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, Cape Town 2010, 01-06 February

Collaborators in this project, which **S**usana **N**orma **M**ankoč **B**orštnik has started almost 15 years ago:
Anamarija Pika **Borštnik Bračič**, Gregor **Bregar**, Matjaž **Breskvar**, Dragan **Lukman**, Holger Bech **Nielsen** (first of all), others.

- *Phys. Lett.* **B 292**, 25-29 (1992),
- *Modern Phys. Lett.* **A 10**, 587-595 (1995),
- *Int. J. Theor. Phys.* **40**, 315-337 (2001).
  Phys. Rev. **D 62** (04010-14) (2000),
- *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.

WHAT DOES the APPROACH OFFER and HOW DOES IT?

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

- A spinor carries only **two kinds of spins**, **no charges** and interacts in $d = 1 + 13$ with the **vielbeins** and the two kinds of the **spin connections**.
- 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 simple action in** $d = 1 + 13$ **manifests** in $d = 1 + 3$, after the breaks of the starting symmetry, **all the properties of families of quarks and leptons**:

  It is **a part of the simple starting action**, which **manifests the Yukawa coupling**,

  the **Higgs are a part of vielbeins, interacting with the spin connections**

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

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 others.

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 of the families**.
- It is a part of the simple starting Lagrangean for a spinor in $d = 1 + 13$ which carries two kinds of spins and interacts with the gravitational fields—**the vielbeins** and the **two kinds** of **spin connections**—which manifests in d=1+3 the known effective Lagrange density for spinors and gauge 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 Yukawa couplings**, while vielbeins manifest the Higgs fields.
- **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 couplings 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 LHC**. The lowest among the **decoupled** four families is the **candidate** for forming the **Dark matter** clusters.

The ACTION of the APPROACH

There are **two kinds of the Clifford algebra objects which determine the properties of spinors (fermions)**:

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

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

Both are used in the Approach to determine properties of spinors.

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

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

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

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

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

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

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

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

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 $\omega_{ab\alpha}$

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

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

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

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

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

The papers, which demonstrate the possibilities, that the break of symmetries can lead to massless fermions:

- hep-th/Januar 2009, coauthors: H.B. Nielsen, D. Lukman,
- *Phys. Lett.* **B 644** (2007)198-202, hep-th/0608006, coauthor: H.B. Nielsen,
- *Phys. Lett.* **B** 10.1016 (2008), hep-th/0612126, arxiv:07.10.1956, coauthor: H.B. Nielsen,
- *Phys. Lett.* **B 633** (2006) 771-775, hep-th/0311037, hep-th/0509101, coauthor: H.B. Nielsen,
- arXiv:0912.4532, p. 103-118, coauthors: H.B. Nielsen, D. Lukman.

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

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

One can explicitly see that:

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 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}.

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 in two steps**:

$SO(1,7) \times U(1)$ 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

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

$$\mathbf{p_{0\pm}} = (\mathbf{p_7} \mp \mathbf{i}\, \mathbf{p_8}) - \frac{1}{2} \mathbf{S^{ab}} \omega_{\mathbf{ab}\pm} - \frac{1}{2} \tilde{\mathbf{S}}^{\mathbf{ab}} \tilde{\omega}_{\mathbf{ab}\pm},$$

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

We put $p_7 = p_8 = 0$.

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

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

$E^{\sigma}{}_{Ai} = \tau^{Ai} x^{\sigma}$,
A$= 1 \cdots$ the U(1) field,
A$= 2 \cdots$ the weak field
and to second kind of fields through $\tilde{S}^{st}$.

$$\begin{aligned}\mathcal{L}_{\mathbf{SB}} &= \frac{1}{2}(\mathbf{p}_{\mathbf{0}\mu}\,\mathbf{g}_{\sigma\tau})(\mathbf{p}_{\mathbf{0}}^{\mu}\,\mathbf{g}^{\sigma\tau}) + \\ &\text{similar terms with } p_0^{\mu} - \\ &-\mathbf{V}(\mathbf{g}_{\sigma\tau})\end{aligned}$$

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

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

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.

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

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

Our technique

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

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

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

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

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

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

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

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

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

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

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

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

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

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} (for both sectors):

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

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

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

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

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

$$\overset{03}{(\tilde{-}i)}\overset{12}{(\tilde{-})} \quad \overset{03}{(+i)}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{910}{(+)}\overset{1112}{(-)}\overset{1314}{(-)} =$$

$$\overset{03}{[+i]}\overset{12}{[+]} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{910}{(+)}\overset{1112}{(-)}\overset{1314}{(-)}$$

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

BREAKING THE STARTING SYMMETRY SO(1,13)

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

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

$\downarrow$

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

$\swarrow$ eight massless families $\searrow$

$SO(1,3) \times SO(4) \times U(1)$ $SU(3)$

$\mathbf{SO(1,3)} \times \mathbf{SU(2)} \times \mathbf{U(1)}$ four families stay massless, four families obtain masses $\mathbf{SU(3)}$

$\downarrow$

The Standard Model type of breaking

$\downarrow$

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

- 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 eight families ($2^{8/2-1} = 8$, determined by the symmetry of $SO(1,7)$) massless.

- We are studying (with H.B. Nielsen, D. Lukman) on a toy model of $d = 1+5$ how to obtain after breaking symmetries massless spinors chirally coupled to the Kaluza-Klein-like gauge fields. Boundaries and the "effective two dimensionalities" turn out to be very promising.

Eight families of quarks of a particular colour or of leptons:
a right handed member with the spin 1/2.

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	$\overset{03}{[+i]}\overset{12}{[+]}\overset{56}{(+)}\overset{78}{(+)}$
$VIII_R$	$\overset{03}{[+i]}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{[+]}$

There are two further breaks:

BREAK I

From $SO(1,7) \times U(1) \times SU(3)$ **to**
$SO(1,3) \times SU(2) \times U(1) \times SU(3)$ (at E around 10^{13} GeV or lower).

- It leads to the symmetries of the **hyper charge** $U(1)$**, the weak charge** $SU(2)$, the spin $SO(1,3)$ and the colour charge $SU(3)$.
- It leaves **four of the families massless and mass protected** (since they are singlets with respect to one of the two $\tilde{\mathbf{SU}}\mathbf{(2)}$, and only the left handed carry the weak charge), while **four of the families obtain the Yukawa couplings determined by the scale of break**.
- There are the vielbeins $e^a{}_\alpha$ which cause the breaking (together with the spinors' gauge fields). There are vielbeins which manifest the gauge fields

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

	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	$-\tilde{g}^2 \tilde{A}^{23}_{-} + \tilde{g}^N \tilde{A}^{N^3}_{-}$	$\frac{\tilde{g}^2}{\sqrt{2}} \tilde{A}^{2-}_{-}$	$\frac{\tilde{g}^N}{\sqrt{2}} \tilde{A}^{N-}_{-}$	**0**
VI	0	0	0	0	$-\frac{\tilde{g}^2}{\sqrt{2}} \tilde{A}^{2+}_{-}$	$-\tilde{g}^2 \tilde{A}^{23}_{-} + \tilde{g}^N \tilde{A}^{N^3}_{-}$	**0**	$\frac{\tilde{g}^N}{\sqrt{2}} \tilde{A}^{N-}_{-}$
VII	0	0	0	0	$-\frac{\tilde{g}^N}{\sqrt{2}} \tilde{A}^{N-}_{-}$	**0**	$\tilde{g} \tilde{A}^{23}_{-} - \tilde{g}^N \tilde{A}^{N^3}_{-}$	$\frac{\tilde{g}}{\sqrt{2}} \tilde{A}^{2-}_{-}$
$VIII$	0	0	0	0	**0**	$-\frac{\tilde{g}^N}{\sqrt{2}} \tilde{A}^{N+}_{-}$	$-\frac{\tilde{g}}{\sqrt{2}} \tilde{A}^{2+}_{-}$	$\tilde{g} \tilde{A}^{23}_{-} - \tilde{g}^N \tilde{A}^{N^3}_{-}$

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

and massive of $\tau^{\mathbf{2i}}$,
$\tilde{\tau}^{\mathbf{2}} = (\frac{1}{2}(S^{58} + S^{67}), \frac{1}{2}(S^{57} - S^{68}), \frac{1}{2}(S^{56} + S^{78}))$

Similar breaks occur in the $\tilde{\mathbf{S}}^{\mathbf{ab}}$ sector.

- The properties of the upper massive four families are under consideration, treating loop corrections.
- **The lowest one of the upper four families (all with no Yukawa couplings to the lowest four families) is predicted to constitute the dark matter**.

BREAK II

From $SO(1,3) \times SU(2) \times U(1) \times SU(3)$ to $SO(1,3) \times U(1) \times SU(3)$ (at the weak scale) **leading to the massive four lowest families**, three of them are the measured ones, **the fourth is predicted to be possibly seen at the LHC.**

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

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

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

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

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

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**.

Mass matrices on the tree level

	I	II	III	IV	V	VI	VII	VIII
I	**XXXX**	$-\tilde{A}^{++}_{-}$ ((03),(12))	$-\tilde{A}^{++}_{-}$ ((56),(78))	**0**	0	0	0	0
II	$-\tilde{A}^{--}_{-}$ ((03),(12))	**XXXY**	**0**	$-\tilde{A}^{++}_{-}$ ((56),(78))	0	0	0	0
III	$\tilde{A}^{--}_{-}$ ((56),(78))	**0**	**XXYX**	$-\tilde{A}^{++}_{-}$ ((03),(12))	0	0	0	0
IV	**0**	$\tilde{A}^{--}_{-}$ ((56),(78))	$-\tilde{A}^{--}_{-}$ ((03),(12))	**XYXX**	0	0	0	0
V	0	0	0	0	**YYYY**	$\frac{\tilde{g}^{2}}{\sqrt{2}}\tilde{A}^{2-}_{-}$	$\frac{\tilde{g}^{N}}{\sqrt{2}}\tilde{A}^{N-}_{-}$	**0**
VI	0	0	0	0	$-\frac{\tilde{g}^{2}}{\sqrt{2}}\tilde{A}^{2+}_{-}$	**YYYZ**	**0**	$\frac{\tilde{g}^{N}}{\sqrt{2}}\tilde{A}^{N}_{-}$
VII	0	0	0	0	$-\frac{\tilde{g}^{N}}{\sqrt{2}}\tilde{A}^{N-}_{-}$	**0**	**YYZY**	$\frac{\tilde{g}}{\sqrt{2}}\tilde{A}^{2}_{-}$
VIII	0	0	0	0	**0**	$-\frac{\tilde{g}^{N}}{\sqrt{2}}\tilde{A}^{N+}_{-}$	$-\frac{\tilde{g}}{\sqrt{2}}\tilde{A}^{2+}_{-}$	**YZYY**

NUMERICAL RESULTS FOR THE LOWER FOUR FAMILIES

The **second break influences the massless** (lower four) **families and the massive** (upper four) **families**.

(The properties of the upper four families after the second break are under consideration.)

We present the (two years old) results for the lowest four families, evaluated the Yukawa couplings on the tree level. We allowed u-quarks, **d**-quarks, ν and **e** to have their **own Yukawa couplings** even in the $\tilde{\mathbf{S}}^{\mathbf{ab}}$ regime to mimic going beyond the tree level.

The influence of the loops contributions in distinguishing through the quantum numbers of $\mathbf{Q}$ and $\mathbf{Q}'$ a nd $\tau^{\pm}$ among the family members is under consideration.

	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 (**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

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

I AM OFFERING THE ANSWER TO THE QUESTION WHAT DOES CONSTITUTE THE DARK MATTER

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 and all their properties must lead to the predictions 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**, predicted by the **Approach unifying spins and charges** and due to the Approach having the Yukawa couplings to the lower four families equal to zero (in comparison with the age of the universe).
- There are several candidates for the massive Dark matter constituents in the literature, known as **WIMP**s—weakly interacting massive particles.
- Our Dark matter **fifth family quarks, clustered into baryons**, are **are not WIMPS**. They interact during forming clusters in the evolution of the universe with the colour force, baryons interact with the **"nuclear like force"** and if they are very massive the weak force start to dominate, the fifth

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

- The masses of the fifth family members 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 $10^{13}\ TeV$.
- They interact with the **weak, colour and $U(1)$** interaction.
- 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, we are able to estimate their interaction with the ordinary matter commenting direct measurements.

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

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

The mass of the cluster is approximately

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

. (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	$4.2 \cdot 10^2$	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: 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 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 shall take the **fifth family mass** as the **parameter to be determined from the today's Dark matter density** and assume **no fifth family particle—anti-particle asymmetry**.

Both, the masses and the asymmetry follow from our starting Lagrangean, if (when) we would be able to calculate them. But for heavy enough fifth family baryons this assymetry is not important.

- In the energy interval we treat, the **one gluon exchange is the dominant contribution up to ≈ 1 GeV** when the colour phase transition occurs.
- 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 happenning.
- More accurate evaluations are in progress.

To follow the behaviour of the fifth family members in the expanding universe, we need to solve the corresponding coupled Boltzmann equations, for which we need to evaluate:

- 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).
- The probability for quarks and anti-quarks of the fifth family to annihilate at the colour phase transition ($Tk_b \approx 1$ GeV).

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 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 $n_{\bar{q}_5}$

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

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

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

The number density of the fifth family quarks $\mathbf{n_{q_5}}$ ($\mathbf{\bar{n}_{q_5}}$) 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.

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

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

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

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

- 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) and accordingly with the very large momentum, 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**.
- The colourless **fifth family baryons**, being bound into very small clusters, **do not feel the colour phase transition**.

Evolution

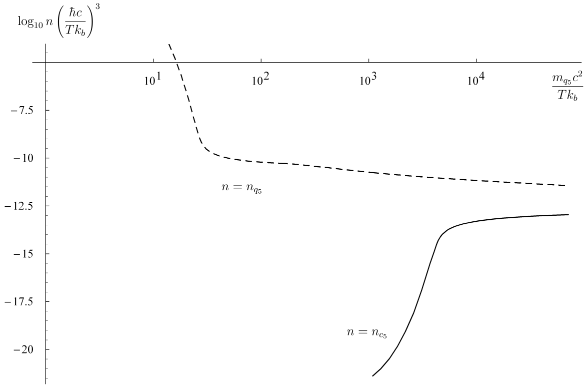

Figure: The dependence of the two number densities n_{q_5} (of the fifth family quarks) and n_{c_5} (of the fifth family clusters) as the function of $\frac{m_{q_5} c^2}{T k_b}$ is presented for the values $m_{q_5} c^2 = 71\ \mathrm{TeV}$, $\eta_{c_5} = \frac{1}{50}$ and $\eta_{(q\bar{q})_b} = 1$. We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

$$\mathbf{10}\ \mathrm{TeV} < \mathbf{m_{q_5}\, c^2} < \mathbf{4} \cdot \mathbf{10^2}\mathrm{TeV}. \qquad (3)$$

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

$$\mathbf{10^{-8}}\mathrm{fm}^{\mathbf{2}} < \sigma_{\mathbf{c_5}} < \mathbf{10^{-6}}\mathrm{fm}^{\mathbf{2}}. \qquad (4)$$

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

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

- **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 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,

$\sigma(A) = \sigma_0 \, A^4$,

- $\sigma_0 = 9 \, \pi \mathbf{r}_{c_5}^2 \, \varepsilon_{\sigma_{nucl}}, \quad \frac{1}{30} < \varepsilon_{\sigma_{nucl}} < 30$,
  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:
  $\sigma_{c_5} \approx (10^{-6} \, \mathrm{fm})^2 \, \frac{m_{c_5}}{\mathrm{GeV}}$.

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) what follows

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

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

$\varepsilon = \varepsilon_\rho\, \varepsilon_{\mathbf{v_{dmES}}}\, \varepsilon_\sigma,$
$\mathbf{10^{-3}} < \varepsilon < \mathbf{10^2}$, 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/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 $121 \cdot 2$ days with 1 kg of Ge ($A = 73$) detect

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

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

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

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** to $200\, TeV < m_{q_5} c^2 < 10^5\, TeV$.
- **Cosmological evolution requires that masses of the fifth family quarks are not larger than a few** 100 **TeV.**
- We have checked also all the other cosmological and noncosmological measurements.
- **None** is up to now in contradiction with the prediction of the **Approach unifying spin and charges** that the fifth family members, with neutrino included, constitute the Dark Matter.

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**. We are not yet able to tell the massess of the fourth family members. We are studying their properties bellow the tree level.
- **The properties of the higher four families**, on the tree and bellow the tree level, are under considerations.
- **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.**
  4. **Their behaviour in the colour phase transition**. More accurate evaluations are now in process.

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**.
- **I am also predicting, 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—some main steps are already done or are in the process:

- **The way how does the breaking of symmetries occur and define the scales.**
- **The behaviour of quarks and leptons** (neutrinos) **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.**
- **The discrete symmetries and their nonconservation within the Approach.**
- **Many other not jet solved problems**.