The Spin-Charge-Family theory offers the explanation for all the assumptions of the Standard model, for the Dark matter, for the Matter-antimatter asymmetry, for... , making several predictions

Norma Susana Mankoč Borštnik, University of Ljubljana, FMF

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More than **40 years ago** the **standard model** offered an **elegant new step** in understanding the origin of fermions and bosons. It postulated:

- The existence of the **massless family members**: **coloured quarks and colourless leptons**, **both left and right handed**, the **left handed members** distinguishing from the **right handed ones** in the **weak** and **hyper charges** and correspondingly **mass protected**.
- The existence of **massless families to each of a family member.**

- The existence of the **massless** **gauge fields** to the observed **charges** of the family **members**.
- The existence of a massive **scalar field** carrying the weak charge $\pm\frac{1}{2}$ and the hyper charge $\mp\frac{1}{2}$ with "nonzero vacuum expectation values", breaking the weak and the hyper charge and correspondingly breaking the **mass protection**.

Gauge fields before the electroweak break

- **Three massless vector fields**, **the gauge fields of the three charges**.

name	hand-edness	weak charge	hyper charge	colour charge	elm charge
hyper photon	0	0	0	colourless	0
weak bosons	0	**triplet**	0	colourless	**triplet**
gluons	0	0	0	**colour octet**	0

They all are vectors in $d = (3 + 1)$, in the adjoint representations with respect to the weak, colour and hyper charges.

- **The existence** of the **Yukawa couplings**

$$\mathbf{Y}^{\alpha} \frac{\mathbf{v}}{\sqrt{2}},$$

which, together (with the **gluons** and) the **scalar Higgs** - after it breaks the weak and the hyper charge by gaining nonzero vacuum expectation values - take care of the masses of **fermions** and of the **weak bosons**.

- **The Higgs field**, **the scalar** **in** $d = (3+1)$, **a doublet with respect to the weak charge**. $P_R = (-1)^{2s+3B+L} = 1$.

name	hand-edness	weak charge	hyper charge	colour charge	elm charge
$0 \cdot$ **Higgs**$_u$	0	$\frac{1}{2}$	$\frac{1}{2}$	**colourless**	**1**
$< Higgs_d >$	0	$-\frac{1}{2}$	$\frac{1}{2}$	**colourless**	**0**

name	hand-edness	weak charge	hyper charge	colour charge	elm charge
$< Higgs_u >$	0	$\frac{1}{2}$	$-\frac{1}{2}$	**colourless**	**0**
$0 \cdot$ **Higgs**$_d$	0	$-\frac{1}{2}$	$-\frac{1}{2}$	**colourless**	-1

α name	hand- edness $-4iS^{03}S^{12}$	weak charge τ^{13}	hyper charge Y	colour charge	elm charge Q
u_L^i	-1	$\frac{1}{2}$	$\frac{1}{6}$	colour triplet	$\frac{2}{3}$
d_L^i	-1	$-\frac{1}{2}$	$\frac{1}{6}$	colour triplet	$-\frac{1}{3}$
ν_L^i	-1	$\frac{1}{2}$	$-\frac{1}{2}$	colourless	0
e_L^i	-1	$-\frac{1}{2}$	$-\frac{1}{2}$	colourless	-1
u_R^i	1	weakless	$\frac{2}{3}$	colour triplet	$\frac{2}{3}$
d_R^i	1	weakless	$-\frac{1}{3}$	colour triplet	$-\frac{1}{3}$
ν_R^i	1	weakless	0	colourless	0
e_R^i	1	weakless	-1	colourless	-1

Members of each of the $i = 1, 2, 3$ massless families before the electroweak break. Each family contains the left handed weak charged quarks and the right handed weak chargeless quarks, belonging to the colour triplet $(1/2, 1/(2\sqrt{3}))$, $(-1/2, 1/(2\sqrt{3}))$, $(0, -1/(\sqrt{3}))$.

The *standard model* assumptions have been confirmed without offering surprizes.

The last unobserved field, the Higgs scalar, detected in June 2012, was confirmed in March 2013.

What questions should one ask to see the next step beyond the standard model?

- Where do families originate? Why there exist families at all? How many families are there?
- Why there are left and right handed family members, distinguishing so much in charges?
  Why family members – quarks and leptons – manifest so different properties if they all start as massless?
- How is the origin of the scalar field (the Higgs) and the Yukawa couplings connected with the origin of families?
- How many scalar fields determine properties of the so far (and others possibly be) observed fermions and masses of weak bosons?

- **Why is the Higgs scalar, or are all the scalar fields, if there are several, doublets with respect to the weak and the hyper charge?**
- **Are there also scalar fields with the colour charge in the fundamental representation and where, if they are, they manifest?**
- **Where** does the **dark matter originate?**
- **Where** does the **dark energy originate and why is it so small?**
- **Where** does the **"ordinary" matter-antimatter asymmetry originate?**
- Where do the **charges and correspondingly the so far (and others possibly be) observed gauge fields originate?**

- What is the dimension of space? $(3+1)$?, $((d-1)+1)$?
- **What** is the role of the **symmetries**– discrete, continuous, global and gauge – in Nature?
- And others.

My statement:

- **An elegant trustworthy step beyond the standard model must offer answers to several open questions, explaining:**
  o The origin of charges.
  o The origin of families and their properties.
  o The origin of scalar fields and their properties.
  o The origin of vector gauge fields and their properties.
  o The origin of dark matter.
  o The origin of "ordinary" matter-antimatter asymmetry.
- **There exist not yet observed families, gauge fields, scalar fields.**
- **Dimension of space is larger than 4** (very probably infinite).
- **Inventing a next step which covers only one of the open questions, can hardly be the right step.**

In the literature NO explanation for the existence of the families can be found, which would not just assume the family groups. Several extensions of the standard model are, however, proposed, like:

- **A tiny extension: The inclusion of the right handed neutrinos into the family.**
- **The $SU(3)$ group is assumed to describe – not explain – the existence of three families.**
  Like the Higgs scalar charges are in the fundamental representations of the groups, alsoYukawas are assumed to be scalar fields, in the fundamental representation of the $SU(3)$ group.

- **SU(5) and SU(10) grand unified theories are proposed, unifying all the charges.** But the **spin** (the handedness) **is** obviously connected with the (weak and the hyper) charges.
- **Supersymmetric theories, assuming the existence of bosons with the charges of quarks and leptons and fermions with the charges of the gauge vector fields, although having several nice properties, are not, to my understanding, the right next step beyond the** *standard model*.

The **Spin-Charge-Family theory does offer the explanation for the assumptions of the standard model and answers the above cited open questions!**

- A brief introduction into the **spin-charge-family theory**.

- **Spinors carry in $d \geq (13+1)$ TWO kinds of SPIN, no charges**.

  o The **Dirac spin (γ^a) in $d = (13+1)$ describes in $d = (3+1)$ the spin and ALL the charges of quarks and leptons, left and right handed**.

  o The **second kind of the spin $(\tilde{\gamma}^a)$ describes FAMILIES**.

  o There is **NO third kind of spin.**

- **Spinors interact correspondingly with the vielbeins and the two kinds of the spin connection fields.**
- **In** $d = (3+1)$ the **spin-connection fields, together with the vielbeins, manifest either** as the
  o vector gauge fields with all the **charges** in the **adjoint representations** or as
  o the scalar gauge fields with the **charges with respect to the space index** in the **fundamental representations** and all the other **charges** in the **adjoint representations** or as
  o tensor gravitational field.

There are two kinds of scalar fields with respect to $d = (3+1)$:

- **Those** (with zero "spinor charge"), **which are doublets with respect to the weak charge and the second** $SU(2)_{II}$ **charge and are in adjoint representations** with respect to all the other **charges**.
  o These scalars are candidates for describing the Higgs scalar and Yukawa couplings.

- **Those** (with twice the "spinor charge") **carrying the triplet colour charge with respect to the space index, and all the other charges in the adjoint representations**.
  o These scalars transform antileptons into quarks, and antiquarks into quarks and back and are candidates for contributing to matter-antimatter asymmetry of our universe and to proton decay.
- **There are no additional scalar fields in the spin-charge-family theory.**

- **The (assumed) scalar condensate of two right handed neutrinos with the family quantum numbers of the upper four families (there are two four family groups)**, appearing above 10^{16} GeV

  o breaks the CP symmetry, causing the matter-antimatter asymmetry and the proton decay,

  o couples to all the scalar fields, making them massive,

  o couples to all the phenomenologically unobserved vector gauge fields, making them massive.

- The vector fields, **which do not couple to the condensate and remain massless, are:**
  o the hyper charge vector field.

  o the weak vector fields,

  o the colour vector fields,

  o the gravity fields.

  The $SU(2)_{II}$ symmetry breaks due to the - assumed - condensate.

- **When the scalar fields with the space index $(7,8)$ gain nonzero vacuum expectation values,**
  o they cause the electroweak break,
  o breaking the weak and the hyper charge.
  o They change their own masses,
  o bring masses to the weak bosons,
  o bring masses to the families of quarks and leptons.
- **The only gauge fields which do not couple to these scalars and remain massless are the electromagnetic and colour vector gauge fields, and gravity.**
- **There are two times four decoupled massive families of quarks and leptons after the electroweak break .**

- **It is extremely encouraging for the spin-charge-family theory, that a simple starting action manifests in the low energy regime all the directly or indirectly observed phenomena and that only the**
  O condensate and
  O nonzero vacuum expectation values of all the scalar fields with $s = (7, 8)$ do the job.

A look "inside" the spin-charge-family theory.

There are two kinds of the Clifford algebra objects (only two):

- The **Dirac γ^a operators** (used by Dirac 80 years ago).
- The **second one:** $\tilde{\gamma}^a$, which I recognized in the Grassmann space.

$$
\begin{aligned}
\{\gamma^{\mathbf{a}}, \gamma^{\mathbf{b}}\}_+ &= \mathbf{2}\eta^{\mathbf{ab}} = \{\tilde{\gamma}^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_+, \\
\{\gamma^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_+ &= 0, \\
(\tilde{\gamma}^{\mathbf{a}}\mathbf{B} : &= \mathbf{i}(-)^{\mathbf{n_B}}\mathbf{B}\gamma^{\mathbf{a}}\,)\,|\psi_0>, \\
(\mathbf{B} &= a_0 + a_a\gamma^a + a_{ab}\gamma^a\gamma^b + \cdots + a_{a_1\cdots a_d}\gamma^{a_1}\ldots\gamma^{a_d})|\psi_0>
\end{aligned}
$$

$(-)^{n_B} = +1, -1$, when the object B has a Clifford even or odd character, respectively.

$|\psi_0>$ is a vacuum state on which the operators γ^a **apply**.

$$\mathbf{S}^{ab} := (i/4)(\gamma^a\gamma^b - \gamma^b\gamma^a),$$

$$\tilde{\mathbf{S}}^{ab} := (i/4)(\tilde{\gamma}^a\tilde{\gamma}^b - \tilde{\gamma}^b\tilde{\gamma}^a),$$

$$\{\mathbf{S}^{ab}, \tilde{\mathbf{S}}^{cd}\}_- = 0.$$

- $\tilde{\mathbf{S}}^{ab}$ define the equivalent representations with respect to $\mathbf{S}^{ab}$.

My **recognition:**

- If γ^a **are used to describe the spin and the charges of spinors,**
  $\tilde{\gamma}^a$ **can be used to describe families of spinors**.

Must be used!!

A simple action for **a spinor which carries in $d = (13+1)$ only two kinds of a spin** (no charges) and for **the gauge fields**

$$\mathbf{S} = \int d^d x \, E \, \mathcal{L}_f + \int d^d x \, E \, (\alpha \, R + \tilde{\alpha} \, \tilde{R})$$

$$\mathcal{L}_f = \frac{1}{2}(\bar{\psi} \, \gamma^a p_{0a} \psi) + h.c.$$

$$p_{0a} = f^{\alpha}{}_a p_{0\alpha} + \frac{1}{2E} \{p_\alpha, E f^{\alpha}{}_a\}_-$$

$$\mathbf{p_{0\alpha}} = \mathbf{p}_\alpha - \frac{\mathbf{1}}{\mathbf{2}} \mathbf{S^{ab}} \omega_{\mathbf{ab}\alpha} - \frac{\mathbf{1}}{\mathbf{2}} \tilde{\mathbf{S}}^{\mathbf{ab}} \tilde{\omega}_{\mathbf{ab}\alpha}$$

- **The only internal degrees of freedom of spinors fermions) are the two kinds of the spin.**
- **The only gauge fields are the gravitational ones – vielbeins and the two kinds of spin connections.**
- **Either γ^a or $\tilde{\gamma}^a$ transform as vectors in d,**

$$
\begin{aligned}
&\gamma'^a = \Lambda^a{}_b \ \gamma^b\,, \quad \tilde{\gamma}'^a = \Lambda^a{}_b \ \tilde{\gamma}^b\,,\\
&\delta\gamma^c = -\tfrac{i}{2}\,\alpha_{ab}\,S^{ab}\,\gamma^c = \alpha^c{}_a\gamma^a\,,\\
&\delta\tilde{\gamma}^c = -\tfrac{i}{2}\,\alpha_{ab}\,\tilde{S}^{ab}\,\tilde{\gamma}^c = \alpha^c{}_a\,\tilde{\gamma}^a\,,\\
&\delta A^{c\dots ef} = -\tfrac{i}{2}\,\alpha_{ab}\,\mathcal{S}^{ab}\,A^{c\dots ef} = \alpha^e{}_a\,A^{c\dots af}\,,\\
&\mathcal{S}^{ab}\,A^{c\dots e\dots f} = i\,(\eta^{ae}\,A^{c\dots b\dots f} - \eta^{be}\,A^{c\dots a\dots f})
\end{aligned}
$$

and correspondingly also $f^{\alpha}{}_a\,\omega_{bc\alpha}$ and $f^{\alpha}{}_a\,\tilde{\omega}_{bc\alpha}$ transform as tensors with respect to the flat index a.

- The action for spinors seen from d=(3+1) and analyzed with respect to the standard model groups as subgroups of $SO(1+13)$:

$$
\begin{aligned}
\mathcal{L}_f &= \bar{\psi}\gamma^m (p_m - \sum_{A,i} g^A \tau^{Ai} A^{Ai}_m)\psi + \\
&\{ \sum_{s=[7],[8]} \bar{\psi}\gamma^s p_{0s}\, \psi\} + \\
&\{ \sum_{s=[5],[6]} \bar{\psi}\gamma^s p_{0s}\, \psi + \\
&\sum_{t=[9],\dots[14]} \bar{\psi}\gamma^t p_{0t}\, \psi\}\,, \\
&+ \text{the rest}\,,\,,
\end{aligned}
$$

The action

$$
\begin{aligned}
p_{0m} &= \{p_m - \sum_A g^A \vec{\tau}^A \vec{A}^A_m\} \\
m &\in (0,1,2,3)\,, \\
p_{0s} &= f^\sigma_s [p_\sigma - \sum_A g^A \vec{\tau}^A \vec{A}^A_\sigma - \sum_A \tilde{g}^A \vec{\tilde{\tau}}^A \vec{\tilde{A}}^A_\sigma]\,, \\
s &\in (7,8)\,, \\
p_{0s} &= f^\sigma_s [p_\sigma - \sum_A g^A \vec{\tau}^A \vec{A}^A_\sigma - \sum_A \tilde{g}^A \vec{\tilde{\tau}}^A \vec{\tilde{A}}^A_\sigma]\,, \\
s &\in (5,6)\,, \\
p_{0t} &= f^{\sigma'}_t (p_{\sigma'} - \sum_A g^A \vec{\tau}^A \vec{A}^A_{\sigma'} - \sum_A \tilde{g}^A \vec{\tilde{\tau}}^A \vec{\tilde{A}}^A_{\sigma'})\,, \\
t &\in (9,10,11,\ldots,14)\,,
\end{aligned}
$$

$$\mathbf{A}^{Ai}_{s} = \sum_{a,b} c^{Ai}{}_{ab}\,\omega_{abs}\,,$$

$$\mathbf{A}^{Ai}_{t} = \sum_{a,b} c^{Ai}{}_{ab}\,\omega_{abt}\,,$$

$$\tilde{\mathbf{A}}^{Ai}_{s} = \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\,\tilde{\omega}_{abs}\,,$$

$$\tilde{\mathbf{A}}^{Ai}_{t} = \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\,\tilde{\omega}_{abt}\,.$$

$$\begin{aligned}
\tau^{\mathbf{Ai}} &= \sum_{a,b} c^{Ai}{}_{ab}\, \mathbf{S}^{\mathbf{ab}}\,, \\
\tilde{\tau}^{\mathbf{Ai}} &= \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\, \tilde{\mathbf{S}}^{\mathbf{ab}}\,, \\
\{\tau^{\mathbf{Ai}}, \tau^{\mathbf{Bj}}\}_- &= i\delta^{AB} f^{Aijk} \tau^{\mathbf{Ak}}\,, \\
\{\tilde{\tau}^{\mathbf{Ai}}, \tilde{\tau}^{\mathbf{Bj}}\}_- &= i\delta^{AB} f^{Aijk} \tilde{\tau}^{\mathbf{Ak}}\,, \\
\{\tau^{\mathbf{Ai}}, \tilde{\tau}^{\mathbf{Bj}}\}_- &= 0\,.
\end{aligned}$$

o τ^{Ai} stay for the standard model charge groups,
for the second $SU(2)_{II}$,
for the "spinor" charge,
$\tilde{\tau}^{Ai}$ denote the family quantum numbers.

$$\vec{N}_{(L,R)} : = \frac{1}{2}(S^{23} \pm iS^{01}, S^{31} \pm iS^{02}, S^{12} \pm iS^{03}),$$

$$\vec{\tau}^{(1,2)} : = \frac{1}{2}(S^{58} \mp S^{67}, S^{57} \pm S^{68}, S^{56} \mp S^{78}),$$

$$\vec{\tau}^{3} := \frac{1}{2}\{S^{9\,12} - S^{10\,11}, S^{9\,11} + S^{10\,12}, S^{9\,10} - S^{11\,12}, S^{9\,14} - S^{10\,13}, S^{9\,13} + S^{10\,14}, S^{11\,14} - S^{12\,13}, S^{11\,13} + S^{12\,14}, \frac{1}{\sqrt{3}}(S^{9\,10} + S^{11\,12} - 2S^{13\,14})\},$$

$$\tau^{4} := -\frac{1}{3}(S^{9\,10} + S^{11\,12} + S^{13\,14}), \quad Y := \tau^{4} + \tau^{23},$$

$$Y' := -\tau^{4}\tan^{2}\vartheta_{2} + \tau^{23}, Q := \tau^{13} + Y, Q' := -Y\tan^{2}\vartheta_{1} + \tau^{13},$$

and equivalently for $\tilde{S}^{ab}$ and $\mathcal{S}^{ab}$.

Breaks of symmetries when starting with **massless spinors** (fermions) and **vielbeins and the two kinds of spin connection fields**

The action

$$\mathbf{SO(1,13)} \times \widetilde{\mathbf{SO}(1,13)} \times$$

BREAK I

$$\downarrow$$

$$\mathbf{SO(1,7)} \times \quad \mathbf{U(1)} \times \quad \mathbf{SU(3)}$$
$$\times \widetilde{\mathbf{SO}(1,7)}$$

$\swarrow$ eight massless families $\searrow$

$$\mathbf{SO(1,3)} \times \mathbf{SO(4)} \times \mathbf{U(1)} \times \quad (\widetilde{\mathbf{SU}(2)}_{\mathbf{I}\,\widetilde{\mathbf{SO}}(1,3)} \times \widetilde{\mathbf{SU}(2)}_{\mathbf{I}\,\widetilde{\mathbf{SO}}(4)}) \times \quad (\widetilde{\mathbf{SU}(2)}_{\mathbf{II}\,\widetilde{\mathbf{SO}}(1,3)} \times \widetilde{\mathbf{SU}(2)}_{\mathbf{II}\,\widetilde{\mathbf{SO}}(4)}) \times \quad \mathbf{SU(3)}$$

(devided into two groups)

BREAK II

$$\underbrace{\hphantom{xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx}}$$

$$\downarrow$$

The Standard Model like way of breaking

$$\downarrow$$

$$\mathbf{SO(1,3)} \times \mathbf{U(1)} \times \mathbf{SU(3)}$$

$\times$(two groups of four massive families)

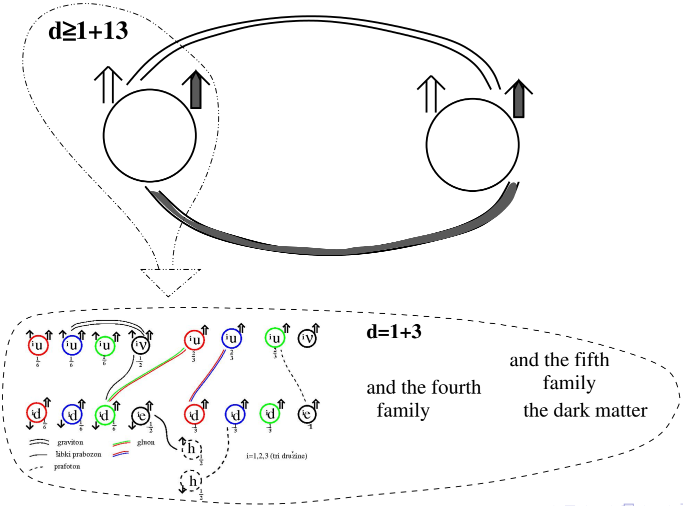
Breaking the starting symmetry from:

- $SO(1,13) \times \widetilde{SO}(1,13)$ to
  $SO(1,7) \times \widetilde{SO}(1,7) \times U(1)_{II} \times SU(3)$ (at E $\geq 10^{16}$ GeV)
  o makes spin in $d=(1+3)$ of two groups of massless spinors connected with the weak and the hyper charge ,
- $SO(1,7) \times \widetilde{SO}(1,7) \times U(1)_{II} \times SU(3)$ to
  $SO(1,3) \times SU(2)_{I} \times SU(2)_{II} \times U(1)_{II} \times SU(3)$
  $\widetilde{SO}(1,3) \times \widetilde{SU}(2)_{I} \times \widetilde{SU}(2)_{II}$
  o makes manifesting each member of the two groups of massless families in $d=(1+3)$ the weak ($SU(2)_{I}$), **the hyper ($SU(2)_{II}$)**, **the colour ($SU(3)$)** and **the "spin charge" ($U(1)=\tau^4$)**.

- **Both breaks leave** **eight families** **($2^{8/2-1}=8$, determined by the symmetry of $SO(1,7)$), massless.**
- **The appearance of the condensate of the two right handed neutrinos** **coupled to spin 0 makes all the boson fields - that is the fields with the space index $s \geq 5$ - and the vector bosons, $m < 5$, with the charge which is the superposition of** **($SU(2)_{II}$)** and **$\mathbf{U(1)_{II}}$**, **massive,** **while the** **colour, elm, weak and hyper** **vector gauge fields remain massless.**

- **At the electroweak break** from $SO(1,3) \times SU(2)_I \times U(1)_I \times SU(3)$ to $SO(1,3) \times U(1) \times SU(3)$ **the scalar fields with the space index $s = (7,8)$ obtain nonzero vacuum expectation values, o breaking correspondingly the weak and the hyper charge and changing their own masses. o They leave massless only the colour and the elm gauge fields, while all eight massless families gain masses.**
- **To the electroweak break several scalar fields contribute, all with the weak and the hyper charge of the** *standard model* **Higgs, carrying besides the weak and the hyper charge either the family members quantum numbers (Q,Q',Y') or the family quantum numbers.**

- **Both, $SO(n)$ and $\widetilde{SO}(n)$ break simultaneously.**
- We studied (with H.B. Nielsen, D. Lukman) on a toy model of $d = (1+5)$ conditions which lead after breaking symmetries to massless spinors chirally coupled to the Kaluza-Klein-like gauge fields.


d≧1+13
d=1+3
and the fourth family
and the fifth family
the dark matter
graviton
šibki prabozon
prafoton
gluon
i=1,2,3 (tri družine)

Our technique to represent spinors works elegantly.

- N. S. Mankoč Borštnik, *J. Math. Phys.* **34**, 3731 (1993),
- *J. of Math. Phys.* **43**, 5782-5803 (2002), hep-th/0111257,
- *J. of Math. Phys.* **44** 4817-4827 (2003), hep-th/0303224, the last two with H.B. Nielsen.

$$\overset{ab}{(\pm \mathbf{i})}: = \frac{1}{2}(\gamma^{\mathbf{a}} \mp \gamma^{\mathbf{b}}), \ \overset{ab}{[\pm \mathbf{i}]} := \frac{1}{2}(1 \pm \gamma^{\mathbf{a}}\gamma^{\mathbf{b}})$$

$$\text{for } \eta^{aa}\eta^{bb} = -1,$$

$$\overset{ab}{(\pm)}: = \frac{1}{2}(\gamma^{\mathbf{a}} \pm \mathbf{i}\gamma^{\mathbf{b}}), \ \overset{ab}{[\pm]} := \frac{1}{2}(1 \pm i\gamma^{\mathbf{a}}\gamma^{\mathbf{b}}),$$

$$\text{for } \eta^{aa}\eta^{bb} = 1$$

with γ^a which are the usual **Dirac operators**

$$\mathbf{S}^{ab} \overset{ab}{(\mathbf{k})} = \frac{k}{2} \overset{ab}{(\mathbf{k})}, \quad \mathbf{S}^{ab} \overset{ab}{[\mathbf{k}]} = \frac{k}{2} \overset{ab}{[\mathbf{k}]},$$
$$\tilde{\mathbf{S}}^{ab} \overset{ab}{(\mathbf{k})} = \frac{k}{2} \overset{ab}{(\mathbf{k})}, \quad \tilde{\mathbf{S}}^{ab} \overset{ab}{[\mathbf{k}]} = -\frac{k}{2} \overset{ab}{[\mathbf{k}]}.$$

γ^a **transforms** $\overset{ab}{(k)}$ **into** $\overset{ab}{[-k]}$**, never to** $\overset{ab}{[k]}$**.**

$\tilde{\gamma}^a$ transforms $\overset{ab}{(k)}$ **into** $\overset{ab}{[k]}$**, never to** $\overset{ab}{[-k]}$**.**

- One Weyl representation of one family contains all the **family members** with the **right handed neutrinos included**. It includes also **antimembers**, reachable by $\mathbb{C}_{\mathcal{N}}\ \mathcal{P}_{\mathcal{N}}$ **on a family member**.
- There are $2^{(7+1)/2-1} = 8$ **families**, which decouple into twice four families, with the quantum numbers $(\tilde{\tau}^{2i}, \tilde{N}_R^i)$ and $(\tilde{\tau}^{1i}, \tilde{N}_L^i)$, respectively.

S^{ab} generate **all the members of one family**. The eightplet (the representation of $SO(7,1)$) of quarks of a particular colour charge

i		$\vert^a\psi_i>$	$\Gamma^{(3,1)}$	S^{12}	$\Gamma^{(4)}$	τ^{13}	τ^{23}	Y	τ^4
		Octet, $\Gamma^{(7,1)}=1$, $\Gamma^{(6)}=-1$, of quarks							
1	$\mathbf{u_R^{c1}}$	$\stackrel{03}{(+\mathbf{i})}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{6}$
2	u_R^{c1}	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{6}$
3	d_R^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{[-]}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{1}{6}$
4	$\mathbf{d_R^{c1}}$	$\stackrel{03}{[-\mathbf{i}]}\stackrel{12}{[-]} \mid \stackrel{56}{[-]}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{1}{6}$
5	d_L^{c1}	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \mid \stackrel{56}{[-]}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
6	$\mathbf{d_L^{c1}}$	$\stackrel{03}{(+\mathbf{i})}\stackrel{12}{[-]} \mid \stackrel{56}{[-]}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
7	$\mathbf{u_L^{c1}}$	$\stackrel{03}{[-\mathbf{i}]}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
8	u_L^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \mid \stackrel{56}{(+)}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$-\frac{1}{2}$	-1	$\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$

$\gamma^0\gamma^7$ and $\gamma^0\gamma^8$ transform $\mathbf{u_R}$ of the 1^{st} row into $\mathbf{u_L}$ of the 7^{th} row, and $\mathbf{d_R}$ of the 4^{rd} row into $\mathbf{d_L}$ of the 6^{th} row, doing what the Higgs scalars and γ^0 do in the Stan. model.

- **All the vector gauge fields, manifesting at the observable energies, have all the properties assumed by the *standard model*.**
  They carry with respect to the space index $m \in (0,1,2,3)$ the vector degrees of freedom while they have additional internal degrees of freedom ($\tau^{Ai} = \sum_{st} c^{Ai}{}_{st}$) in the adjoint representations.

Analyzing all the indexes of the gauge fields, manifesting at low energy, with respect to $\mathcal{S}^{ab}$, where $A^{Ai}_{m} = C^{Aist}\,\omega_{stm}$ and $\mathcal{S}^{ab}$, applies on index (s,t,m) as follows

$$\mathcal{S}^{ab}\,\omega_{stm} \;\; = \;\; i\,(\delta^{a}_{s}\,\omega_{btm...g} - \delta^{b}_{e}\,\omega_{atm})\,,$$

one finds that the weak, colour and hyper charge fields have just the properties required for them by the *standard model*.

- **There are several scalar gauge fields - twice three triplets with respect to the family quantum numbers ($\tilde{\tau}^{Ai} = \sum \tilde{c}^{Ai}{}_{st} \tilde{S}^{st}$) and 3 singlets with the quantum numbers (Q,Q',Y') - which manifest at the so far observable energies as the Higgs's scalar** and **the Yukawa couplings**.
  They all carry the weak charge and the hyper charge as required by the *standard model*, **for the Higg's scalar, while all the rest of quantum numbers are in the adjoint representations**.

Their properties have to be analyzed with respect to the generators of the corresponding subgroups, expressible with $\mathcal{S}^{ab}$.

The scalar condensate of two right handed neutrinos couple to all the scalar and vector gauge fields, except to the weak charge $SU(2)_I$, the hyper charge $U(1)$, and the colour $SU(3)$ charge gauge fields, as well as the gravity, leaving them massless.

state	S^{03}	S^{12}	τ^{13}	τ^{23}	τ^{4}	Y	Q	$\tilde{\tau}^{13}$	$\tilde{\tau}^{23}$	$\tilde{Y}$	$\tilde{Q}$	$\tilde{N}_R^3$	$\tilde{N}_L^3$
$\lvert\nu_{\mathbf{1R}}^{\mathbf{VIII}} >_{\mathbf{1}} \lvert\nu_{\mathbf{2R}}^{\mathbf{VIII}} >_{\mathbf{2}}$	0	0	0	1	-1	0	0	0	1	0	0	1	0
$\lvert\nu_{1R}^{VIII} >_1 \lvert e_{2R}^{VIII} >_2$	0	0	0	0	-1	-1	-1	0	1	0	0	1	0
$\lvert e_{1R}^{VIII} >_1 \lvert e_{2R}^{VIII} >_2$	0	0	0	-1	-1	-2	-2	0	1	0	0	1	0

Scalars form 2 doublets, $s = (5, 6, 7, 8)$, and a triplet and an antitriplet, $s = (9, \ldots, 14)$.

There are no additional scalars.

The two doublets are:

	state	τ^{13}	$\tau^{23} = Y$	spin	τ^{4}	Q
$A^{Ai}_{\stackrel{78}{(-)}}$	$A^{Ai}_7 + iA^{Ai}_8$	$+\frac{1}{2}$	$-\frac{1}{2}$	0	0	0
$A^{Ai}_{\stackrel{56}{(-)}}$	$A^{Ai}_5 + iA^{Ai}_6$	$-\frac{1}{2}$	$-\frac{1}{2}$	0	0	-1
$A^{Ai}_{\stackrel{78}{(+)}}$	$A^{Ai}_7 - iA^{Ai}_8$	$-\frac{1}{2}$	$+\frac{1}{2}$	0	0	0
$A^{Ai}_{\stackrel{56}{(+)}}$	$A^{Ai}_5 - iA^{Ai}_6$	$+\frac{1}{2}$	$+\frac{1}{2}$	0	0	$+1$

There are $A^{Ai}_{\stackrel{78}{(-)}}$ and $A^{Ai}_{\stackrel{78}{(+)}}$ which gain a nonzero vacuum expectation values at the electroweak break.
Index Ai determine the family and the family members (Q,Q',Y') quantum numbers.

The triplets and the anti-triplets are:

	state	τ^{33}	τ^{38}	spin	τ^{4}	Q
$A^{Ai}_{9\,10\,(+)}$	$A^{Ai}_{9} - iA^{Ai}_{10}$	$+\frac{1}{2}$	$\frac{1}{2\sqrt{3}}$	0	$-\frac{1}{3}$	$-\frac{1}{3}$
$A^{Ai}_{11\,12\,(+)}$	$A^{Ai}_{11} - iA^{Ai}_{12}$	$-\frac{1}{2}$	$\frac{1}{2\sqrt{3}}$	0	$-\frac{1}{3}$	$-\frac{1}{3}$
$A^{Ai}_{13\,14\,(+)}$	$A^{Ai}_{13} - iA^{Ai}_{14}$	0	$-\frac{1}{\sqrt{3}}$	0	$-\frac{1}{3}$	$-\frac{1}{3}$
$A^{Ai}_{9\,10\,(-)}$	$A^{Ai}_{9} + iA^{Ai}_{10}$	$-\frac{1}{2}$	$-\frac{1}{2\sqrt{3}}$	0	$+\frac{1}{3}$	$+\frac{1}{3}$
$A^{Ai}_{11\,12\,(-)}$	$A^{Ai}_{11} + iA^{Ai}_{12}$	$\frac{1}{2}$	$-\frac{1}{2\sqrt{3}}$	0	$+\frac{1}{3}$	$+\frac{1}{3}$
$A^{Ai}_{13\,14\,(-)}$	$A^{Ai}_{13} + iA^{Ai}_{14}$	0	$\frac{1}{\sqrt{3}}$	0	$+\frac{1}{3}$	$+\frac{1}{3}$

They cause the transitions of **anti-leptons into quarks and anti-quarks into quarks and back**, **transforming matter into antimatter and back**. **The condensate breaks CP symmetry**, **offering the explanation for the matter-antimatter asymmetry in the universe.**

Scalars with s=(7,8) gain nonzero vacuum expectation values breaking the weak and the hyper symmetry, and conserving the electromagnetic and colour charge.

$$\begin{aligned}
\mathbf{A}^{\mathbf{Ai}}_{\mathbf{s}} &\supset \left(\mathbf{A}^{\mathbf{Q}}_{\mathbf{s}}\,, \mathbf{A}^{\mathbf{Q}'}_{\mathbf{s}}\,, \mathbf{A}^{\mathbf{Y}'}_{\mathbf{s}}\,, \tilde{\tilde{\mathbf{A}}}^{\tilde{\mathbf{1}}}_{\mathbf{s}}\,, \tilde{\tilde{\mathbf{A}}}^{\tilde{\mathbf{N}}_{\tilde{\mathbf{L}}}}_{\mathbf{s}}\,, \tilde{\tilde{\mathbf{A}}}^{\tilde{\mathbf{2}}}_{\mathbf{s}}\,, \tilde{\tilde{\mathbf{A}}}^{\tilde{\mathbf{N}}_{\tilde{\mathbf{R}}}}_{\mathbf{s}} \right),\\
\tau^{\mathbf{Ai}} &\supset \left(\mathbf{Q},\ \ \mathbf{Q}',\ \ \mathbf{Y}',\ \ \tilde{\tilde{\tau}}^{\mathbf{1}},\ \ \tilde{\tilde{\mathbf{N}}}_{\mathbf{L}},\ \ \tilde{\tilde{\tau}}^{\mathbf{2}},\ \ \tilde{\tilde{\mathbf{N}}}_{\mathbf{R}} \right),\\
\mathbf{s} &= (\mathbf{7},\mathbf{8})\,.
\end{aligned}$$

Ai denotes family quantum numbers and Q, Q', Y'.

The **mass term** in the **starting action** (p_s, when treating the lowest energy solutions, is left out)

$$
\begin{aligned}
\mathcal{L}_M &= \sum_{s=(7,8),Ai} \bar{\psi}\,\gamma^s\,(-\tau^{Ai}\,A^{Ai}_s)\psi = \\
&-\bar{\psi}\,\{\stackrel{78}{(+)}\;\tau^{Ai}\,(A^{Ai}_7 - i\,A^{Ai}_8) + \stackrel{78}{(-)}\;\tau^{Ai}\,(A^{Ai}_7 + i\,A^{Ai}_8)\,\}\psi\;, \\
&\stackrel{78}{(\pm)} = \frac{1}{2}\,(\gamma^7 \pm\, i\,\gamma^8\,)\,,\quad A^{Ai}_{\stackrel{78}{(\pm)}} := (A^{Ai}_7 \mp i\,A^{Ai}_8)\,.
\end{aligned}
$$

Operators Y, Q and τ^{13}, applied on $(A^{Ai}_{7} \mp i\, A^{Ai}_{8})$

$$\tau^{\mathbf{13}}\,(A^{Ai}_{7} \mp i\, A^{Ai}_{8}) = \pm\frac{1}{2}\,(A^{Ai}_{7} \mp i\, A^{Ai}_{8})\,,$$
$$\mathbf{Y}\,(A^{Ai}_{7} \mp i\, A^{Ai}_{8}) = \mp\frac{1}{2}\,(A^{Ai}_{7} \mp i\, A^{Ai}_{8})\,,$$
$$\mathbf{Q}\,(A^{Ai}_{7} \mp i\, A^{Ai}_{8}) = 0$$

manifest that **all** $(A^{Ai}_{7} \mp i\, A^{Ai}_{8})$ have quantum numbers of the **Higgs's scalar of the standard model**, "dressing", after **gaining nonzero expectation values**, the right handed members of a family with appropriate charges, so that they gain charges of the left handed partners:
$A^{Ai}_{7} + i\, A^{Ai}_{8}$ "dresses" u_R, ν_R and $A^{Ai}_{7} - i\, A^{Ai}_{8}$ "dresses" d_R, e_R, with quantum numbers of their left handed partners, just as required by the "standard model".

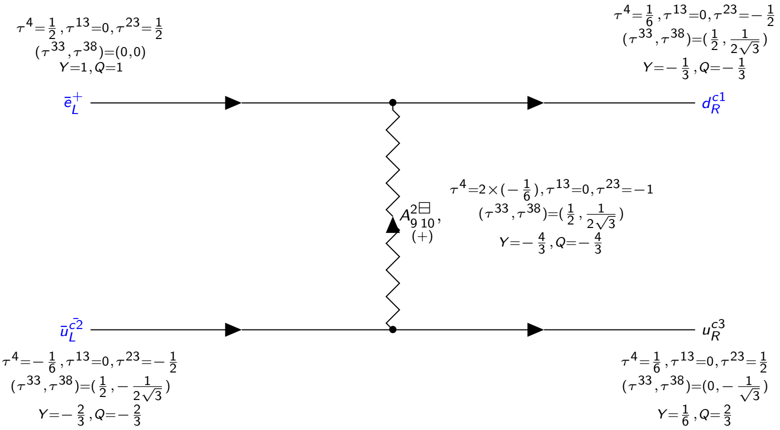
Ai either measures the **Q,Q',Y'** charges of the right handed family members or **transforms a family member of one family into the same family member of another family, within each** of the **two groups of four families**, manifesting in each group of four families $SU(2) \times SU(2)$ **symmetry**.

Eight families of u_R (spin 1/2, colour $(\frac{1}{2}, \frac{1}{2\sqrt{3}})$) and of colourless ν_R (spin 1/2). All have the weak charge $\tau^{13}=0$, $\tau^{23}=\frac{1}{2}$, $\tilde{\tau}^4=-\frac{1}{2}$. Quarks have "spinor" q.no. $\tau^4=\frac{1}{6}$ and leptons $\tau^4=-\frac{1}{2}$. The first four families have $\tilde{\tau}^{23}=0$, $\tilde{N}^3_R=0$, the second four families have $\tilde{\tau}^{13}=0$, $\tilde{N}^3_L=0$.

				$\tilde{\tau}^{13}$	$\tilde{N}^3_L$
$u^{c1}_{R\,1}$	$\overset{03}{(+i)}\overset{12}{[+]}\mid\overset{56}{[+]}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,1}$	$\overset{03}{(+i)}\overset{12}{[+]}\mid\overset{56}{[+]}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$-\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,2}$	$\overset{03}{[+i]}\overset{12}{(+)}\mid\overset{56}{[+]}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,2}$	$\overset{03}{[+i]}\overset{12}{(+)}\mid\overset{56}{[+]}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$-\frac{1}{2}$	$\frac{1}{2}$
$u^{c1}_{R\,3}$	$\overset{03}{(+i)}\overset{12}{[+]}\mid\overset{56}{(+)}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,3}$	$\overset{03}{(+i)}\overset{12}{[+]}\mid\overset{56}{(+)}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,4}$	$\overset{03}{[+i]}\overset{12}{(+)}\mid\overset{56}{(+)}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,4}$	$\overset{03}{[+i]}\overset{12}{(+)}\mid\overset{56}{(+)}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$\frac{1}{2}$	$\frac{1}{2}$
				$\tilde{\tau}^{23}$	$\tilde{N}^3_R$
$u^{c1}_{R\,5}$	$\overset{03}{(+i)}\overset{12}{(+)}\mid\overset{56}{(+)}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,5}$	$\overset{03}{(+i)}\overset{12}{(+)}\mid\overset{56}{(+)}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$-\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,6}$	$\overset{03}{(+i)}\overset{12}{(+)}\mid\overset{56}{[+]}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,6}$	$\overset{03}{(+i)}\overset{12}{(+)}\mid\overset{56}{[+]}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$-\frac{1}{2}$	$\frac{1}{2}$
$u^{c1}_{R\,7}$	$\overset{03}{[+i]}\overset{12}{[+]}\mid\overset{56}{(+)}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,7}$	$\overset{03}{[+i]}\overset{12}{[+]}\mid\overset{56}{(+)}\overset{78}{(+)}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,8}$	$\overset{03}{[+i]}\overset{12}{[+]}\mid\overset{56}{[+]}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{[-]}\;\overset{13\,14}{[-]}$	$\nu_{R\,8}$	$\overset{03}{[+i]}\overset{12}{[+]}\mid\overset{56}{[+]}\overset{78}{[+]}\Vert\overset{9\,10}{(+)}\;\overset{11\,12}{(+)}\;\overset{13\,14}{(+)}$	$\frac{1}{2}$	$\frac{1}{2}$

Before the electroweak break all the families are mass protected and correspondingly massless.

Let us look at scalar triplets, causing the **birth of a proton** from the left handed **positron**, **antiquark** and **quark**:



These two quarks, d_R^{c1} and u_R^{c3} can bind (at low enough energy) together with u_R^{c2} into the colour **chargeless baryon - a proton**.

After the appearance of the **condensate** the **CP is broken**.

In the expanding universe, fulfilling the Sakharov request for appropriate nonthermal equillibrium, **these triplet scalars have a chance to explain the matter-antimatter asymmetry**.

The opposite transition makes the proton decay.

- **In the standard model** the **family members**, the **families**, the **gauge vector fields**, the **scalar Higgs**, the **Yukawa couplings**, exist by the **assumption**.
- ** In the **spin-charge-family theory all these properties follow from the simple starting action** with **two kinds of spins** and with **gravity only** .

  ** The theory offers the explanation also for the **dark matter**, the stable of the upper four families does this.

  ** The theory offers the explanation also for the **matter-antimatter asymmetry**, the condensate, breaking CP symmetry together with the massive triplet scalars do that.

  ** All the **scalar** and all the **vector** gauge fields are **directly or indirectly observable**.

- Due to

$$\begin{aligned}
\tau^{1+}\tau^{1-}\,\mathbf{A}^{\mathbf{Ai}}{}_{\overset{78}{(+)}} &= \mathbf{A}^{\mathbf{Ai}}{}_{\overset{78}{(+)}}\,,\\
\tau^{1-}\tau^{1+}\,\mathbf{A}^{\mathbf{Ai}}{}_{\overset{78}{(-)}} &= \mathbf{A}^{\mathbf{Ai}}{}_{\overset{78}{(-)}}\,,\\
Q\,\mathbf{A}^{\mathbf{Ai}}{}_{\overset{78}{(\mp)}} &= 0\,,\\
Q'\,\mathbf{A}^{\mathbf{Ai}}{}_{\overset{78}{(\mp)}} &= \pm\frac{1}{2\cos^2\theta_1}\;,\mathbf{Ai}^{\mathbf{Ai}}{}_{\overset{78}{(\mp)}}\,.\,,
\end{aligned}$$

the **vector gauge fields** $A^{1\pm}_m (= W^{\pm}_m)$ and $A^{Q'}_m\ (= Z_m)$ $= \cos\theta_1 A^{13}_m - \sin\theta_1 A^{Y}_m$ become massive, while $A^{Q}_m\ (= A_m)$ $= \sin\theta_2 A^{13}_m + \cos\theta_1 A^{Y}_m$ remain massless, if $\frac{g^1}{g^Y}\tan\theta_1 = 1$.

- Correspondingly the mass term of the **vector gauge bosons** is

$$(p_{0m}\, A^{Ai}_{\substack{78\\(\mp)}})^{\dagger}\, (p_0{}^{m}\, A^{Ai}_{\substack{78\\(\mp)}}) \to$$
$$(\frac{1}{2})^2\, (g^1)^2\, v^2 (\frac{1}{(\cos\theta_1)^2}\, Z^{Q'}_m Z^{Q'\, m} + 2\, W^{+}_m W^{-\, m})\,,$$

$$Tr(A^{vAi\dagger}_{\mp}\, A^{vAi}_{\mp}) = \frac{v^2}{2}\,.$$

- These scalars with the weak and the hyper charge $(\mp\frac{1}{2}, \pm\frac{1}{2})$, respectively, determine masses of all the members of the **lower four families**, as well as of the **upper four families**, together with the **gauge vector fields** and the **condensate**. **Both groups of four families** manifest on the tree level and in all loop corrections the $SU(2) \times SU(2) \times U(1)$ **symmetry**:

$$\mathcal{M}^\alpha = \begin{pmatrix} -a_1 - a & e & d & b \\ e & -a_2 - a & b & d \\ d & b & a_2 - a & e \\ b & d & e & a_1 - a \end{pmatrix}^\alpha ,$$

under the conditions that the mass matrix elements are real. **Consequently the mixing matrices are orthogonal**. We study symmetries of mass matrices in loop corrections [arXiv:0912.4532]

- **Concrete predictions?**.

With G. Bregar we did calculations, treating, as required by the "spin-charge-family" theory, quarks and leptons in an equivalent way.

- Although any **(n-1)x (n-1)** submatrix of an unitary **n x n** matrix determines the **nxn** matrix for **n** $\geq$ **4** uniquely, in our case it appears evidently that the measured mixing matrix elements are not accurately enough even for quarks to predict the masses of the fourth family members. **We can say only that most probably the fourth family quark masses might be close to** 1 **TeV or even above**.
- The **fourth family masses for quarks and also for leptons are not very sensitive to the accuracy of the measured masses of the lower three families, important are mixing matrices**.

- The **last** **data for mixing matrix of quarks** **are in better agreement with our prediction for the** 3×3 **submatrix elements of the** 4×4 **mixing matrix than the previous ones**.

  Our **fit** **to the last data predicts how will** the 3×3 **submatrix elements change** in the **next more accurate measurements**.

  Results are presented for two choices of the fourth family quark masses:

  Case 1. $m_{u_4} = m_{d_4} = 700$ GeV,
  Case 2. $m_{u_4} = m_{d_4} = 1\,200$ GeV.
  [arxiv:1412.5866]

$$
|V_{(ud)}| = \left(\begin{array}{c|cccc}
exp_o & 0.97425 \pm 0.00022 & 0.2252 \pm 0.0009 & 0.00415 \pm 0.00049 & \\
exp_n & 0.97425 \pm 0.00022 & 0.2253 \pm 0.0008 & 0.00413 \pm 0.00049 & \\
\hline
old_1 & 0.97423 & 0.22531 & 0.00299 & 0.01021 \\
old_2 & 0.97425 & 0.22536 & 0.00301 & 0.00474 \\
new_1 & 0.97423(4) & 0.22539(7) & 0.00299 & 0.00776(1) \\
new_2 & 0.97423[5] & 0.22538[42] & 0.00299 & 0.00793[466] \\
\hline
exp_o & 0.230 \pm 0.011 & 1.006 \pm 0.023 & 0.0409 \pm 0.0011 & \\
exp_n & 0.225 \pm 0.008 & 0.986 \pm 0.016 & 0.0411 \pm 0.0013 & \\
\hline
old_1 & 0.22526 & 0.97338 & 0.04238 & 0.00160 \\
old_2 & 0.22534 & 0.97336 & 0.04239 & 0.00212 \\
new_1 & 0.22534(3) & 0.97335 & 0.04245(6) & 0.00349(60) \\
new_2 & 0.22531[5] & 0.97336[5] & 0.04248 & 0.00002[216] \\
\hline
exp_o & 0.0084 \pm 0.0006 & 0.0429 \pm 0.0026 & 0.89 \pm 0.07 & \\
exp_n & 0.0084 \pm 0.0006 & 0.0400 \pm 0.0027 & 1.021 \pm 0.032 & \\
\hline
old_1 & 0.00663 & 0.04197 & 0.99910 & 0.00040 \\
old_2 & 0.00663 & 0.04198 & 0.99910 & 0.00021 \\
new_1 & 0.00667(6) & 0.04203(4) & 0.99909 & 0.00038 \\
new_2 & 0.00667 & 0.04206[5] & 0.99909 & 0.00024[21] \\
\hline
old_1 & 0.00959 & 0.00388 & 0.00031 & 0.99995 \\
old_2 & 0.00414 & 0.00315 & 0.00011 & 0.99999 \\
new_1 & 0.00677(60) & 0.00517(26) & 0.00020 & 0.99996 \\
new_2 & 0.00773 & 0.00178 & 0.00022 & 0.99997[9]
\end{array}\right) . \qquad (1)
$$

- The higher are the fourth family members masses, the closer are the mass matrices to the **democratic matrices** for either quarks or leptons,which is expected.

Mixing matrix and masses for quarks:

- **Any value for the fourth family masses, let say from arround 700 GeV (even lower) up to TeV (even higher), are possible.**

$$
\begin{aligned}
\mathbf{M}^{\mathbf{u}}_{\mathbf{d}}/MeV/c^2 &= (1.24703, 620.141, 172\,000., 1\,200\,000.)\,, \\
\mathbf{M}^{\mathbf{d}}_{\mathbf{d}}/MeV/c^2 &= (2.92494, 54.793, 2\,899., 1\,200\,000.)\,,
\end{aligned}
$$

-

$$
V_{ud} = \begin{pmatrix} 0.97425 & 0.22542 & 0.00299 & \mathbf{0.00466} \\ -0.22535 & 0.97335 & 0.04248 & -\mathbf{0.00216} \\ 0.00667 & -0.04205 & 0.99909 & -\mathbf{0.00021} \\ -\mathbf{0.00405} & -\mathbf{0.00316} & -\mathbf{0.00010} & \mathbf{0.99999} \end{pmatrix} .
$$

The fourth family matrix elements are not very sensitive to the fourth family quark masses.

Mass matrices of quarks:

- $$M^u = \begin{pmatrix} 354761. & 256877. & 257353. & 342539. \\ 256877. & 350107. & 342539. & 257353. \\ 257353. & 342539. & 336204. & 256877. \\ 342539. & 257353. & 256877. & 331550. \end{pmatrix},$$

- $$M^d = \begin{pmatrix} 300835. & 299263. & 299288. & 300710. \\ 299263. & 300714. & 300710. & 299288. \\ 299288. & 300710. & 300765. & 299263. \\ 300710. & 299288. & 299263. & 300644. \end{pmatrix},$$

The stable family of the upper four families group is the candidate to form the Dark Matter.

The upper four families are decoupled from the lower four families, but the mass matrices still manifest the $\widetilde{SU}(2)_{II\widetilde{SO}(3,1)} \times \widetilde{SU}(2)_{II\widetilde{SO}(4)}$ **symmetry**.

- Their masses are influenced by:
  o the $\widetilde{SU}(2)_{II\widetilde{SO}(3,1)} \times \widetilde{SU}(2)_{II\widetilde{SO}(4)}$ **scalar fields with the corresponding family quantum numbers**,
  o the scalars $(A^{Q}_{\substack{78\\(\mp)}}, A^{Q'}_{\substack{78\\(\mp)}}, A^{Y'}_{\substack{78\\(\mp)}})$, and
  o the condensate of the two right handed neutrinos of the upper four families.

- The baryons of the lowest (the stable one) contribute to the **Dark Matter.**
- With G. Bregar we investigate this possibility carefully.

  hep-ph/0711.4681, p.189-194; *Phys. Rev.* **D 80**, 083534 (2009).

- Since the masses of the fifth family lie much above the known three and the predicted fourth family masses, the baryons made out of the fifth family are heavy, forming small enough clusters with small enough scattering amplitude among themselves and with the ordinary matter to be the candidat for the **dark matter**.
- We make a rough estimation of properties of clusters of the members of the fifth family (u_5, d_5, ν_5, e_5), which have the properties of the lower four families: the same family members and interacting with the same gauge fields.
- We use a simple (Bohr like) model to estimate the size and the binding energy of the fifth family baryon, since the fifth family quarks are heavy enough to interact with one gluon exchange only.

- We estimate the behavior of such clusters in the evolution of the Universe.
- We estimate the behavior of such clusters when hitting our Earth, and in particular direct measurements of them, the DAMA/NaI and DAMA-LIBRA and other experiments measuring the dark matter, in dependence of the mass of the fifth family.
- **The elm. neutral fifth family baryons (neutrinos also contribute) form the dark matter.**
- **Direct measurements and cosmological evolution limit my fifth family mass** to $10\, TeV < m_{q_5} c^2 < 10^4\, TeV$.
- The dark matter baryons are opening an interesting new "fifth family nuclear" dynamics.

- The **spin-charge-family** theory is obviously offering also the explanation for the hierarchy problem. The mass matrices of the two four families groups are almost democratic, causing spreading of the fermion masses from 10^{16} GeV to 1 MeV (far below for leptons).

Can the spin-charge-family theory explain the smallness of the Dark energy?

It might be, if we find the Lagrange density, for which the number of boson states would be equal to the number of fermion states. There are $2^d \times d$ gauge fields involved in the Lagrangean

$$\mathcal{L}_f = \bar{\psi}\,\gamma^a (p_a - \sum_{n=0}^{d} \gamma^{a_1} \cdots \gamma^{a_n}\, \omega_{a_1 \cdots a_n})\,.$$

Without the factor d space degrees of freedom (which is indeed at most $d-2$ due to masslessness and gauge invariance of boson fields) the number of fermion states is equal to the number of boson states, each of them equal to 2^d.

Would this replace supersymmetry?

Scalar doublets, $s = (5, 6, 7, 8)$ and **scalar triplets and antitriplets**, $s = 9, 10, \ldots, 14$,

although they are scalars with either weak and hyper charge or the colour charge in the fundamental representations, **are certainly not a kind of supersymmetric particles:**

- **They have not appropriate "spinor charge"**, in the common laguage **R parity** and
- **they have all the other charges in the adjoint representations.**

To Summarize:

The spin-charge-family theory offers

- **a next step beyond the standard model, offering answers to several open questions. It explains:**
  o The origin of charges.
  o The origin of families.
  o The origin of scalar fields.
  o The origin of vector fields.
  o The properties of families.
  o The properties of scalar fields.
  o The properties of vector fields.
  o The origin of "ordinary" matter-antimatter asymmetry.
  o The origin of the dark matter.
  o It might hopefully explain, why is the dark energy so small!

- **The spin-charge-family theory predicts:**

  o New families, the fourth family will be observed at the LHC, the fifth one forms the dark matter.

  o New scalar fields, some of them measurable at the LHC, and also the $SU(2)_{II}$ vector gauge fields.

  o New "nuclear" matter made out of heavy stable family members.

- **Offers possible explanation:**

  o For the matter-antimatter asymmetry in the universe.

  o For the proton decay.

- **Should offer explanation for the smallness and the appearance of the dark energy.**

- **The dimension of space-time** **Dimension is larger than** 4 (very probably infinite).

- **o The spin-charge-family theory is expected to have many a thing in common with other proposed theories, models, ideas.**
- **o More than I am working on the spin-charge-family theory more phenomenological, directly or indirectly observed, properties appear to be describable within this project.**