The *Spin-Charge-Family-Theory*, which offers the mechanism for generating families, predicts the fourth family and explains the origin of the dark matter

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Collaborators on this project, which **S**usana **N**orma **M**ankoč **B**orštnik has started almost 15 years ago:
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- *Phys. Lett.* **B 292**, 25-29 (1992),
- *Modern Phys. Lett.* **A 10**, 587-595 (1995),
- *Int. J. Theor. Phys.* **40**, 315-337 (2001).
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- *Phys. Lett.* **B 633** (2006) 771-775, **B 644** (2007) 198-202, **B** (2008) 110.1016, (2006), hep-th/0311037, hep-th/0509101, with H.B.N.
- hep-ph/0401043, hep-ph/0401055, hep-ph/0301029,
- *Phys. Rev.* , **D 74** 073013-16 (2006), hep-ph/0512062, with A.B.B..
  hep-ph/0606159, with M.B., D.L..
- *New Jour. of Phys.* **10** (2008) 093002, hep-ph/0606159, hep/ph-07082846, with G.B., M.B., D.L.
- *Phys. Rev.* **D** (2009) 80.083534, astro-ph¿arXiv: 0907.0196, with G.B.

The **Spin-Charge-Family-Theory** is offering **the explanation for the existence of families, family members and for the appearance of mass matrices. It predicts more than three families and more than one scalar field**.

- Spinors carry (only) **two kinds of spin**. The **Dirac spin takes care in $d = 1 + 3$ of the spin and the charges** of quarks and leptons, the **second kind of spin generates families**.
- **A simple action in $d = (1 + 13)$ manifests** in $d = (1 + 3)$, after appropriate breaks of the starting symmetry, effectively the **standard model action** for fermions and gauge fields, predicting several scalar fields.

- It is a part of a simple starting Lagrange density for a spinor in $d = (1 + 13)$, which **manifests in $d = (1 + 3)$ the mass matrices on a tree level**.
- **The way of breaking symmetries determines the charges and the properties of families, as well as the coupling constants of the gauge fields**.
- There are **two times four families** with zero matrix elements among the members of the first and the second group of families. The three from the lowest four families are the observed ones, the **fourth family might** (as the first rough estimations show) **be seen at the LHC**. The lowest among the **decoupled** upper four families is the **candidate** for forming the **Dark matter** clusters.

The ACTION

There are **two kinds of the Clifford algebra objects**:

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

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

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

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

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

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

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

- I recognized: If γ^a **describe the spin and the charges of spinors,**
  describe $\tilde{\gamma}^a$ **their families**.

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

$$
\begin{aligned}
S &= \int d^dx\, E\, \mathcal{L}_f + \\
&\quad \int d^dx\, E\, (\alpha\, R + \tilde{\alpha}\, \tilde{R}) \\
\mathcal{L}_f &= \frac{1}{2}(E\bar{\psi}\,\gamma^a p_{0a}\psi) + h.c. \\
p_{0a} &= f^{\alpha}{}_a p_{0\alpha} + \frac{1}{2E}\,\{p_\alpha, Ef^{\alpha}{}_a\}_- \\
\mathbf{p}_{0\alpha} = \mathbf{p}_\alpha &\quad - \frac{\mathbf{1}}{\mathbf{2}}\mathbf{S}^{\mathbf{ab}}\omega_{\mathbf{ab}\alpha} - \frac{\mathbf{1}}{\mathbf{2}}\tilde{\mathbf{S}}^{\mathbf{ab}}\tilde{\omega}_{\mathbf{ab}\alpha}
\end{aligned}
$$

The Einstein action for a free gravitational field is assumed to be linear in the curvature

$$\begin{aligned}
\mathcal{L}_g &= E\,(\alpha_\omega\, R + \tilde{\alpha}_{\tilde{\omega}} \tilde{R}),\\
R &= f^{\alpha[a} f^{\beta b]}\,(\omega_{ab\alpha,\beta} - \omega_{ca\alpha}\omega^{c}{}_{b\beta}),\\
\tilde{R} &= f^{\alpha[a} f^{\beta b]}\,(\tilde{\omega}_{ab\alpha,\beta} - \tilde{\omega}_{ca\alpha}\tilde{\omega}^{c}{}_{b\beta}),
\end{aligned}$$

with $E = \det(e^{a}{}_{\alpha})$
and $f^{\alpha[a} f^{\beta b]} = f^{\alpha a} f^{\beta b} - f^{\alpha b} f^{\beta a}$.

The action for spinors can formally be rewritten as

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

$$
\tau^{Ai} = \sum_{a,b} c^{Ai}{}_{ab}\, S^{ab},
$$

$$
\{\tau^{Ai}, \tau^{Bj}\}_- = i\delta^{AB} f^{Aijk} \tau^{Ak}
$$

If there is no gravity in $d = (1+3)$ the vielbeins together with the two kinds of the spin connection fields are expected to manifest, after the break of symmetries, the effective action

$$
\begin{aligned}
S_b \;=\; & \int d^{(1+3)}x \,\{-\frac{\varepsilon^A}{4}\, \mathbf{F}^{\mathbf{Aimn}}\, \mathbf{F}^{\mathbf{Ai}}{}_{\mathbf{mn}} \\
& + \frac{1}{2}\,(m_{A_V i})^2\, \mathbf{A}^{\mathbf{Ai}}_{\mathbf{m}} \mathbf{A}^{\mathbf{Ai\,m}} \\
& + \text{contributions of scalar massive fields.}\}
\end{aligned}
$$

The summation over A, i is assumed.

Before the electroweak breaks

$$\mathbf{A} = 1 \quad \mathbf{U(1)} \text{ hyper charge} \quad i = \{1\} \qquad \cdots\cdots \text{usually } \mathbf{Y},$$
$$\mathbf{A} = 2 \quad \mathbf{SU(2)} \text{ weak charge} \quad i = \{1,2,3\} \qquad \cdots \text{usually } \tau^{\mathbf{i}},$$
$$\mathbf{A} = 3 \quad \mathbf{SU(3)} \text{ colour charge} \quad i = \{1,\cdots,8\} \qquad \cdots \text{usually } \lambda^{\mathbf{i}}/\mathbf{2},$$

and the family quantum numbers :

$$\tilde{\tilde{\tau}}^{\mathbf{2}}, \quad \tilde{\tilde{\mathbf{N}}}_{\mathbf{R}}, \text{with respect which the upper four families are doublets},$$
$$\tilde{\tilde{\tau}}^{\mathbf{1}}, \quad \tilde{\tilde{\mathbf{N}}}_{\mathbf{L}}, \text{with respect to which the lower four families are doublets},$$

all are generators of invariant subgroups of $SO(1,7)$.

After the electroweak break

$$\mathbf{A} = 1 \quad \mathbf{U(1)} \text{ elm charge} \quad i=\{1\} \qquad \cdots\cdots \text{usually } \mathbf{Q},$$
$$\mathbf{A} = 2 \text{ broken } \mathbf{SU(2)} \text{ charge} \quad i=\{+,-,3\} \quad \cdots \text{usually } \tau^{\pm}, \mathbf{Q}',$$
$$\mathbf{A} = 3 \quad \mathbf{SU(3)} \text{ colour charge} \quad i=\{1,\cdots,8\} \quad \cdots \text{usually } \lambda^{\mathbf{i}}/\mathbf{2},$$

family quantum numbers :

two groups of four families $\mathbf{\Sigma} = \mathbf{II}, \mathbf{I}$,

in each group the family index i $=\in (\mathbf{1}, \mathbf{2}, \mathbf{3}, \mathbf{4})$, There are (so far assumed) **breaks of the starting symmetries which make that only the measured gauge fields manifest at low energies**.

One Weyl spinor representation in $d = (1 + 13)$ with the

spin, determined by S^{ab} as the only internal degree of freedom of one family,

manifests, if analysed in terms of the subgroups

$SO(1,3) \times U(1) \times SU(2) \times SU(3)$,

in four-dimensional **"physical"** space

as the **ordinary spinor** with **all known charges** of **one family** of the **left handed weak charged** and the **right handed weak chargeless** quarks and leptons with the right handed neutrinos included.

The **second kind** of the Clifford algebra objects $\tilde{S}^{ab}$

takes care of **families**

by generating equivalent representations with respect to S^{ab}.

MASS MATRICES OF FERMIONS, SCALAR AND GAUGE FIELDS

A simple **action for massless spinors in $d = (1 + 13)$** **manifests in $d = (1 + 3)$** as the **standard model fermion action**, with **mass matrices** included. To the **mass matrices several scalar fields contribute on the tree and beyond the tree level**.

The **action for the two kinds of the spin connection fields**, linear in both curvatures, **manifests in $d = 1 + 3$** at low energies **scalar and gauge fields**.

The symmetry $SO(1,7) \times U(1)$ **breaks in two steps**:

$SO(1,7) \times U(1)_{II}$ into $SO(1,3) \times SU(2)_{I} \times SU(2)_{II} \times U(1)_{II}$
with **eight massless families**

then into $SO(1,3) \times SU(2)_{I} \times U(1)_{I}$

leading to **four massive families**,
decoupled from the **four** (three of them of the Standard model)
massless families

and then into $SO(1,3) \times U(1)$

with **two decoupled groups of massive four families of quarks and leptons**.

The mass matrices

$$\psi^{\dagger}\gamma^{0}\mathbf{M}\psi = \psi^{\dagger}\gamma^{0}\gamma^{s}\mathbf{p}_{0s}\psi$$
$$= \psi^{\dagger}\,\gamma^{0}\{\overset{78}{(+)}\;\mathbf{p}_{0+} + \overset{78}{(-)}\;\mathbf{p}_{0-}\}\psi,$$

$$\mathbf{p}_{0\pm} = (\mathbf{p}_{7} \mp \mathbf{i}\;\mathbf{p}_{8}) - \frac{1}{2}\mathbf{S}^{\mathbf{ab}}\omega_{\mathbf{ab}\pm} - \frac{1}{2}\tilde{\mathbf{S}}^{\mathbf{ab}}\tilde{\omega}_{\mathbf{ab}\pm},$$

$$\omega_{ab\pm} = \omega_{ab7} \mp i\;\omega_{ab8},$$
$$\tilde{\omega}_{ab\pm} = \tilde{\omega}_{ab7} \mp i\;\tilde{\omega}_{ab8}$$

We put $p_7 = p_8 = 0$.

The **vielbeins** together with the two kinds of **spin connection fields** in $d > (1+3)$ manifest in $d = (1+3)$ massless and massive **gauge fields**

$$e^{a}{}_{\alpha} = \begin{pmatrix} \delta^{m}{}_{\mu} & e^{m}{}_{\sigma} = 0 \\ e^{s}{}_{\mu} = e^{s}{}_{\sigma}\mathbf{E}^{\sigma}{}_{\mathbf{Ai}}\mathbf{A}^{\mathbf{Ai}}_{\mu} & \mathbf{e}^{\mathbf{s}}{}_{\sigma} \end{pmatrix}$$

Here $\mathbf{E}^{\sigma}{}_{\mathbf{Ai}}\,\mathbf{A}^{\mathbf{Ai}}_{\mu}$ stays for $\tau^{\mathbf{Ai}}\,x^{\sigma}\;\mathbf{A}^{\mathbf{Ai}}_{\mu}$.

A= 1 $\cdots$ the **U(1) field**, **A= 2** $\cdots$ the **weak field**, **A= 3** $\cdots$ the **colour field**,

The **vielbeins** and the two kinds of **spin connection fields** manifest in $d = (1+3)$ also massive **scalar fields**.

- To the break of symmetries from $SU(2)_I \times SU(2)_{II} \times U(1)_{II}$ to $SU(2)_I \times U(1)_I$ only scalar fields which are triplets with repect to $\vec{\tilde{\tau}}^2$ and $\vec{\tilde{N}}_R$ (are assumed to) contribute.
  $\mathbf{\tilde{A}_s^{2i}}$, $\mathbf{\tilde{A}_s^{\tilde{N}_R i}}$.
- To the break of symmetries from $SU(2)_I \times U(1)_I$ to $U(1)$ both kinds of scalar fields (are assumed) to contribute, those which are triplets with repect to $\vec{\tilde{\tau}}^1$ and $\vec{\tilde{N}}_L$
  $\mathbf{\tilde{A}_s^{1i}}$, $\mathbf{\tilde{A}_s^{\tilde{N}_L i}}$
  and singlets
  $\mathbf{A_s^{Y'}}$, $\mathbf{A_s^{Q'}}$, $\mathbf{A_s^{Q}}$.

Our technique to represent spinor states

Our technique to represent spinors works elegantly.

- *J. of Math. Phys.* **43**, 5782-5803 (2002), hep-th/0111257,
- *J. of Math. Phys.* **44** 4817-4827 (2003), hep-th/0303224, both 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**

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

$$
\begin{aligned}
\gamma^{\mathbf{a}} \overset{\mathbf{ab}}{(\mathbf{k})} &= \eta^{aa}\overset{\mathbf{ab}}{[-\mathbf{k}]}, \quad \gamma^{\mathbf{b}} \overset{\mathbf{ab}}{(\mathbf{k})} = -ik\overset{\mathbf{ab}}{[-\mathbf{k}]},\\
\gamma^{\mathbf{a}} \overset{\mathbf{ab}}{[\mathbf{k}]} &= \overset{\mathbf{ab}}{(-\mathbf{k})}, \qquad \gamma^{\mathbf{b}} \overset{\mathbf{ab}}{[\mathbf{k}]} = -ik\eta^{aa}\overset{\mathbf{ab}}{(-\mathbf{k})}
\end{aligned}
$$

$$
\begin{aligned}
\tilde{\gamma}^{\mathbf{a}} \overset{\mathbf{ab}}{(\mathbf{k})} &= -i\eta^{aa}\overset{\mathbf{ab}}{[\mathbf{k}]}, \quad \tilde{\gamma}^{\mathbf{b}} \overset{\mathbf{ab}}{(\mathbf{k})} = -k\overset{\mathbf{ab}}{[\mathbf{k}]},\\
\tilde{\gamma}^{\mathbf{a}} \overset{\mathbf{ab}}{[\mathbf{k}]} &= i\overset{\mathbf{ab}}{(\mathbf{k})}, \qquad \tilde{\gamma}^{\mathbf{b}} \overset{\mathbf{ab}}{[\mathbf{k}]} = -k\eta^{aa}\overset{\mathbf{ab}}{(\mathbf{k})}.
\end{aligned}
$$

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

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

Our technique

$$\stackrel{ab}{(\mathbf{k})}\stackrel{ab}{(\mathbf{k})} = 0, \quad \stackrel{ab}{(\mathbf{k})}\stackrel{ab}{(-\mathbf{k})} = \eta^{aa}\stackrel{ab}{[\mathbf{k}]}, \quad \stackrel{ab}{[\mathbf{k}]}\stackrel{ab}{[\mathbf{k}]} = \stackrel{ab}{[\mathbf{k}]},$$

$$\stackrel{ab}{[\mathbf{k}]}\stackrel{ab}{[-\mathbf{k}]} = 0, \quad \stackrel{ab}{(\mathbf{k})}\stackrel{ab}{[\mathbf{k}]} = 0, \quad \stackrel{ab}{[\mathbf{k}]}\stackrel{ab}{(\mathbf{k})} = \stackrel{ab}{(\mathbf{k})},$$

$$\stackrel{ab}{(\mathbf{k})}\stackrel{ab}{[-\mathbf{k}]} = \stackrel{ab}{(\mathbf{k})}, \quad \stackrel{ab}{[\mathbf{k}]}\stackrel{ab}{(-\mathbf{k})} = 0.$$

$$\stackrel{ab}{(\tilde{\mathbf{k}})}\stackrel{ab}{(\mathbf{k})} = 0, \quad \stackrel{ab}{(-\tilde{\mathbf{k}})}\stackrel{ab}{(\mathbf{k})} = -i\eta^{aa}\stackrel{ab}{[\mathbf{k}]},$$

$$\stackrel{ab}{(\tilde{\mathbf{k}})}\stackrel{ab}{[\mathbf{k}]} = i\stackrel{ab}{(\mathbf{k})}, \quad \stackrel{ab}{(\tilde{\mathbf{k}})}\stackrel{ab}{[-\mathbf{k}]} = 0.$$

$$\stackrel{ab}{(\tilde{\pm}\mathbf{i})} = \frac{1}{2}(\tilde{\gamma}^{\mathbf{a}} \mp \tilde{\gamma}^{\mathbf{b}}), \quad \stackrel{ab}{(\tilde{\pm}\mathbf{1})} = \frac{1}{2}(\tilde{\gamma}^{\mathbf{a}} \pm \mathbf{i}\tilde{\gamma}^{\mathbf{b}}),$$

The representation of a left handed Weyl spinor in $d = (1 + 13)$, if analysed in terms of the "standard model" symmetries

The representations of families, scalar and gauge fields define the operators:

$SO(1,3)$, the symmetry in $d=(1+3)$ originating in $SO(1,7)$

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

$\vec{\tilde{N}}_{\pm} = \frac{1}{2}\,(\tilde{S}^{23} \pm i\tilde{S}^{01},\, \tilde{S}^{31} \pm i\tilde{S}^{02},\, \tilde{S}^{12} \pm i\tilde{S}^{03})$,

$SU(2)\times SU(2)$, that is of $SO(4)$ originating in $SO(1,7)$

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

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

$SU(3)\times U(1)$ originating in $SO(6)$

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

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

and equivalently in the $\tilde{S}^{ab}$ sector.

Cartan subalgebra set of the algebra S^{ab} (for both sectors):

$$S^{03}, S^{12}, S^{56}, S^{78}, S^{9\,10}, S^{11\,12}, S^{13\,14},$$
$$\tilde{S}^{03}, \tilde{S}^{12}, \tilde{S}^{56}, \tilde{S}^{78}, \tilde{S}^{9\,10}, \tilde{S}^{11\,12}, \tilde{S}^{13\,14}.$$

A left handed ($\Gamma^{(1,13)} = -1$) eigen state of all the members of the Cartan subalgebra

$$\overset{03}{(+\mathbf{i})}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\;\overset{11\,12}{(-)}\;\overset{13\,14}{(-)}\; |\psi\rangle =$$
$$\frac{1}{2^7}(\gamma^0 - \gamma^3)(\gamma^1 + \mathbf{i}\gamma^2)|(\gamma^5 + \mathbf{i}\gamma^6)(\gamma^7 + \mathbf{i}\gamma^8)||$$
$$(\gamma^9 + \mathbf{i}\gamma^{10})(\gamma^{11} - \mathbf{i}\gamma^{12})(\gamma^{13} - \mathbf{i}\gamma^{14})|\psi\rangle.$$

S^{ab} generate **the members of one family**. The eightplet (the representation of $SO(1,7)$) of quarks of a particular colour charge ($\tau^{33}=1/2$, $\tau^{38}=1/(2\sqrt{3})$, and $\tau^{41}=1/6$)

i		$\vert^a\psi_i>$	$\Gamma^{(1,3)}$	S^{12}	$\Gamma^{(4)}$	τ^{13}	τ^{21}	Y	Y'
		Octet, $\Gamma^{(1,7)}=1$, $\Gamma^{(6)}=-1$, of quarks							
1	$\mathbf{u_R^{c1}}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$	1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$-\frac{1}{3}$
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	$\frac{1}{2}$	$\frac{2}{3}$	$-\frac{1}{3}$
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	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{2}{3}$
4	$\mathbf{d_R^{c1}}$	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \mid \stackrel{56}{[-]}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$	1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{2}{3}$
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	$\mathbf{d_L^{c1}}$	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \mid \stackrel{56}{[-]}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$	-1	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
7	$\mathbf{u_L^{c1}}$	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$	-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	$\frac{1}{6}$	$\frac{1}{6}$

$\psi^{\dagger}\,\gamma^0\{\stackrel{78}{(+)}\;p_{0+}+\stackrel{78}{(-)}\;p_{0-}\}\psi$, $\gamma^0\,\stackrel{78}{(-)}$ transforms $\mathbf{u_R}$ of the 1^{st} row into $\mathbf{u_L}$ of the 7^{th} row, while $\gamma^0\,\stackrel{78}{(+)}$ transforms $\mathbf{d_R}$ of the 4^{rd} row into $\mathbf{d_L}$ of the 6^{th} row, doing what the Higgs and γ^0 do in the Stan. model.

$\tilde{\mathbf{S}}^{ab}$ generate families. **Both vectors below**, the second following from the first after the application of $\tilde{S}^{01}$, **describe** a **right handed u-quark of the same spin and colour**.

$$
\begin{gathered}
\tilde{S}^{01}\ \text{applied on} \\
\stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)} \quad \text{generates} \\
\stackrel{03}{[+i]}\stackrel{12}{[+]} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}\,.
\end{gathered}
$$

Eight families of u_R with the spin $1/2$ of a particular colour and of a **colourless** ν_R :

I_R	u_R^{c1}	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\,|\,\stackrel{56}{(+)}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\,|\,\stackrel{56}{(+)}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
II_R	u_R^{c1}	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\,|\,\stackrel{56}{[+]}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\,|\,\stackrel{56}{[+]}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
III_R	u_R^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\,|\,\stackrel{56}{(+)}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\,|\,\stackrel{56}{(+)}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
IV_R	u_R^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\,|\,\stackrel{56}{[+]}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\,|\,\stackrel{56}{[+]}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
V_R	u_R^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\,|\,\stackrel{56}{(+)}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\,|\,\stackrel{56}{(+)}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
VI_R	u_R^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\,|\,\stackrel{56}{[+]}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\,|\,\stackrel{56}{[+]}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
VII_R	u_R^{c1}	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\,|\,\stackrel{56}{(+)}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\,|\,\stackrel{56}{(+)}\stackrel{78}{(+)}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$
$VIII_R$	u_R^{c1}	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\,|\,\stackrel{56}{[+]}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	ν_R	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\,|\,\stackrel{56}{[+]}\stackrel{78}{[+]}\,||\,\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$

Before the break of $SO(1,3)\times$ $\mathbf{SU(2)_I}$ $\times$ $\mathbf{SU(2)_{II}}$ $\times\mathbf{U(1)_{II}}\times SU(3)$ into $SO(1,3)\times$ $\mathbf{SU(2)_I}\times$ $\mathbf{U(1)_I}\times SU(3)$ all the eight families are massless.

Quantum numbers of the eight families, the same for each member of a particular family

i	$\tilde{\Gamma}^{(1+3)}$	$\tilde{S}^{03}_{L}$	$\tilde{S}^{12}_{L}$	$\tilde{S}^{03}_{R}$	$\tilde{S}^{12}_{R}$	$\tilde{\tau}^{13}$	$\tilde{\tau}^{23}$	$\tilde{\tau}^{4}$	$\tilde{Y}$
1	-1	$-\frac{i}{2}$	$\frac{1}{2}$	0	0	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{2}$
2	-1	$-\frac{i}{2}$	$\frac{1}{2}$	0	0	$-\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{2}$
3	-1	$\frac{i}{2}$	$-\frac{1}{2}$	0	0	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{2}$
4	-1	$\frac{i}{2}$	$-\frac{1}{2}$	0	0	$-\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{2}$
5	1	0	0	$\frac{i}{2}$	$\frac{1}{2}$	0	$\frac{1}{2}$	$-\frac{1}{2}$	0
6	1	0	0	$\frac{i}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{2}$	-1
7	1	0	0	$-\frac{i}{2}$	$-\frac{1}{2}$	0	$\frac{1}{2}$	$-\frac{1}{2}$	0
8	1	0	0	$-\frac{i}{2}$	$-\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{2}$	-1

Quantum numbers of the members – quarks and leptons, left and right handed – of any of the eight families ($i \in \{1, \cdots, 8\}$) presented above

	$\Gamma^{(1+3)}$	S^{03}_L	S^{12}_L	S^{03}_R	S^{12}_R	τ^{13}	τ^{23}	Y	Q	$SU(3)$
u_{Li}	-1	$\mp\frac{i}{2}$	$\pm\frac{1}{2}$	0	0	$\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{2}{3}$	triplet
d_{Li}	-1	$\mp\frac{i}{2}$	$\pm\frac{1}{2}$	0	0	$-\frac{1}{2}$	0	$\frac{1}{6}$	$-\frac{1}{3}$	triplet
ν_{Li}	-1	$\mp\frac{i}{2}$	$\pm\frac{1}{2}$	0	0	$\frac{1}{2}$	0	$-\frac{1}{2}$	0	singlet
e_{Li}	-1	$\mp\frac{i}{2}$	$\pm\frac{1}{2}$	0	0	$-\frac{1}{2}$	0	$-\frac{1}{2}$	-1	singlet
u_{Ri}	1	0	0	$\pm\frac{i}{2}$	$\pm\frac{1}{2}$	0	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{2}{3}$	triplet
d_{Ri}	1	0	0	$\pm\frac{i}{2}$	$\pm\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$-\frac{1}{3}$	triplet
ν_{Ri}	1	0	0	$\pm\frac{i}{2}$	$\pm\frac{1}{2}$	0	$\frac{1}{2}$	0	0	singlet
e_{Ri}	1	0	0	$\pm\frac{i}{2}$	$\pm\frac{1}{2}$	0	$-\frac{1}{2}$	-1	-1	singlet

BREAKING THE STARTING SYMMETRY SO(1,13)

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

$$
\begin{array}{c}
\mathbf{SO(1,13)} \\
\textbf{BREAK I} \\
\downarrow \\
\mathbf{SO(1,7)} \times \qquad \mathbf{U(1)} \times \qquad \mathbf{SU(3)} \\
\swarrow \qquad \text{eight massless families} \qquad \searrow \\
\mathbf{SO(1,3)} \times \mathbf{SO(4)} \times \mathbf{U(1)} \times \quad (\text{eight massless families}) \quad \mathbf{SU(3)} \\
\textbf{BREAK IIa} \\
\underbrace{\mathbf{SO(1,3)} \times \mathbf{SU(2)} \times \mathbf{U(1)} \times \quad (\text{four families stay massless,}) \quad (\text{four families obtain masses}) \quad \mathbf{SU(3)}} \\
\downarrow \\
\textbf{BREAK IIb} \\
\text{The Standard Model type of breaking} \\
\downarrow \\
\mathbf{SO(1,3)} \times \mathbf{U(1)} \times \mathbf{SU(3)}
\end{array}
$$

Vector bosons, scalar fields and fermion mass matrices after the breaks

The break from
$SO(1,3) \times SU(2)_I \times SU(2)_{II} \times U(1)_{II} \times SU(3)$ to
$SO(1,3) \times SU(2)_I \times U(1)_I \times SU(3)$

$$
\begin{aligned}
A^{23}_m &= A^{Y}_m \sin\theta_2 + A^{Y'}_m \cos\theta_2, \quad A^{4}_m = A^{Y}_m \cos\theta_2 - A^{Y'}_m \sin\theta_2,\\
A^{2\pm}_m &= \frac{1}{\sqrt{2}}(A^{21}_m \mp i A^{22}_m),\\
\tilde{A}^{23}_s &= \tilde{A}^{\tilde{Y}}_s \sin\tilde{\theta}_2 + \tilde{A}^{\tilde{Y}'}_s \cos\tilde{\theta}_2, \quad \tilde{A}^{4}_s = \tilde{A}^{\tilde{Y}}_s \cos\tilde{\theta}_2 - \tilde{A}^{\tilde{Y}'}_s \sin\tilde{\theta}_2,\\
\tilde{A}^{2\pm}_s &= \frac{1}{\sqrt{2}}(\tilde{A}^{21}_s \mp i \tilde{A}^{22}_s),
\end{aligned}
$$

for $m = 0,1,2,3$, $s = 7,8$ and particular values of θ_2 and $\tilde{\theta}_2$.
The scalar fields ($\tilde{A}^{\tilde{Y}'}_s$, $\tilde{A}^{2\pm}_s$, $\tilde{A}^{\tilde{N}_R i}_s$, $i = 1,2,3,$) (are assumed to) have nonzero vacuum expectation values.

Mass matrices of **quarks and leptons** after the **break of** $SU(2)_I \times SU(2)_{II} \times U(1)_{II}$ **into** $SU(2)_I \times U(1)_I$ on a **tree level**.

Σ_i	I_1	I_2	I_3	I_4	II_1	II_2	II_3	II_4
I_1	**0**	**0**	**0**	**0**	0	0	0	0
I_2	**0**	**0**	**0**	**0**	0	0	0	0
I_3	**0**	**0**	**0**	**0**	0	0	0	0
I_4	**0**	**0**	**0**	**0**	0	0	0	0
II_1	0	0	0	0	$\frac{1}{2}(\tilde{a}^{23}_{\pm} + \tilde{a}^{\tilde{N}^3_R}_{\pm})$	$-\tilde{a}^{\tilde{N}^-_R}_{\pm}$	**0**	$-\tilde{a}^{2-}_{\pm}$
II_2	0	0	0	0	$-\tilde{a}^{\tilde{N}^+_R}_{\pm}$	$\frac{1}{2}(-\tilde{a}^{23}_{\pm} + \tilde{a}^{\tilde{N}^3_R}_{\pm})$	$-\tilde{a}^{2-}_{\pm}$	**0**
II_3	0	0	0	0	**0**	$-\tilde{a}^{2+}_{\pm}$	$\frac{1}{2}(\tilde{a}^{23}_{\pm} - \tilde{a}^{\tilde{N}^3_R}_{\pm})$	$-\tilde{a}^{\tilde{N}^-_R}_{\pm}$
II_4	0	0	0	0	$-\tilde{a}^{2+}_{\pm}$	**0**	$-\tilde{a}^{\tilde{N}^+_R}_{\pm}$	$\frac{1}{2}(\tilde{a}^{23}_{\pm} + \tilde{a}^{\tilde{N}^3_R}_{\pm})$

It then follows that
the gauge fields ($\mathbf{A^{Y'}_m}$, $\mathbf{A^{2\pm}_m}$) "of the charges "

$\mathbf{Y'} = \tau^{\mathbf{23}} + \tau^{\mathbf{4}} \tan^2 \theta_2$,
$\tau^{\mathbf{2\pm}} = \frac{1}{2}\,((\mathbf{S^{58}} + \mathbf{S^{67}}) \pm i(\mathbf{S^{57}} - \mathbf{S^{68}}))$,
manifest as massive fields.

There are nonzero vacuum expectation values of the scalar fields ($\tilde{\mathbf{A}}^{\tilde{\mathbf{Y}}'}_{\mathbf{s}}$, $\tilde{\mathbf{A}}^{\mathbf{2\pm}}_{\mathbf{s}}$), and of ($\tilde{\mathbf{A}}^{\tilde{\mathbf{N}}_{\mathbf{R}}\mathbf{i}}_{\mathbf{s}}$, $i = 1, 2, 3,$).

The break from $SO(1,3) \times SU(2)_I \times U(1)_I \times SU(3)$ to $SO(1,3) \times U(1) \times SU(3)$ leads to gauge and scalar fields:

$$
\begin{aligned}
A^{13}_m &= A_m \sin\theta_1 + Z_m \cos\theta_1 ,\\
A^{Y}_m &= A_m \cos\theta_1 - Z_m \sin\theta_1 ,\\
W^{\pm}_m &= \frac{1}{\sqrt{2}}(A^{11}_m \mp i A^{12}_m),\\
\tilde{A}^{13}_s &= \tilde{A}^{\tilde{Q}}_s \sin\tilde{\theta}_1 + \tilde{A}^{\tilde{Q}'}_s \cos\tilde{\theta}_1 ,\\
\tilde{A}^{Y}_s &= \tilde{A}^{\tilde{Q}}_s \cos\tilde{\theta}_1 - \tilde{A}^{\tilde{Q}'}_s \sin\tilde{\theta}_1 ,\\
\tilde{A}^{1\pm}_s &= \frac{1}{\sqrt{2}}(\tilde{A}^{11}_s \mp i \tilde{A}^{12}_s),\\
& A^{Y'}_s, \quad A^{Q'}_s, \quad A^{Q}_s .
\end{aligned}
$$

for $m = 0,1,2,3$, $s = 7,8$, and particular values of $\theta_1 = \theta_w$ and $\tilde{\theta}_1$. are assumed to have nonzero vacuum expectation values.

Mass matrices of **quarks and leptons** after the **break of** $SU(2)_I \times U(1)_I$ **into** $U(1)$ on a **tree level**.

To mass matrices besides $\tilde{A}^{1i}_s$, $\tilde{A}^{\tilde{Y}'}$ and $\tilde{A}^{\tilde{N}_L i}$, also $A^{Y'}_s$, $A^{Q'}_s$ and A^{Q}_s contribute.

	I_1	I_2	I_3	I_4
I_1	$-\frac{1}{2}\,(\tilde{a}^{13}_{\pm} + \tilde{a}^{\tilde{N}^3_L}_{\pm})$	$\tilde{a}^{\tilde{N}^-_L}_{\pm}$	0	$\tilde{a}^{1-}_{\pm}$
I_2	$\tilde{a}^{\tilde{N}^+_L}_{\pm}$	$\frac{1}{2}(-\tilde{a}^{13}_{\pm} + \tilde{a}^{\tilde{N}^3_L}_{\pm})$	$\tilde{a}^{1-}_{\pm}$	0
I_3	0	$\tilde{a}^{1+}_{\pm}$	$\frac{1}{2}\,(\tilde{a}^{13}_{\pm} - \tilde{a}^{\tilde{N}^3_L}_{\pm})$	$\tilde{a}^{\tilde{N}^-_L}_{\pm}$
I_4	$\tilde{a}^{1+}_{\pm}$	0	$\tilde{a}^{\tilde{N}^+_L}_{\pm}$	$\frac{1}{2}\,(\tilde{a}^{13}_{\pm} + \tilde{a}^{\tilde{N}^3_L}_{\pm})$

It then follows that the gauge fields

$\mathbf{A^{Q'}_m} = \mathbf{Z_m}, \quad \mathbf{A^{1\pm}_m} = \mathbf{W^{\pm}_m}$
"of the charges "
$\mathbf{Q'} = \tau^{\mathbf{13}} + \mathbf{Y} \tan^2\theta_1,$
$\tau^{\mathbf{1\pm}} = \frac{1}{2}((\mathbf{S^{58}} - \mathbf{S^{67}}) \pm i(\mathbf{S^{57}} + \mathbf{S^{68}})),$
manifest as massive fields,
while the gauge field

$\mathbf{A^{Q}_m} = \mathbf{A_m}$
"of the charge"
$\mathbf{Q} = \tau^{\mathbf{4}} + \mathbf{S^{56}}$
stays massless, in agreement with the Standard model.

- The **electroweak break** influences the lower (strongly) and the upper (slightly) four families.
- For each family member $\alpha \in (\mathbf{u}\,, \mathbf{d}\,, \nu\,, \mathbf{e})$ are the vacuum expectation values of $\mathbf{A}^{\mathbf{Y}'}_{\mathbf{s}}$, $\mathbf{A}^{\mathbf{Q}'}_{\mathbf{s}}$, $\mathbf{A}^{\mathbf{Q}}_{\mathbf{s}}$ the same for all eight families.
  Therefore **on the tree level the mass matrices** of $\mathbf{u}$ and ν are strongly correleted and so are those of $\mathbf{d}$ and $\mathbf{e}$.
- In loop corrections all the fields $\mathbf{A}^{\mathbf{Y}'}_{\mathbf{m}}$, $\mathbf{A}^{\mathbf{Q}'}_{\mathbf{m}}$, $\mathbf{A}^{\mathbf{Y}'}_{\mathbf{s}}$, $\mathbf{A}^{\mathbf{Q}'}_{\mathbf{s}}$, $\mathbf{A}^{\mathbf{Q}}_{\mathbf{s}}$, as well as $\tilde{\mathbf{A}}^{(2,1)\mathbf{i}}_{\mathbf{s}}$ and $\tilde{\mathbf{A}}^{\tilde{\mathbf{N}}_{(\mathbf{R},\mathbf{L})}\mathbf{i}}_{\mathbf{s}}$ start to contribute **coherently**.

The effective Lagrange density for spinors is after the electroweak break as follows

$$
\begin{aligned}
\mathcal{L}_{\mathbf{f}} &= \bar{\psi}\,(\gamma^{\mathbf{m}}\,\mathbf{p_{0m}} - \mathbf{M})\psi\,,\\
p_{0m} &= p_m - \{e\,Q\,A_m + g^1 \cos\theta_1\, Q'\, Z^{Q'}_m + \frac{g^1}{\sqrt{2}}\,(\tau^{1+}W^{1+}_m + \tau^{1-}W^{1-}_m \\
&+ g^2 \cos\theta_2\, Y'\, A^{Y'}_m + \frac{g^2}{\sqrt{2}}\,(\tau^{2+}A^{2+}_m + \tau^{2-}A^{2-}_m)\,,\\
\bar{\psi}\,\mathbf{M}\,\psi &= \bar{\psi}\,\gamma^{\mathbf{s}}\,\mathbf{p_{0s}}\psi\\
p_{0s} &= p_s - \{\tilde{g}^{\tilde{N}_R}\,\vec{\tilde{N}}_R\vec{\tilde{A}}^{\tilde{N}_R}_s + \tilde{g}^{\tilde{Y}'}\,\tilde{Y}'\,\tilde{A}^{\tilde{Y}'}_s + \frac{\tilde{g}^2}{\sqrt{2}}\,(\tilde{\tau}^{2+}\,\tilde{A}^{2+}_s + \tilde{\tau}^{2-}\,\tilde{A}^{2-}_s)\\
&+ \tilde{g}^{\tilde{N}_L}\vec{\tilde{N}}_L\vec{\tilde{A}}^{\tilde{N}_L}_s + \tilde{g}^{\tilde{Q}'}\,\tilde{Q}'\tilde{A}^{\tilde{Q}'}_s + \frac{\tilde{g}^1}{\sqrt{2}}\,(\tilde{\tau}^{1+}\,\tilde{A}^{1+}_s + \tilde{\tau}^{1-}\,\tilde{A}^{1-}_s)\\
&+ e\,Q\,A_s + g^1\,\cos\theta_1\,Q'\,Z^{Q'}_s + g^2\cos\theta_2\,Y'\,A^{Y'}_s\,\}\,.
\end{aligned}
$$

It is a hope that the mass matrices, strongly correlated on the tree level, will after the loop corrections (in all orders) manifest the properties

$$\mathbf{M} = \sum_{k=0,k'=0,k''=0}^{\infty} Q^k \, Q'^{k'} \, Y'^{k''} \, \mathbf{M}_{QQ'Y'\,kk'k''} \,, \tag{2}$$

There is a term in loop corrections which might contribute a lot to properties of neutrinos, since it transforms a right handed neutrino into his left handed charge conjugated partner

$$\psi^{\dagger}\,\gamma^{\mathbf{0}}\,\overset{\mathbf{78}}{(-)}\,\mathbf{p_{0-}}\,\psi\,,$$
$$p_{0-} = -(\tilde{\tau}^{1+}\,\tilde{A}^{1+}_{-} + \tilde{\tau}^{1-}\,\tilde{A}^{1-}_{-})\,\mathcal{O}^{[+]}\,\mathcal{A}^{\mathcal{O}}_{[+]},$$
$$\mathcal{O}^{[+]} = \overset{78}{[+]}\,\overset{56}{(-)}\,\overset{9\,10}{(-)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}\,.$$

It is chosen to contribute to only the lower group of four families.

Mass matrices manifest, on the tree level as well as with all the loop corrections, twice four by diagonal matrices

$$\mathbf{M}^{\alpha} = \begin{pmatrix} \mathbf{M}^{\alpha\, \mathbf{II}} & 0 \\ 0 & \mathbf{M}^{\alpha\, \mathbf{I}} \end{pmatrix}.$$

On the tree level we have for each $\alpha = \{u, d, \nu, e\}$ and each group of four families $\Sigma = II, I$

$$\mathcal{M}_{(o)} = \begin{pmatrix} -a_2 & e & b & 0 \\ e & -a_1 & 0 & b \\ b & 0 & a_1 & e \\ 0 & b & e & a_2 \end{pmatrix},$$

All the matrix elements are expressible with the vacuum expectation values of the scalar fields originating in ω's and $\tilde{\omega}$'s and with loop corrections to which dynamical scalar fields and massive gauge fields contribute.

The mass matrices have on the tree level only a few parameters. The off diagonal terms are the same for u-quarks and ν-leptons and the same for d-quarks and e-leptons, that is they are strongly correlated.

With Albino Hernandez Galeana we are in progress studying properties of mass matrices in loop corrections

$$\begin{aligned} \psi^{\alpha}_{\Sigma\,(L,R)} &= V^{\alpha}_{\Sigma}\, \Psi^{\alpha}_{\Sigma\,(L,R)}\,, \\ V^{\alpha}_{\Sigma} &= V^{\alpha}_{\Sigma\,(o)}\, V^{\alpha}_{\Sigma\,(1)} \cdots V^{\alpha}_{\Sigma\,(k)} \cdots . \end{aligned}$$

$\Psi^{\alpha\,(k)}_{\Sigma(L,R)}$ includes up to (k) loops corrections

$$\begin{aligned} V^{\alpha}_{\Sigma\,(o)}\, \Psi^{\alpha\,(o)}_{\Sigma\,(L,R)} &= \psi^{\alpha}_{\Sigma\,(L,R)}\,, \\ V^{\alpha}_{\Sigma\,(o)}\, V^{\alpha}_{\Sigma\,(1)} \cdots V^{\alpha}_{\Sigma\,(k)}\, \Psi^{\alpha\,(k)}_{\Sigma(L,R)} &= \psi^{\alpha}_{\Sigma(L,R)}\,, \end{aligned}$$

with $\psi^{\alpha}_{\Sigma\,(L,R)}$ representing massless states and $\Psi^{\alpha\,(o)}_{\Sigma\,(L,R)}$ the massive ones. We shall check also the Majorana type of contributions, which manifest for neutrinos.

Taking the tree level parameters as free, as well as the masses of gauge fields and scalar dynamical fields involved in the loop corrections, we study mass matrices with one and (may be) two loop corections:

- **The properties of the upper massive four families**. In particular of the **stable** one, since it might **explain the dark matter**.
- **The properties of the lower four families to show that loop corrections influence drastically the tree level mass matrices** leading to **measurable properties of the lower three families and predicting properties of the fourth family**, more accurately than we have succeded so far.

- The properties of the lower four families from New Jour. of Phys. **10** (2008) 093002, under the assumptions which we are now proving.

For the **u**-quarks the mass matrix is as follows

$$\begin{pmatrix} (9,22) & (-150,-83) & 0 & (-306,304) \\ (-150,-83) & (1211,1245) & (-306,304) & 0 \\ 0 & (-306,304) & (171600,176400) & (-150,-83) \\ (-306,304) & 0 & (-150,-83) & 200000 \end{pmatrix}$$

and for the **d**-quarks the mass matrix is

$$\begin{pmatrix} (5,11) & (8.2,14.5) & 0 & (174,198) \\ (8.2,14.5) & (83,115) & (174,198) & 0 \\ 0 & (174,198) & (4260,4660) & (8.2,14.5) \\ (174,198) & 0 & (8.2,14.5) & 200000 \end{pmatrix}.$$

This corresponds to the following values for the masses of the **u** and the **d** quarks (**the fourth family masses are assumed**)

$$
\begin{aligned}
m_{u_i}/GeV &= (0.005, 1.220, 171., 215.),\\
m_{d_i}/GeV &= (0.008, 0.100, 4.500, 285.),
\end{aligned}
$$

and the mixing matrix for the quarks

$$
\begin{pmatrix}
-0.974 & -0.226 & -0.00412 & \mathbf{0.00218}\\
0.226 & -0.973 & -0.0421 & \mathbf{-0.000207}\\
0.0055 & -0.0419 & 0.999 & \mathbf{0.00294}\\
\mathbf{0.00215} & \mathbf{0.000414} & \mathbf{-0.00293} & \mathbf{0.999}
\end{pmatrix}.
$$

- Below the tree level the contributions from the massive gauge fields ($\mathbf{Z_m}, \mathbf{W^{\pm}_m}$) and the dynamical massive scalar fields ($\tilde{\tilde{\mathbf{A}}}^{1\pm}_{\mathbf{s}}, \tilde{\mathbf{A}}^{\tilde{\mathbf{Q}}'}_{\mathbf{s}}$) are studied.
- Rough estimations done so far predict that the **fourth family might be seen at the LHC or at somewhat higher energies.**

The scalar fields contributing to masses of fermions and gauge bosons in the **spin-charge-family-theory**

$$\begin{aligned}\hat{\phi} \;&=\; \overset{78}{(\mp)}\; \{\tilde{g}^{\tilde{N}_L}\, \tilde{\mathbf{N}}_L\, \tilde{\mathbf{A}}^{\tilde{N}_L}_{\mp} + \tilde{g}^{1}\, \tilde{\tau}^{1}\, \tilde{\mathbf{A}}^{1}_{\mp}\\ &+\; e\, Q\, A_{\mp} + g^{Q'}\, Q'\, Z^{Q'}_{\mp} + g^{Y'}\, Y'\, A^{Y'}_{\mp}\}\end{aligned}$$

manifest effectively, after gaining non zero vacuum expectation values, **the properties of the "standard model" Higgs**. $\overset{78}{(\mp)}$, makes them behaving as carrying the "weak charge" in a doublet representation and the hypercharge $(\mp)\,\frac{1}{2}$. The rest in the bracket takes care of Yukawa couplings.

- **To the masses of the gauge fields several scalar fields contribute, effectively as in the standard model.**
- **Their contribution to the fermion mass matrices is expected to manifest the existence of the fourth family and the stable fifth family**
- **and in the events in which these scalar fields are produced or decay.**

THE APPROACH MIGHT HAVE THE ANSWER TO THE QUESTION
WHAT DOES CONSTITUTE THE DARK MATTER

- We study the possibility that the **Dark matter constituents are clusters of the stable fifth family of quarks and leptons**, predicted by the **spin-carge-family-theory**.
- Our Dark matter **fifth family quarks, clustered into baryons**, **interact during forming clusters in the evolution of the universe with the colour force**, the fifth family baryons interact with the **"nuclear like fifth family force"** and in the case that they are very massive the weak force dominates, the fifth family neutrinos interact with the weak force.

What do we know about the properties of the fifth family members so far? (*Phys. Rev. D* **80**, 083534 (2009))

- The masses of the fifth family members must be pretty above the known three and the predicted fourth family masses—at around 10 **TeV** or higher—and **much bellow** the break of $SO(1,7)$ to $SO(1,3) \times SU(2) \times SU(2)$, which occurs bellow 10^{13} TeV.
- They interact with the **weak, colour,** $U(1)$ interaction and with the "fifth family Yukawas".
- When following the fifth family members through the evolution of the universe up to the today's Dark matter several breaks of symmetries and phase transitions occur.
- Knowing their interactions with the gauge fields their interaction with the ordinary matter in direct measurements can be estimated.

So far made estimations of the properties of the upper four families predict that the masses of the fifth family members are approximately the same.

There are several possibilities.

- The most probable seems the possibility that d_5 **is the lightest quark** and consequently $n_5 = u_5 d_5 d_5$ **is the lightest fifth family baryon**.
- Maxim Yu. Khlopov studies the possibility that u_5 **is the lightest quark** and that the fermion-antifermion assymetry privileges antifermions and that correspondingly $\bar{u}_5 \bar{u}_5 \bar{u}_5$ is the lightest fifth family anti baryon, which then forms the dark matter.

Evaluation of the properties of the fifth family baryons

We use the **Bohr (hydrogen)-like model to estimate the binding energy and the size of the fifth family neutron** $(u_5 d_5 d_5)$, assuming that the differences in masses of the fifth family quarks makes the n_5 stable

$$E_{c_5} \approx -3\,\frac{1}{2}\,\left(\frac{2}{3}\,\alpha_c\right)^2\,\frac{m_{q_5}}{2}\,c^2, \quad r_{c_5} \approx \frac{\hbar c}{\frac{2}{3}\,\alpha_c\,\frac{m_{q_5}}{2}\,c^2}. \tag{3}$$

The mass of the cluster is approximately

$$m_{c_5}\,c^2 \approx 3 m_{q_5}\,c^2 (1 - (\frac{1}{3}\,\alpha_c)^2) \tag{4}$$

. (We use the factor of $\frac{2}{3}$ for a two quark pair potential and of $\frac{4}{3}$ for an quark and anti-quark pair potential.)

The **Bohr (hydrogen)-like model gives for the fifth family baryon n_5**

$\frac{m_{q_5} c^2}{\mathrm{TeV}}$	α_c	$\frac{E_{c_5}}{m_{q_5} c^2}$	$\frac{r_{c_5}}{10^{-6}\mathrm{fm}}$	$\frac{\Delta m_{ud} c^2}{\mathrm{GeV}}$
1	0.16	-0.016	$3.2 \cdot 10^3$	0.05
10	**0.12**	**-0.009**	$\mathbf{4.2 \cdot 10^2}$	**0.5**
$\mathbf{10^2}$	**0.10**	**-0.006**	**52**	**5**
10^3	0.08	-0.004	6.0	50
10^4	0.07	-0.003	0.7	$5 \cdot 10^2$
10^5	0.06	-0.003	0.08	$5 \cdot 10^3$

Table: m_{q_5} in TeV/c^2 is the assumed fifth family quark mass, α_c is the coupling constant of the colour interaction at $E \approx (-E_{c_5}/3)$ which is the kinetic energy of quarks in the baryon, r_{c5} is the corresponding average radius. Then $\sigma_{c_5} = \pi r_{c_5}^2$ is the corresponding scattering cross section.

- **The nucleon-nucleon cross section is for the fifth family nucleons obviously for many orders of magnitude smaller than for the first family nucleons.**
- The binding energy is of the two orders of magnitude smaller than the mass of a cluster at $m_{q_5} \approx 10$ TeV to 10^6 TeV.

Evolution of the abundance of the fifth family members in the universe:

To estimate the behaviour of our stable heavy family of quarks and anti-quarks in the expanding universe we need to know:

- the masses of our fifth family members,
- their particle—anti-particle asymmetry.

We take the **fifth family mass** as the **parameter to be determined from the today's Dark matter density**.

For **heavy enough masses the particle—anti-particle asymmetry** is unimportant.
The **particle—anti-particle asymmetry** starts to be important **below 10 TeV**.

Both, the masses and the asymmetry should follow from our starting Lagrangean, if (when) we would be able to calculate them.

- In the energy interval we treat the freezing out the **colour field manifests dominantly through the one gluon exchange, up to ≈ 1 GeV** when the colour phase transition starts. There are also the weak and $U(1)$ fields and the "fifth family Yukawa couplings", the contributions of which are smaller.
- The fifth family quarks and anti-quarks start to freeze out when the temperature of the plasma falls close to $m_{q_5}\, c^2/k_b$.
- They are forming clusters (bound states) when the temperature falls close to the binding energy of the fifth family baryons.

- When the three quarks or three anti-quarks of the fifth family form a **colourless baryon** (or anti-baryon), they **decouple from the rest of the plasma** due to small scattering cross section manifested by the average radius presented in the above Table, manifesting the **"nuclear force" among the fifth family baryons**.
- The fifth family quarks (or coloured clusters), which survive up to the colour phase transition, deplete at the phase transition (before the first family quarks start to form with them the colourless hadrons), due to their very high mass and binding energy. We made a rough estimation of how and why this is happening. The proof has not yet been done.

We solve the Boltzmann equation, which treats **in the expanding universe** the number density of all the fifth family quarks as well as of their baryons as a function of the temperature T (T $= T(t)$, t is the time parameter).

The fifth family quarks scatter with anti-quark into all the other relativistic quarks and anti-quarks ($< \sigma v >_{q\bar{q}}$) and into gluons ($< \sigma v >_{gg}$).

At the beginning, when the quarks are becoming non-relativistic and start to freeze out, the formation of bound states is negligible.

- The Boltzmann equation for the fifth family quarks n_{q_5} (and equivalently for anti-quarks $n_{\bar{q}_5}$

$$a^{-3}\frac{d(a^3\mathbf{n_{q_5}})}{dt} = <\sigma v>_{q\bar{q}}\;\; n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5} \left(-\frac{n_{q_5} n_{\bar{q}_5}}{n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5}} + \frac{n_q n_{\bar{q}}}{n^{(0)}_{q} n^{(0)}_{\bar{q}}} \right) + <\sigma v>_{gg}\;\; n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5} \left(-\frac{n_{q_5} n_{\bar{q}_5}}{n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5}} + \frac{n_g n_g}{n^{(0)}_{g} n^{(0)}_{g}} \right).$$

$n^{(0)}_i = g_i \, (\frac{m_i c^2 T k_b}{(\hbar c)^2})^{\frac{3}{2}} e^{-\frac{m_i c^2}{T k_b}}$ for $m_i c^2 >> T k_b$ (which is our case and to $\frac{g_i}{\pi^2}\,(\frac{T k_b}{\hbar c})^3$ for $m_i c^2 << T k_b$).

- When the temperature of the expanding universe falls close enough to the binding energy of the cluster of the fifth family quarks (and anti-quarks), the bound states of quarks (and anti-quarks) and the clusters of fifth family baryons (in our case neutrons n_5) (and anti-baryons $\bar{n}_5$—anti-neutrons) start to be formed.
- The corresponding Boltzmann equation for the number of baryons n_{c_5} reads

$$a^{-3}\,\frac{d(a^3\mathbf{n_{c_5}})}{dt} \;=\; <\sigma v>_{c_5}\; n_{q_5}^{(0)^2}\left(\left(\frac{\mathbf{n_{q_5}}}{n_{q_5}^{(0)}}\right)^2-\frac{n_{c_5}}{n_{c_5}^{(0)}}\right).$$

The number density of the fifth family quarks $\mathbf{n_{q_5}}$ ($\bar{\mathbf{n}}_{\mathbf{q_5}}$) which has above the temperature of the binding energy of the clusters of the fifth family quarks (almost) reached the decoupled value, starts to decrease again due to the formation of the clusters.

$$
\begin{aligned}
& a^{-3}\frac{d(a^3\mathbf{n_{q_5}})}{dt} = \\
& <\sigma v>_{c_5}\;\; n^{(0)}_{q_5}\, n^{(0)}_{q_5} \left[-\left(\frac{n_{q_5}}{n^{(0)}_{q_5}}\right)^2 + \frac{\mathbf{n_{c_5}}}{n^{(0)}_{c_5}} - \frac{\eta_{(q\bar{q})_b}}{\eta_{c_5}} \left(\frac{n_{q_5}}{n^{(0)}_{q_5}}\right)^2 \right] + \\
& <\sigma v>_{q\bar{q}}\;\; n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5} \,(-\frac{n_{q_5} n_{\bar{q}_5}}{n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5}} + \frac{n_q n_{\bar{q}}}{n^{(0)}_{q} n^{(0)}_{\bar{q}}}) + \\
& <\sigma v>_{gg}\;\; n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5} \,(-\frac{n_{q_5} n_{\bar{q}_5}}{n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5}} + \frac{n_g n_g}{n^{(0)}_{g} n^{(0)}_{g}}).
\end{aligned}
$$

- At the temperature < 1 **GeV/c^2 the colour phase transition starts** and **the fifth family quarks and anti-quarks and the coloured fifth family clusters**, all with a very large mass (several 10^8 MeV to be compared with 300 MeV of the first family dressed quarks), with a very large binding energy (see Table above) and also with the large scattering cross section (which all the quarks obtain at the coloured phase transition) **deplete before forming the hadrons with the lower family members**. This is waiting to be proved.
- The colourless **fifth family baryons**, being bound into very small clusters, **do not feel the colour phase transition**.

Evolution

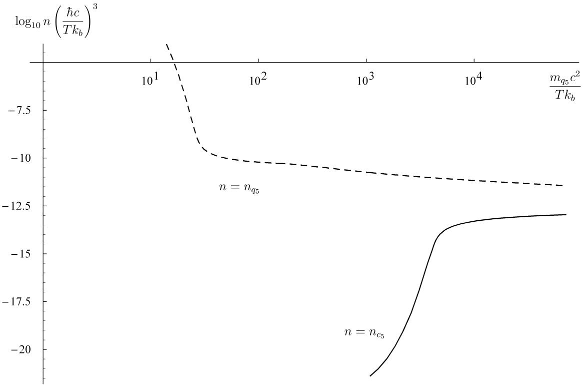

Figure: The dependence of the two number densities n_{q_5} (of the fifth family quarks) and n_{c_5} (of the fifth family clusters) as the function of $\frac{m_{q_5} c^2}{T k_b}$ is presented for the values $m_{q_5} c^2 = 71\ \mathrm{TeV}$, $\eta_{c_5} = \frac{1}{50}$ and $\eta_{(q\bar{q})_b} = 1$. We take $g^* = 91.5$.

From the calculated decoupled number density of baryons and anti-baryons of the fifth family quarks (anti-quarks) $n_{c_5}(T_1)$ at the temperature $T_1 k_b = 1$ GeV, where we stopped our calculations (as a function of the quark mass and of the two parameters η_{c_5} and $\eta_{(q\bar{q})_b}$, which measure the inaccuracy of our calculations), the today's mass density of the dark matter follows $a_1^3 n_{c_5}(T_1) = a_2^3 n_{c_5}(T_2)$, with the today's $a_0 = 1$ and $T_0 = 2.7..^0$ K)

- $$\rho_{\mathbf{dm}} \;=\; \Omega_{dm}\rho_{cr} = 2\,\mathbf{m_{c_5}}\,\mathbf{n_{c_5}(T_1)}\left(\frac{T_0}{T_1}\right)^3 \frac{g^*(T_1)}{g^*(T_0)},$$

$\frac{m_{q_5} c^2}{\mathrm{TeV}}$	$\eta_{(q\bar{q})_b} = \frac{1}{10}$	$= \frac{1}{3}$	$= 1$	$= 3$	$= 10$
$\eta_{c_5} = \frac{1}{50}$	21	36	71	159	417
$\eta_{c_5} = \frac{1}{10}$	12	20	39	84	**215**
$\eta_{c_5} = \frac{1}{3}$	9	14	25	54	134
$\eta_{c_5} = 1$	8	11	19	37	88
$\eta_{c_5} = 3$	7	**10**	15	27	60
$\eta_{c_5} = 10$	7*	8*	13	22	43

Table: **The fifth family quark mass** is presented, calculated for different choices of η_{c_5} and of $\eta_{(q\bar{q})_b}$, which take care of the inaccuracy of our calculations.

We read from the above Table the **mass interval** for the **fifth family quarks' mass**

$$\mathbf{10}\ \mathrm{TeV} < \mathbf{m_{q_5}\, c^2} < \mathbf{4 \cdot 10^2}\mathrm{TeV}. \tag{5}$$

From this mass interval we estimate from the Bohr-like model the **cross section** for the **fifth family neutrons** $\pi (r_{c_5})^2$:

$$\mathbf{10^{-8}}\mathrm{fm}^{\mathbf{2}} < \sigma_{\mathbf{c_5}} < \mathbf{10^{-6}}\mathrm{fm}^{\mathbf{2}}. \tag{6}$$

It is at least $10^{-6}\times$ smaller than the cross section for the first family neutrons.

Dynamics of the heavy family baryons in our galaxy

- Our Sun's velocity: $v_S \approx (170 - 270)$ **km/s.**
- **Locally dark matter density ρ_{dm} is known within a factor of 10** accurately:
  $\rho_{dm} = \rho_0\, \varepsilon_\rho, \rho_0 = 0.3 GeV/(c^2\, cm^3)$,
  we put $\frac{1}{3} < \varepsilon_\rho < 3$.
- The **local velocity of the dark matter clusters $\vec{v}_{dm}$ is unknown**, the estimations are **very model dependant**.
- The velocity of the Earth around the center of the galaxy is equal to: $\vec{v}_E = \vec{v}_S + \vec{v}_{ES}$,
  $v_{ES} = 30$ km/s,
  $\frac{\vec{v}_S \cdot \vec{v}_{ES}}{v_S\, v_{es}} \approx \cos\theta \sin\omega t, \theta = 60^0$.

- **The flux** per unit time and unit surface of our Dark matter clusters hitting the Earth:
  $\Phi_{dm} = \sum_i \frac{\rho_{dmi}}{m_{c_5}} \left|\vec{v}_{dm\,i} - \vec{v}_E\right|$ is $\approx$ equal to

$$\Phi_{dm} \approx \sum_i \frac{\rho_{dmi}}{m_{c_5}} \{ \left|\vec{v}_{dm\,i} - \vec{v}_S\right| - \vec{v}_{ES} \cdot \frac{\vec{v}_{dmi} - \vec{v}_S}{\left|\vec{v}_{dmi} - \vec{v}_S\right|} \}.$$

- **We assume** $\sum_i \left|\vec{v_{dmi}} - \vec{v_S}\right| \rho_{dmi} = \varepsilon_{v_{dmS}}\, \varepsilon_\rho\, v_S\, \rho_0$, and correspondingly
- $\sum_i \vec{v}_{ES} \cdot \frac{\vec{v}_{dmi} - \vec{v}_S}{\left|\vec{v}_{dmi} - \vec{v}_S\right|} = v_{ES} \varepsilon_{v_{dmES}} \cos\theta \, \sin\omega t$, with ω for our Earth rotation around our Sun.
- We evaluate $\frac{1}{3} < \varepsilon_{v_{dmS}} < 3$ **and** $\frac{1}{3} < \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} < 3$.

The cross section for our heavy dark matter baryon n_5 to **elastically** scatter on an **ordinary nucleus** with A nucleons in the Born approximation:

$\sigma_{c_5 A} = \frac{1}{\pi \hbar^2} < |M_{c_5 A}| >^2 \; m_A^2$,
$m_A \approx= m_{n_1} A^2 \cdots$ the mass of the ordinary nucleus,
$\sigma(A) = \sigma_0 \, A^4$,

- $\boldsymbol{\sigma_0 = 9 \, \pi r_{c_5}^2 \, \varepsilon_{\sigma_{nucl}}}$, $\quad \boldsymbol{\frac{1}{30} < \varepsilon_{\sigma_{nucl}} < 30}$, when the **"nuclear force"** dominates,
- $\boldsymbol{\sigma_0 = \frac{m_{n_1} G_F}{\sqrt{2\pi}} (\frac{A-Z}{A})^2 \varepsilon_{\sigma_{weak}}}$ $(= (10^{-6} fm \frac{A-Z}{A})^2 \, \varepsilon_{\sigma_{weak}})$, $\varepsilon_{\sigma_{weak}} \approx 1$, when the **weak force** dominates ($m_{q_5} > 10^4$ TeV).
- The scattering cross section **among** our heavy neutral baryons n_5 is determined by the weak interaction: $\boldsymbol{\sigma_{c_5} \approx (10^{-6} \text{ fm})^2 \frac{m_{c_5}}{\mathrm{GeV}}}$.

Direct measurements of the fifth family baryons as dark matter constituents:

- Let us assume that the DAMA/NaI, CDMS, XENON100 and CoGeNT measure our heavy dark matter clusters.
- **We look for limitations these experiments might put on properties of our heavy family members.**
- Let an experiment has N_A nuclei per kg with A nucleons.
- At $v_{dmE} \approx 200$ km/s are the $3A$ scatters strongly bound in the nucleus, so that the whole nucleus with A nucleons elastically scatters on a heavy dark matter cluster.
- The number of events per second (R_A) taking place in N_A nuclei is equal to (the cross section is at these energies almost independent of the velocity) what follows

$$\mathbf{R_A} = \mathbf{N_A}\,\frac{\rho_0}{\mathbf{m_{c_5}}}\,\sigma(\mathbf{A})\,\mathbf{v_S}\,\varepsilon_{\mathbf{v_{dmS}}}\,\varepsilon_\rho\,(\mathbf{1}+\frac{\varepsilon_{\mathbf{v_{dmES}}}}{\varepsilon_{\mathbf{v_{dmS}}}}\,\frac{\mathbf{v_{ES}}}{\mathbf{v_S}}\,\cos\theta\,\sin\omega\mathbf{t}),$$

$$\Delta R_A = R_A(\omega t = \tfrac{\pi}{2}) - R_A(\omega t = 0) = N_A\,R_0\,A^4\,\frac{\varepsilon_{v_{dmES}}}{\varepsilon_{v_{dmS}}}\,\frac{v_{ES}}{v_S}\,\cos\theta,$$
$$R_0 = \sigma_0\,\rho_0 3\,m_{q_5}\,v_S\,\varepsilon.$$

$\varepsilon = \varepsilon_\rho\,\varepsilon_{\mathbf{v_{dmES}}}\,\varepsilon_\sigma,$
$\mathbf{10^{-4}} < \varepsilon < \mathbf{10^2}$, for the "nuclear-like force" dominating
$\mathbf{10^{-2}} < \varepsilon < \mathbf{10^1}$, for the weak force dominating

Let $\varepsilon_{\mathbf{cut\,A}}$ determine the efficiency of a particular experiment to detect a dark matter cluster collision, then

$$\mathbf{R_{A\,exp}} \approx \mathbf{N_A}\,\mathbf{R_0}\,\mathbf{A^4}\,\varepsilon_{\mathbf{cut\,A}} = \mathbf{\Delta R_A}\varepsilon_{\mathbf{cut\,A}}\,\frac{\varepsilon_{\mathbf{v_{dmS}}}}{\varepsilon_{\mathbf{v_{dmES}}}}\,\frac{\mathbf{v_S}}{\mathbf{v_{ES}}\,\cos\theta}.$$

If DAMA/NaI is measuring our heavy family baryons (scattering mostly on I, $A_I = 127$, we neglect Na, with $A = 23$)

$R_{I\ dama} \approx \Delta R_{dama} \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} \frac{v_S}{v_{SE}\ \cos 60^0}$,

most of unknowns are hidden in ΔR_{dama}.

For Sun's velocities $v_S = 100, 170, 220, 270$ km/s
we find $\frac{v_S}{v_{SE} \cos\theta} = 7, 10, 14, 18$ respectively.

DAMA/LIBRA (NaI) publishes $\Delta R_{I\ dama} = 0,052$ **counts per day and per kg of NaI.**
Then $R_{I\ dama} = 0,052\, \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} \frac{v_S}{v_{SE} \cos\theta}$ counts per day and per kg.

CDMS, XENON100, CoGeNT should then already measure our dark matter clustres.

The experimets – XENON100, CoGeNT – seems to be close to measure something, but far from confirming annual modulation or even the DAMA/LIBRA experiment.

ε might even be smaller (we are making now more precize evaluations), $\varepsilon = 10^{-4}$. Then CDMS, XENON100, CoGeNT experiments are still in agreement with the predictions that n_5 are at least the important part of the dark matter, but in this case our predictions would not explain the DAMA/LIBRA (NaI) experiment. Except if our fifth family quarks are lighter, around $10\,TeV$ or slightly lighter, as Maxim Yu. Khlopov assumed in his scenario.

Comparison of the CDMS and DAMA/LIBRA experiment

$$R_{Ge}\, \varepsilon_{cut\, cdms} \approx \frac{8.3}{4.0} \left(\frac{73}{127}\right)^4 \frac{\varepsilon_{cut\, cdms}}{\varepsilon_{cut\, dama}} \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} \frac{v_S}{v_{SE} \cos\theta}\, 0.052 \cdot 121 \cdot 2\,,$$

which is for $v_S = 100, 170, 220, 270$ km/s

equal to $\quad (20,\ 32,\ 42,\ 50)\, \frac{\varepsilon_{cut\, cdms}}{\varepsilon_{cut\, dama}} \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}}.$

XENON100 should see 10 times more.

- **DAMA limits the mass of our fifth family quarks** to a few $20\, TeV < m_{q_5} c^2 < 10^5\, TeV$.
- **Cosmological evolution requires that masses of the fifth family quarks are not larger than a few 100 TeV.**
- We have checked also all the other cosmological and noncosmological measurements.

- **Also the fifth family neutrinos might contribute to the dark matter. We are studying the behaviour of these neutrinos in the expanding universe taking into account annihilation properties of the weakly interacting particles bellow the weak symmetry breaks**.

CONCLUDING REMARKS

There is a lot of open questions which the **standard model** of the electroweak and colour interactions **leaves unanswered**.

The approach unifying spin and charges is offering the (new) way to answer these questions:

- **It offers the explanation for the origin of the charges**, **of the gauge fields and of the scalar fields**, in the sense of the Kaluza-Klein-like theories.
- **It offers the mechanism for generating families, the only mechanism in the literature, to my knowledge, which does not on one or another way put the families by hand, and correspondingly explains the origin of the mass matrices**.

It predicts:

- **In the low energy regime four families (with nonzero mixing matrices)**,
  the fourth to be possibly seen at the LHC.
- The mass matrices, which lead to the masses and the mixing matrices of quarks and leptons. The influence of the loop corrections are under consideration.
- **The stable fifth family which is the candidate to form the dark matter**.
- **Since there are several scalar fields, the production of scalar fields and their decay might significantly differ from the prediction of the standard model.**

Open problems to be solved—some main steps are already done or are in the process:

- **The way how do loop corrections influencing the mass matrices** of the **family members** **evaluated on the tree level hopefully lead to the observed masses and mixing matrices of the family members.**
- **Masses and coupling constants of the scalar fields and their production and decay and their contributions to the currents, which should be in agreement with the experimental data.No flavour changing neutral currents have been observed.**
- **The discrete symmetries and their nonconservation within the spin-charge-family-theory.**

- **The way how does breaking of symmetries occur in the evolution of the universe and define scales.**
- **The behaviour of quarks and leptons and gauge fields at the phase transitions of the cosmic plasma ($SU(2)$ and $SU(3)$).**
- **Many other not jet solved problems.**