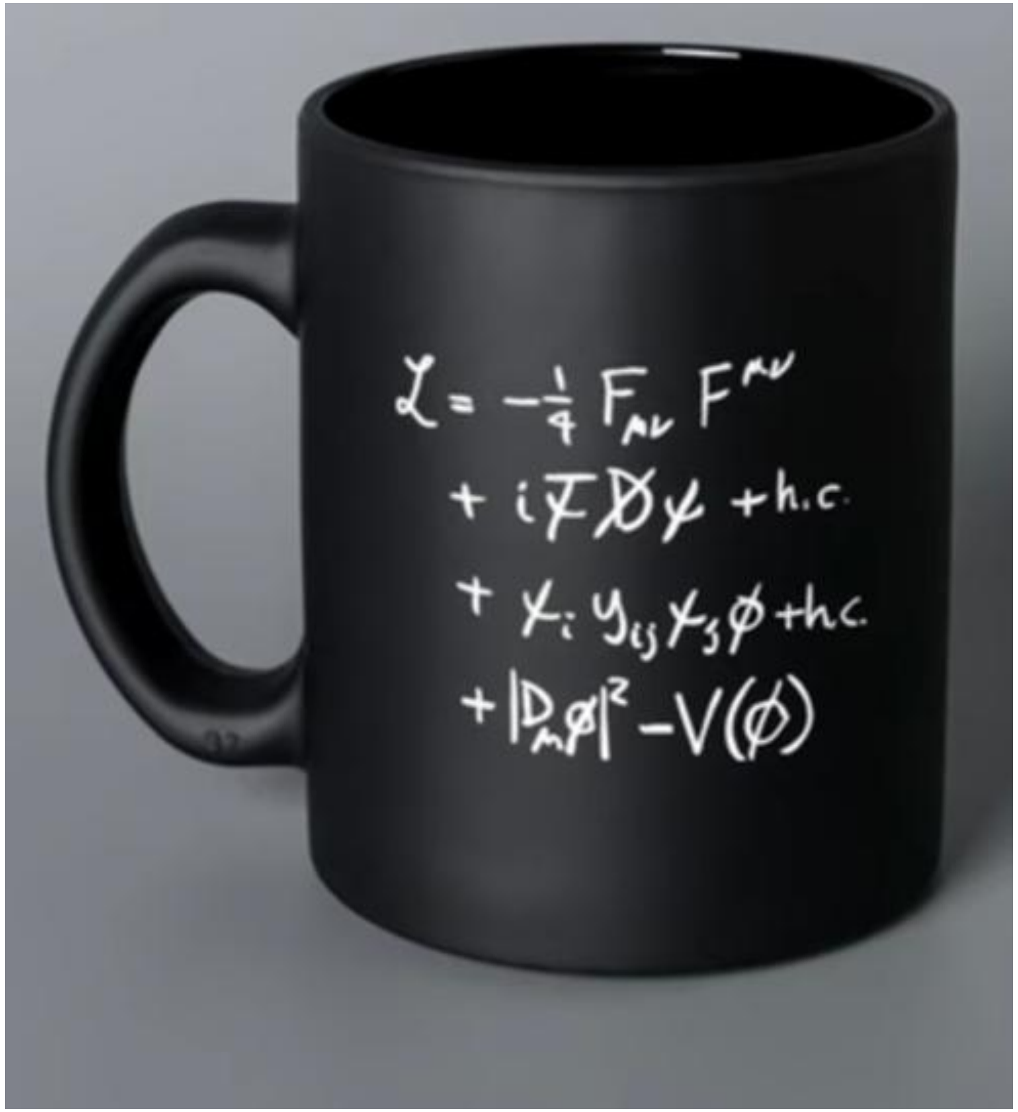
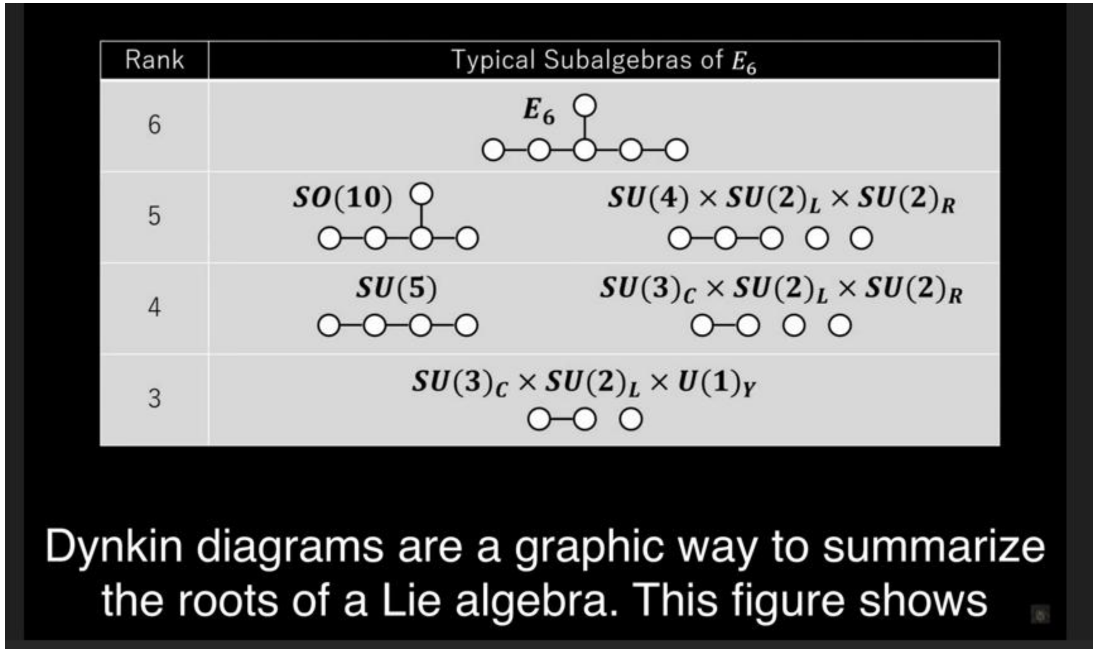
STANDARD MODEL
-beyond and aside-

Djordje Šijački



…beyond…



- g-2

- Fermilab, Chicago, USA
- 150 people from 40 institutions in 7 countries
- Studies spinning muons

- LHCb

- CERN, Switzerland/France
- 1260 people from 74 scientific institutes in 16 countries
- Has seen a deficiency of muons

Simetrije u fizici EČ i KTP

KM Poincare sim. Wigner* 1939.

Lorentz sim Dirac* 1928.

SU(2) Izospin sim. Heisenberg 1930.

SU(3) sim Gell-Mann 1961.
Ne'eman*

, SU(4)
: SU(6) Weinberg - Salam 1967. ...

Standard Model sim

$SU(3)_C \otimes SU(2)_L \times U(1)$ Fritzsch - Gell-Mann-Leutwyler 1973.

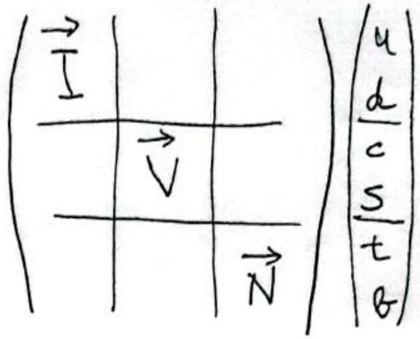
GUT

⋮

$SU(6)_F$ simetrija hadrona (kvarkova)

$SU(2)$, $SU(3)$, $SU(4)$, $SU(5)$

$\{u, d; c, s; t, b\}$



SU(6) Flavor symmetry

$SU(2)$ I – spin
$SU(2)$ V – spin
$SU(2)$ N – spin

} tri generacije kvarkova

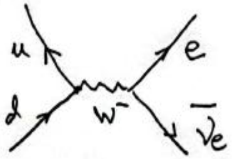
Prirode $SU(6)_F$?

(1)

× Narušena simetrija
× jakih interakcija

(2)

Slabe interakcije povezuju kvarkove ALI i leptone



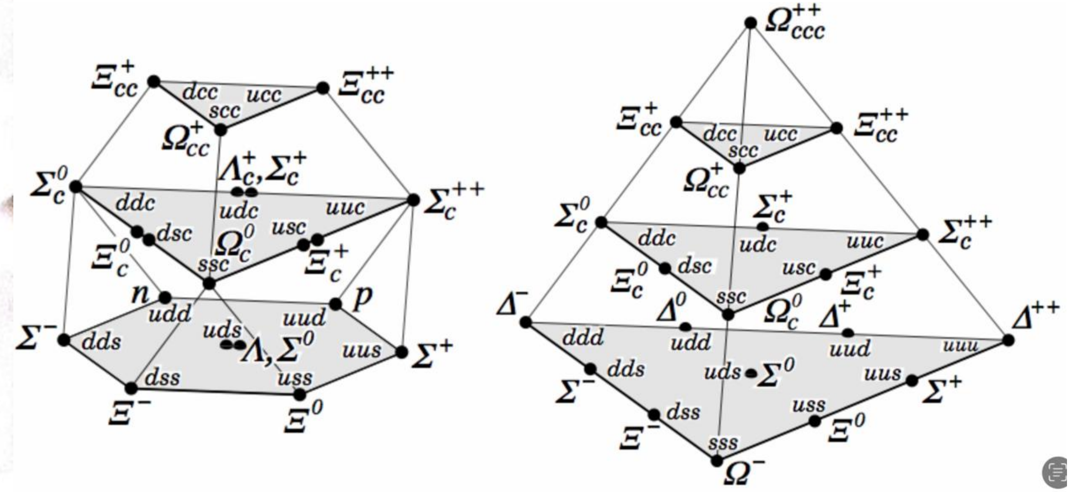
(3)

Fenomenološka pravila slabih interakcije $\Delta I = \frac{1}{2}$, $\Delta Q = \Delta S = 1$ ...

(4)

$\Rightarrow SU(6)_F$ sim. leptona !

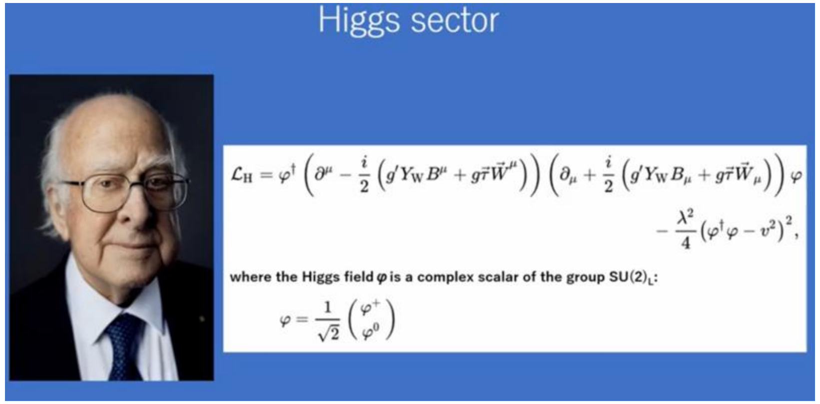
$$\begin{pmatrix} \nu_e \\ e \\ \hline \nu_\mu \\ \mu \\ \hline \nu_\tau \\ \tau \end{pmatrix}$$

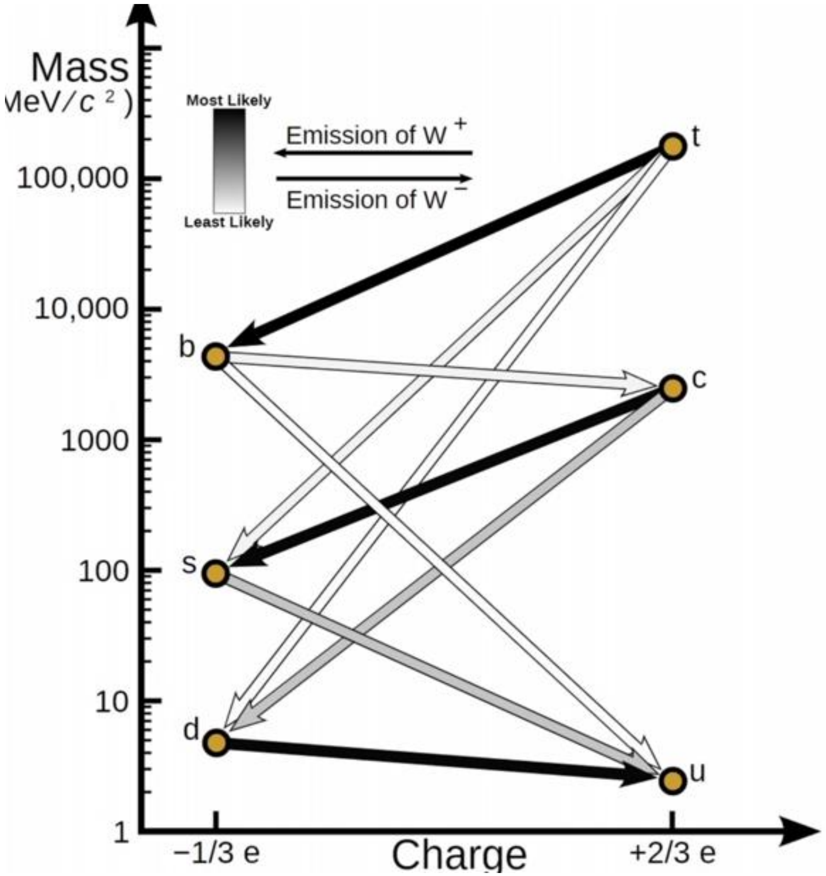


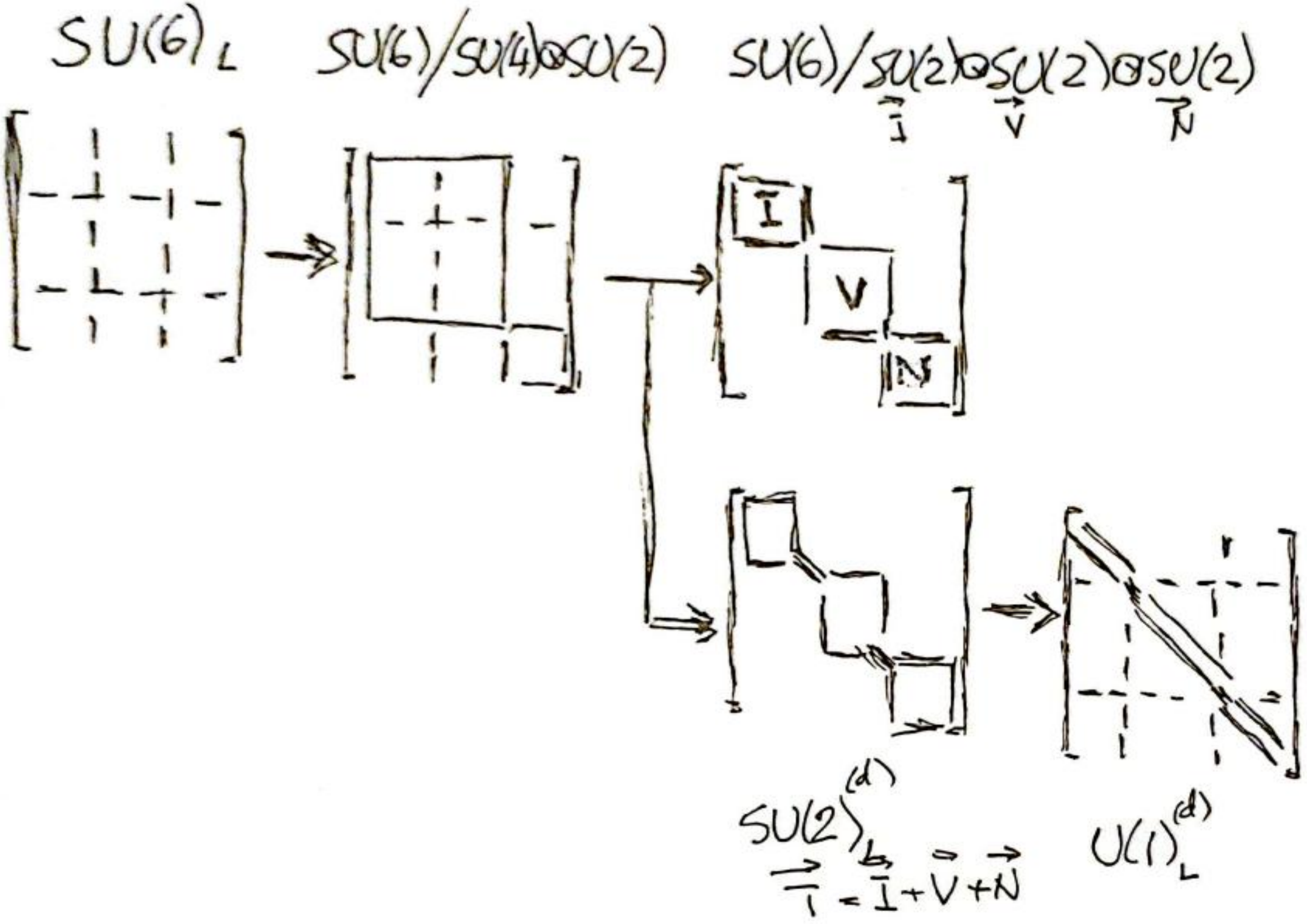
standardni model SM

struktura

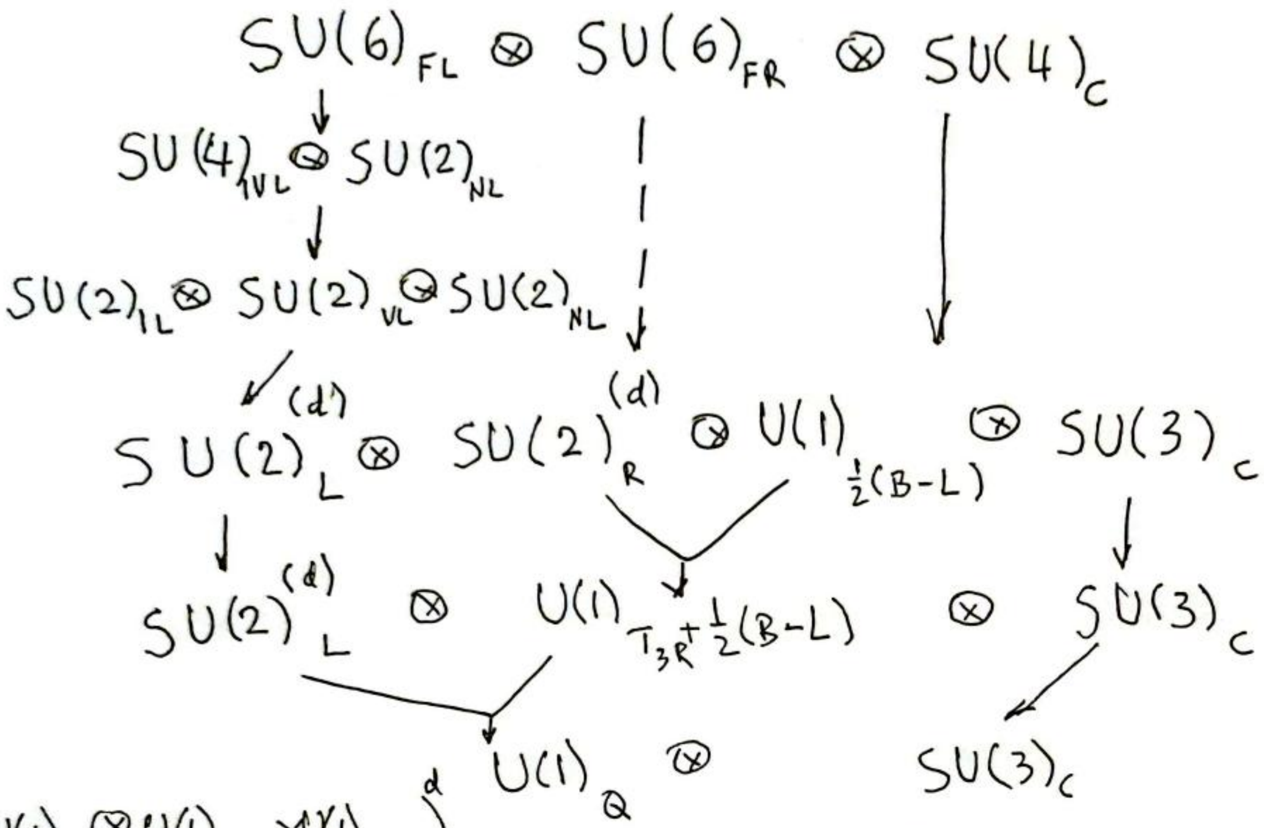
- Globalna simetrija: $SU(3)_C \times \underbrace{SU(2)_L \times U(1)_Y}_{\downarrow \; U(1)_Q}$
  → W^+, W^-, Z^0, A
- Fermioni: $\left[\begin{pmatrix} u \\ d \end{pmatrix} \begin{pmatrix} c \\ s \end{pmatrix} \begin{pmatrix} t \\ b \end{pmatrix}\right] \times 3$
  L: $\begin{pmatrix} \nu_e \\ e \end{pmatrix} \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix} \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}$
  R $(u)_R, \dots \; (e_R) \dots$
- Higgsovo polje $\begin{pmatrix} \varphi^+ \\ \varphi^0 \end{pmatrix}$
  → narušava dilatacionu sim.
- Mešanje fermiona
  - Cabibbo – Kobayashi – Maskawa
  - oscilacije neutrina
- Spontano narušenje simetrije
  ~~D~~ $SU(2)_T \otimes U(1)_Y \to U(1)_Q$ (d)
  $U(1)_Q = \left(U(1)_{T_3} \times U(1)_Y\right)$
  $\vec{T} \equiv \vec{I} + \vec{V} + \vec{X}$
  $Q = T_{3L} + T_{3R} + \frac{1}{2}(B-L)$







SU(6)_L
SU(6)/SU(4)⊗SU(2)
SU(6)/SU(2)⊗SU(2)⊗SU(2)
I V N
I
V
N
SU(2)^(d)_L
T = I + V + N
U(1)^(d)_L



$$U(1)_Q = \left(U(1)_{I_3L} \otimes U(1)_{T_3R} \times U(1)_{\frac{1}{2}(B-L)}\right)^d$$

$$Q = T_{3L} + \underbrace{T_{3R} + \frac{1}{2}(B-L)}_{\frac{1}{2}Y_W}$$

$$\vec{T} = \vec{I} + \vec{V} + \vec{N}$$

SU(6/4) PATTERN

AZ_1	W_1^+	Z_2	W_2^+	Z_3	W_3^+	u_R	u_G	u_B	ν_e
W_1^-	AZ_1	W_2^-	Z_2	W_3^-	Z_3	d_R	d_G	d_B	e
Z_3	W_3^+	AZ_1	W_1^+	Z_2	W_2^+	c_R	c_G	c_B	ν_μ
W_3^-	Z_3	W_1^-	AZ_1	W_2^-	Z_2	s_R	s_G	s_B	μ
Z_2	W_2^+	Z_3	W_3^+	AZ_1	W_1^+	t_R	t_G	t_B	ν_τ
W_2^-	Z_2	W_3^-	Z_3	W_1^-	AZ_1	b_R	b_G	b_B	τ
$\bar{u}_R$	$\bar{d}_R$	$\bar{c}_R$	$\bar{s}_R$	$\bar{t}_R$	$\bar{b}_R$	$AG_{R\bar{R}}$	$G_{R\bar{G}}$	$G_{R\bar{B}}$	X_1
$\bar{u}_G$	$\bar{d}_G$	$\bar{c}_G$	$\bar{s}_G$	$\bar{t}_G$	$\bar{b}_G$	$G_{G\bar{R}}$	$AG_{G\bar{G}}$	$G_{G\bar{B}}$	X_2
$\bar{u}_B$	$\bar{d}_B$	$\bar{c}_B$	$\bar{s}_B$	$\bar{t}_B$	$\bar{b}_B$	$G_{B\bar{R}}$	$G_{B\bar{G}}$	$AG_{B\bar{B}}$	X_3
$\bar{\nu}_e$	e^+	$\bar{\nu}_\mu$	μ^+	$\bar{\nu}_\tau$	τ^+	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	A

$$SU(6)_F / SU(2)^{(d)}$$

$$SU(2)^d = (SU(2)_I \otimes SU(2)_V \otimes SU(2)_N)^{(d)}$$

Phys. Bull., Vol. 32, 1981. Printed in Great Britain

IS THE END IN SIGHT FOR THEORETICAL PHYSICS?

S W Hawking

In this article I want to discuss the possibility that the goal of theoretical physics might be achieved in the not too distant future, say, by the end of the century. By this I mean that we might have a complete, consistent and unified theory of the physical interactions which would describe all possible observations. Although we have

…lues of the parameters …itrary but that they are picked out very care- …e example, if the pro- difference were not …s of the electron, one … couple of hundred or …hat make up the ele- …asis of chemistry and

given kind from being in any … matter particles are divided … groups, the hadrons, which are co… quarks, and the leptons, which co… remainder.

The interactions are divid… omenologically into four cate… order of strength they are: the s… lear forces which interact only…