New stable family from the approach unifying spins and charges Offering the mechanism for generating families the approach unifying spins and charges is predicting the fourth family and the dark matter candidate.

N.S. Mankoč Borštnik
University of Ljubljana

VIA lecture, 21 November 2008

Collaborators in this project, which has started almost 15 years ago: Anamarija Pika Borštnik Bračič, Gregor Bregar, Matjaž Breskvar, Dragan Lukman, Holger Bech Nielsen, Jože Vrabec, Maxim Khlopov, 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** 771-775 (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..
- *New J. of Phys.*, **10** (2008) 093002, hep/ph-07082846.

I am developing the **Approach unifying spins and charges** by:

- looking for the general proofs that this Approach can lead in the observable energy region (low energy region) to the observable phenomena,
- finding out to which extend can the Approach answer the open questions of the Standard model.

The open questions, which I am answering together with my collaborators, are:

1. Why do only the left handed spinors carry the weak charge, while the right handed are weak chargeless?
2. Where do charges originate?
3. Where do families of quarks and leptons come from?
4. What does determine the strength of the Yukawa couplings and accordingly the weak scale?
5. Are among the members of the families candidates for the Dark matter clusters?
6. and several other questions

Approach unifying spins and charges offers the answers to these questions:

- By assuming that spinors (fermions) carry **only two kinds of the spin, no charges**.
  One kind is described by the Dirac Clifford algebra objects γ^a**s** and **unifies spins and charges**.
  The second kind of the Clifford algebra objects $\tilde{\gamma}^a$**s** **determines families**.
- By assuming a simple Lagrange density for a massless spinor and the corresponding gauge fields–**vielbeins and spin connections**–which then after breaking the starting symmetries leads to observable phenomena.

- 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.
- γ^a takes therefore care of the spin and the charges. $\tilde{\gamma}^a$ generates families.
- It is a part of a simple starting Lagrange density for a spinor in $d = 1 + 13$, which manifests in d=1+3 the Lagrange density for spinors as assumed by the Standard model before the break of the electroweak symmetry, manifesting the hyper charge, the colour charge and the weak charge and coupling the spinor to the corresponding massless gauge fields and manifesting (more than three observed) families.

- **The way of breaking symmetries determines the types of 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 (due to the first rough estimations) **be seen at LHC**. **The lowest** among the **decoupled** four families is the candidate for forming the **Dark matter** clusters.

Two kinds of the Clifford algebra objects:

- **The Dirac** γ^a operators (used by Dirac 80 years ago),
- **The second one:** $\tilde{\gamma}^a$ (I started to recognized this as a possible mechanism to generate families more than 15 years ago),

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

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

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

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

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

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

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

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

I assume **the Einstein action** for a free gravitational field, which is **linear in the curvature**

$$
\begin{aligned}
S &= \int d^d x \; E \; (R + \tilde{R}), \\
R &= f^{\alpha[a} f^{\beta b]} \; (\omega_{ab\alpha,\beta} - \omega_{ca\alpha} \omega^{c}{}_{b\beta}), \\
\tilde{R} &= f^{\alpha[a} f^{\beta b]} \; (\tilde{\omega}_{ab\alpha,\beta} - \tilde{\omega}_{ca\alpha} \tilde{\omega}^{c}{}_{b\beta}).
\end{aligned}
$$

$f^{\alpha[a} f^{\beta b]} = f^{\alpha a} f^{\beta b} - f^{\alpha b} f^{\beta a}$

The Yukawa couplings

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

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

We put $p_7 = p_8 = 0$.

Our technique to represent spinors and work elegantly with them

- *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.

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

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

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

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

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

γ^a **transform** $\overset{ab}{(k)}$ **into** $\overset{ab}{[-k]}$**,** $\tilde{\gamma}^a$ **transform** $\overset{ab}{(k)}$ **into** $\overset{ab}{[k]}$**.**

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

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

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

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: $\mathbf{u_R^{c1}}$

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

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	$\mathbf{u_R^{c1}}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \vert \stackrel{56}{(+)}\stackrel{78}{(+)} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$-\frac{1}{3}$
2	u_R^{c1}	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \vert \stackrel{56}{(+)}\stackrel{78}{(+)} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$-\frac{1}{3}$
3	d_R^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \vert \stackrel{56}{[-]}\stackrel{78}{[-]} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{2}{3}$
4	d_R^{c1}	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \vert \stackrel{56}{[-]}\stackrel{78}{[-]} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{2}{3}$
5	d_L^{c1}	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \vert \stackrel{56}{[-]}\stackrel{78}{(+)} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
6	d_L^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \vert \stackrel{56}{[-]}\stackrel{78}{(+)} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
7	$\mathbf{u_L^{c1}}$	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \vert \stackrel{56}{(+)}\stackrel{78}{[-]} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-1	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
8	u_L^{c1}	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \vert \stackrel{56}{(+)}\stackrel{78}{[-]} \Vert \stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(-)}\;\stackrel{13\,14}{(-)}$	-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 $\mathbf{u_R^{c1}}$ of the $\mathbf{1^{st}}$ row into $\mathbf{u_L^{c1}}$ of the $\mathbf{7^{th}}$ row, while $\gamma^0\,\stackrel{78}{(+)}$ transforms d_R^{c1} of the 3^{rd} row into d_L^{c1} of the 5^{th} row, doing what the Higgs and γ^0 do in the Standard model. $\gamma^a\,\stackrel{ab}{(k)} = \eta^{aa}\,\stackrel{ab}{[-k]}$, $\stackrel{ab}{(-k)}\stackrel{ab}{(k)} = \eta^{aa}\,\stackrel{ab}{[-k]}$,

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

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

$$2i\,\tilde{S}^{01} \qquad \overset{03}{(+i)}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\overset{11\,12}{(-)}\overset{13\,14}{(-)} =$$

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

Break of symmetries

$SO(1,13)$

$\downarrow$

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

$\swarrow$? ? ? $\searrow$

$SO(1,3) \times SO(4) \times U(1)$ $SO(1,3) \times SU(2) \times U(1)$ $SU(3)$ $SU(3)$

$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}$

$\downarrow$

?

$\downarrow$

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

Yukawa couplings:

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

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**.

We assume:

- Breaking symmetries from $SO(1,13)$ to $SO(1,7)\times U(1)\times SU(3)$ occurs at very high energy scale and leave very heavy all the families except one which is left massless.
- There are $2^{8/2-1}=8$ families (the symmetry $SO(1,7)$ determines them).
- Two ways of breaking from $SO(1,7)\times U(1)$ to $SO(1,3)\times U(1)$ in the $\tilde{S}^{ab}\tilde{\omega}_{ab\pm}$ sector.

A. In the ordinary sector would the term $S^{sa}\omega_{sa\pm}$, with $s = 5, 6$ and $a \neq 5, 6$, transform u-quarks into d-quarks—the mass term would accordingly not conserve the electromagnetic charge. We forbid such terms in both sectors: the ordinary $S^{ab}\omega_{ab\pm}$ and $\tilde{S}^{ab}\omega_{ab\pm}$ sector.

Eight families decouple into two times four families, well separated in masses. We study properties of the lower energy four families with the assumption that mass matrices are real and symmetric (no CP is studied yet).

B. First we break in both sectors $SO(1,7) \times U(1)$ into $SO(1,3) \times SO(4) \times U(1)$ (by putting all $\omega_{am\pm}$ and $\tilde{\omega}_{am\pm}, m = 0,1,2,3, \; a = 5,6,7,8$ equal to zero), eight families decouple into two times four families.

Then we break $SO(4) \times U(1)$ in two successive breaks first into $SU(2) \times U(1)$ and then to $U(1)$.

The assumption that the first break occurs at much higher energy then the second one (which occurs at the weak scale) makes the two times four families well separated in masses. We then study the properties of the lower four families.

A. and B.: Eight starting families

u_R^{I}	$\overset{03}{(+i)}\overset{12}{(+)}\overset{56}{(+)}\overset{78}{(+)} \mid\mid \cdots$
u_R^{II}	$\overset{03}{[+i]}\overset{12}{[+]}\overset{56}{(+)}\overset{78}{(+)} \mid\mid \cdots$
u_R^{III}	$\overset{03}{(+i)}\overset{12}{(+)}\overset{56}{[+]}\overset{78}{[+]} \mid\mid \cdots$
u_R^{IV}	$\overset{03}{[+i]}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{[+]} \mid\mid \cdots$
u_R^{V}	$\overset{03}{[+i]}\overset{12}{(+)}\overset{56}{(+)}\overset{78}{[+]} \mid\mid \cdots$
u_R^{VI}	$\overset{03}{(+i)}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{(+)} \mid\mid \cdots$
u_R^{VII}	$\overset{03}{[+i]}\overset{12}{(+)}\overset{56}{[+]}\overset{78}{(+)} \mid\mid \cdots$
u_R^{VIII}	$\overset{03}{(+i)}\overset{12}{[+]}\overset{56}{(+)}\overset{78}{[+]} \mid\mid \cdots$

Eight starting families break into twice four families

α	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	$XXXX$

A.

Four families of u_R (and correspondingly four octets which can be reached by $\stackrel{ac}{(k)}\stackrel{bd}{(l)}$).

$$
\begin{array}{ll}
I. & \stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \ldots \\
II. & \stackrel{03}{[+i]}\stackrel{12}{[+]} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \mid\mid \ldots \\
III. & \stackrel{03}{[+i]}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{[+]} \mid\mid \ldots \\
IV. & \stackrel{03}{(+i)}\stackrel{12}{[+]} \mid \stackrel{56}{(+)}\stackrel{78}{[+]} \mid\mid \ldots.
\end{array}
$$

The Yukawa couplings $-\mathcal{L}_Y = \psi^\dagger \gamma^0 \{ \overset{78}{(+)} \; p_{0+} + \overset{78}{(-)} \; p_{0-} \} \psi$, with $p_{0\pm}$ expressible in terms of $\omega_{ab\pm}$ (only the diagonal terms) and $\tilde{\omega}_{ab\pm}$ (all the non diagonal and also the diagonal terms) can be represented as

α	I_R	II_R	III_R	IV_R
I_L	a_α	$\frac{\tilde{\omega}_{327\alpha}+\tilde{\omega}_{018\alpha}}{2}$	$\frac{\tilde{\omega}_{387\alpha}+\tilde{\omega}_{078\alpha}}{2}$	$\frac{\tilde{\omega}_{187\alpha}}{2}$
II_L	$\frac{\tilde{\omega}_{327\alpha}+\tilde{\omega}_{018\alpha}}{2}$	$a_\alpha + (\tilde{\omega}_{127\alpha} - \tilde{\omega}_{038\alpha})$	$\frac{\tilde{\omega}_{187\alpha}}{2}$	$\frac{\tilde{\omega}_{387\alpha}-\tilde{\omega}_{078\alpha}}{2}$
III_L	$\frac{\tilde{\omega}_{387\alpha}+\tilde{\omega}_{078\alpha}}{2}$	$\frac{\tilde{\omega}_{187\alpha}}{2}$	$\frac{k_\alpha(\tilde{\omega}_{387\alpha}+\tilde{\omega}_{078\alpha})}{2}$	$\frac{k_\alpha}{2}\tilde{\omega}_{187\alpha}$
IV_L	$\frac{\tilde{\omega}_{187\alpha}}{2}$	$\frac{\tilde{\omega}_{387\alpha}-\tilde{\omega}_{078\alpha}}{2}$	$\frac{k_\alpha}{2}\tilde{\omega}_{187\alpha}$	$\frac{k_\alpha(\tilde{\omega}_{387\alpha}-\tilde{\omega}_{078\alpha})}{2}$

Taking into account that experimental data for the known families of quarks seem to suggest twice weakly coupled two and two families, we require that mass matrices have the shape

$$\begin{pmatrix} A & B \\ B & C = A + kB \end{pmatrix}. \tag{1}$$

with $k_u = -k_d$, $k_\nu = -k_e$,
$\tilde{\omega}_{abs_{u,\nu}} = b_{abs_{u,\nu}} \, \tilde{\omega}_{abs_{d,e}}$,
for $(abs) = (018)(078)(127)(387)$.
There are 3 angles determining the diagonalization of the mass matrices,
those for u related uniquely to those for d
and those for ν related to those for e,
which lead to

$$
\begin{aligned}
\tilde{\omega}_{018u} &= \frac{1}{2}[\frac{m_{u2}-m_{u1}}{\sqrt{1+({}^{a}\eta)^2}} + \frac{m_{u4}-m_{u3}}{\sqrt{1+({}^{b}\eta)^2}}],\\
\tilde{\omega}_{078u} &= \frac{1/2}{\sqrt{1+(\frac{k}{2})^2}}[\frac{{}^{a}\eta\,(m_{u2}-m_{u1})}{\sqrt{1+({}^{a}\eta)^2}} - \frac{{}^{b}\eta\,(m_{u4}-m_{u3})}{\sqrt{1+({}^{b}\eta)^2}}],\\
\tilde{\omega}_{127u} &= \frac{1}{2}[\frac{{}^{a}\eta\,(m_{u2}-m_{u1})}{\sqrt{1+({}^{a}\eta)^2}} + \frac{{}^{b}\eta\,(m_{u4}-m_{u3})}{\sqrt{1+({}^{b}\eta)^2}}],\\
\tilde{\omega}_{187u} &= \frac{1}{2\sqrt{1+(\frac{k}{2})^2}}[-\frac{m_{u2}-m_{u1}}{\sqrt{1+({}^{a}\eta)^2}} + \frac{m_{u4}-m_{u3}}{\sqrt{1+({}^{b}\eta)^2}}],\\
\tilde{\omega}_{387u} &= \frac{1}{2\sqrt{1+(\frac{k}{2})^2}}[(m_{u4}+m_{u3})-(m_{u2}+m_{u1})],\\
a_u &= \frac{1}{2}(m_{u1}+m_{u2}-\frac{{}^{a}\eta\,(m_{u2}-m_{u1})}{\sqrt{1+({}^{a}\eta)^2}}), \qquad (2)
\end{aligned}
$$

Equivalently for d quarks, neutrinos and electrons. Here

$$a_{u.\nu} = A^I_{u,\nu} - \frac{1}{2}\tilde{\omega}_{038_{u,\nu}} + \frac{1}{2}(\frac{k_{u,\nu}}{2} - \sqrt{1 + (\frac{k_{u,\nu}}{2})^2})(\tilde{\omega}_{078_{u,\nu}} + \tilde{\omega}_{387_{u,\nu}}),$$

and equivalently for the d-quarks and electrons.

No. of parameters 8, no. of data: 9

We use the Monte-Carlo program to fit—within the experimental accuracy—our free parameters $\tilde{\omega}_{abc}$

so that our mass matrices reproduce the experimental data.

We predict—in this very rough estimation because of several assumptions, we made— treating equivalently quarks and leptons

i. masses of the fourth family and

ii. mixing matrices.

We obtain:

	u	d	ν	e
k	-0.085	0.085	-1.25	1.254
${}^{a}\eta$	-0.225	0.225	1.58	-1.584
${}^{b}\eta$	0.420	-0.440	-0.162	0.162

	u	d	u/d	ν	e	ν/e
$\lvert\tilde{\omega}_{018}\rvert$	21205	42547	0.498	10729	21343	0.503
$\lvert\tilde{\omega}_{078}\rvert$	49536	101042	0.490	31846	63201	0.504
$\lvert\tilde{\omega}_{127}\rvert$	50700	101239	0.501	37489	74461	0.503
$\lvert\tilde{\omega}_{187}\rvert$	20930	42485	0.493	9113	18075	0.505
$\lvert\tilde{\omega}_{387}\rvert$	230055	114042	2.017	33124	67229	0.493
a^a	94174	6237		1149	1142	

Masses for quarks

$$
\begin{aligned}
m_{u_i}/GeV &= (0.0034, 1.15, 176.5, 285.2),\\
m_{d_i}/GeV &= (0.0046, 0.11, 4.4, 224.0),
\end{aligned}
$$

and the corresponding mixing matrix

$$
\begin{pmatrix}
0.974 & 0.223 & 0.004 & 0.042\\
0.223 & 0.974 & 0.042 & 0.004\\
0.004 & 0.042 & 0.921 & 0.387\\
0.042 & 0.004 & 0.387 & 0.921
\end{pmatrix},
$$

Masses for leptons

$$
\begin{aligned}
m_{\nu_i}/GeV &= (1\ 10^{-12}, 1\ 10^{-11}, 5\ 10^{-11}, 84.0),\\
m_{e_i}/GeV &= (0.0005, 0.106, 1.8, 169.2),
\end{aligned}
$$

and the corresponding mixing matrix

$$
\begin{pmatrix}
0.697 & 0.486 & 0.177 & 0.497\\
0.486 & 0.697 & 0.497 & 0.177\\
0.177 & 0.497 & 0.817 & 0.234\\
0.497 & 0.177 & 0.234 & 0.817
\end{pmatrix}.
$$

Both in agreement with the references
Phys. Lett. **B 592** (2004)1,
Phys.Scripta **T121** (2005) 72, hep-ph/0410030v1
Phys. Lett. **B 529**(2002) 111, hep-ph/0111028,
Phys.Lett. **B 476** (2000) 107, hep-ph/9911535v1
Phys. Atom.Nucl. **66** (2003) 2169; *Yad.Fiz.* **66** (2003) 2219,
hep-ph/0301268v2.

B. We let $SO(1,7) \times U(1)$ **break first to** $SO(1,3) \times SO(4) \times U(1)$ requiring that $\tilde{\omega}_{sm\pm} = 0$, **with** $s = 5, 6, 7, 8$; $m = 0, 1, 2, 3$.

The eight families break into two decoupled four families.

At the break $SO(4) \times U(1)$ into $SU(2) \times U(1)$ (at some large scale) new fields $\tilde{A}^{Y}_{\pm}$ and $\tilde{A}^{Y'}_{\pm}$ are formed:

$$\begin{aligned} \tilde{A}^{23}_{\pm} &= \tilde{A}^{Y}_{\pm} \sin\tilde{\theta}_2 + \tilde{A}^{Y'}_{\pm} \cos\tilde{\theta}_2, \\ \tilde{A}^{41}_{\pm} &= \tilde{A}^{Y}_{\pm} \cos\tilde{\theta}_2 - \tilde{A}^{Y'}_{\pm} \sin\tilde{\theta}_2, \end{aligned} \tag{3}$$

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

Small enough $\tilde{\theta}_2$ makes the two four families be well separated in masses. The same is assumed to happen in the S^{ab} sector.

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

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

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 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

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

Brief repeat:

- We started with a simple Lagrange density suggested by **the approach unifying spins and charges** with one Weyl spinor in $d = 1 + 13$, which carries only **the spin (no charges)** and interacts with only **the gravity through vielbeins and the two kinds of the spin connection fields**, which are the gauge fields of S^{ab} and $\tilde{S}^{ab}$, respectively.
- There are S^{ab}, which determine in $d = (1 + 3)$ the **spin and all the charges**. One Weyl spinor representation includes (if analyzed with respect to the Standard model groups) the left handed weak charged quarks and leptons and the right handed weak chargeless quarks and leptons.
- $\tilde{S}^{ab}$ **generate an even number of families.**

- It is **a part of a simple starting action which manifests as Yukawa couplings** of the Standard model $\psi^{\dagger}\gamma^{0}\gamma^{s}p_{0s}\psi,\ s=7,8,$ with $p_{0s}=-\frac{1}{2}S^{ab}\omega_{abs}-\frac{1}{2}\tilde{S}^{ab}\tilde{\omega}_{abs}$ contributing to diagonal and off diagonal elements of mass matrices.
- Making assumptions about possible ways of breaking symmetries, each of the two assumed ways leads at "low energy sector" to four times four mass matrices for four families of quarks and leptons, two by two weakly coupled and all three also weakly coupled to the fourth one.
- **The case B. seems to me more acceptable.**

- The way **A.** of breaking symmetries leads to the masses of the fourth family in agreement with the experimental data, predicting that the fourth family appears at low enough energies to be measured with new accelerators. The three families are weakly coupled to the fourth one.
- The way **B.**, although leading to mass matrices with only two off diagonal elements for each type of quarks and leptons, has too many free parameters to predict the masses of the fourth family. For chosen masses of the fourth family, however, the way **B.** predicts the couplings of the fourth to the first three families. Letting the fourth family mass growing, the fourth family very slowly decouples from the first three. The way **B.** also predicts, for example, the changed values for $|V_{31}|/|V_{32}| = 0.128 - 0.149$, acceptable since four instead of three families at weak scale contribute to this value.

- **The lowest family among the higher four families is the candidate to form the Dark matter clusters**.

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 –$\approx$ 10 TeV– and much bellow the break of $SO(1,7)$ to $SO(1,3) \times SU(2) \times SU(2)$, which occurs bellow 10^{10} 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 make a rough estimation of properties of clusters of the **members of the fifth family** (u_5, d_5, ν_5, e_5), with **(due to the Approach) all the properties of the lower four families: having the same family members and interacting with the same gauge fields.**

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-like model for three heavy enough quarks** gives the binding energy

$$
\begin{aligned}
E_{c_5} &= -\frac{3}{2}\, m_{q_5} c^2 (3\alpha_c)^2, \\
r_{c_5} &= \frac{\hbar c}{3\alpha_c m_{q_5} c^2}, \\
m_{c_5} c^2 &= 3 m_{q_5} c^2 (1 - \frac{1}{2}(3\alpha_c)^2). \\
\alpha_c(E^2) &= \frac{\alpha_c(M^2)}{1 + \frac{\alpha_c(M^2)}{4\pi}(11 - \frac{2N_F}{3})\ln(\frac{E^2}{M^2})} \\
\alpha_c((91\ \mathrm{GeV})^2) &= 0.1176(20),
\end{aligned}
$$

It follows for a cluster of the fifth family baryon n_5

$\frac{m_{q_5} c^2}{\mathrm{TeV}}$	α_c	$\frac{E_{c_5}}{\mathrm{TeV}}$	$\frac{r_{c5}}{10^{-7}\mathrm{fm}}$	$\frac{\pi r_{c5}^2}{(10^{-7}\mathrm{fm})^2}$
10^2	0.09	1.8	150	$6.8 \cdot 10^4$
10^4	0.07	100	1.9	12
10^6	0.05	6500	0.024	$1.9 \cdot 10^{-3}$

Table: Properties of a cluster of the fifth family quarks as a candidate for the dark matter constituents within the Bohr-like model, m_{q_5} in TeV/c^2 is the assumed fifth family quark mass.

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.

Dynamics of the heavy family baryons in our galaxy:

Our Sun 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,

$\frac{\vec{v}_S \cdot \vec{v}_{ES}}{v_S \, v_{es}} \approx \cos\theta, \theta = 60^0$.

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

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

We assume $\sum_i \left|\vec{v_{dmi}} - \vec{v_S}\right| \rho_{dmi} = \varepsilon_{v_{dmS}}\, \varepsilon_\rho\, v_S\, \rho_0$, and correspondingly $\sum_i \vec{v}_{ES} \cdot \frac{\vec{v}_{dmi} - \vec{v}_S}{|\vec{v}_{dmi} - \vec{v}_S|} = v_{ES} \varepsilon_{v_{dmES}} \cos\theta \, \sin\omega t$, 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)

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

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

$$R_0 = \sigma_0 \, \rho_0 3 \, m_{q_5} \, v_S \, \varepsilon.$$

$\varepsilon = \varepsilon_\rho \, \varepsilon_{v_{dmES}} \, \varepsilon_\sigma,$

$10^{-3} < \varepsilon < 10^2$, 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
$200\, TeV < m_{q_5} c^2 < 10^5\, TeV$.

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

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

$$< \sigma_5 v/c > \;=\; \frac{1}{\beta}\,\frac{T_1 k_B}{m_{c_5} c^2}\,\sqrt{g^*}\,(\frac{a(T^1)\,T^1}{a(T^0)\,T^0})^3\,\sqrt{\frac{4\pi^3 G}{45(\hbar\, c)^3}}\,\frac{(T_0\, k_b)^3}{\rho_{cr} c^4}\,\frac{1}{\Omega_5},$$

$\frac{T_1 k_B}{m_{c_5} c^2}(\frac{a(T^1)\,T^1}{a(T^0)\,T^0})^3 \approx 10^{-3}$, $g^* \approx 200\,,$

$\sqrt{\frac{4\pi^3\, G}{45(\hbar c)^3}}\,\frac{(T_0\, k_b)^3}{\rho_{cr}\, c^4} = 200\,(10^{-7} fm)^2$, leading to

$(10^{-7} fm)^2 < \sigma_5 < (10^{-6} fm)^2$**.**

The relativistic one gluon exchange scattering of quarks (very approximately): $\sigma = 8\,\pi(\frac{3\alpha_c(E)}{E})^2$, gives the mass limit

10^2 **TeV** $< m_{q_5}\, c^2 < 10^3$ **TeV**.

(**DAMA experiment gave:** $200\, TeV < m_{q_5} c^2 < 10^5\, TeV$.)

Concluding remarks:

The approach unifying spins and charges, offering a mechanism for generating families, predicts that the fifth family is a candidate to form the dark matter.

While the measured density of the dark matter does not put much limitation on the properties of heavy enough clusters, the DAMA/NaI experiments (Int.J. Mod.Phys. D13 (2004) 2127-2160, astro-ph/0501412, astro-ph/0804.2738v1.) do if they measure our heavy fifth family clusters:

$200\,\mathrm{TeV} < \mathrm{m}_{\mathrm{q}_5}\mathrm{c}^2 < 6.10^4\,\mathrm{TeV}$

and so does the cosmological evolution:

$(10^{-5}\,fm)^2 < \sigma_{c_5} < (3.10^{-7}\,fm)^2$.

If DAMA/NaI measures our fifth family baryons, CDMS (Z. Ahmed et al., astro-ph/0802.3530) will see them in the near future.