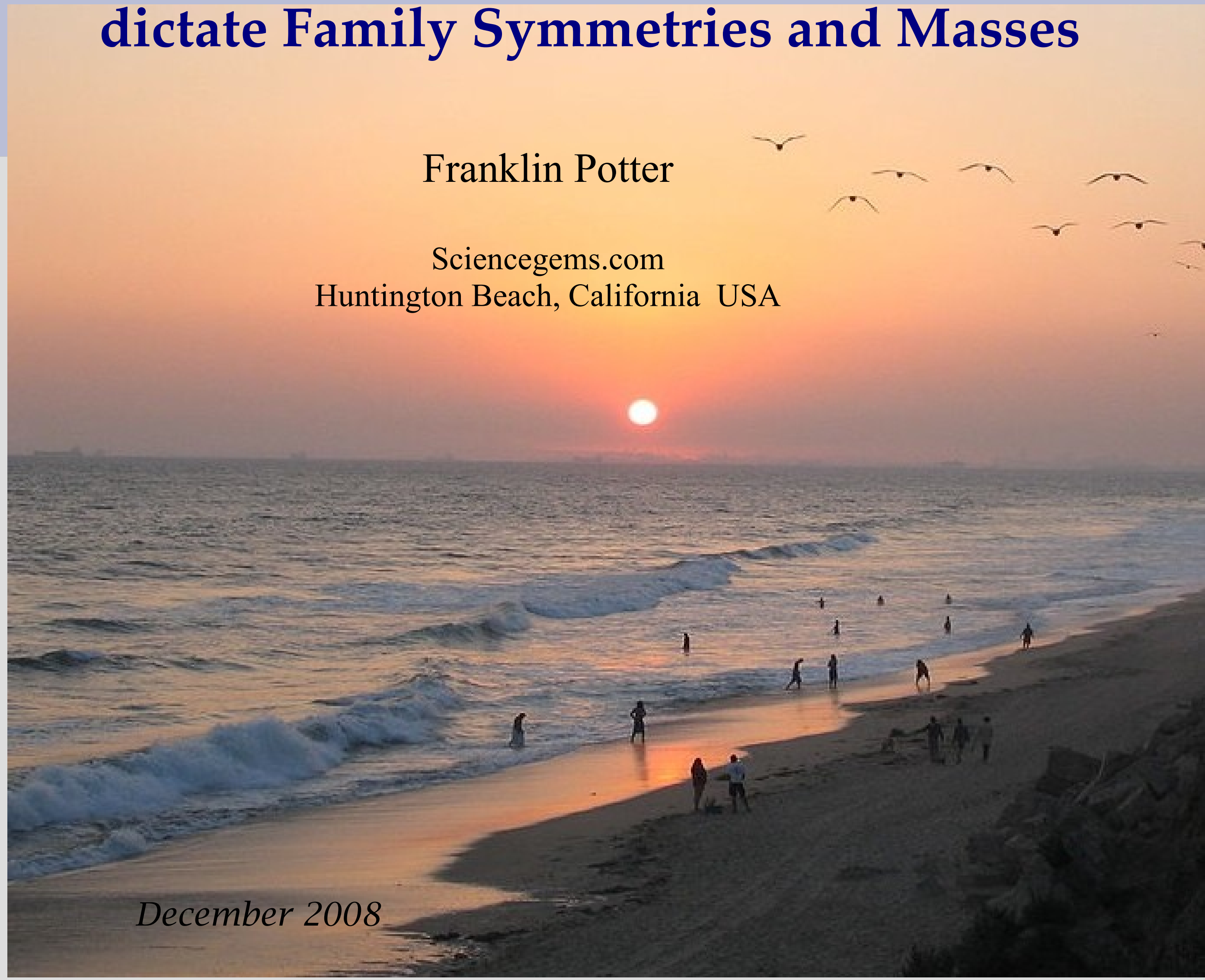
Discrete Rotational Subgroups of the Standard Model dictate Family Symmetries and Masses



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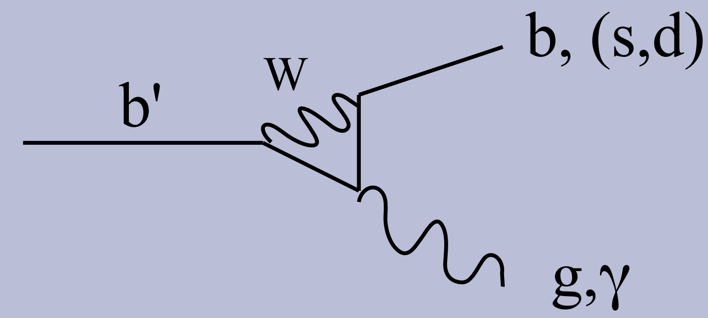
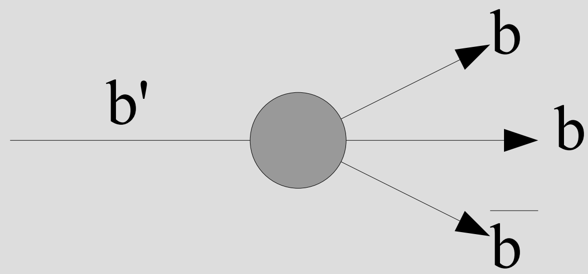
Finite Rotational Group Approach

from 1994 & 2006 F. Potter articles



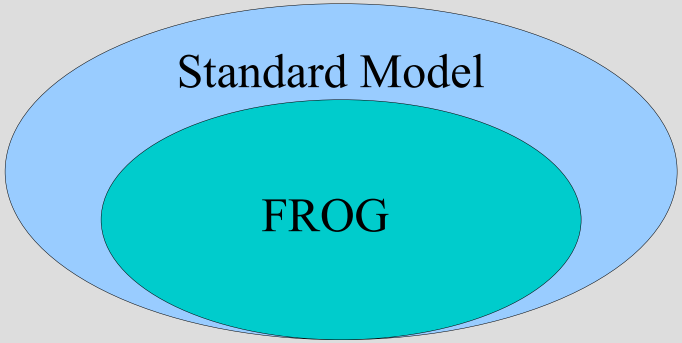
IF: b' quark detected in LHC @ ~ 80 GeV



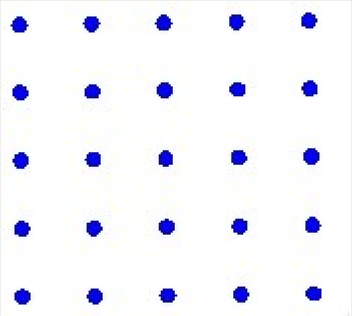
THEN:

t' quark @ ~ 2600 GeV

- Fits within realm of Standard Model which acts like a "cover"



Most likely the bigger picture is ...

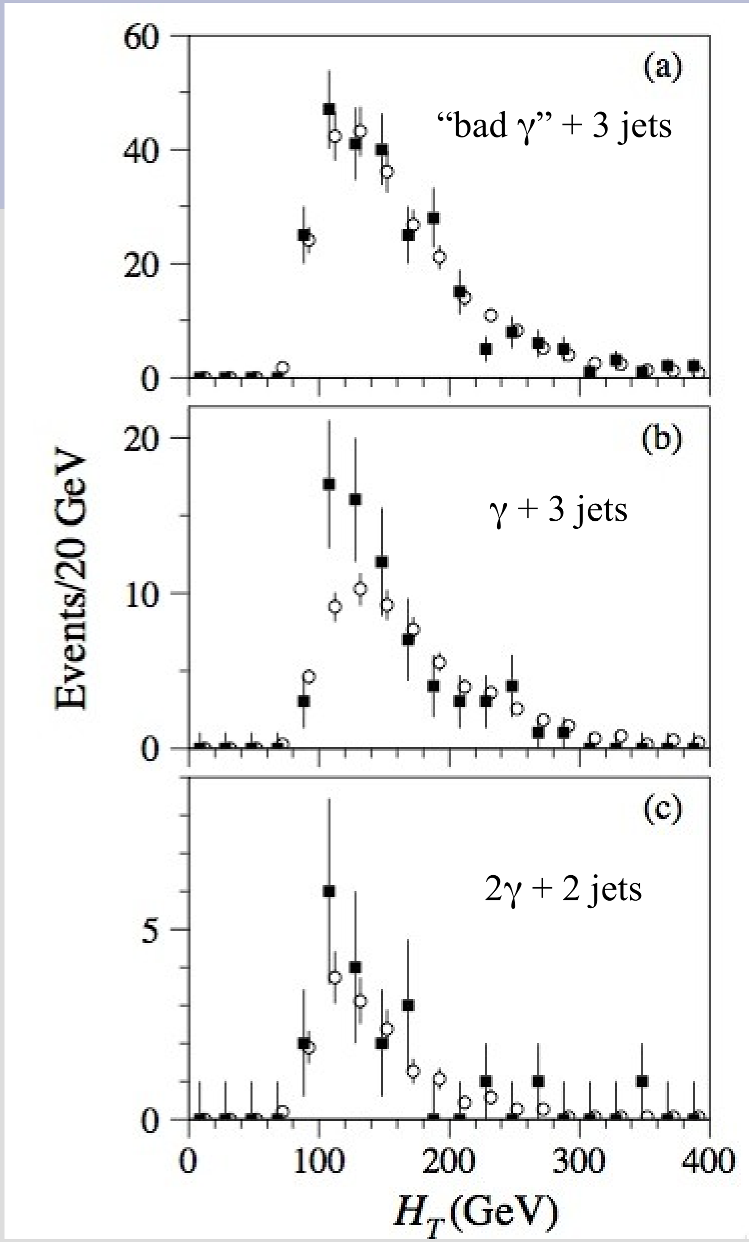


- Spacetime is discrete at Planck scale
- Discrete symmetries <u>dictate</u> fundamental physics
- "God had *no* choice in the creation of the world!"

1996 DØ Search for FCNC b' → b + γ and b' → b + gluon

hep-ex-9611021

Integrated luminosity is 93 pb^{-1}.

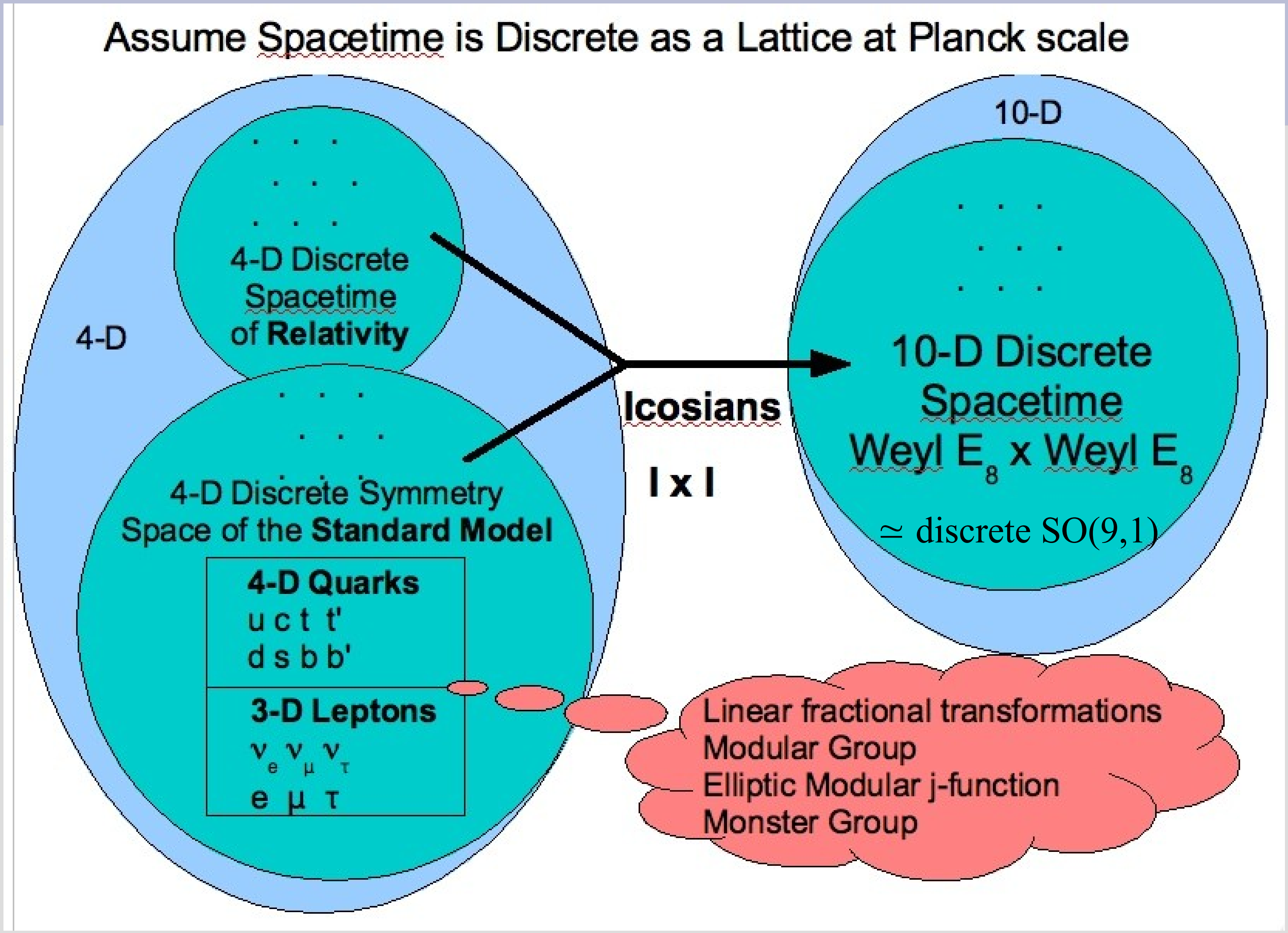


Conclusion:

"There is a slight, but not statistically significant, excess of data over background."

"... $H_T \geq 1.6\ m_{b'}$, where H_T is defined as the scalar sum of the transverse energies (E_T's) of the photons, jets, and any b-tagging muons in the event."

Overview


Assume Spacetime is Discrete as a Lattice at Planck scale
4-D
4-D Discrete Spacetime of Relativity
4-D Discrete Symmetry Space of the Standard Model
4-D Quarks
u c t t'
d s b b'
3-D Leptons
ν e ν μ ν τ
e μ τ
Icosians
I x I
10-D
10-D Discrete Spacetime
Weyl E8 x Weyl E8
≃ discrete SO(9,1)
Linear fractional transformations
Modular Group
Elliptic Modular j-function
Monster Group

Symmetry Breaking to Finite Rotation Groups

Flavor symmetry breaking → binary finite rotational subgroups of SU(2)

leptons in R^3: <3,3,2>, <4,3,2>, <5,3,2>

quarks in R^4: <3,3,3>, <4,3,3>, <3,4,3>, <5,3,3>

- 'Duplication' of families explained

EW symmetry breaking → finite rotational subgroup of $SU(2)_L \times U(1)_Y$

$\langle 5,3,2 \rangle_{normal} \times \langle 5,3,2 \rangle_{reciprocal}$

- No Higgs needed!

3 Lepton Families ⇔ 3-D binary polyhedral groups

Lepton states span R^3, a subspace of $R^4 \simeq C^2 \simeq Q$

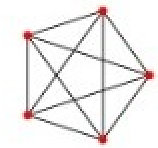
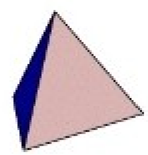
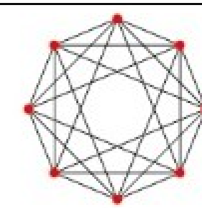
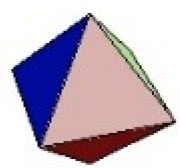
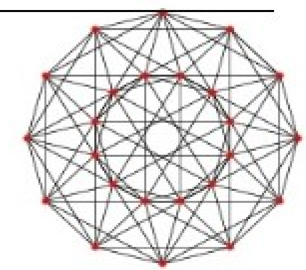
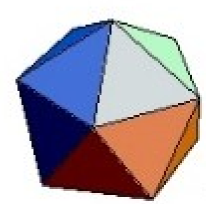
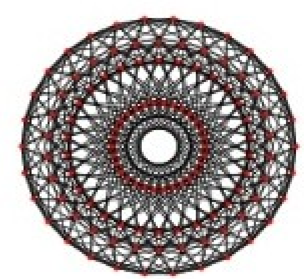
Group	Order	Flavor	Mass (MeV)	N
<3,3,2>	24	e	0.51	1
		ν_e	~0	
<4,3,2>	48	μ	105.7	108
		ν_μ	~0	
<5,3,2>	120	τ	1776	1728
		ν_τ	~0	

4 Quark Families ⇔ 4-D binary polytope groups

Quark states span R^4, a 'subspace' of $R^4 \simeq C^2 \simeq Q$

Group	Order	Flavor	Mass (GeV)	N	Prediction (GeV)	
<3,3,3>	120	u	0.004	¼?	0.38	
		d	0.007			0.011
<4,3,3>	384	c	1.5	1	1.5	
		s	0.2			0.046
<3,4,3>	1152	t	165	108	160	
		b	5			5
<5,3,3>	14400	t'	?	1728	2600	
		b'	?			80

Geometric Visions

Invariant	Leptons		3-D	Quarks		4-D
{1/4}				u d	<3,3,3>	
1	ν_e e	<3,3,2>		c s	<4,3,3>	
108	ν_μ μ	<4,3,2>		t b	<3,4,3>	
1728	ν_τ τ	<5,3,2>		t' b'	<5,3,3>	

Electroweak connections

$R^4 \simeq C^2 \simeq Q$: Work in unitary plane C^2 for EW flavor states

1) LH doublets from LH screw transformations
2) RH singlets from RH screw transformations
3) Clifford algebra: Normal unitary plane C^2 &

   Conjugate unitary plane C'^2
4) SU(2) x I: $\rightarrow$ *gauge* equivalence $\rightarrow$ mass positive for antiparticles

n.b. $U(1)_Y$ does same as I ?

Invariant FROG functions ...

$R^4 \simeq C^2 \simeq Q$: Work in unitary plane C^2 for EW flavor states

In polynomial basis:

Group	Invariant Ratio
<3, 3, 2>	$\frac{w_1}{w_2} = \frac{\left(z_1^4 - 2\, i \sqrt{3}\, z_1^2 z_2^2 + z_2^4\right)^3}{\left(z_1^4 + 2\, i \sqrt{3}\, z_1^2 z_2^2 + z_2^4\right)^3}$
<4, 3, 2>	$\frac{w_1}{w_2} = \frac{(z_1^8 + 14\, z_1^4 z_2^4 + z_2^8)^3}{108\, z_1^4 z_2^4 (z_1^4 - z_2^4)^4}$
<5, 3, 2>	$\frac{w_1}{w_2} = \frac{-\{(z_1^{20} + z_2^{20}) + 228\,(z_1^{15} z_2^5 - z_1^5 z_2^{15}) - 494\, z_1^{10} z_2^{10}\}^3}{1728\,\{z_1 z_2 (z_1^{10} + 11\, z_1^5 z_2^5 - z_2^{10})\}^5}$

- Each lepton group has 2 *independent* polynomials w_1 and w_2 in C^2
- Ratio w_1/w_2 invariant under all linear fractional transformations
- 1-to-1 mapping from z-sphere to w-sphere requires the N's
- N from syzygy among the 3 invariant polynomials for each group

j-invariant and mass ratios

see T. Gannon
http://arxiv.org/pdf/math/0109067v1

$$J(\tau) = \frac{1}{1728}\left[q^{-1} + \sum_{n=1}^{\infty} c(n)\, q^{n}\right]$$

$$f(\tau) = \frac{a\tau + b}{c\tau + d}$$

$f(\tau)$ a rational function of $J(\tau)$

F. Klein (1884) pointed out that

$$N\, w_1/w_2 = J(\tau),$$

$\tau \rightarrow \tau+1$ and $\tau \rightarrow -1/\tau$: $PSL(2,\mathbb{Z})$

the absolute invariant $J(\tau)$ of elliptic modular functions being expressed in terms of a modulus τ, the ratio of two periods on the lattice. Define $q = \exp(2\pi i\tau)$, with the c(n) all integers related to the Monster group!

1) $J(\tau)$ has a simple pole at $q = 0 \rightarrow$ Cauchy residue theorem, etc.
2) N ratios $\Rightarrow$ Mass ratios
3) Mass is invariant under linear fractional transformations
4) Quark N values same because groups are related in C^2

Quark Color possibility ...

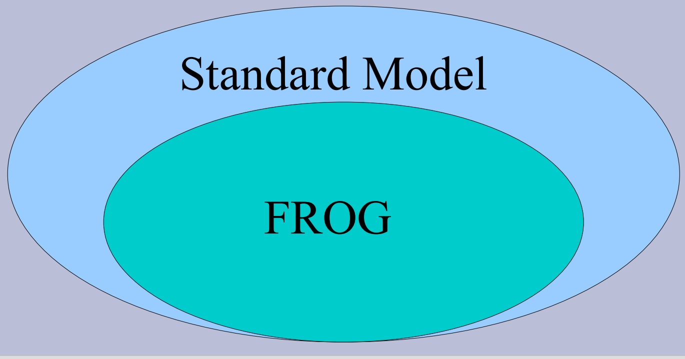
$R^4 \simeq C^2 \simeq Q$: Work in R^4 for color states

- Rotations in R^4 occur simultaneously in 2 orthogonal planes
- 3 pairs: red = [wx, yz], green = [xy, zw], blue = [yw, xz]
- Red quark state:

$$\begin{pmatrix} \begin{pmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{pmatrix} & \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \\ \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} & \begin{pmatrix} \cos\beta & \sin\beta \\ -\sin\beta & \cos\beta \end{pmatrix} \end{pmatrix}$$

- 8 special rotations = 8 gluons [agrees with SU(3) gens.]
- Exact color symmetry
- no-rotation combinations = hadrons, i.e., qqq,qq-bar,3q-bar
- should be discrete rotations at Planck scale

Lepton & Quark Quick Review



1) Lepton & Quark subgroups of SU'(2) = SU(2) x I
2) Finite binary rotational groups in 3-D and 4-D
3) 3 lepton families & 4 quark families
4) LH doublets & RH singlets for weak interaction
5) Odd parity particles in C^2; Even parity antiparticles in C'^2
6) Triangle anomalies? Only applies for point particles?
7) All the math handled by unit quaternions $q = w+xi+yj+zk$
8) Leptons in (i,j,k) [with w for *time* coordinate?]
9) Quarks 4-D → non-existence in 3+1 spacetime →confinement
10) Quarks must combine 2-fold or 3-fold to make 3-D hadrons

Some interesting consequences ...

- Particle – antiparticle asymmetry due to CP violation via CKM4
  because >10^{13} increase in Jarlskog imvariant
  (see W.-S. Hou http://arxiv.org/pdf/0810.3396v2)
- Muon g – 2 theoretical value approaches measured value?
- Reason for more than the 1st family of leptons & quarks
- Fundamental mathematics dictates fundamental physics
- Eliminates 'nesting' of more levels within levels
  because lepton and quark properties 'emerge' from
  discrete space lattice which has no measurable property

Assumptions for unification:

- Internal symmetry space is discrete and 4-D (consider Riemann sphere)
- Spacetime is discrete and 4-D as 3 + 1 (see Penrose's 'heavenly' sphere)
- Operations in the two spaces are independent even though they are 'carved' from the same discrete space
- Finite rotation groups required for both
- ...

$\langle 5,3,2\rangle_{\text{normal}} \text{ x } \langle 5,3,2\rangle_{\text{reciprocal}} \Rightarrow$ (240 special quaternions → icosians)

Telescoping from 4-D to 8-D space with icosians

Icosians have the form

$$q_i = (e_1 + e_2\sqrt{5}) + (e_3 + e_4\sqrt{5})i + (e_5 + e_6\sqrt{5})j + (e_7 + e_8\sqrt{5})k$$

where the e_j are special rational numbers so that the 120 icosians are permutations of

$$(\pm 1,0,0,0),\ (\pm 1/2,\pm 1/2,\pm 1/2,\pm 1/2),\ (0,\pm 1/2,\pm g/2,\pm G/2)$$

with $g = G^{-1} = G-1 = (-1+\sqrt{5})/2$.

n.b. in each pair only one of e_j is nonzero ⇒ really 4-D

Telescoping from 4-D to 8-D space with icosians

- 240 icosians/octonions make E_8 lattice in R^8 - from discrete SM
- 240 icosians/octonions make E_8 lattice in R^8 - from Lorentz 'boost'
- Weyl E_8 – the finite group of discrete symmetries of E_8 lattice

  leads to: Weyl E_8 x Weyl E_8 = "Weyl" SO(9,1)

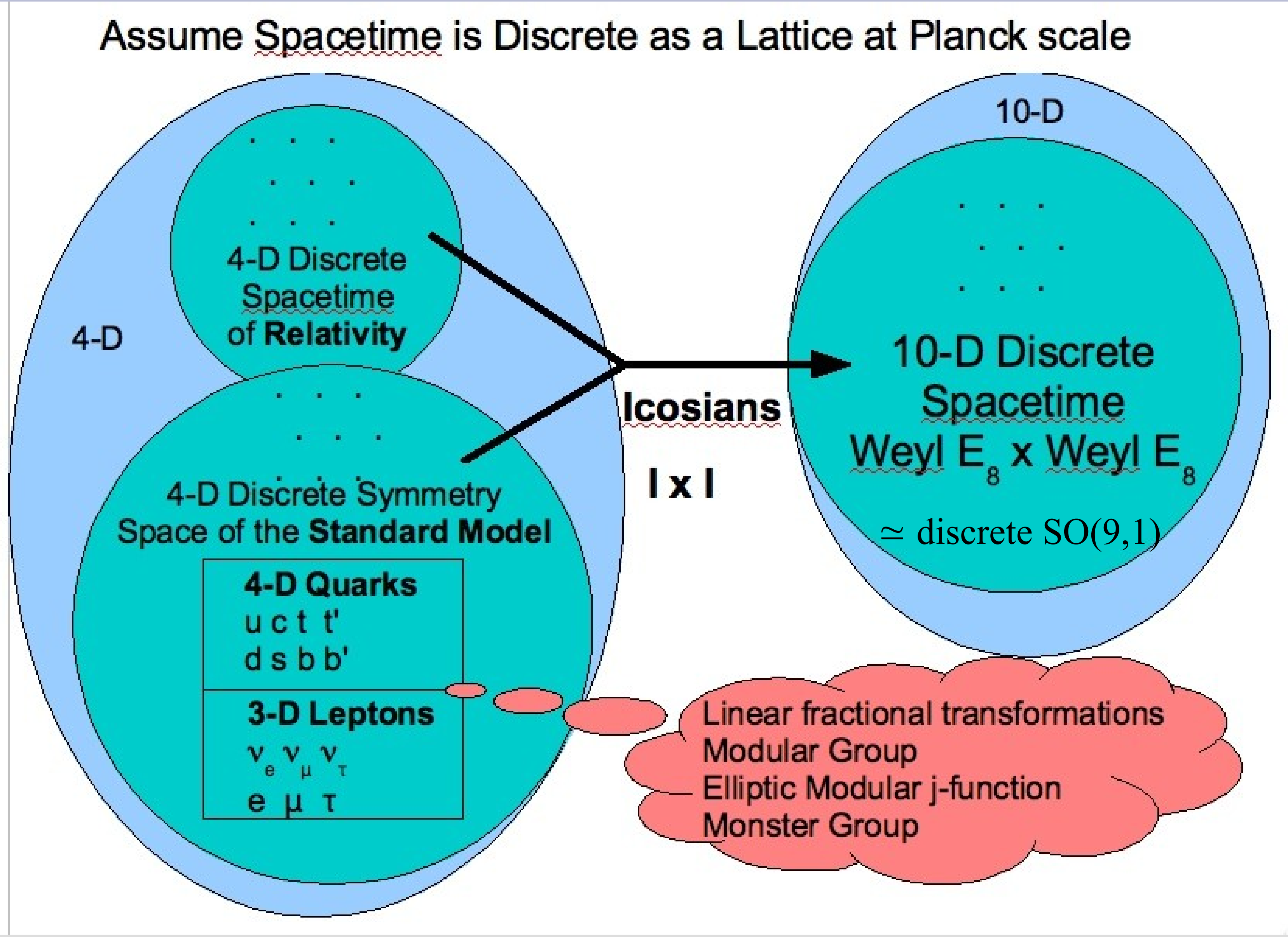
The Surprise: 10-D *discrete* spacetime breaks down into

4-D *discrete* spacetime + 4-D *discrete* internal symmetry space!

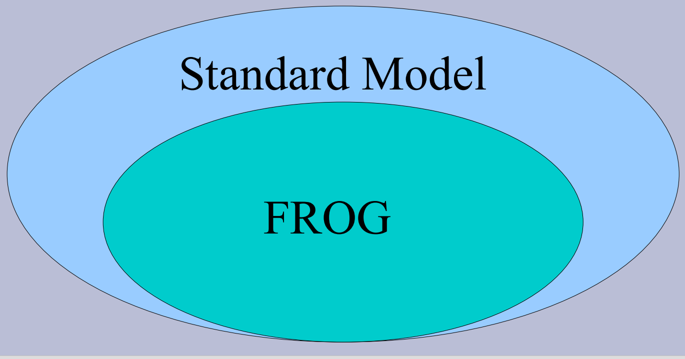
Unique connection !

In 4-D: PSL(2,C) = SO(3,1) In 8-D: PSL(2,O) = SO(9,1)

Overview again:



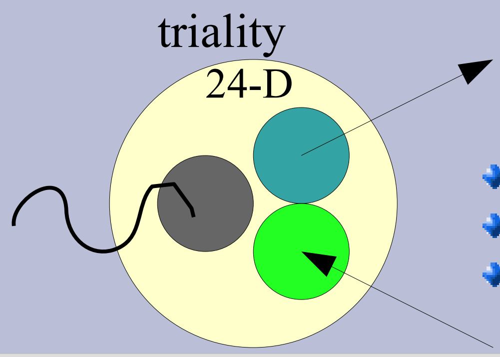
Summary



- Standard Model “covers” finite rotation groups really well
- Symmetry breaking to finite groups
- Leptons & Quarks in 3-D & 4-D subspaces
- Quark confinement →hadron combinations for 3-D
- Mass ratios related to j-invariant of modular functions
- Implies discrete spacetime at Planck scale
- Unique 4-D → 8-D via icosians
- Weyl E_8 x Weyl E_8 ≅ discrete SO(9,1)
- Emergent physical properties – no more nesting!
- Possible explanation for particle-antiparticle asymmetry, muon g-2

Where is the b' quark?

Gracias, Valencia!



- 24-D Leech
- Monster
- QM codes

- 1994 article:
  "**Geometrical Basis for the Standard Model**"
  International Journal of Theoretical Physics, Vol. 33 (1994), pp. 279-305,

online: http://www.sciencegems.com/gbsm.html

- 2006 article:
  "**Unification of Interactions in Discrete Spacetime**"

online: http://www.ptep-online.com/index_files/2006/PP-04-01.PDF

- DISCRETE '08 presentation slides online:

  http://www.sciencegems.com/DISCRETE08.PDF