure of the multiverse.
3) **“bits are hyperdimensional”** (Correlithms) random points in >20 dimensional space are maximal “Standard distance” apart, leading to information creating bullseye when similar.

# About Doug Matzke



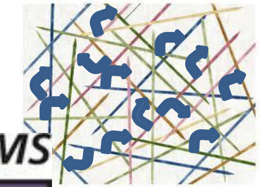


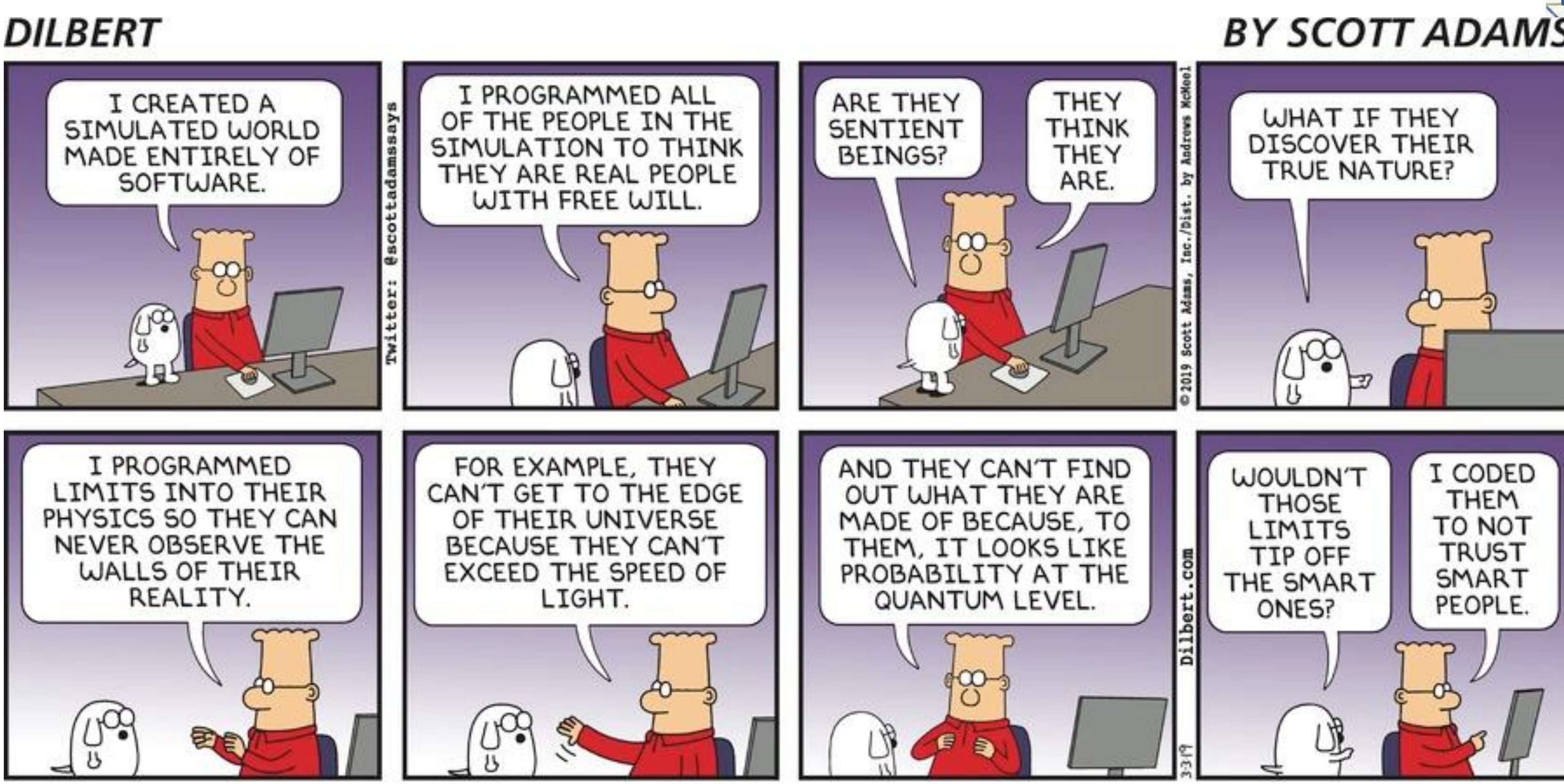




- My moniker is Quantum Doug
- Programming for over 55 years, IEEE Life Member
- Chairman of PhysComp '92 and PhysComp '94
  - ANPA Session in PC'94
  - See my 3 ANPA talks on my YouTube channel
- Written over 40 papers/talks and 10 patents
  - Will Physical Scalability Sabotage Perf. Gains?
- PhD in Quantum Computing in 2002 at UT Dallas
  - Quantum Computing using Geometric Algebra
  - Built GALG symbolic math tool in python
  - GALG research for last 20 years (w/Mike Manthey)
  - Proposed differences vs standard models
- Awarded $1 million SBIR grants on topics:
  - Neural and quantum computing
  - Patents issued and Correlithm Book Released
- Bit-Physics and Source Science
  - Deep Reality coauthor **William A. Tiller (deceased)**
  - Co-Founder of company www.CoherentSpaces.life

# Bits form Quantum Source Substrate





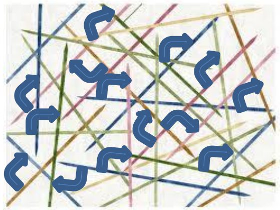

**Richard Feynman**

"Nature isn't classical, dammit, and if you want to make a simulation of nature, you'd better make it quantum mechanical, and by golly it's a wonderful problem, because it doesn't look so easy."

Protobit substrate is spacelike "bit matrix"

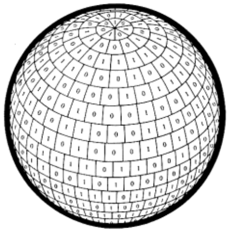
Quantum substrate is required to efficiently simulate a quantum universe

# Bit-Physics: true end to Reductionism

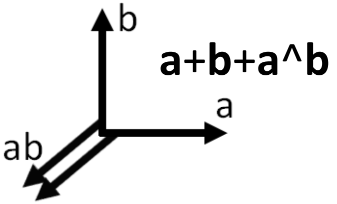


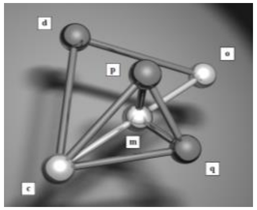
Bits are more fundamental than “fifth state of matter”

1. **“bits are physical” (Landauer’s principle):** thus effecting the physical universe. Bits show up as fundamental discrete increments to black holes. Wheeler’s “it from bit”.
2. **“bits are protophysical” (Matzke’s principle):** which means that the topological mathematics supporting hyperdimensional bits is fundamental as the substrate structure of the multiverse. My approach is representing bits using anticommutative Geometric Algebra, which is “mostly” equivalent to Hilbert Spaces.
3. **“bits are hyperdimensional”** (**Correlithms**) random points in >20 dimensional space are maximal “Standard distance” apart, leading to information creating bullseye when similar. This hyperdimensional bit-soup is spacelike.

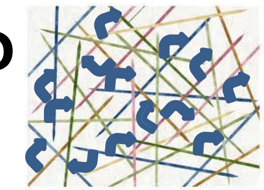


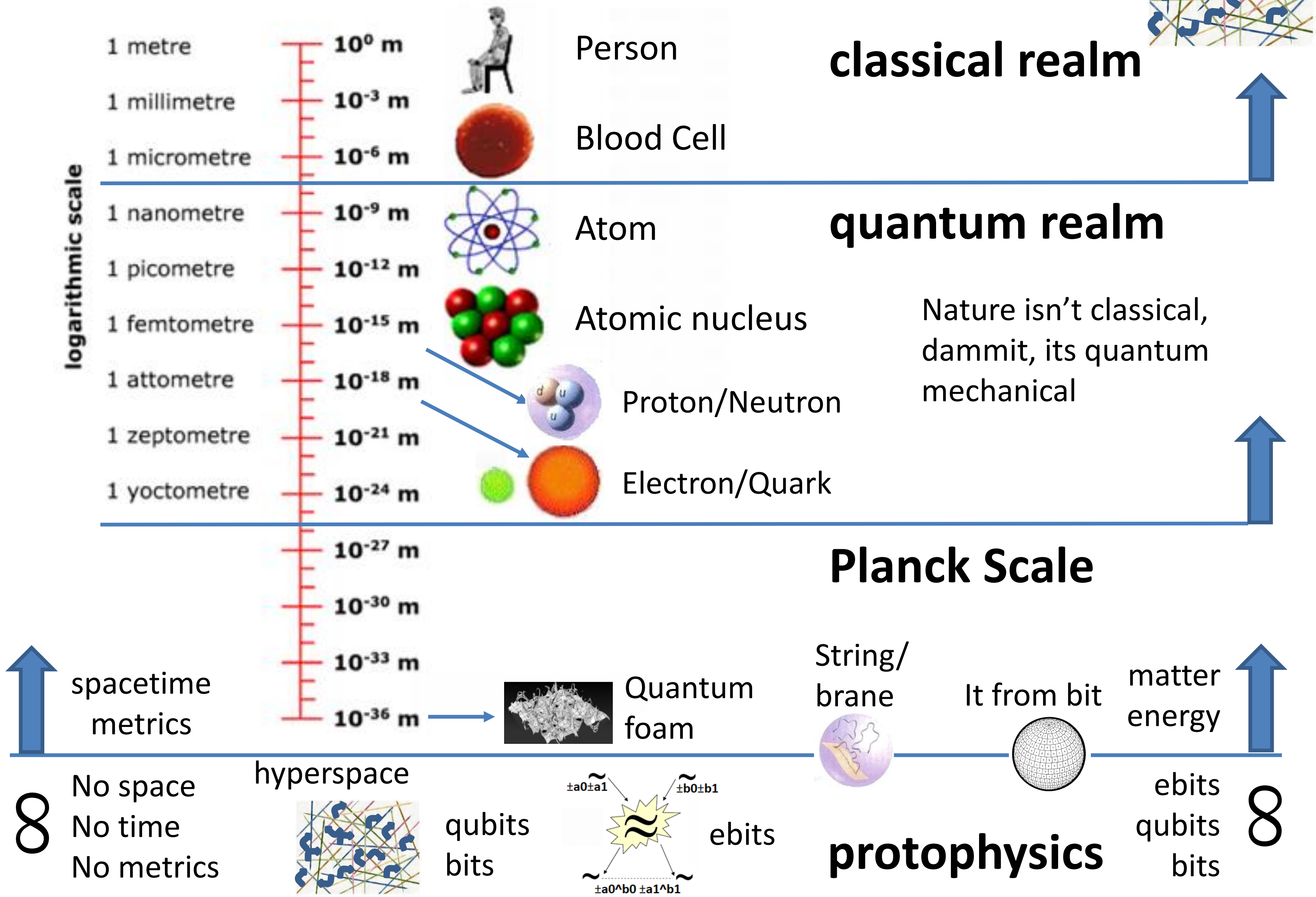
“It from Bit”



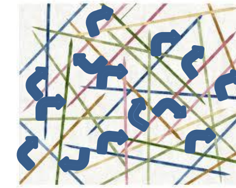



# What is below classical and quantum?

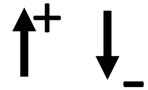


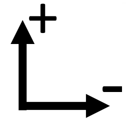


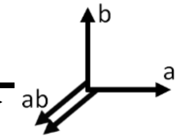
# 1D, 2D, 3D, 4D, 5D, 6D and N-D

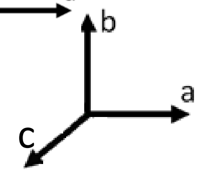


- 0D: void of distinctions
- 1D: Bit-physics
- 2D: Flat world, qubits, neutrinos, W/Z bosons
- 3D: Classical worldview, standard model S/T/M/E

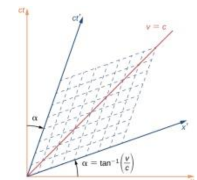


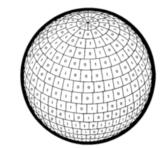




**quaternions** ➔ $i^2=j^2=k^2=ijk=-1$

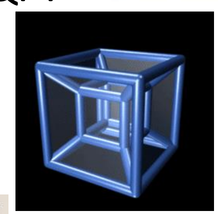


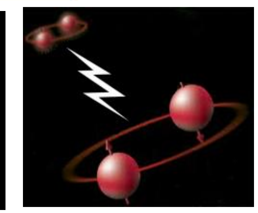


**Spacetime Divide**

- 3D+1T: Relativistic worldview, space contraction/time dilation, QFT

**Spacelike Divide includes Dark quarks/matter/energy**





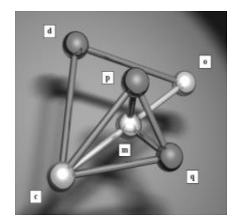
- 4D: Ebit Entanglement – spooky action at distant, all entangled

**tauquernions** are entangled

**Information/Entropy Divide – no S/T/M/E**

- 5D: Odd/evens **tauquinions** are entangled
- 6D: ???

**Correlithm/Meaning Divide when > 20 dimensions**

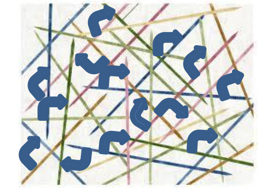


- nD: Bit physics substrate for thoughts and meaning

**Infinity Divide**

- ∞D: Real & Infinite Intelligence

# Protophysics - emergence of Primitive Space and Time



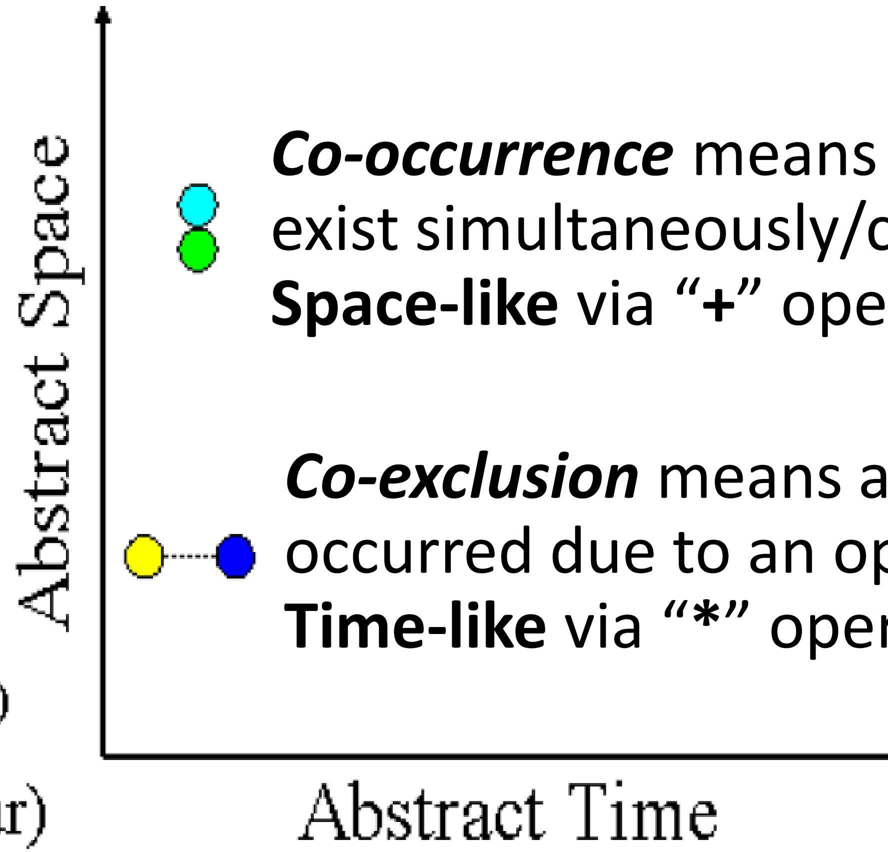
$a + b = b + a$

$c - d \longleftrightarrow d - c$

$c - d \mid d - c$

$c - d + d - c = 0$

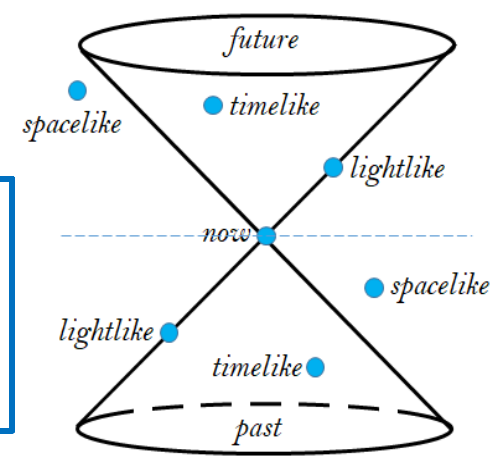
(or cannot occur)




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

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

Only 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:** 

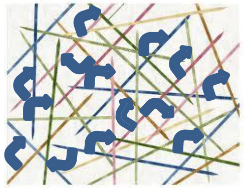
Person again shows a coin (indistinguishable from 1st)

**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**

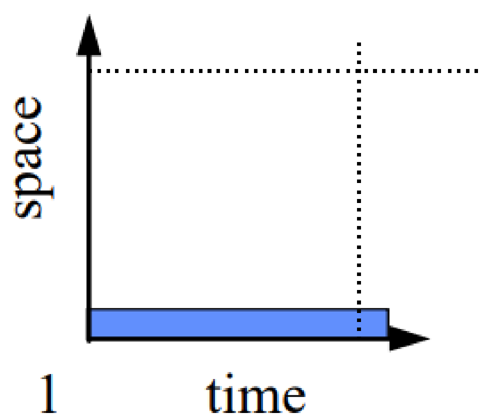
# Shor Algorithm: Quantum Polynomial Time

Information is Protophysical PhysComp 96

## Thought Experiment 1

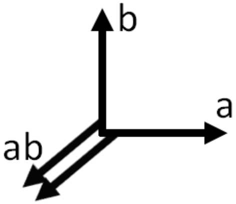
NP complete algorithms and implmentations:

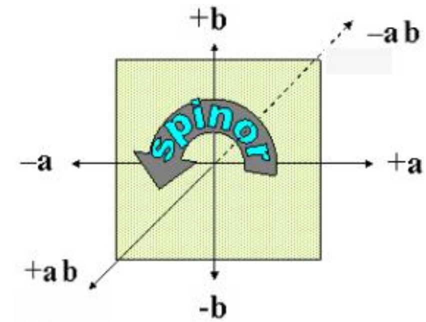
– 1 Spatially bound - time longer than universe



# Geometric Algebra Introduction

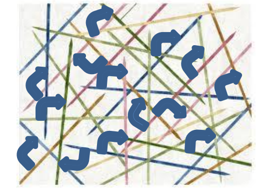
- Vectors, bivector, trivectors, n-vectors, multivectors
- Multivector Spaces (for $G_n$ size is $3^{(2^{**}n)}$)
  - $G_0$ is size 3: {0, ±1}
  - $G_1$ is size 9: {0, ±1, ±**a**} **bits**
  - $G_2$ is size 81: {0, ±1, ±**a**, ±**b**, ±**ab**} **qubits**
  - $G_3$ is size 6,561: {0, ±1, ±**a**, ±**b**,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



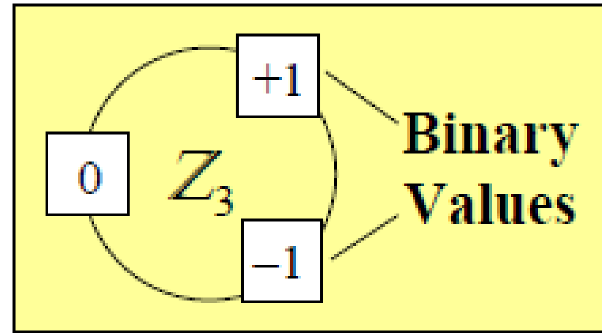

- Anti-commuting vector space
  - **ab** = –**ba** → (**ab**)$^2$ = **abab =** –1 so any bivector **xy** = $\sqrt{-1}$ is spinor *i*
- Arithmetic Operators over $Z_3$ = {±1=T/F, 0=does not exist}
  - +, * (geometric ~ ⊗), outer (**a**^**a**=0,**a**^**b**=**ab**), inner (**a**•**a**=1,**a**•**b**=0)
- 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

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

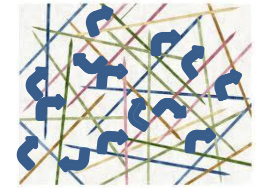
+ (a0^b0) - (a0^b1) - (a1^b0) + (a1^b1)

```
>>> 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**

# Complexity Signatures



Multivector = Equivalent Row Vector

$$\begin{array}{rl} \mathbf{abc} = & [- + + - + - - +] \\ +1 = & [+ + + + + + + +] \\ \hline \mathbf{abc}+1 = & [0 - - 0 - 0\ 0 -] \end{array} \rightarrow (0, 4, 4)$$

Multivector = Equivalent Row Vector

$$\begin{array}{rl} \mathbf{abc} = & [- + + - + - - +] \\ -1 = & [- - - - - - - -] \\ \hline \mathbf{abc}-1 = & [+\ 0\ 0 + 0 + +\ 0] \end{array} \rightarrow (0, 4, 4)$$

Given any multivector in $\mathbb{G}_n$ and its corresponding row vector, compute a tuple (#0s, #+s, #–s) based on the counts of elements in the row vector. The sorted tuple, represents the state complexity of the multivector.

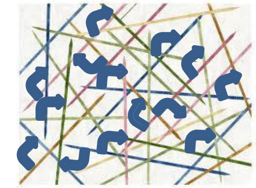
| Space | Signature | Count | Description | Structural complexity | Bits |
|---|---|---|---|---|---|
| n=0 | (0, 0, 1) | 3 | Scalars {0, ±1} → [±] | 0 | 0 |
| n=1 | (0, 0, 2) | 3 | Scalars {0, ±1} → [±±] | 0 | 1.58 |
| all=9 | (0, 1, 1) | 6 | Vectors ±**x** & ±1±**x** → [±∓] | 1 | 0.58 |
| n=2 | ((0, 0, 4), 0) | 3 | Scalars {0, ±1} → [±±±±] | 0 | 4.75 |
| all=81 | ((0, 1, 3), 3) | 24 | Row Decode ±(1±**x**)(1±**y**) | 3 | 1.75 |
| | ((0, 2, 2), 1) | 18 | GA Singletons ±**x** and ±**xy** | 1 | **2.17** |
| | ((1, 1, 2), 2) | 36 | ±**x** ± **y** and ±1 ± **x** ± **y** | 2 | **1.17** |

Add structural complexity (singleton count) to the signature to support larger spaces.

Signatures are root of indistinguishability

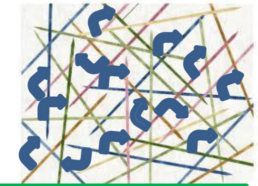
* Coin Demo 1.000 bit = 2.17 – 1.17

# More Signatures in $\mathbb{G}_3$ & $\mathbb{G}_4$

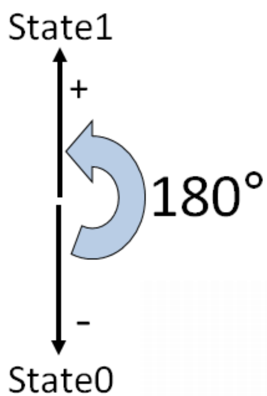


| Space | Signature | Count | Description | Bits |
|---|---|---|---|---|
| n=3 | ((0, 0, 8), 0) | 3 | Scalars {0, ±1} → [±±±± ±±±±] | 11.1 |
| 6,561 | ((0, 1, 7), 7) | 48 | Row Decode ±(1±**w**)(1±**x**)(1±**y**) →[±000 0000] | 7.09 |
| | ((0, 2, 6), 3) | 168 | **±x ±y ±xy is a neutrino** | **5.29** |
| | ((0, 3, 5), 6) | 336 | **±x ±y ±xy ±xz ±yz ±xyz is a neutron plus ±xyz** | **4.29** |
| | ((0, 4, 4), 1) | 42 | Singletons ±**x**, ±**xy** and ±**xyz** | **7.29** |
| | ((0, 4, 4), 4) | 168 | Some variations of ±**y** ±**z** ±**xy** ±**xz** **is a meson** | **5.29** |
| | ((2, 2, 4), 2) | 252 | Co-occurrence ±**x** ±**y** **is a qubit** | 4.70 |
| | ((2, 3, 3), 3) | 672 | Co-occurrence ±**x** ±**y** ±**z** **is a photon** | **3.29** |
| | <not shown 5 signatures of 14 total bins> | | | |
| | ((1, 3, 4), 4) | 1,344 | Smallest information content in $\mathbb{G}_3$(e.g. ±**a**±**b**±**c**±**xy**) | 2.29 |
| n=4 | ((0, 0, 16), 0) | 3 | Scalars {0, ±1} → [±±±± ±±±± ±±±± ±±±±] | 23.8 |
| $3^{(2**n)}$ | ((0, 1, 15), 15) | 96 | Row Decode ±(1±**w**)(1±**x**)(1±**y**)(1±**z**) | 18.8 |
| | ((0, 8, 8), 1) | 90 | Singletons ±**x**, ±**xy**, ±**xyz** and ±**wxyz** | **18.9** |
| | ((4, 4, 8), 2) | 1,260 | Co-occurrence ±**x** ±**y**, ±**wx** ±**yz** , ±**w** ±**xyz** | 15.1 |
| | <not shown 81 signatures of 86 total bins> | | | |
| | ((4, 5, 7), 11) | 5,040K | Smallest information content in $\mathbb{G}_4$ (11 singletons) | **3.09** |

# Proto-Bits are the Source of Quantum States

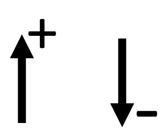


## Bit – 1 dim



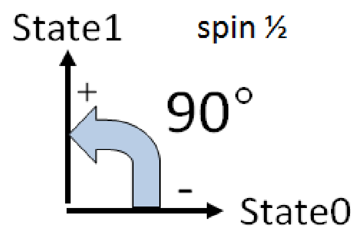

3 orientations ±1, 0

Orthonormal vectors **a**, **b**, …

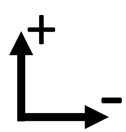



bit-vectors are protodimensions and distinctions

## Qubit - 2 dims

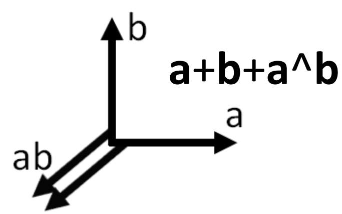



bivectors **a^b**



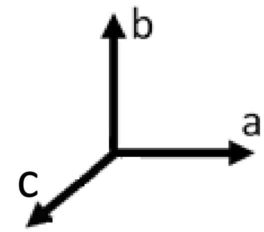

$c_0|0\rangle + c_1|1\rangle$

oriented spinors

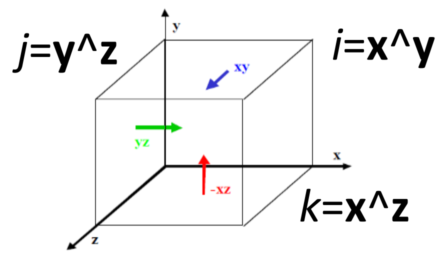



qubits, neutrinos and W/Z bosons

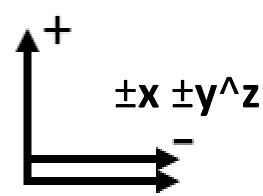
## Qutrit - 3 dims




trivectors **a^b^c**




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

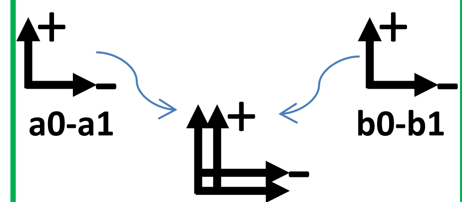



Quarks

photons, gluons, quarks, mesons, electrons, neutrinos

## Ebit – 4 dims

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




**spacelike**

Bell Operator
$\mathcal{B}$ **= S$_A$ + S$_B$ =**
**a0^a1 + b0^b1**

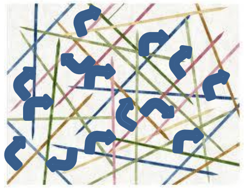
Magic Operator
$\mathcal{M}$ **= S$_A$ - S$_B$ =**
**a0^a1 - b0^b1**

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

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

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

# Bosons $X^2=0$ (Nilpotents)



Find all bosons in $\mathbb{G}$ using: $\boxed{\text{gasolve([a,b, ...], lambda X: X*X, 0)}}$

| Space | Count | Boson Multivector | Boson Description |
|---|---|---|---|
| $\mathbb{G}_0$ & $\mathbb{G}_1$ | **Total** 0 | Exclude 0 from this table | $0^2=0$ |
| $\mathbb{G}_2$ | **Total** 8 | | (qubit space) |
| | 8 | **±x ±xy** = **±x***(1 ± **y**) | Weak Force Bosons W/Z |
| **$\mathbb{G}_3$** | **Total 80** | ***quarks are: ±x ±yz** | **(Standard model Space)** |
| | 8 | **±a ±b ±c** | Photonic Boson (Qutrit) |
| | 24 | **±x ±xy** | Weak Force Bosons in $\mathbb{G}_3$ |
| | 8 | **±ab ±ac ±bc** | Quaternions are bosonic |
| | 24 | **±x ±z ±xy ±yz** | Mesons are two quarks |
| | 16 | **±x ±y ±z ±xy ±xz ±yz** | Strong Force (Gluons) |
| **$\mathbb{G}_4$** | **Total 7,280** | | **30 Different signatures** |
| | 80 | **±x ±xy** and **±w ±xyz** | Weak and Dark Bosons |
| | 528 | (**ab** - **cd**) + (**ac** + **bd**) + (**ad** - **bc**) & … | 16 Higgs Boson & others |
| | … | … | 28 more signatures |

$\mathbb{G}_3$ is equivalent to Pauli Algebra and $\mathbb{G}_4$ contains Dirac Algebra. Also Parsevals Identity

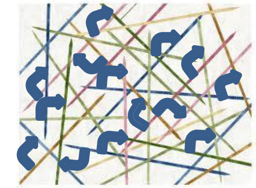
# Particles $X^2=1$ (Unitary)

Find all Unitaries in $\mathbb{G}$ using: gasolve([a,b, …], lambda X: X*X, 1)

| Space | Count | Unitary Multivector | Particle Description |
|---|---|---|---|
| $\mathbb{G}_1$ | **Total** 2 | **± a** | Exclude scalar value of ±1 |
| $\mathbb{G}_2$ | **Total** 12 | | (qubit space) |
| | 4 | ±**x** | Vectors are distinctions |
| | 8 | ±**a** ±**b** ±**ab** | 4 Neutrinos and 4 antineutrinos |
| **$\mathbb{G}_3$** | **Total 90** | ***quarks are: ±x ±yz** | **(Standard model Space)** |
| | 6 | ±**x** | Vectors are distinctions |
| | 24 | ±**x** ±**y** ±**xy** | Neutrinos (3x8=24) |
| | 12 | ±**xy** ±**xz** | Electrons (3x4=12) |
| | 48 | ±**x** ±**y** ±**z** ±**xy** ±**xz** | Protons (neutrons = xyz protons) |
| **$\mathbb{G}_4$** | **Total 12,690** | | **17 Different signatures** |
| | 10 | ±**x** and ±**wxyz** | Vectors and Mass Carrier |
| | … | … | 16 more signatures |

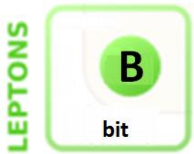
For $\mathbf{X}^2 = \mathbf{X}$ (Idempotent) and $\mathbf{U}^2 = 1$ (Unitary) then $\mathbf{X} = -1 \pm \mathbf{U}$ (proof $\mathbf{X}^2 = (-1 \pm \mathbf{U})^2 = \mathbf{X}$)

# Bit Grades of Primitive "Particles"



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

Bit in $G_1$

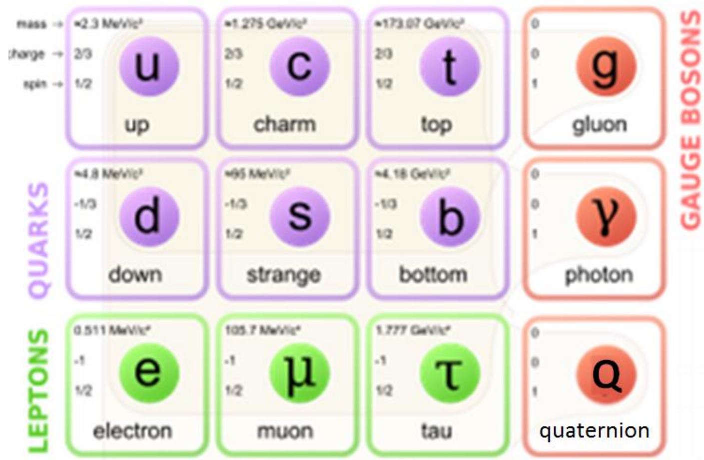



9 states

primitives in $G_2$ plus qubit

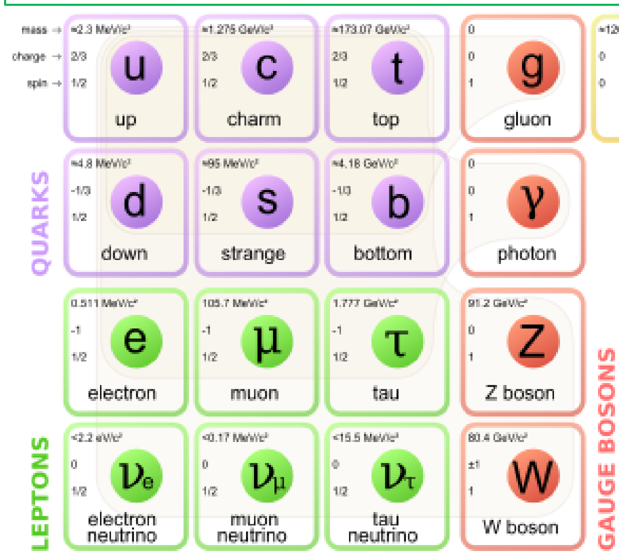

81 states

primitives in $G_3$

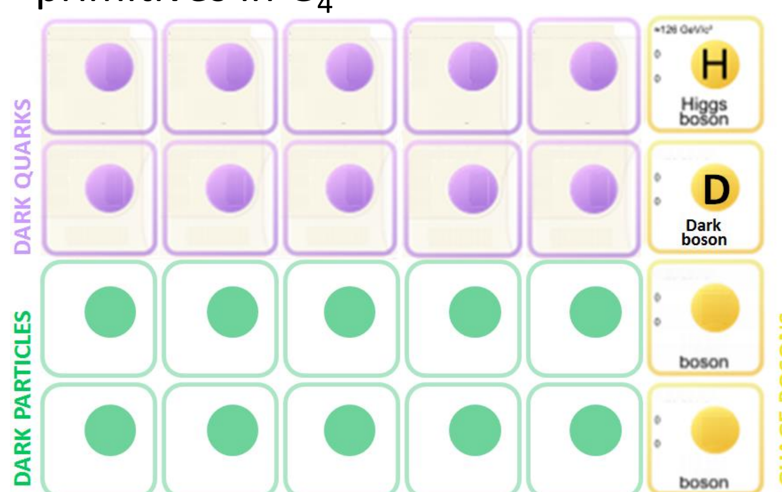



6561 states

Standard Model (from Wikipedia - SU3 symmetry)

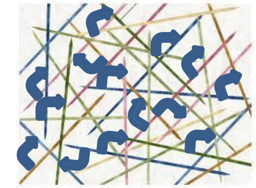



primitives in $G_4$

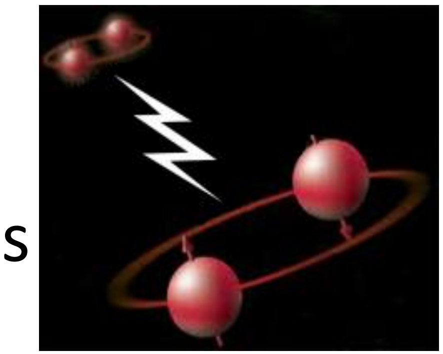



>43 million states 17 particles and 30 bosons

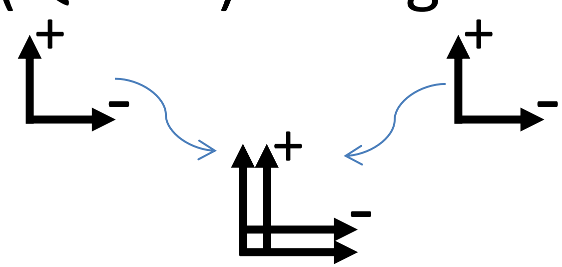
# Definition of Entanglement:



Entanglement is a quantum property:

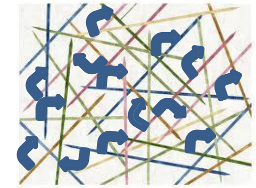


- Only Quantum systems (not classical)
- Non-local in 3D due to 4 actual dimensions
- Einstein's "Spooky action at a distance"
- EPR and Bell/Magic states/operators are well defined
- Property known as *inseparable* quantum states
- Bell/Magic Operators are irreversible in GALG*
- Multiple things (Qubits) acting as one thing (Ebit)

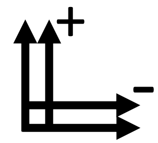


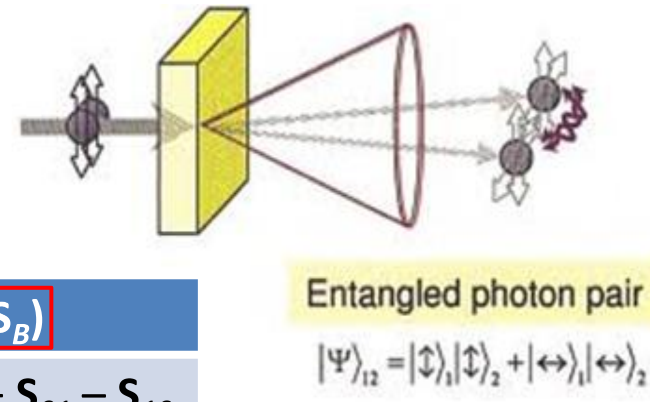

* Geometric Algebra

# Ebits: Entangled Qubits



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



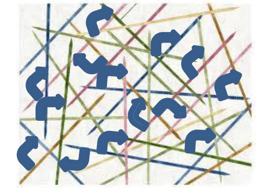




| $B_{(i+1)mod4} = B_i \boxed{(S_A + S_B)}$ | $M_{(i+1)mod4} = M_i \boxed{(S_A - S_B)}$ |
|---|---|
| $B_0 = \mathbf{A_0\ B_0\ Bell} = -\ \mathbf{S}_{00} + \mathbf{S}_{11} = \Phi^+$ | $M_0 = \mathbf{A_0\ B_0\ Magic} = +\ \mathbf{S}_{01} - \mathbf{S}_{10}$ |
| $B_1 = B_0\ \mathbf{Bell} = +\ \mathbf{S}_{01}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

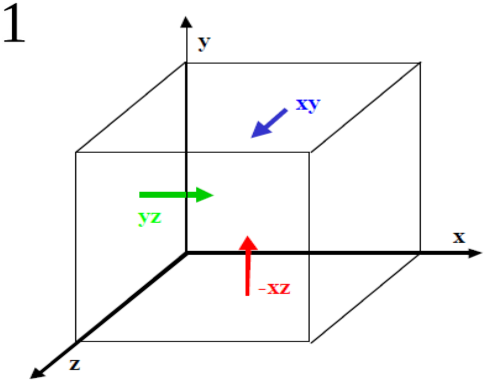
$$\Phi^{\pm} = |00\rangle \pm |11\rangle$$
$$\Psi^{\pm} = |01\rangle \pm |10\rangle$$

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

# 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)
```

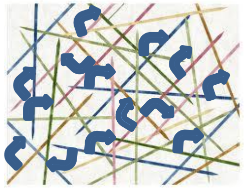
| * | $\mathcal{T}_i$ | $\mathcal{T}_j$ | $\mathcal{T}_k$ |
|---|---|---|---|
| $\mathcal{T}_i$ | 1 + **abcd** | –**ad** + **bc** | **ac** + **bd** |
| $\mathcal{T}_j$ | **ad** – **bc** | 1 + **abcd** | –**ab** + **cd** |
| $\mathcal{T}_k$ | –**ac** – **bd** | **ab** – **cd** | 1 + **abcd** |

| * | $\mathcal{T}_i$ | $\mathcal{T}_y$ | $\mathcal{T}_k$ |
|---|---|---|---|
| $\mathcal{T}_i$ | "–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** | $M_3 = -M_1$ | $M_0 = -M_2$ |
| **Magic** | $M_3 = -M_1$ | $M_2 = -M_0$ |
| **Magic** | $M_1 = -M_3$ | $M_0 = -M_2$ |
| **Magic** | $M_1 = -M_3$ | $M_2 = -M_0$ |

| $\mathcal{T}_i'$ | $\mathcal{T}_j'$ | $\mathcal{T}_k'$ |
|---|---|---|
| **Bell** | $B_2 = -B_0$ | $B_1 = -B_3$ |
| **Bell** | $B_2 = -B_0$ | $B_3 = -B_1$ |
| **Bell** | $B_0 = -B_2$ | $B_1 = -B_3$ |
| **Bell** | $B_0 = -B_2$ | $B_3 = -B_1$ |

# Higgs Bosons are Entangled



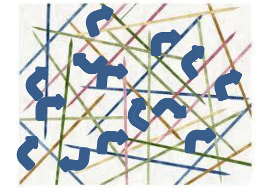
- The proposed Higgs Boson in $\mathbb{G}_4$:
  - $\mathcal{H} = \mathcal{T}_i + \mathcal{T}_j + \mathcal{T}_k$ (where $\mathcal{H}^2 = 0$)
  - Eight triples: $\pm\mathcal{T}_i \pm\mathcal{T}_j \pm\mathcal{T}_k$ (and 8 more for $\pm\mathcal{T}_i' \pm\mathcal{T}_j' \pm\mathcal{T}_k'$)
- Also various factorizations: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

    For X = $\mathcal{H}$ then $\mathbf{X\,abcd} = \mathbf{abcd\,X} = \pm\,\mathbf{X}$
  - $\mathcal{M} = \{\mathbf{X} = \pm\mathbf{ab} \pm\mathbf{ac} \pm\mathbf{bc} \pm\mathbf{ad} \pm\mathbf{bd} \pm\mathbf{cd} \mid \mathbf{X}^2 = \pm\mathbf{abcd}\}$ (48)

    For X = $\mathcal{M}$ then only $\mathbf{X\,abcd} = \mathbf{abcd\,X}$

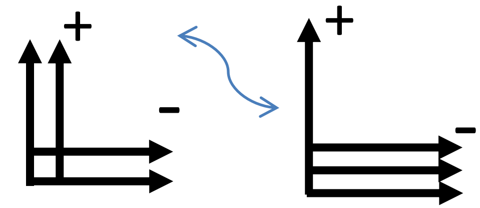
    sig ((4, 6, 6), 6) = 32 and sig ((0, 6, 10), 6) = 16

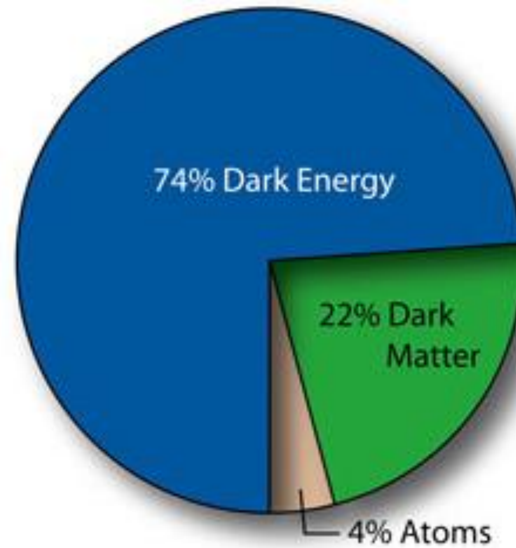
# Dark Bosons are also Entangled



(**wx+yz**)(**xyz**) = (–**x+wyz**) and also (**w+xyz**)(**wxy**) = (**wz+xy**)

| State Name | Entangled State | $\mathcal{D}_B$ = State * (wxy)† |
|---|---|---|
| Bell | + **wx** + **yz** | – **y** – **wxz** |
| B0 | – **wy** + **xz** | – **x** + **wyz** |
| B1 | + **wz** + **xy** | – **w** – **xyz** |
| B2 | + **wy** – **xz** | + **x** – **wyz** |
| B3 | – **wz** – **xy** | + **w** + **xyz** |
| | | |
| Magic | + **wx** – **yz** | – **y** + **wxz** |
| M0 | + **wz** – **xy** | + **w** – **xyz** |
| M1 | – **wy** – **xz** | – **x** – **wyz** |
| M2 | – **wz** + **xy** | – **w** + **xyz** |
| M3 | + **wy** + **xz** | + **x** + **wyz** |

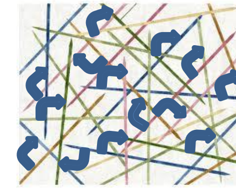



Quarks: ± **w** ± **xy**
Dark bosons: ± **w** ± **xyz**

† Results are dark bosons $\mathcal{D}_B$ where $(\mathcal{D}_B)^2 = 0$ and are entangled since $\mathcal{D}_B$ are not separable.

# Dark Matter is Entangled



- Define set $\mathcal{D}$ as sum of 4 dark bosons (count 256) :

$\mathcal{D} = \{(\pm\mathbf{w} \pm\mathbf{xyz}) + (\pm\mathbf{x} \pm\mathbf{wyz}) + (\pm\mathbf{y} \pm\mathbf{wxz}) + (\pm\mathbf{z} \pm\mathbf{wxy})\}$

where $\mathcal{D}$ is the largest *odd sub-algebra* of $\mathbb{G}_4$ and rotations $\{\mathbf{xyz}\,\mathcal{D}\} = \{-1 + \mathbf{wxyz} + \mathcal{H} \cup \mathcal{M}\}$

- The elements of $\mathcal{D}^2$ form three (four) subsets:

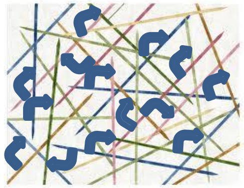
$\mathcal{D}_q = \{\mathcal{D} \in \mathrm{D} \mid \mathrm{D}^2 = \mathbf{xy} + \mathbf{xz} + \mathbf{yz}\}$ (count 128, sig ((2, 7, 7), 8), 6.87 bits)

$\mathcal{D}_0 = \{\mathcal{D} \in \mathrm{D} \mid \mathrm{D}^2 = 0\}$ (Bosons) (count 32, sig ((4, 4, 8), 8), 5.53 bits)

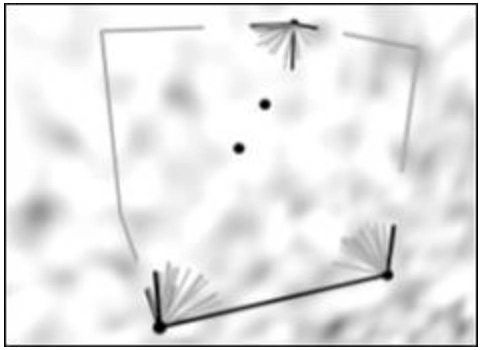
$\mathcal{D}_u = \{\mathcal{D} \in \mathrm{D} \mid \mathrm{D}^2 = (\mathbf{w} + \mathbf{x})(\mathbf{y} + \mathbf{z})\ \&\ \mathrm{D}^8 = 1$ (2 qubits) (count 96)

- $\mathcal{D}_u$ with (count 80, sig ((4, 4, 8), 8), 5.53 bits)
- $\mathcal{D}_u$ with (count 16, sig ((1, 1, 14), 8), 15.9 bits)

# Content Addressable Memory Math

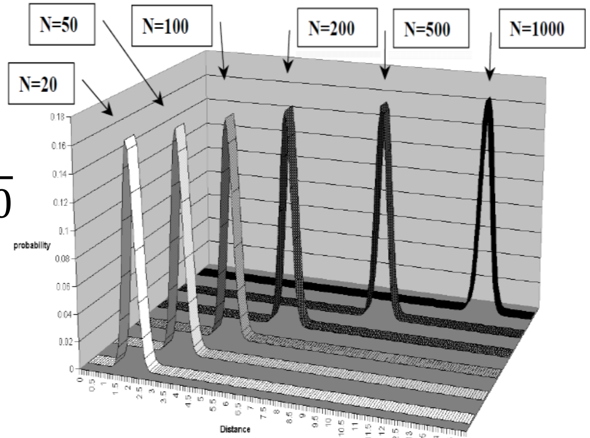


- Pick a random point P in a 3 dimensional space – easy
- Pick a random point P in a 100 dimensional space – hard
- Pick 2nd point Q in a each space – compute distance
- Pick many points X in a each space – compute distances
- Find the distances have an average value and std deviation

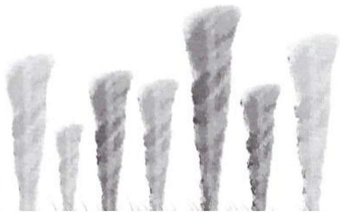


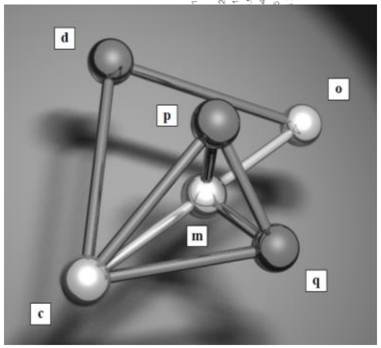
**Correlithms for dimensions N>20 and midpoint M: (unit cube)**

- Euclidean Distance PQ is $\sqrt{N/6}$ (standard distance)
- Standard dev of PQ is $\sqrt{7/120}$ (independent of N)
- Distance MP or MQ is $\sqrt{N/12}$ (standard radius) & $\sqrt{1/60}$
- For big N standard distance/radius are constants
  - Intrinsic normalization measure (similar to light year)
- Correlithms known as CAM/sparse distributed coding
  - related to cell phone CDMA and spread spectrum

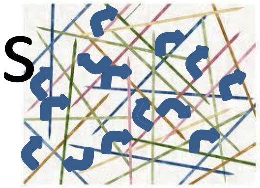



Mathematics for meaning:
the data (bits) are the address

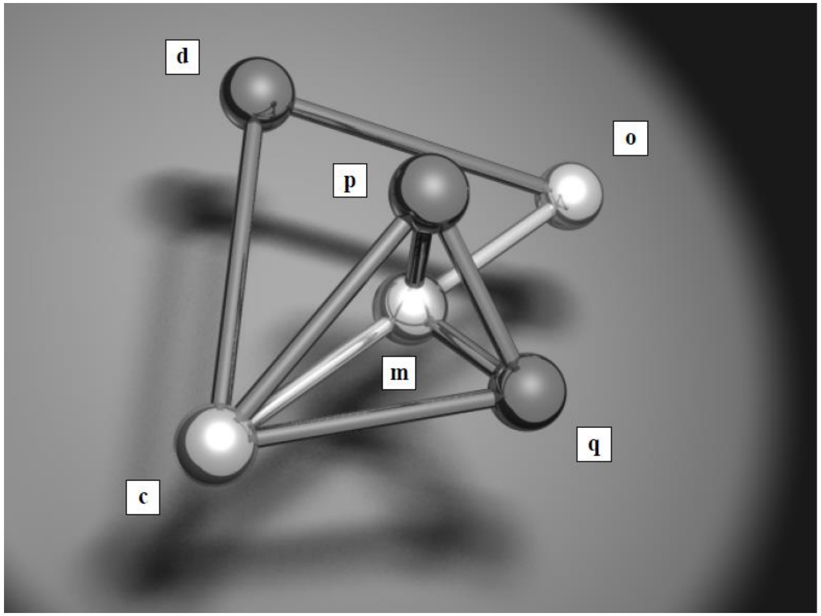




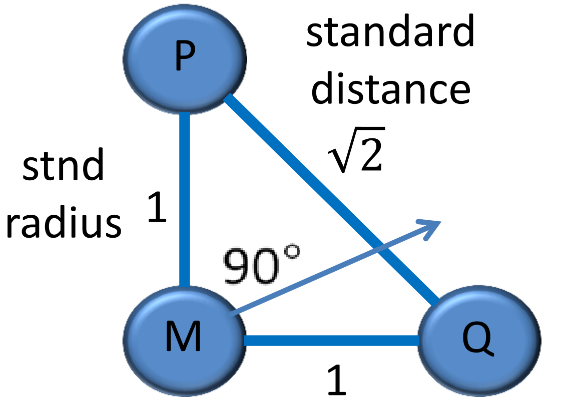
# Probabilistic geometries from randomness



| Lines | Raw Distance | Normalized Distance |
|---|---|---|
| MQ=MP | $\sqrt{N/12}$ (radius) | 1 |
| PQ | $\sqrt{N/6}$ (distance) | $\sqrt{2}$ |
| MC=MO | $\sqrt{N/4}$ | $\sqrt{3}$ |
| CP=CQ | $\sqrt{N/3}$ | $\sqrt{4}$ |
| DC=DO | $\sqrt{N/2}$ | $\sqrt{6}$ |
| CO | $\sqrt{N}$ | $\sqrt{12}$ |




M = middle
C = corner
O = opposite corner
D = random corner
P/Q = random points

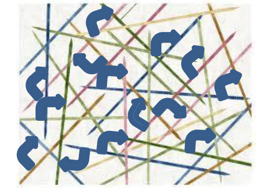



Superposition vector of states with phase angles

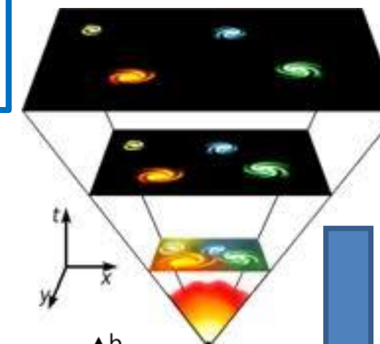
**12 dims is special since MP = 1**
**M = mid/null/void point**

Big thought vectors built from small vectors are orthogonal in hyperdimensional spaces. This is the mathematics of law of attraction.

# Summary: How to Bootstrap the universe

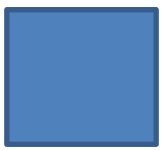


As spacelike bits coalesce in the bit matrix, they form qubits, bosons, particles, ebits, S/T based on the bit state likely hood



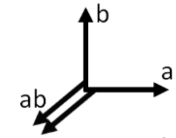
$\mathbb{G}_1$ Space like Bits ↑+ ↓− ↑+ ↓− ↑+ ↓− ↑+ ↓−

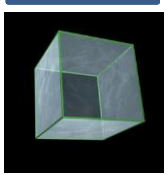
0.58 bits



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

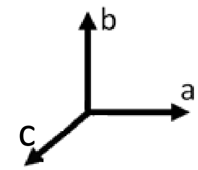
2.17 bits

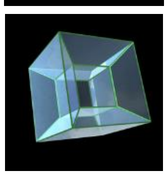


$\mathbb{G}_3$ Quaternions (Space), photons, mesons …

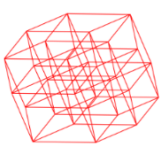
7.29 bits



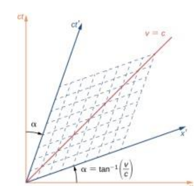



$\mathbb{G}_4$ Tauquernions, entanglement, Higgs, Dark M/E

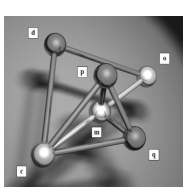
18.9 bits



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

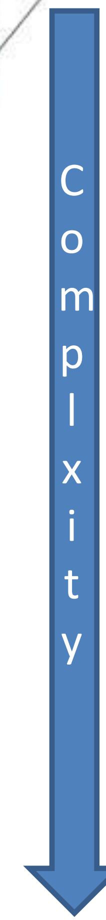


…

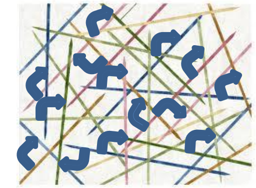


$\mathbb{G}_n$ Spacelike Correlithms, Thought

< Standard distance is information



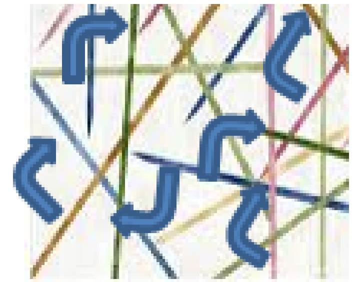
# More on Source Science & Bit-Physics

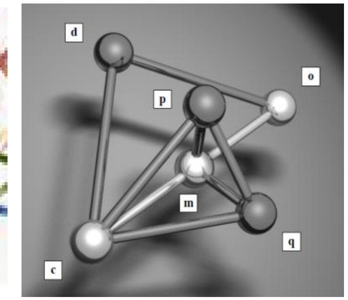


All my talks and papers are found at

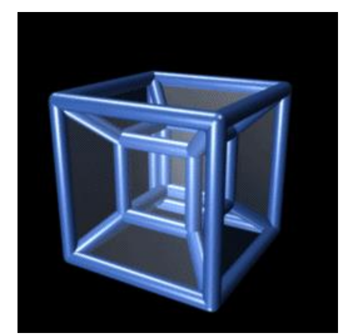
www.QuantumDoug.com

and www.DeepRealityBook.com







# End of Presentation

Questions and Answers