The approach unifying spins and charges is offering a new way beyond the Standard model: A simple action, in which in $d > 1+3$ spinors carry only two kinds of spins, no charges, manifests in $d = 1+3$ the Standard model effective Lagrangean—with the families, Higgs and Yukawa couplings included—predicting the fourth family and the Dark matter candidate.

N.S. Mankoč Borštnik, Moscow 2009, 19-25 August

Collaborators in this project, which **SNMB** has started almost 15 years ago:
Anamarija Pika **Borštnik Bračič**, Gregor **Bregar**, Matjaž **Breskvar**, Dragan **Lukman**, Holger Bech **Nielsen** (first of all), Jože **Vrabec**, others.

- *Phys. Lett.* **B 292**, 25-29 (1992),
- *Modern Phys. Lett.* **A 10**, 587-595 (1995),
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- 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.
- astro-ph¿arXiv: 0907.0196, with G.B.

INTRODUCTION

The **approach unifying spins and charges** is offering **a new way beyond the Standard model** of the electroweak and colour interactions:

- Spinors carry in $d > 4$ only **two kinds of the spin, no charges.**
- The **Dirac spin manifests in** $d = 1 + 3$ **the spin and all the charges** of quarks and leptons, the **second kind of spin generates families.**
- A spinor interacts in $d = 1 + 13$ with the **vielbeins** and the (two kinds of) the **spin connections.**
- **A simple action in** $d = 1 + 13$ **manifests** in $d = 1 + 3$, after the break of the starting symmetry, **all the properties of families of quarks and leptons**, as assumed by the Standard model. It is **a part of the simple starting action**, which **manifests the Yukawa coupling**, the **Higgs are a part of vielbeins**

I am looking for

- **general proofs that this Approach does lead in the observable (low) energy region to the observable phenomena**,
- **how many of the open questions of the standard models does the Approach answer**.

The open questions, which I am trying to answer, together with my collaborators, are:

1. Where do families of quarks and leptons come from?
2. What does determine the strength of the Yukawa couplings and accordingly the weak scale?
3. Why do only the left handed spinors carry the weak charge, while the right handed are weak chargeless?
4. How many families appear at (soon) observable energies?
5. Are among the members of the families the candidates for the dark matter?
6. How does the evolution of the universe determine the today observable matter and energy?
7. Where do charges come from?
8. And several other questions.

The **approach unifying spins and charges offers the answers to these questions**:

- The representation of one Weyl spinor of the group SO(1,13), **manifests the left handed weak charged quarks and leptons and the right handed weak chargeless quarks and leptons**.
- There are two kinds of the Clifford algebra objects. **One kind takes care of the spin and the charges**, **the other generates families**.
- It is a part of a simple starting Lagrange density for a spinor in $d = 1 + 13$ (which carries nothing but two kinds of spins, **no charges**) and interacts with the gravitational fields only–**the vielbeins and the spin connections** of the two kinds–which manifests in d=1+3 the Lagrange density for spinors as assumed by the Standard model before the break

- It is a part of a simple starting Lagrange density for a spinor in $d = (1 + 13)$, which **manifests in d=1+3 the Yukawa couplings**, playing the role of the Higgs field of the Standard model.
- **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 Yukawa matrix elements among the members which do not belong to the same four families' group. The three from the lowest four families are the observed ones, the **fourth family** might (as the first rough estimations show) **be seen at LHC**. The lowest among the **decoupled** four families is the **candidate** for forming the **Dark matter** clusters.

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

$$\begin{aligned}
\{\gamma^{\mathbf{a}}, \gamma^{\mathbf{b}}\}_+ &= \mathbf{2}\eta^{\mathbf{ab}} = \{\tilde{\gamma}^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_+, \\
\{\gamma^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_+ &= 0, \\
\tilde{\gamma}^{\mathbf{a}}\mathbf{B} : &= \mathbf{i}(-)^{\mathbf{n_B}}\mathbf{B}\gamma^{\mathbf{a}},
\end{aligned}$$

$$\mathbf{S}^{ab} := (i/4)(\gamma^a\gamma^b - \gamma^b\gamma^a),$$
$$\tilde{\mathbf{S}}^{ab} := (i/4)(\tilde{\gamma}^a\tilde{\gamma}^b - \tilde{\gamma}^b\tilde{\gamma}^a),$$
$$\{\mathbf{S}^{ab}, \tilde{\mathbf{S}}^{cd}\}_- = 0.$$

- I recognized: If γ^a **describe the spins 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**

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

$e^a{}_\alpha f^\alpha{}_b = \delta^a{}_b,\ e^a{}_\alpha f^\beta{}_a = \delta^\beta_\alpha$

Latin indices $a, b, .., m, n, .., s, t, ..$ denote a **tangent space** (a flat index),

Greek indices $\alpha, \beta, .., \mu, \nu, ..\sigma, \tau..$ denote an **Einstein index** (a curved index).

Letters from the **beginning of both the alphabets** indicate a **general index** ($a, b, c, ..$ and $\alpha, \beta, \gamma, ..$),

from the **middle of both** the alphabets the **observed dimensions** $0, 1, 2, 3$ ($m, n, ..$ and $\mu, \nu, ..$),

indices from the **bottom** of the alphabets indicate the **compactified** dimensions ($s, t, ..$ and $\sigma, \tau, ..$).

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

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

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

Variation of the action brings for $\omega_{ab\alpha}$

$$
\begin{aligned}
\omega_{ab\alpha} \;=\;& -\frac{1}{2E}\Big\{ e_{e\alpha} e_{b\gamma}\, \partial_\beta (E f^{\gamma[e} f^{\beta}{}_{a]}) + e_{e\alpha} e_{a\gamma}\, \partial_\beta (E f^{\gamma}{}_{[b} f^{\beta e]}) \\
& \qquad - e_{e\alpha} e^{e}{}_{\gamma}\, \partial_\beta \big(E f^{\gamma}{}_{[a} f^{\beta}{}_{b]}\big) \Big\} \\
& - \frac{e_{e\alpha}}{4} \Big\{ \bar{\Psi} \Big(\gamma_e S_{ab} + \frac{3i}{2} (\delta^e_b \gamma_a - \delta^e_a \gamma_b) \Big) \Psi \Big\} \\
& - \frac{1}{d-2} \Big\{ e_{a\alpha} \Big[\frac{1}{E} e^{d}{}_{\gamma} \partial_\beta \Big(E f^{\gamma}{}_{[d} f^{\beta}{}_{b]} \Big) + \frac{1}{2} \bar{\Psi} \gamma^d S_{db} \Psi \Big] \\
& \qquad - e_{b\alpha} \Big[\frac{1}{E} e^{d}{}_{\gamma} \partial_\beta \Big(E f^{\gamma}{}_{[d} f^{\beta}{}_{a]} \Big) + \frac{1}{2} \bar{\Psi} \gamma^d S_{da} \Psi \Big\} \Big]
\end{aligned}
$$

and for $\tilde{\omega}_{ab\alpha}$

$$\begin{aligned}
\tilde{\omega}_{ab\alpha} &= -\frac{1}{2E}\Big\{ e_{e\alpha} e_{b\gamma}\, \partial_\beta (E f^{\gamma[e} f^{\beta}{}_{a]}) + e_{e\alpha} e_{a\gamma}\, \partial_\beta (E f^{\gamma}{}_{[b} f^{\beta e]}) \\
&\qquad - e_{e\alpha} e^{e}{}_{\gamma}\, \partial_\beta \big(E f^{\gamma}{}_{[a} f^{\beta}{}_{b]}\big) \Big\} \\
&- \frac{e_{e\alpha}}{4} \Big\{ \bar{\Psi} \Big(\gamma_e \tilde{S}_{ab} + \frac{3i}{2} (\delta^e_b \gamma_a - \delta^e_a \gamma_b) \Big) \Psi \Big\} \\
&- \frac{1}{d-2} \Big\{ e_{a\alpha} \Big[\frac{1}{E} e^{d}{}_{\gamma} \partial_\beta \Big(E f^{\gamma}{}_{[d} f^{\beta}{}_{b]} \Big) + \frac{1}{2} \bar{\Psi} \gamma^d \tilde{S}_{db} \Psi \Big] \\
&\qquad - e_{b\alpha} \Big[\frac{1}{E} e^{d}{}_{\gamma} \partial_\beta \Big(E f^{\gamma}{}_{[d} f^{\beta}{}_{a]} \Big) + \frac{1}{2} \bar{\Psi} \gamma^d \tilde{S}_{da} \Psi \Big\} \Big]
\end{aligned}$$

The action for spinors can formally be rewritten as

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

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

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

There are **particular breaks —the particular isomertries— of the starting symmetries which make that only the measured gauge fields manifest at low energies**:

the **spin connections** $\omega_{st\mu}$ are expressible with the **vielbeins** ${e^s}_\mu$ in $d = 1 + 3$ and the present spinor fields.

$$
\begin{aligned}
A &= 1 \quad U(1) \text{ hyper charge} \quad i = \{1\} \qquad \text{usual not. } Y, \\
A &= 2 \quad SU(2) \text{ weak charge} \quad i = \{1,2,3\} \qquad \text{usual not. } \tau^i, \\
A &= 3 \quad SU(3) \text{ colour charge} \quad i = \{1,\cdots,8\} \qquad \text{usual not. } \lambda^i/2,
\end{aligned}
$$

One can see that:
one Weyl spinor representation in $d = (1 + 13)$ with the **spin as the only internal degree of freedom**
manifests, if analyzed 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** $(SO(1,3))$ **spinor** with **all the known charges** of **one family** of the **left handed weak charged** and the **right handed weak chargeless** quarks and leptons of the Standard model.

The **second kind** of the Clifford algebra objects $\tilde{S}^{ab}$
takes care of the **families**
by generating the equivalent representations with respect to S^{ab},
which **generate spin and charges**.

THE YUKAWA COUPLINGS and HIGGS' FIELDS

It is a **part** of the simple **starting action for spinors in** $d = 1 + 13$ which manifests in $d = 1 + 3$ the **Yukawa couplings**.

It is a **part** of the simple **starting vielbeins in** $d = 1 + 13$ which manifests in $d = 1 + 3$ the **scalar** (Higgs') **fields**.

The symmetry $SO(1,7) \times U(1)$ **breaks twice**:

$SO(1,7) \times U(1)$ into $SO(1,3) \times SU(2) \times U(1)$

leading to the Standard model **massless quarks and leptons** of **four** (not three families)
and **massive**, **decoupled** in the Yukawa couplings from the lower mass families, **four** families.

Accordingly there are **two kinds of Higgs fields**.

The Yukawa couplings

$$
\begin{aligned}
-\mathcal{L}_Y &= \psi^\dagger \gamma^0 \gamma^s p_{0s} \psi \\
&= \psi^\dagger\, \gamma^0 \{ \stackrel{78}{(+)}\; p_{0+} + \stackrel{78}{(-)}\; p_{0-} \} \psi,
\end{aligned}
$$

$$
\begin{aligned}
p_{0\pm} &= (p_7 \mp i\; p_8) - \\
& \quad \frac{1}{2} S^{ab} \omega_{ab\pm} - \frac{1}{2} \tilde{S}^{ab} \tilde{\omega}_{ab\pm}, \\
\omega_{ab\pm} &= \omega_{ab7} \mp i\; \omega_{ab8}, \\
\tilde{\omega}_{ab\pm} &= \tilde{\omega}_{ab7} \mp i\; \tilde{\omega}_{ab8}
\end{aligned}
$$

We put $p_7 = p_8 = 0$.

The **vielbeins** in $d > (1+3)$ manifest the Higgs.

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

$E^{\sigma}{}_{Ai} = \tau^{Ai} x^{\sigma}$,

A$= 1 \cdots$ the U(1) field,

A$= 2 \cdots$ the weak field.

$$\mathcal{L}_{SB} = \frac{1}{2}(p_{0\mu}\, g_{\sigma\tau})(p_0^{\mu}\, g^{\sigma\tau}) + \text{similar terms with } p_0^{\mu} - V(g_{\sigma\tau})$$

$p_{0\mu}$ is the **covariant momentum** concerning the $U(1)$ and $SU(2)$ charge

$g_{\sigma\tau} = e^{s}{}_{\sigma}\, e_{s\tau}$

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.

$$\begin{aligned}
\overset{ab}{(\pm i)}: &= \frac{1}{2}(\gamma^a \mp \gamma^b), \quad \overset{ab}{[\pm i]} := \frac{1}{2}(1 \pm \gamma^a \gamma^b) \\
&\text{for } \eta^{aa}\eta^{bb} = -1, \\
\overset{ab}{(\pm)}: &= \frac{1}{2}(\gamma^a \pm i\gamma^b), \quad \overset{ab}{[\pm]} := \frac{1}{2}(1 \pm i\gamma^a \gamma^b), \\
&\text{for } \eta^{aa}\eta^{bb} = 1
\end{aligned}$$

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

Our technique

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

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

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

Our technique

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** $\overset{ab}{[-k]}$**.**

Our technique

$$
\begin{aligned}
\stackrel{ab}{(k)}\stackrel{ab}{(k)} &= 0, \quad \stackrel{ab}{(k)}\stackrel{ab}{(-k)} = \eta^{aa} \stackrel{ab}{[k]}, \quad \stackrel{ab}{[k]}\stackrel{ab}{[k]} = \stackrel{ab}{[k]},\\
\stackrel{ab}{[k]}\stackrel{ab}{[-k]} &= 0, \quad \stackrel{ab}{(k)}\stackrel{ab}{[k]} = 0, \quad \stackrel{ab}{[k]}\stackrel{ab}{(k)} = \stackrel{ab}{(k)},\\
\stackrel{ab}{(k)}\stackrel{ab}{[-k]} &= \stackrel{ab}{(k)}, \quad \stackrel{ab}{[k]}\stackrel{ab}{(-k)} = 0.
\end{aligned}
$$

$$
\begin{aligned}
\stackrel{ab}{\tilde{(k)}}\stackrel{ab}{(k)} &= 0, \quad \stackrel{ab}{\tilde{(-k)}}\stackrel{ab}{(k)} = -i\eta^{aa} \stackrel{ab}{[k]},\\
\stackrel{ab}{\tilde{(k)}}\stackrel{ab}{[k]} &= i \stackrel{ab}{(k)}, \quad \stackrel{ab}{\tilde{(k)}}\stackrel{ab}{[-k]} = 0.
\end{aligned}
$$

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

THE REPRESENTATION OF A SPINOR IN $d = 1 + 13$ ANALYZED IN TERMS OF THE STANDARD MODEL SYMMETRIES

Cartan subalgebra set of the algebra S^{ab}

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

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

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

S^{ab} generate a representation—the members of one family.
The eightplet (the representation of $SO(1,7)$) of quarks of a particular color 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	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	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	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	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	$\frac{1}{6}$	$\frac{1}{6}$

$-\mathcal{L}_Y = \psi^\dagger\, \gamma^0 \{\stackrel{78}{(+)}\; p_{0+} + \stackrel{78}{(-)}\; p_{0-}\}\psi$, $\gamma^0 \stackrel{78}{(-)}$ transforms u_R of the 1^{st} row into u_L of the 7^{th} row, while $\gamma^0 \stackrel{78}{(+)}$ transforms d_R of the 3^{rd} row into d_L of the 5^{th} row, doing what the Higgs and γ^0 do in the Standard

$\tilde{S}^{ab}$ generate families.

$$\tilde{S}^{03} = \frac{i}{2}[\overset{03}{(\tilde{+}i)}\overset{12}{(\tilde{+})} + \overset{03}{(\tilde{-}i)}\overset{12}{(\tilde{+})} + \overset{03}{(\tilde{+}i)}\overset{12}{(\tilde{-})} + \overset{03}{(\tilde{-}i)}\overset{12}{(\tilde{-})}]$$

Both vectors bellow describe a right handed u-quark of the same colour.

$$\overset{03}{(\tilde{-}i)}\overset{12}{(\tilde{-})} \qquad \overset{03}{(+i)}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\overset{11\,12}{(-)}\overset{13\,14}{(-)} =$$

$$\overset{03}{[+i]}\overset{12}{[+]} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\overset{11\,12}{(-)}\overset{13\,14}{(-)}$$

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

Raising and lowering operators:

$\stackrel{ac}{(k)}\stackrel{bd}{(l)}$

and

$\stackrel{ac}{(\tilde{k})}\stackrel{bd}{(\tilde{l})}$

$\gamma^0 \stackrel{78}{(-)}$ transforms the right handed weak chargeless u_R-quark into the left handed weak charged u_L-quark:

$$\gamma^0 \stackrel{78}{(-)} \quad \stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)} = \stackrel{03}{[-i]}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$$

$\stackrel{ac}{(\tilde{k})}\stackrel{bd}{(\tilde{l})}$ transform one family into another.

BREAKING THE STARTING SYMMETRY SO(1,13)

Breaks of symmetries

$$
\begin{array}{c}
\underbrace{
\begin{array}{ccccc}
 & & SO(1,13) & & \\
 & & \downarrow & & \\
 & & SO(1,7)\times & & SU(3)\times U(1) \\
\swarrow & & & \searrow & \\
? & & ? & ? & \\
SO(1,3)\times SO(4)\times U(1) & & & & SU(3) \\
 & & SO(1,3)\times SU(2)\times U(1) & & SU(3)
\end{array}
} \\
\downarrow \\
? \\
\downarrow \\
\mathrm{SO}(1,3)\times \mathrm{U}(1)\times \mathrm{SU}(3)
\end{array}
$$

- Breaking symmetries from $SO(1,13)$ to $SO(1,7) \times U(1) \times SU(3)$ occurs at very high energy scale (E $> 10^{16}$ GeV) and leaves very heavy all the families except one which is left massless.
  With H.B. Nielsen we studied possibilities of such way of breaking on the toy model of $d = 1 + 5$.
- There are $2^{8/2-1} = 8$ families—the symmetry $SO(1,7)(\times U(1))$ determines them.

There are two further breaks:

- From $SO(1,7) \times U(1)$ to $SO(1,3) \times SU(2) \times U(1)$ (at E around 10^{13} GeV) which leaves **four of the families massless and mass protected** (since only the left handed carry the weak charge), while **four of the families obtain the Yukawa couplings determined by the scale of break**.
- From $SO(1,3) \times SU(2) \times U(1)$ to $SO(1,3) \times U(1)$ (the Standard model type of breaking) bringing the masses to the light four families.

All the members of eight families have after the second break the same quantum numbers, that is the same quarks and leptons, coupling to the same gauge fields, but differing in Yukawa couplings.

There are the vielbeins $e^{a}{}_{\alpha}$ which manifest the breaking (caused by spinors fields too).

There are vielbeins which manifest the gauge fields
$e^{s}{}_{\mu} = e^{s}{}_{\sigma} E^{\sigma}{}_{Ai} A^{Ai}_{\mu}$

$E^{\sigma}{}_{Ai} = \tau_{Ai}\, x^{\sigma}$.
$e^{s}{}_{\mu}$ are expressible by $\omega_{ab\alpha}$ (and influenced by $\tilde{\omega}_{ab\alpha}$).

Accordingly do $\omega_{st\mu}$ appear as gauge fields, while $\tilde{\omega}_{ab\mu}$ do not at al.

- Break I

The **first break** from
$SO(1,7) \times U(1) \times SU(3)$ **to**
$SO(1,3) \times SU(2) \times U(1) \times SU(3)$
leads to the symmetries of the **hyper charge and the weak charge**
$U(1), SU(2)$,
(together with $SO(1,3)$ and $SU(3)$)
as good quantum numbers.

There **appears Higgs**, determined by vielbeins $e^{s}{}_{\tau}$,
coupled to the gauge field $A^{Y'}_{\mu}$,
to which it brings the mass,
while A^{Y}_{μ}, A^{1i}_{μ}, $i = 1,3$ stay massless.
$s, \sigma = 5,6,7,8; m, \mu = 0,1,2,3.$

The eight families break into two decoupled four families:
Four massless and four (very) **massive,** provided that the angle $\tilde{\theta}_2 = 0$. We take also $\theta_2 = 0$.
At the break new fields $\tilde{A}^{Y}_{s}$ and $\tilde{A}^{Y'}_{s}$ are formed:

$$\begin{aligned} \tilde{A}^{23}_{s} &= \tilde{A}^{Y}_{s} \sin\tilde{\theta}_2 + \tilde{A}^{Y'}_{s} \cos\tilde{\theta}_2, \\ \tilde{A}^{41}_{s} &= \tilde{A}^{Y}_{s} \cos\tilde{\theta}_2 - \tilde{A}^{Y'}_{s} \sin\tilde{\theta}_2, \end{aligned} \tag{1}$$

with indices $\alpha = \sigma$ only, these are the scalar fields of the new operators:

$$\tilde{Y} = \tilde{\tau}^{41} + \tilde{\tau}^{23}, \quad \tilde{Y}\prime = \tilde{\tau}^{23} - \tilde{\tau}^{41} \tan\tilde{\theta}_2,$$

with $\tilde{\tau}^{23} = \frac{1}{2}(\tilde{S}^{56} + \tilde{S}^{78}), \quad \tilde{\tau}^{41} = -\frac{1}{3}(\tilde{S}^{9\,10} + \tilde{S}^{11\,12} + \tilde{S}^{13\,14})$.

In the S^{ab} sector appear massless gauge fields of
$Y = \tau^4 + \tau^{23}$, and τ^{1i}
$\vec{\tau^1} = (\frac{1}{2}(S^{58} - S^{67}), \frac{1}{2}(S^{57} + S^{68}), \frac{1}{2}(S^{56} - S^{78}))$

and massive of $Y' = \tau^{23}$.
$\tau^{23} = \frac{1}{2}(S^{56} + S^{78})$, $\tilde{\tau}^{23} = \frac{1}{2}(\tilde{S}^{56} + \tilde{S}^{78})$
$\tilde{Y} = \tilde{\tau}^4 + \tilde{\tau}^{23}$, $\tilde{Y}' = \tilde{\tau}^{23}$.

τ^4 is from $SO(6)$ after breaking into $SU(3) \times U(1)$,
$\tilde{\tau}^{41} = -\frac{1}{3}(\tilde{S}^{9\,10} + \tilde{S}^{11\,12} + \tilde{S}^{13\,14})$
τ^{23} is from one of the two $SU(2)$ contained in $SO(4)$ after breaking into $SU(2)$ and (together with τ^4) into $U(1)$.

Let us point out that S^{ab} **transforms one member of the spinor representation of one family into another member of the same representation (and the same family)**.

$\tilde{S}^{ab}$ **transforms one member of the spinor representation of a particular family into the same member but of a different family**.

There appear nonzero Yukawa couplings due
to the term $\psi^\dagger \gamma^0 \gamma^s p_{0s} \psi$
and nonzero $f^{\sigma}{}_{s}\, \tilde{\omega}_{ab\sigma}$.

It is easy to understand, why there are four massless and four massive families. There are twice four families:

- Half of them are singlets with respect to $\tilde{\tau}^{2i}$, $i = 1, 2, 3$, accordingly $\tilde{\tau}^{2i}\, \tilde{A}^{2i}_{s}$ give to them no contribution.
- Half of them are triplets with respect to $\tilde{\tau}^{2i}$, $i = 1, 2, 3$, $\tilde{\tau}^{2i}\, \tilde{A}^{2i}_{s}$ contribute to their mass.

  where $\tilde{A}^{2i}_{s}$ is expressible with $\tilde{\omega}_{st\sigma}$.

Eight families of quarks and leptons of a right handed quark or lepton with the spin 1/2. $S^{ab}, a, b \in \{0,1,2,3,5,6,7,8\}$ reach all the members of one family of a particular colour charge.

I_R	$\overset{03}{[+i]}\overset{12}{(+)}\overset{56}{(+)}\overset{78}{[+]}$
II_R	$\overset{03}{(+i)}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{(+)}$
III_R	$\overset{03}{[+i]}\overset{12}{(+)}\overset{56}{[+]}\overset{78}{(+)}$
IV_R	$\overset{03}{(+i)}\overset{12}{[+]}\overset{56}{(+)}\overset{78}{[+]}$
V_R	$\overset{03}{(+i)}\overset{12}{(+)}\overset{56}{(+)}\overset{78}{(+)}$
VI_R	$\overset{03}{(+i)}\overset{12}{(+)}\overset{56}{[+]}\overset{78}{[+]}$
VII_R	$\overset{03}{[+i]}\overset{12}{[+]}\overset{56}{(+)}\overset{78}{(+)}$
VIII	03 12 56 78 [illegible]

The Yukawa couplings

$$-\mathcal{L}_Y = \psi^\dagger \gamma^0 \{ \overset{78}{(+)} p_{0+} + \overset{78}{(-)} p_{0-} \} \psi,$$

with

$$p_{0\pm} = (p_5 \mp i p_6) - \tilde{Y}' \frac{\tilde{g}}{c} \tilde{A}^{23}_{\pm} - \tilde{\tau}^{2-} \frac{\tilde{g}}{\sqrt{2}\, c} \tilde{A}^{2-}_{\pm} - \tilde{\tau}^{2+} \frac{\tilde{g}}{\sqrt{2}\, c} \tilde{A}^{2+}_{\pm}. \quad (2)$$

The **Yukawa couplings** for $u-$quarks after the **break of** $SO(1,7)\times U(1)$ **into** $SO(1,3)\times SU(2)\times U(1)$.

	I	II	III	IV	V	VI	VII	$VIII$
I	0	0	0	0	0	0	0	0
II	0	0	0	0	0	0	0	0
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	$-\frac{\tilde{g}}{c}\,\tilde{A}^{23}_{-}$	$\frac{\tilde{g}}{\sqrt{2}\,c}\,\tilde{A}^{2-}_{-}$	0	0
VI	0	0	0	0	$-\frac{\tilde{g}}{\sqrt{2}\,c}\,\tilde{A}^{2+}_{-}$	$-\frac{\tilde{g}}{c}\,\tilde{A}^{23}_{-}$	0	0
VII	0	0	0	0	0	0	$\frac{\tilde{g}}{c}\,\tilde{A}^{23}_{-}$	$\frac{\tilde{g}}{\sqrt{2}\,c}\,\tilde{A}^{2-}_{-}$
$VIII$	0	0	0	0	0	0	$-\frac{\tilde{g}}{\sqrt{2}\,c}\,\tilde{A}^{2+}_{-}$	$\frac{\tilde{g}}{c}\,\tilde{A}^{23}_{-}$

After the break of $SO(1,7) \times U(1)$ into $SO(1,3) \times SU(2) \times U(1)$ the **four lower families are massless and mass protected**, the left handed u-quarks carry the weak charge, the right handed do not.

If $|\frac{\tilde{g}}{c}\,\tilde{A}^{23}_{-}| >> |\frac{\tilde{g}}{\sqrt{2}\,c}\,\tilde{A}^{2-}_{-}|$,
the four massive families have all approximately the same mass.

If the $|\frac{\tilde{g}}{c}\,\tilde{A}^{23}_{-}| \approx |\frac{\tilde{g}}{\sqrt{2}\,c}\,\tilde{A}^{2-}_{-}|$
then two families have much lower mass than the other two.

Since $\tau^{2\pm}$ do not distinguish between quarks and leptons, the masses of quarks and leptons are the same.

- Break II.

At the weak scale $SU(2) \times U(1)$ breaks into $U(1)$ in both sectors.

In the $\tilde{S}^{ab}$ sector new fields $\tilde{A}_s, \tilde{Z}_s$ appear
$\tilde{A}^{13}_s = \tilde{A}_s \sin\tilde{\theta}_1 + \tilde{Z}_s \cos\tilde{\theta}_1,$
$\tilde{A}^{Y}_s = \tilde{A}_s \cos\tilde{\theta}_1 - \tilde{Z}_s \sin\tilde{\theta}_1,$

the gauge fields of
$\tilde{Q} = \tilde{\tau}^{13} + \tilde{Y} = \tilde{S}^{56} + \tilde{\tau}^{41},$
$\tilde{Q}' = -\tilde{Y}\tan^2\tilde{\theta}_1 + \tilde{\tau}^{13},$

with $\tilde{e} = \tilde{g}^{Y}\cos\tilde{\theta}_1, \tilde{g}' = \tilde{g}^{1}\cos\tilde{\theta}_1,$ $\tan\tilde{\theta}_1 = \frac{\tilde{g}^{Y}}{\tilde{g}^{1}}.$

The Yukawa couplings

$$
\begin{aligned}
-\mathcal{L}_Y &= \psi^\dagger \gamma^0 \gamma^s p_{0s} \psi \\
&= \psi^\dagger \, \gamma^0 \{ \overset{78}{(+)} \; p_{0+} + \overset{78}{(-)} \; p_{0-} \} \psi,
\end{aligned}
$$

can be rewritten as follows

$$\begin{aligned}
\mathcal{L}_Y &= \psi^\dagger \gamma^0 \{ \overset{78}{(+)} (\sum_{y=Y,Y'} y A^y_+ + \frac{-1}{2} \sum_{(ab)} \tilde{S}^{ab} \tilde{\omega}_{ab+})) + \\
& \overset{78}{(-)} (\sum_{y=Y,Y'} y A^y_- + \frac{-1}{2} \sum_{(ab)} \tilde{S}^{ab} \tilde{\omega}_{ab-}) \\
& \overset{78}{(+)} \sum_{\{(ac)(bd)\},k,l} \overset{ac}{(\tilde{k})} \overset{bd}{(\tilde{l})} \tilde{A}^{kl}_+ ((ac),(bd)) \;\; + \\
& \overset{78}{(-)} \sum_{\{(ac)(bd)\},k,l} \overset{ac}{(\tilde{k})} \overset{bd}{(\tilde{l})} \tilde{A}^{kl}_- ((ac),(bd)) \} \psi,
\end{aligned}$$

with $k, l = \pm 1$, if $\eta^{aa}\eta^{bb} = 1$ and $\pm i$, if $\eta^{aa}\eta^{bb} = -1$, while $Y = \tau^{21} + \tau^{41}$ and $Y' = -\tau^{21} + \tau^{41}$, $(ab), (cd), \cdots$ **Cartan only**.

There are several possibilities how to further break the symmetries in the $\tilde{S}^{ab}$ sector,
which occurs when the weak scale break occurs.

One can make that on the tree level the massless four families break into twice two families,
the lower two (almost) massless,
which for neutrinos leads to three almost massless families,
but not for electrons and quarks.

This work is in progress and is in need of collaborators.

There is a progress made also in the understanding how are the vielbeins connected with the scalar fields (Higgs), gauge fields and the Yukawa couplings.
Also this is in progress and calls for collaborators.

I am presenting the old numerical results, when a particular way of breaking symmetries has led to some predictions (Gregor's diploma work).
The $\omega_{ab\alpha}$-s and $\tilde{\omega}_{ab\alpha}$-s, determining the Yukawa couplings for the lower four families,
and correspondingly influencing the upper four families as well,
are assumed to be different for u-quarks, d-quarks, ν and e,
having in mind that going beyond the tree level would take care of these differences.

NUMERICAL RESULTS FOR THE LOWER FOUR FAMILIES

The second break influences the massive (upper) four families as well. We have not yet studied the properties of the upper four families after the second break.
Partly because the calculations bellow the tree level for the lower four families must be done first.

	I_R	II_R	III_R	IV_R	V_R	VI_R	VII_R	$VIII_R$
I_L	$XXXX$	$-\tilde{A}^{++}_{-}$ $((03),(12))$	$-\tilde{A}^{++}_{-}$ $((56),(78))$	0	0	0	0	0
II_L	$-\tilde{A}^{--}_{-}$ $((03),(12))$	$XXXX$	0	$-\tilde{A}^{++}_{-}$ $((56),(78))$	0	0	0	0
III_L	$\tilde{A}^{--}_{-}$ $((56),(78))$	0	$XXXX$	$-\tilde{A}^{++}_{-}$ $((03),(12))$	0	0	0	0
IV_L	0	$\tilde{A}^{--}_{-}$ $((56),(78))$	$-\tilde{A}^{--}_{-}$ $((03),(12))$	$XXXX$	0	0	0	0
V_L	0	0	0	0	$XXXX$	0	$-\tilde{A}^{+-}_{-}$ $((56),(78))$	$-\tilde{A}^{-+}_{-}$ $((03),(12)$
VI_L	0	0	0	0	0	$XXXX$	$-\tilde{A}^{+-}_{-}$ $((03),(12))$	$\tilde{A}^{-+}_{-}$ $((56),(78)$
VII_L	0	0	0	0	$\tilde{A}^{-+}_{-}$ $((56),(78))$	$-\tilde{A}^{-+}_{-}$ $((03),(12))$	$XXXX$	0
$VIII_L$	0	0	0	0	$-\tilde{A}^{+-}_{-}$ $((03),(12))$	$-\tilde{A}^{+-}_{-}$ $((56),(78))$	0	$XXXX$

The new fields determine the mass matrices, which have the form

	I	II	III	IV
I	$a_\pm$	$\frac{\tilde{g}^m}{\sqrt{2}}\tilde{A}^{+N_+}_\pm$	$-\frac{\tilde{g}^1}{\sqrt{2}}\tilde{A}^{1+}_\pm$	0
II	$\frac{\tilde{g}^m}{\sqrt{2}}\tilde{A}^{-N_+}_\pm$	$a_\pm + \frac{1}{2}\tilde{g}^m(\tilde{A}^{3N_-}_\pm + \tilde{A}^{3N_+}_\pm)$	0	$-\frac{\tilde{g}^1}{\sqrt{2}}\tilde{A}^{1+}_\pm$
III	$\frac{\tilde{g}^1}{\sqrt{2}}\tilde{A}^{1-}_\pm$	0	$a_\pm + \tilde{e}\tilde{A}_\pm + \tilde{g'}\tilde{Z}_\pm$	$\frac{\tilde{g}^m}{\sqrt{2}}\tilde{A}^{+N_+}_\pm$
IV	0	$\frac{\tilde{g}^1}{\sqrt{2}}\tilde{A}^{1-}_\pm$	$\frac{\tilde{g}^m}{\sqrt{2}}\tilde{A}^{-N_+}_\pm$	$a_\pm + \tilde{e}\tilde{A}_\pm + \tilde{g'}\tilde{Z}_\pm + \frac{1}{2}\tilde{g}^m(\tilde{A}^{3N_-}_\pm + \tilde{A}^{3N_+}_\pm)$

The mass matrix for the lower four families of u-quarks $(-)$ and d-quarks $(+)$ is not assumed to be real and symmetric.
We parameterize

$$\begin{pmatrix} a_\pm & b_\pm & -c_\pm & 0 \\ b_\pm & a_\pm + d_{1\pm} & 0 & -c_\pm \\ c_\pm & 0 & a_\pm + d_{2\pm} & b_\pm \\ 0 & c_\pm & b_\pm & a_\pm + d_{3\pm} \end{pmatrix}$$

Fitting these parameters with the Monte-Carlo program to the experimental data within the known accuracy and to the assumed values for the fourth family masses we get for the u-quarks the mass matrix

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

and for the d-quarks the mass matrix

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

This corresponds to the following values for the masses of the u and the d quarks

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

and the mixing matrix for the quarks

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

DO I HAVE THE RIGHT ANSWER TO THE QUESTIONS

WHAT ARE THE DARK MATTER CONSTITUENTS?

The candidate for the Dark matter constituent must have the following properties:

1. It must be stable in comparison with the age of the Universe.
2. Its density distribution within a galaxy is approximately spherically symmetric and decreases approximately with the second power of the radius of the galaxy.
3. The scattering amplitude of a cluster of constituents with the ordinary matter and among the Dark matter clusters must be small enough and the properties of the clusters must be such that all the predictions are in agreement with the observations.
4. The Dark matter constituents and accordingly also the clusters had to have a chance to be formed during the evolution of our Universe so that they agree with the today observed properties of the Universe.

We study the possibility that the **Dark matter constituents are clusters of the stable fifth family of quarks and leptons**, which due to the Approach has the matrix elements in the Yukawa couplings to the lower four families zero (in comparison with the age of the universe).

The masses of the fifth family lie much 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 $10^{13}\ TeV$. 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 have the chance to form the Dark matter constituents.

We estimate the properties of the **fifth family members** (u_5, d_5, ν_5, e_5) and of the fifth family **baryons** .
Due to what I have presented and discussed, **the approach unifying spin and charges** predicts that the fifth family has all the properties of the lower four families: the **same family members and the interactions with the same gauge fields, AFTER the last break, but not during the evolution of the universe,** when the **phase transitions of** $SU(3)$ and **very probably also for** $SU(2)$ is **felt differently for the fifth than for the first family.**

Properties of the fifth family baryons

We use **a simple (the Bohr like) model to estimate the size and the binding energy 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.

We estimate the behavior of such clusters in the **evolution** of the Universe as candidates for the Dark matter constituents, which do not contradict all the cosmologic observations.

We **estimate** the behavior of such clusters when hitting our Earth and in particular the **DAMA/NaI** and DAMA-LIBRA experiments in dependence of the mass of the fifth family and when hitting the **CDMS** experiment.

The **Bohr (hydrogen)-like model for three heavy enough quarks** gives the binding energy

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

The mass of the cluster is approximately

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

. 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.

It follows for a cluster of 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	$4.2 \cdot 10^2$	0.5
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: The properties of a cluster of the fifth family quarks within the extended Bohr-like (hydrogen-like) model from Appendix I. 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 $E \approx (-E_{c_5}/3)$ (Eq.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 binding energy is approximately $\frac{1}{100}$ of the mass of the cluster (it is $\approx \frac{\alpha_c^2}{3}$).
The baryon n_5 $(u_5 d_5 d_5)$ is lighter than the baryon p_5, $(u_{q_5} d_{q_5} d_{q_5})$ if $\Delta m_{ud} = (m_{u_5} - m_{d_5})$ is smaller than $(0.05, 0.5, 5, 50, 500, 5000)$ GeV for the six values of the $m_{q_5} c^2$ on Table 1, respectively.
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:

(S. Dodelson, Modern Cosmology, Academic Press Elsevier 2003)

To estimate the behaviour of our stable heavy family quarks and anti-quarks in the expanding universe we need to know:
i.) the masses of our fifth family members,
ii.) their particle—anti-particle asymmetry.
We need to evaluate: i.) their thermally averaged scattering cross sections (as the function of the temperature) for scattering i.a.) into all the relativistic quarks and anti-quarks of lower families ($<\sigma v>_{q\bar{q}}$), i.b.) into gluons ($<\sigma v>_{gg}$), i.c.) into (annihilating) bound states of a fifth family quark and an anti-quark ($<\sigma v>_{(q\bar{q})_b}$), i.d.) into bound states of two fifth family quarks and into the fifth family baryons ($<\sigma v>_{c_5}$) (and equivalently into two anti-quarks and into anti-baryons),
ii.) the probability for quarks and anti-quarks of the fifth family to annihilate at the colour phase transition ($Tk_b \approx 1$ GeV).

The quarks and anti-quarks start to freeze out when the temperature of the plasma falls close to $m_{q_5}\, c^2/k_b$ (k_b is the Boltzmann constant). They are forming clusters (bound states) when the temperature falls close to the binding energy. 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 Table.

We assume no asymmetry between the fifth family quarks and anti-quarks.
To see how many fifth family quarks and anti-quarks succeed to form the fifth family baryons and anti-baryons we solve the Boltzmann equations as a function of time (or temperature).
needed in the Boltzmann equations

$$
\begin{aligned}
<\sigma v>_{q\bar{q}} &= \frac{16\,\pi}{9}\,\left(\frac{\alpha_c \hbar c}{m_{q_5}\, c^2}\right)^2,\\
<\sigma v>_{gg} &= \frac{37\,\pi}{108}\,\left(\frac{\alpha_c \hbar c}{m_{q_5}\, c^2}\right)^2\\
<\sigma v>_{c_5} &= \eta_{c_5}\; 10\,\left(\frac{\alpha_c \hbar c}{m_{g_5}\, c^2}\right)^2\, c\,\sqrt{\frac{E_{c_5}}{T k_b}}\,\ln\frac{E_{c_5}}{T k_b},\\
<\sigma v>_{(q\bar{q})_b} &= \eta_{(q\bar{q})_b}\; 10\,\left(\frac{\alpha_c \hbar c}{m_{g_5}\, c^2}\right)^2\, c\,\sqrt{\frac{E_{c_5}}{T k_b}}\,\ln\frac{E_{c_5}}{T k_b},
\end{aligned}
$$

Let T_0 is the today's black body radiation temperature, $T(t)$ the actual (studied) temperature, $a^2(T^0) = 1$ and $a^2(T) = a^2(t)$ is the metric tensor component in the expanding flat universe—the Friedman-Robertson-Walker metric:
$\mathrm{diag}\, g_{\mu\nu} = (1, -a(t)^2, -a(t)^2, -a(t)^2)$, $(\frac{\dot{a}}{a})^2 = \frac{8\pi G}{3}\rho$, with $\rho = \frac{\pi^2}{15}\, g^*\, T^4$, $T = T(t)$, g^* measures the number of degrees of freedom of those of the four family members (f) and gauge bosons (b), which are at the treated temperature T ultra-relativistic $(g^* = \sum_{i\in \mathrm{b}} g_i + \frac{7}{8}\sum_{i \in \mathrm{f}} g_i)$. $H_0 \approx 1.5\, 10^{-42}\, \frac{\mathrm{GeV}c}{\hbar c}$ is the present Hubble constant and $G = \hbar c/(m^2_{pl})$, $m_{pl}c^2 \approx 1.2 \cdot 10^{19}$ GeV.

We solve the Boltzmann equation, which treats in the expanding universe the number density of all the fifth family quarks as a function of time t.
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.

Evolution

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

$n^{(0)}_i = g_i \,(\frac{m_i c^2 T k_b}{(\hbar c)^2})^{\frac{3}{2}} e^{-\frac{m_i c^2}{T k_b}}$ 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 $m_i c^2 << T k_b$).

Since the ultra-relativistic quarks and anti-quarks of the lower families are in the thermal equilibrium with the plasma and so are gluons, it follows $\frac{n_q n_{\bar{q}}}{n_q^{(0)} n_{\bar{q}}^{(0)}} = 1 = \frac{n_g n_g}{n_g^{(0)} n_g^{(0)}}$.

Taking into account that $(a\,T)^3\, g^*(T)$ is a constant it is appropriate to introduce a new parameter $x = \frac{m_{q_5} c^2}{k_b T}$ and the quantity $Y_{q_5} = n_{q_5}\, (\frac{\hbar c}{k_b T})^3$, $Y^{(0)}_{q_5} = n^{(0)}_{q_5}\, (\frac{\hbar c}{k_b T})^3$.

$\frac{dx}{dt} = \frac{h_m\, m_{q_5} c^2}{x}$, with $h_m = \sqrt{\frac{4\pi^3 g^*}{45}}\, \frac{c}{\hbar c\, m_{pl} c^2}$, Eq. 5 transforms into

$$\frac{dY_{q_5}}{dx} = \frac{\lambda_{q_5}}{x^2}\, (Y^{(0)2}_{q_5} - Y^2_{q_5}),$$

$$\lambda_{q_5} = \frac{(<\sigma v>_{q\bar{q}} + <\sigma v>_{gg})\, m_{q_5} c^2}{h_m\, (\hbar c)^3}.$$

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

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

Again

$$\begin{aligned} Y_{c_5} &= n_{c_5}\,(\frac{\hbar c}{k_b T})^3, \\ Y^{(0)}_{c_5} &= n^{(0)}_{c_5}\,(\frac{k_b T}{\hbar c})^3, \end{aligned}$$

and $\lambda_{c_5} = \frac{<\sigma v>_{c_5}\, m_{q_5} c^2}{h_m\,(\hbar c)^3}$,
with the same x and h_m as above.

$$\frac{dY_{c_5}}{dx} = \frac{\lambda_{c_5}}{x^2}\,(Y^2_{q_5} - Y_{c_5}\,Y^{(0)}_{q_5}\,\frac{Y^{(0)}_{q_5}}{Y^{(0)}_{c_5}}).$$

The number density of the fifth family quarks n_{q_5} (and correspondingly Y_{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 of the fifth family quarks (and anti-quarks) as well as due to forming the bound state of the fifth family quark and an anti-quark, which annihilates into gluons.

$$a^{-3}\frac{d(a^3 n_{q_5})}{dt} =$$

$$< \sigma v >_{c_5} \;\; n^{(0)}_{q_5}\, n^{(0)}_{q_5} \left[- \left(\frac{n_{q_5}}{n^{(0)}_{q_5}} \right)^2 + \frac{n_{c_5}}{n^{(0)}_{c_5}} - \frac{\eta_{(q\bar{q})_b}}{\eta_{c_5}} \left(\frac{n_{q_5}}{n^{(0)}_{q_5}} \right)^2 \right] +$$

$$< \sigma v >_{q\bar{q}} \;\; n^{(0)}_{q_5}\, n^{(0)}_{\bar{q}_5} \, (-\frac{n_{q_5} n_{\bar{q}_5}}{n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5}} + \frac{n_q n_{\bar{q}}}{n^{(0)}_{q} n^{(0)}_{\bar{q}}}) +$$

$$< \sigma v >_{gg} \;\; n^{(0)}_{q_5}\, n^{(0)}_{\bar{q}_5} \, (-\frac{n_{q_5} n_{\bar{q}_5}}{n^{(0)}_{q_5} n^{(0)}_{\bar{q}_5}} + \frac{n_g n_g}{n^{(0)}_{g} n^{(0)}_{g}}),$$

with $\eta_{(q\bar{q})_b}$ and η_{c_5} defined above.

There follow the coupled equations for Y_{q_5} and Y_{c_5}

$$
\begin{aligned}
\frac{dY_{q_5}}{dx} &= \frac{\lambda_{c_5}}{x^2}\,(-Y_{q_5}^2 + Y_{c_5}\, Y_{q_5}^{(0)}\,\frac{Y_{q_5}^{(0)}}{Y_{c_5}^{(0)}}) + \frac{\lambda_{(q\bar{q})_b}}{x^2}\,(-Y_{q_5}^2) \\
&+ \frac{\lambda_{q_5}}{x^2}\,(Y_{q_5}^{(0)2} - Y_{q_5}^2),
\end{aligned}
$$

$\lambda_{(q\bar{q})_b} = \frac{<\sigma v>_{(q\bar{q})_b}\, m_{q_5}\, c^2}{h_m\,(\hbar c)^3}$ Gregor solved this equation together with the above equation for Y_{c_5}.

We obtain

$\frac{m_{q_5} c^2}{\mathrm{TeV}}$	$\eta_{(q\bar{q})_b} = 1$	$\eta_{(q\bar{q})_b} = \frac{1}{3}$	$\eta_{(q\bar{q})_b} = 3$	$\eta_{(q\bar{q})_b} = 10$
$\eta_{c_5} = 1$	19	11	37	
$\eta_{c_5} = 3$	15	9.5	27	
$\eta_{c_5} = \frac{1}{3}$	25	14	54	
$\eta_{c_5} = 10$	13	–	22	
$\eta_{c_5} = \frac{1}{10}$	39	20	84	
$\eta_{c_5} = \frac{1}{50}$	71	–	–	417

Table: The fifth family quark mass is presented, calculated for different choices of η_{c_5} (which takes care of the probability that a colourless cluster of three quarks (anti-quarks) instead of two are formed) and of $\eta_{(q\bar{q})_b}$ (which takes care of the annihilation of a bound state of quark—anti-quark). .

Evolution

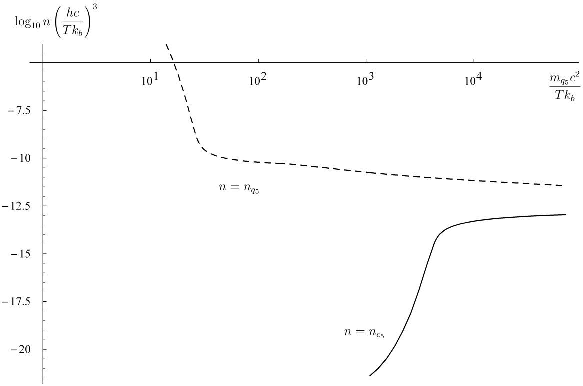

Figure: The dependence of the two number densities n_{q_5} (of the fifth family quarks) and n_{c_5} (of the fifth family clusters) as the function of $\frac{m_{q_5} c^2}{T k_b}$ is presented for the values $m_{q_5} c^2 = 71\ \mathrm{TeV}$, $\eta_{c_5} = \frac{1}{50}$ and $\eta_{(q\bar{q})_b} = 1$. We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

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

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

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

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

(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 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:
$\Phi_{dm} = \sum_i \frac{\rho_{dmi}}{m_{c_5}} |\vec{v}_{dm\,i} - \vec{v}_E|$ to be $\approx$ equal to

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

We assume $\sum_i |\vec{v_{dmi}} - \vec{v_S}|\,\rho_{dmi} = \varepsilon_{v_{dmS}}\,\varepsilon_\rho\, v_S\, \rho_0$, and correspondingly $\sum_i \vec{v}_{ES} \cdot \frac{\vec{v}_{dmi} - \vec{v}_S}{|\vec{v}_{dmi} - \vec{v}_S|} = v_{ES}\varepsilon_{v_{dmES}} \cos\theta \, \sin\omega t$, with ω for our Earth rotation around our.
$\frac{1}{3} < \varepsilon_{v_{dmS}} < 3$ 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,
$\sigma(A) = \sigma_0 \, A^4$,

- $\sigma_0 = 9 \, \pi \, r_{c_5}^2 \, \varepsilon_{\sigma_{nucl}}, \quad \frac{1}{30} < \varepsilon_{\sigma_{nucl}} < 30$, when the "nuclear force" dominates,
- $\sigma_0 = \frac{m_{n_1} G_F}{\sqrt{2\pi}} (\frac{A-Z}{A})^2 \varepsilon_{\sigma_{weak}} \; (= (10^{-6} fm \frac{A-Z}{A})^2 \, \varepsilon_{\sigma_{weak}})$, $\varepsilon_{\sigma_{weak}} \approx 1$, 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:** $\sigma_{c_5} \approx (10^{-6} \; fm)^2 \frac{m_{c_5}}{\mathrm{GeV}}$.

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

Let us assume that DAMA/NaI and CDMS measure our heavy dark matter clusters.
We look for limitations these two 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 $3A$ scatterers 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)

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

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

$\varepsilon = \varepsilon_\rho\, \varepsilon_{v_{dmES}}\, \varepsilon_\sigma,$
$10^{-3} < \varepsilon < 10^2$, for the "nuclear-like force" dominating
$10^{-2} < \varepsilon < 10^1$, for the weak force dominating

For $\frac{\varepsilon_{v_{dmES}}}{\varepsilon_{v_{dmS}}} \frac{v_{ES}}{v_S} \cos\theta$ small and $\varepsilon_{cut\,A}$ determining the efficiency of a particular experiment to detect a dark matter cluster collision.

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

If DAMA/NaI is measuring our heavy family baryons scattering mostly on I ($A_I = 127$, we neglect Na, with $A = 23$), then $R_{I\,dama} \approx \Delta R_{dama} \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}}\, \frac{v_S}{v_{SE}\ \cos 60^0}$.

Most of unknowns except v_S, the cut off procedure and $\frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}}$ 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/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 should then in 121 days with 1 kg of Ge ($A = 73$) detect $R_{Ge}\,\varepsilon_{cut\;cdms} \approx \frac{8.3}{4.0}\,(\frac{73}{127})^4\,\frac{\varepsilon_{cut\;cdms}}{\varepsilon_{cut\;dama}}\,\frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}}\,\frac{v_S}{v_{SE}\cos\theta}\,0.052\cdot 121$
,
which is for
$v_S = 100, 170, 220, 270$ km/s
equal too
$(10, 16, 21, 25)\,\frac{\varepsilon_{cut\;cdms}}{\varepsilon_{cut\;dama}}\,\frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}}$.

CDMS has found no event.

If $\frac{\varepsilon_{cut\ cdms}}{\varepsilon_{cut\ dama}} \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}}$ **is small enough, CDMS will measure our fifth family clusters in the near future.**

DAMA limits the mass of our fifth family quarks $200\,TeV < m_{q_5} c^2 < 10^5\,TeV$.

Cosmological evolution requires that masses of the fifth family quarks are not larger than a few 100 **TeV.**

Concluding remarks:

The approach unifying spin and charges is offering the new way beyond the Standard models:

- **It explains the origin of the charges**, **of the gauge fields and of the scalar fields** **(Higgs)**.
- **It is offering the mechanism for generating families** (the only mechanism in the literature, to my knowledge) and correspondingly **explains the origin of the Yukawa couplings**.

It predicts:

- **Four families (connected by the Yukawa couplings)**, **the fourth to be possibly seen at the LHC** and correspondingly the masses and the mixing matrices.
- **The stable fifth family which is the candidate to form the dark matter**.

We evaluated:

- **The properties of the lower four families.**
- **The properties of the fifth family quarks:**
  1. **Their forming the neutral clusters.**
  2. **Their decoupling from the rest of plasma in the evolution of the universe.**
  3. **Their interaction with the ordinary matter (with the first family baryons) and among themselves.**

I am concluding:

- **There are more than the observed three families, the fourth family will possibly be seen at the LHC.**
- **The fifth family, decoupled from the lower four families** (no Yukawa couplings to the lower four families) is the candidate to form the dark matter, **provided that the mass of the fifth family quarks is a few hundred TeV**.
- **We also predict, that if DAMA experiments measure our fifth family neutrons, the other direct experiments will "see" the dark matter in a few years.**

Open problems to be solved although the main steps are done:

- **The way how does the breaking of symmetries occur and define the scales.**
- **The behaviour of quarks and leptons** (neutrinos in particular) **and gauge fields at the phase transitions of the plasma (**$SU(2)$ **and** $SU(3)$**)**.
- **The way how do the loop corrections influence the Yukawa couplings evaluated on the tree level and define correspondingly the differences in masses and mixing matrices.**
- Many other not jet solved problems.