How far can we understand nature with the spin-charge-family theory? :

i. The internal spaces of fermions and bosons in my way

ii. Short overview of the spin-charge-family theory and its achievements

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http://bsm.fmf.uni-lj.si/bled2022bsm/presentations.html
FMF 13th Februar 2023

February 14, 2023

Some publications:

- *Phys. Lett.* **B 292**, 25-29 (**1992**), *J. Math. Phys.* **34**, 3731-3745 (**1993**), *Mod. 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, *JHEP* **04** (**2014**) 165, *Fortschritte Der Physik-Progress in Physics*, **(2017)** with **H.B.Nielsen**,
- *Phys. Rev.* **D 74** 073013-16 (**2006**), with **A.Borštnik Bračič**,
- *New J. of Phys.* **10** (**2008**) 093002, arxiv:1412.5866, with **G. Bregar, M. Breskvar, D. Lukman**,
- *Phys. Rev.* **D** (**2009**) 80.083534, with **G. Bregar**,
- *New J. of Phys.* (**2011**) 103027, *J. Phys. A: Math. Theor.* **45** (**2012**) 465401, *J. Phys. A: Math. Theor.* **45** (**2012**) 465401, *J. of Mod. Phys.* **4** (**2013**) 823-847, arxiv:1409.4981, **6** (**2015**) 2244-2247, *Phys. Rev.* **D 91** (**2015**) 6, 065004, . *J. Phys.: Conf. Ser. 845 01* **IARD 2017**, *Eur. Phys. J.C.* **77** (2017) 231, Rev. Artile in **Progress in Particle and Nuclear Physics**, **http://doi.org/10.1016.j.ppnp.2021.103890**

Many years ago (in 1990) I recognized that the Grassmann algebra offers the description of the internal spaces of fermions, and the internal spaces of bosons.

I also recognized in that time that the Grassmann algebra suggests two Clifford sub algebras which are appropriate to describe the internal spaces of fermions.

In the meantime, I worked on, together with the collaborators, mainly on the problem what solutions does the Clifford algebra offer in physics of elementary fields and cosmology in even dimensional space, if **in a simple action in $d = (13 + 1)$ fermions carry only spins and interact with gravity only.**

In the last year and a half I started to prove that in even-dimensional spaces the Clifford odd algebra describes the internal space of fermions,
the **Clifford even algebra describes the internal spaces of their corresponding gauge fields.**

In the last half of the year I recognized that in odd-dimensional spaces both algebras, even and odd, gain the properties of the Fadeev-Popov ghost fields, introduced into gauge quantum field theories to maintain the consistency of the path integral formulation.
(To make the contribution of the Feynman diagrams finite.)

I shall first explain the description of the internal spaces of fermion and boson fields,

comparing the way used in the standard model and in my spin-charge-family theory,

and then, very shortly, **the achievements of the spin-charge-family theory so far .**

All elementary particles and fields have their internal spaces.

We call them spins and charges.

I am pointing out my way and usual way of presenting the internal spaces of fields.

The achievements of my spin-charge-family theory, for which I predict that it is the next step beyond both standard models, electroweak and cosmological, are built on the description of the internal spaces of fermion and boson fields with the odd and even Clifford algebra,

enabling to describe all the properties of quarks and leptons and antiquarks and antileptons and their interaction fields in an unique, elegant and simple, way.

The more work is put into my project named the **spin-charge-family theory**, the more answers to the open questions in elementary fermion and boson fields and in cosmology the project offers.

Let us start with presenting **my way** of describing **internal spaces** of **fermion** and **boson fields** offering the anti-commutation relations which **explain the second quantization** for **fermion** and **boson fields**, proposed by Dirac.

$$\{\psi(\vec{x})\,,\,\psi^{\dagger}(\vec{x'})\}_{+} = \delta(\vec{x}-\vec{x'})\,,\ \textbf{fermions}\,,$$
$$\{\dot{\mathcal{A}}_{\alpha}(\vec{x})\,,\,\mathcal{A}_{\beta}(\vec{x'})\}_{-} = i\eta_{\alpha\beta}\delta(\vec{x}-\vec{x'})\,,\ \textbf{bosons}\,,$$

In the literature the groups are used to describe spins and charges.

Either internal or ordinary spaces are assumed to be invariant under Lorentz transformations. This is true also for my way of presenting the internal degrees of freedom.

$$
\begin{aligned}
\{M^{ab}, M^{cd}\}_- &= i\{M^{ad}\eta^{bc} + M^{bc}\eta^{ad} - M^{ac}\eta^{bd} - M^{bd}\eta^{ac}\}\,, \\
\{M^{ab}, p^{c}\}_- &= -i\eta^{ac}p^{b} + i\eta^{cb}p^{a}\,, \\
\{M^{ab}, \mathbf{S}^{cd}\}_- &= i\{\mathbf{S}^{ad}\eta^{bc} + \mathbf{S}^{ad} - \mathbf{S}^{ac}\eta^{bd} - \mathbf{S}^{bd}\eta^{ac}\}\,, \\
M^{ab} &= L^{ab} + \mathbf{S}^{ab}\,, \;\; L^{ab} = x^{a}p^{b} - x^{b}p^{a}\,,
\end{aligned}
$$

There are $\frac{d}{2}$ if d is even, and $\frac{d-1}{2}$ if d is odd of commuting M^{ab} – Cartan sub algebra.

Commutation relations are valid for either L^{ab} or S^{ab} in any dimension of space-time, $\{L^{ab}, S^{cd}\}_- = 0$, whatever the dimension of space-time is.

$\eta^{ab} = diag(1, -1, -1, \ldots, -1, -1)$ for $a = (0, 1, 2, 3, 5, \ldots, d)$.

The usual way of presenting the internal space representing spins of fermions, say, of quarks and leptons, is as follows: The choice of the Cartan sub algebra — of the commuting operators of M^{ab} — in $d = 3+1$ is

$$M^{03}, M^{12},$$

in internal space

$$S^{03}, S^{12}\,.$$

One tells the eigenstates of products of $S^{03}S^{12}$, called handedness, and the spin, the eigenstates of S^{12}. For each of the two handedness we have for the eigenvalue of S^{12} two possibilities: There are **right-handed** and **left-handed vectors**

$$\begin{pmatrix} 1 \\ 0 \end{pmatrix}_{R,L}\,, \qquad \begin{pmatrix} 0 \\ 1 \end{pmatrix}_{R,L}\,.$$

The Pauli matrices are used to rotate one spin state into other:

$$\sigma^1 = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \;\; \sigma^2 = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \;\; \sigma^3 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}, \;\; \sigma^0 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}.$$

My way of describing the internal spacesof fermions and bosons is different.

- **I recognized in Grassmann d-dimensional space**

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  that there are 2^d **anti-commuting operators** θ^a**'s and** 2^d **anti-commuting derivatives** $\frac{\partial}{\partial \theta_a}$,

  with the property

  $$(\theta^a)^\dagger = \eta^{aa} \frac{\partial}{\partial \theta_a}$$

  offering $2\times\ 2^d$ **Clifford algebra objects**

  i. The **Dirac** γ^a (recognized 90 years ago in $d = (3+1)$).
  ii. The **second one:** $\tilde{\gamma}^a$,

  $$\gamma^a = (\theta^a - i\, p^{\theta a})\,, \quad \tilde{\gamma}^a = i\,(\theta^a + i\, p^{\theta a})\,,$$

  References can be found in
  Progress in Particle and Nuclear Physics,
  http://doi.org/**10.1016.j.ppnp.2021.103890** .

- The two kinds of the **Clifford algebra objects** **anti-commute**

$$\begin{aligned} \{\gamma^{\mathbf{a}}, \gamma^{\mathbf{b}}\}_{+} &= 2\eta^{\mathbf{ab}} = \{\tilde{\gamma}^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_{+}, \\ \{\gamma^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_{+} &= 0, \end{aligned}$$

- **There are only ONE kind of fermions and ONE kind of their gauge fields observed.**
- **And there are FAMILIES of fermions observed.**
- **The postulate**

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

with $(-)^{n_B} = +1, -1$, if B has a Clifford even or odd character, respectively, and $|\psi_o>$ is a vacuum state on which the operators γ^a **apply**,
REDUCES the Clifford space for fermions for the factor of two,
while the operators $\tilde{\gamma}^a\tilde{\gamma}^b = -2i\tilde{S}^{ab}$ **define the family quantum numbers for the irreducible representations of fermions**.

- I arranged superposition of products of γ^a **to be eigenvectors of the commuting S^{ab}.** The graphics notation was done together with H.B.Nielsen.

$$\textbf{Cartan...} \quad S^{03}, S^{12}, S^{56}, \cdots, S^{d-1\, d},$$

- **nilpotents**

$$S^{ab}\frac{1}{2}(\gamma^a + \frac{\eta^{aa}}{ik}\gamma^b) = \frac{k}{2}\,\frac{1}{2}(\gamma^a + \frac{\eta^{aa}}{ik}\gamma^b), \quad \stackrel{\mathbf{ab}}{(\mathbf{k})} := \frac{\mathbf{1}}{\mathbf{2}}(\gamma^{\mathbf{a}} + \frac{\eta^{\mathbf{aa}}}{\mathbf{ik}}\gamma^{\mathbf{b}})$$

projectors

$$S^{ab}\frac{1}{2}(1 + \frac{i}{k}\gamma^a\gamma^b) = \frac{k}{2}\,\frac{1}{2}(1 + \frac{i}{k}\gamma^a\gamma^b), \quad \stackrel{\mathbf{ab}}{[\mathbf{k}]} := \frac{\mathbf{1}}{\mathbf{2}}(\mathbf{1} + \frac{\mathbf{i}}{\mathbf{k}}\gamma^{\mathbf{a}}\gamma^{\mathbf{b}}),$$

$$(\stackrel{\mathbf{ab}}{(\mathbf{k})})^2 = \mathbf{0}, \qquad (\stackrel{\mathbf{ab}}{[\mathbf{k}]})^2 = \stackrel{\mathbf{ab}}{[\mathbf{k}]},$$

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

With properties

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

$$
\begin{aligned}
\gamma^a \stackrel{ab}{(k)} &= \eta^{aa} \stackrel{ab}{[-k]}\,, \; \gamma^b \stackrel{ab}{(k)} = -ik \stackrel{ab}{[-k]}\,, \; \gamma^a \stackrel{ab}{[k]} = \stackrel{ab}{(-k)}\,, \; \gamma^b \stackrel{ab}{[k]} = -ik\eta^{aa} \stackrel{ab}{(-k)}\,, \\
\tilde{\gamma}^a \stackrel{ab}{(k)} &= -i\eta^{aa} \stackrel{ab}{[k]}\,, \; \tilde{\gamma}^b \stackrel{ab}{(k)} = -k \stackrel{ab}{[k]}\,, \; \tilde{\gamma}^a \stackrel{ab}{[k]} = \; i \stackrel{ab}{(k)}\,, \; \tilde{\gamma}^b \stackrel{ab}{[k]} = -k\eta^{aa} \stackrel{ab}{(k)}\,, \\
\stackrel{ab}{(k)}\stackrel{ab}{(-k)} &= \eta^{aa} \stackrel{ab}{[k]}\,, \; \stackrel{ab}{[k]}\stackrel{ab}{(k)} = \stackrel{ab}{(k)}\,, \; \stackrel{ab}{(k)}\stackrel{ab}{[-k]} = \stackrel{ab}{(k)}\,, \\
\stackrel{ab}{(k)}\stackrel{ab}{[k]} &= \mathbf{0}\,, \stackrel{ab}{[k]}\stackrel{ab}{(-k)} = \mathbf{0}\,, \; \stackrel{ab}{[k]}\stackrel{ab}{[-k]} = \mathbf{0}\,, \\
\stackrel{\underset{\sim}{ab}}{(-k)}\stackrel{ab}{(k)} &= -i\eta^{aa} \stackrel{ab}{[k]}\,, \; \stackrel{\underset{\sim}{ab}}{[k]}\stackrel{ab}{(k)} = \stackrel{ab}{(k)}\,, \; \stackrel{\underset{\sim}{ab}}{(k)}\stackrel{ab}{[k]} = i \stackrel{ab}{(k)}\,, \; \stackrel{\underset{\sim}{ab}}{[-k]}\stackrel{ab}{[k]} = \stackrel{ab}{[k]}\,, \\
\stackrel{\underset{\sim}{ab}}{(k)}\stackrel{ab}{(k)} &= \mathbf{0}\,, \; \stackrel{\underset{\sim}{ab}}{[-k]}\stackrel{ab}{(k)} = \mathbf{0}\,, \; \stackrel{\underset{\sim}{ab}}{(k)}\stackrel{ab}{[-k]} = \mathbf{0}\,, \; \stackrel{\underset{\sim}{ab}}{[k]}\stackrel{ab}{[k]} = \mathbf{0}\,.
\end{aligned}
$$

- Let the internal space of fermions and bosons, described by the Clifford algebra objects, be called "basis vectors", arranged as products of nilpotents and projectors, so that "basis vectors" are eigenstate of all the Cartan members $S^{03}, S^{12}, S^{56}, S^{d-1\,d}$ in even dimensional spaces.
- "Basis vectors", describing fermions have odd number of nilpotents, the rest of projectors. They are Clifford odd "basis vectors".
- "Basis vectors", describing bosons have even number of nilpotents, the rest of projectors. They are Clifford even "basis vectors".

"Basis vectors", describing fermions, $\hat{b}^{m\dagger}_f$, appear in $2^{\frac{d}{2}-1}$ families, each family with $2^{\frac{d}{2}-1}$ members.

o Usual description of quarks and leptons requires to postulate additional group to represent families!

My Clifford odd "basis vectors", $\hat{b}^{m\dagger}_f$. have their Hermitian conjugated partners , $\hat{b}^m_f$, in another group.

Since Clifford odd "basis vectors" are the superposition of odd products of γ^a's they anti-commute as they do their Hermitian conjugated partners.

$$
\begin{aligned}
\{\hat{b}^m_f, \hat{b}^{m'\dagger}_{f'}\}_{*A+} |\psi_{oc}> &= \delta^{mm'}\, \delta_{ff'}\, |\psi_{oc}>\,,\\
\{\hat{b}^m_f, \hat{b}^{m'}_{f'}\}_{*A+} |\psi_{oc}> &= 0 \cdot |\psi_{oc}>\,,\\
\{\hat{b}^{m\dagger}_f, \hat{b}^{m'\dagger}_{f'}\}_{*A+} |\psi_{oc}> &= 0 \cdot |\psi_{oc}>\,,\\
\hat{b}^{m\dagger}_f {}_{*A} |\psi_{oc}> &= |\psi^m_f>\,,\\
\hat{b}^m_f {*A} |\psi_{oc}> &= 0 \cdot |\psi_{oc}>\,,
\end{aligned}
$$

with (m, m') denoting the "family" members and (f, f') "families".

o In USUAL description of quarks and leptons, the corresponding vectors $\binom{1}{0}$, $\binom{0}{1}$ commute as numbers.

- "Basis vectors", describing bosons in my formulation of the internal space appear in two groups with $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ members. They have NO families.

  They have their Hermitian conjugated partners within the same group.

o In USUAL description of boson fields, the corresponding vectors are triplets and just commute – as numbers.

- In my case the Clifford odd "basis vectors" have properties of second quantized fermion fields, transfering anti-commutativity to the creation and annihilation operators.

- In my case Clifford even "basis vectors" have properties of second quantized boson fields, transferring their commutativity to creation and annihilation operators.

Let us comment the case d=(3+1).

- **Clifford odd "basis vectors" appear in two families $(2^{\frac{d}{2}-1})$, each family has two members $(2^{\frac{d}{2}-1})$.**

$$\hat{\mathbf{b}}^{1\dagger}_{1} = \overset{03}{(+\mathbf{i})}\overset{12}{[+]}\,, \qquad \hat{\mathbf{b}}^{1\dagger}_{2} = \overset{03}{[+\mathbf{i}]}\overset{12}{(+)}\,, \quad \begin{pmatrix} 1 \\ 0 \end{pmatrix}_{R}\,, \quad S^{12} = \frac{1}{2}\,,$$

$$\hat{\mathbf{b}}^{2\dagger}_{1} = \overset{03}{[-\mathbf{i}]}\overset{12}{(-)}\,, \qquad \hat{\mathbf{b}}^{2\dagger}_{2} = \overset{03}{(-\mathbf{i})}\overset{12}{[-]}\,, \quad \begin{pmatrix} 0 \\ 1 \end{pmatrix}_{R}\,, \quad S^{12} = -\frac{1}{2}\,,$$

(in my case $\mathbf{S^{01}}, \mathbf{S^{02}}, \mathbf{S^{31}}, \mathbf{S^{32}}$ **rotate** $\hat{b}^{m\dagger}_{f}$ **into** $\hat{b}^{m'\dagger}_{f'}$, in the Dirac's case σ matrices rotate),

and their Hermitian conjugated partners

$$\hat{\mathbf{b}}^{1}_{1} = \overset{03}{(-\mathbf{i})}\overset{12}{[+]}\,, \qquad \hat{\mathbf{b}}^{1\dagger}_{2} = \overset{03}{[+\mathbf{i}]}\overset{12}{(-)}\,, \quad (\mathbf{1}\ \ \mathbf{0})$$

$$\hat{\mathbf{b}}^{2}_{1} = \overset{03}{[-\mathbf{i}]}\overset{12}{(+)}\,, \qquad \hat{\mathbf{b}}^{2}_{2} = \overset{03}{(+\mathbf{i})}\overset{12}{[-]}\,, \quad (\mathbf{0}\ \ \mathbf{1})$$

There are only right handed or only left handed Clifford odd "basis vectors" ,

- **Clifford even** **"basis vectors" with even number of nilpotents appear in two groups of $(2^{\frac{d}{2}-1}\times 2^{\frac{d}{2}-1})$ members, with their Hermitian conjugated partners within the same group.**

Group ${}^{I}\mathcal{A}^{m\dagger}_{f}$

$$
\begin{array}{lcclcc}
 & \mathcal{S}^{03} & \mathcal{S}^{12} & & \mathcal{S}^{03} & \mathcal{S}^{12} \\
{}^{\mathbf{I}}\mathcal{A}^{\mathbf{1}\dagger}_{\mathbf{1}} = \overset{03}{[+\mathbf{i}]}\overset{12}{[+]} & 0 & 0 & ,\; {}^{\mathbf{I}}\mathcal{A}^{\mathbf{1}\dagger}_{\mathbf{2}} = \overset{03}{(+\mathbf{i})}\overset{12}{(+)} & i & 1 \\
{}^{\mathbf{I}}\mathcal{A}^{\mathbf{2}\dagger}_{\mathbf{1}} = \overset{03}{(-\mathbf{i})}\overset{12}{(-)} & -i & -1 & ,\; {}^{\mathbf{I}}\mathcal{A}^{\mathbf{2}\dagger}_{\mathbf{2}} = \overset{03}{[-\mathbf{i}]}\overset{12}{[-]} & 0 & 0\,,
\end{array}
$$

Group ${}^{II}\mathcal{A}^{m\dagger}_{f}$

$$
\begin{array}{lcclcc}
 & \mathcal{S}^{03} & \mathcal{S}^{12} & & \mathcal{S}^{03} & \mathcal{S}^{12} \\
{}^{\mathbf{II}}\mathcal{A}^{\mathbf{1}\dagger}_{\mathbf{1}} = \overset{03}{[+\mathbf{i}]}\overset{12}{[-]} & 0 & 0 & ,\; {}^{\mathbf{II}}\mathcal{A}^{\mathbf{1}\dagger}_{\mathbf{2}} = \overset{03}{(+\mathbf{i})}\overset{12}{(-)} & i & 1 \\
{}^{\mathbf{II}}\mathcal{A}^{\mathbf{2}\dagger}_{\mathbf{1}} = \overset{03}{(-\mathbf{i})}\overset{12}{(+)} & -i & 1 & ,\; {}^{\mathbf{II}}\mathcal{A}^{\mathbf{2}\dagger}_{\mathbf{2}} = \overset{03}{[-\mathbf{i}]}\overset{12}{[+]} & 0 & 0\,,
\end{array}
$$

In my case there is additional way to "rotate" Clifford odd "basis vectors", describing fermions.

Besides by rotating with $S^{01}, S^{02}, S^{31}, S^{32}$

the same can be achieved as well by the application of ${}^{\mathbf{I}}\mathcal{A}^{\mathbf{m}\dagger}_{\mathbf{f}}$.

- ${}^{\mathbf{I}}\mathcal{A}^{2\dagger}_{\mathbf{1}}(=\overset{03}{(-\mathbf{i})}\overset{12}{(-)}) *_A \hat{\mathbf{b}}^{1\dagger}_{\mathbf{1}}(=\overset{03}{(+\mathbf{i})}\overset{12}{[+]}) = \hat{\mathbf{b}}^{2\dagger}_{\mathbf{1}}(=\overset{03}{[-\mathbf{i}]}\overset{12}{(-)})$.

  This means that the Clifford even "basis vector" ${}^{\mathbf{I}}\mathcal{A}^{\mathbf{m}\dagger}_{\mathbf{f}}$ brings to the Clifford odd "basis vector" the integer spin $(0, \pm 1)$.

  ${}^{\mathbf{I}}\mathcal{A}^{\mathbf{m}\dagger}_{\mathbf{f}}$ manifest the properties of the gauge fields to the corresponding $\hat{b}^{m'\dagger}_{f'}$ fermion fields.
- ${}^{I}\mathcal{A}^{m\dagger}_{f}$ have properties of the second quantized boson fields.

$$ {}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}} *_{\mathbf{A}} {}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}'\dagger}_{\mathbf{f}'} \rightarrow \begin{cases} {}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}'} \,, \\ \textbf{or } \mathbf{0}\,, \mathbf{i} = (\mathbf{I}, \mathbf{II})\,. \end{cases} $$

Let us see how does in my way look one family of quarks and leptons and antiquarks and anileptons.

S^{ab} generate **all the members of one family. All are Clifford odd "basis vectors"** .

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

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

The **eightplet** — $SO(7,1)$, — **part is identical for quarks and leptons and separately for antiquarks and antileptons. They distinguish only in** $SU(3) \times U(1)$ **part** — in τ^{33}, τ^{38}, τ^{41}.

i		$\vert^a\psi_i>$	$\Gamma^{(3,1)}$	S^{12}	$\Gamma^{(4)}$	τ^{13}	τ^{23}	Y	Q
		Octet, $\Gamma^{(7,1)} = 1$, $\Gamma^{(6)} = -1$, of leptons							
25	ν_R	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \vert \stackrel{56}{(+)}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	0	0
26	ν_R	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \vert \stackrel{56}{(+)}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	0	0
27	e_R	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \vert \stackrel{56}{[-]}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	-1	-1
28	e_R	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \vert \stackrel{56}{[-]}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	-1	-1
29	e_L	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \vert \stackrel{56}{[-]}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{2}$	-1
30	e_L	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \vert \stackrel{56}{[-]}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{2}$	-1
31	ν_L	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \vert \stackrel{56}{(+)}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{2}$	0
32	ν_L	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \vert \stackrel{56}{(+)}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$-\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{2}$	0

$\gamma^0\gamma^7$ and $\gamma^0\gamma^8$ transform ν_R of the 1^{st} line into ν_L of the 7^{th} line, and e_R of the 4^{rd} line into e_L of the 6^{th} line, doing what the Higgs scalars and γ^0 do in the *standard model*.

S^{ab} generate also **quarks** of the two additional colours and colourless **leptons**, and the corresponding **antiquarks** and **antileptons,** presented below.

Quarks and **leptons**, and **anti quarks** and **antileptons** have **all the properties assumed by the** *standard model*.

i		$\vert^a\psi_i >$	$\Gamma^{(3,1)}$	S^{12}	$\Gamma^{(4)}$	τ^{13}	τ^{23}	Y	τ^4
		Antioctet, $\Gamma^{(7,1)} = -1$, $\Gamma^{(6)} = 1$, of antiquarks							
33	$\bar{d}_L^{\bar{c}1}$	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \vert \stackrel{56}{(+)}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{6}$
34	$\bar{d}_L^{\bar{c}1}$	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \vert \stackrel{56}{(+)}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	-1	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{6}$
35	$\bar{u}_L^{\bar{c}1}$	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \vert \stackrel{56}{[-]}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{2}{3}$	$-\frac{1}{6}$
36	$\bar{u}_L^{\bar{c}1}$	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \vert \stackrel{56}{[-]}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	- 1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{2}{3}$	$-\frac{1}{6}$
37	$\bar{d}_R^{\bar{c}1}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \vert \stackrel{56}{(+)}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$
38	$\bar{d}_R^{\bar{c}1}$	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \vert \stackrel{56}{(+)}\stackrel{78}{[-]} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$
39	$\bar{u}_R^{\bar{c}1}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \vert \stackrel{56}{[-]}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$
40	$\bar{u}_R^{\bar{c}1}$	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \vert \stackrel{56}{[-]}\stackrel{78}{(+)} \vert\vert \stackrel{9\,10}{[-]}\stackrel{11\,12}{[+]}\stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$

$\gamma^0\gamma^7$ and $\gamma^0\gamma^8$ transform $\bar{d}_L$ of the 1^{st} row into $\bar{d}_R$ of the 5^{th} row, and $\bar{u}_L$ of the 4^{rd} row into $\bar{u}_R$ of the 8^{th} row.

All quarks and leptons and antiquarks and antileptons, the "basis vectors" of which are presented in the last three tables, fulfil the anti-commutation relations required by the second quantization postulates, therefore, explaining the second quantization postulates, since the Clifford odd "basis vectors" transfer the anti-commutativity to the creation and their Hermitian conjugated partners annihilation operators. The basis in ordinary space, namely, commute.

Let us introduce the momentum basis in ordinary space

$$\begin{aligned} |\vec{p}> &= \hat{b}^{\dagger}_{\vec{p}}\,|\,0_p\;>\,, \quad <\vec{p}\,| =<\,0_p\,|\,\hat{b}_{\vec{p}}\,,\\ <\vec{p}\,|\,\vec{p}'> &= \delta(\vec{p}-\vec{p}') =<\,0_p\,|\hat{b}_{\vec{p}}\,\hat{b}^{\dagger}_{\vec{p}'}|\,0_p\;>\,,\\ \hat{b}_{\vec{p}}\,\hat{b}^{\dagger}_{\vec{p}'} &= \delta(\vec{p}-\vec{p}')\,,\;<\,0_p\,|\,0_p\;>=1\,. \end{aligned}$$

Then the creation operators can be written in a tensor product, $*_T$:

- for quarks and leptons and antiquarks and antileptons we can write

$$\{\hat{\mathbf{b}}^{s\dagger}_{f}(\vec{p}) \;=\; \sum_{m} c^{sm}{}_{f}\,(\vec{p})\,\hat{b}^{\dagger}_{\vec{p}} *_T\; \hat{b}^{m\dagger}_{f}\}\,|\psi_{oc}> \;*_T\,|0_{\vec{p}}>\,,$$

- for bosons, the gauge fields of quarks and leptons and antiquarks and antileptons, we can write

$$\{{}^{\mathbf{I}}\hat{\mathcal{A}}^{\mathbf{s}\dagger}_{\alpha}(\tilde{\mathbf{p}}) \;=\; \sum_{mf} \mathcal{C}^{\mathbf{sm}}{}_{\mathbf{f}\alpha}\,(\tilde{\mathbf{p}})\,\hat{\mathbf{b}}^{\dagger}_{\tilde{\mathbf{p}}} *_{\mathbf{T}}\, {}^{\mathbf{I}}\hat{\mathcal{A}}^{\mathbf{s}\dagger}_{\mathbf{f}}\}\,|\phi_{ob}> \;*_T\,|0_{\vec{p}}> \;\;.$$

boson fields need additional space index $\mathcal{C}^{sm}_{f\alpha}$.

A simple starting action used in the spin-charge-family theory.

Fermions carry in $d=(13+1)$ only spins, two kinds of spins (no charges) and interact with only the gauge gravitational fields.

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

- **with vielbeins and the two kinds of spin connection fields**

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

What new will come when replacing $\omega_{ab\alpha}$ with ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$?

$$
\begin{aligned}
\mathbf{p}_{0\alpha} &= \mathbf{p}_{\alpha} - \sum_{ab} \frac{1}{2} \mathbf{S}^{\mathbf{ab}} \omega_{\mathbf{ab}\alpha} - \sum_{\mathbf{ab}} \frac{1}{2} \tilde{\mathbf{S}}^{\mathbf{ab}} \tilde{\omega}_{\mathbf{ab}\alpha} \\
&\text{into} \\
\mathbf{p}_{0\alpha} &= \mathbf{p}_{\alpha} - \sum_{mf} \mathcal{C}^{\mathbf{m}}_{\mathbf{f}\alpha}\, {}^{\mathbf{I}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}} - \sum_{mf} \tilde{\mathcal{C}}^{\mathbf{m}}_{\mathbf{f}\alpha}\, {}^{\mathbf{I}}\hat{\tilde{\mathcal{A}}}^{\mathbf{m}\dagger}_{\mathbf{f}}
\end{aligned}
$$

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

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

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

Fermions with only spin in $d = (13+1)$
are observed in $d = (3+1)$ as:

o if carrying ordinary spin, having no weak charge and carrying additional $SU(2)$ charge:
as right handed quarks and leptons,
or as left handed antiquarks and antileptons,

o if carrying ordinary spin, weak charge different from zero and additional $SU(2)$ charge equal zero ,
as left handed quarks and leptons,
or as right handed antiquarks and antileptons.

Leptons are colourless and quarks coloured.
Antileptons are anticolourless and antiquarks are anticoloured.

o SM The electroweak (and colour) standard model assumes NO additional $SU(2)$ charge .

o SM Let us present the electroweak (and colour) standard model, postulated more than **50 years ago**, offering an **elegant new step** in **understanding the origin of fermions and bosons in that time**
by **postulating**:

A.

- **The existence** of **massless family members** with the **charges** in the **fundamental representation of the groups** -
  o the **coloured triplet quarks and colourless leptons**,
  o the **left handed members as the weak charged doublets**,
  o the **right handed weak chargeless members**,
  o the **left handed quarks distinguishing in the hyper charge from the left handed leptons**,
  o each right handed member having a different hyper charge.
- **The existence** of **massless families to each of a family member.**
- **The second quantization postulates of fermion fields.**

- **o SM**

α name	hand-edness $-4iS^{03}S^{12}$	weak charge τ^{13}	hyper charge Y	colour charge	elm charge Q
u^i_L	-1	$\frac{1}{2}$	$\frac{1}{6}$	colour triplet	$\frac{2}{3}$
d^i_L	-1	$-\frac{1}{2}$	$\frac{1}{6}$	colour triplet	$-\frac{1}{3}$
ν^i_L	-1	$\frac{1}{2}$	$-\frac{1}{2}$	colourless	0
e^i_L	-1	$-\frac{1}{2}$	$-\frac{1}{2}$	colourless	-1
u^i_R	1	weakless	$\frac{2}{3}$	colour triplet	$\frac{2}{3}$
d^i_R	1	weakless	$-\frac{1}{3}$	colour triplet	$-\frac{1}{3}$
$[\nu^i_R]$	1	weakless	0	colourless	0
e^i_R	1	weakless	-1	colourless	-1

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

I postulate only that the internal spaces of fermions are described by the Clifford odd "basis vectors";
and all the quantum numbers for quarks and leptons and antiquark and antileptons appear by themselves,
the ones assumed by the *standard model* before the electroweak break.
Since in my case an additional $SU(2)$ charge to the weak charge appears, I do have the right handed neutrino and left handed antineutrino and the *standard model* does NOT have them.
I do have families without postulated them,
and **my quarks and leptons and antiquarks and antileptons have properties of the second quantized fermion fields,**
without postulating.
There are anti-commuting properties of the Clifford odd "basis vectors", which transfer their anti-commutativity to the creation operators.

o SM

B. The postulates of the standard model continue

- **The existence** of **massless vector gauge fields** to the observed **charges** of the **family members**, **carrying charges** in the **adjoint representation of the charge groups**.

  Masslessness was needed for the gauge invariance.

o SM

Gauge fields before the electroweak break

- **Three massless vector fields, the gauge fields of the $U(1), SU(2), SU(3)$ charges of quarks and leptons.**

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

They are vectors, with the space index (0,1,2,3) in $d = (3+1)$, in the adjoint representations with respect to the weak, colour and hyper charges.

o SM
C.

- The **existence of a massive scalar field** - **the higgs**,

  o carrying the weak charge $\pm\frac{1}{2}$ and the hyper charge $\mp\frac{1}{2}$ (as it would be in the fundamental representation of the groups.)

  o gaining at some step the **imaginary mass** and consequently the **constant value** , breaking the weak and the hyper charge and correspondingly breaking the **mass protection**.

- The **existence** of the **Yukawa couplings**, taking care of

  o the properties of **fermions** and

  o the masses of the **heavy bosons**.

o SM

- The **Higgs's field**, **the scalar in** $d = (3+1)$, **a doublet with respect to the weak charge**.

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

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

o SM

D.

- There is the **gravitational field** in $\mathbf{d=(3+1)}$.

- **In the spin-charge-family theory, all vector** and **scalar gauge fields origin in gravity, explaining the origin of the vector and scalar gauge field, which in the standard model are assumed**,
  Eur. Phys. J. C **77** (2017) 231:

  o Vector gauge fields carry space index $(0,1,2,3)$, and **scalar gauge fields, higgs, carry space index** $(7,8)$**. Both origin in two spin connection fields**, the **gauge fields** of $\gamma^a\gamma^b$ and $\tilde{\gamma}^a\tilde{\gamma}^b$, and in

  o vielbeins, the gauge fields of momenta,
  Eur. Phys. J. C **77** (2017) 231, [arXiv:1604.00675].

- **There are additional scalar fields, explaining the matter anti-matter asymmetry in the universe, carrying space index** $(9,10,dots,14)$.

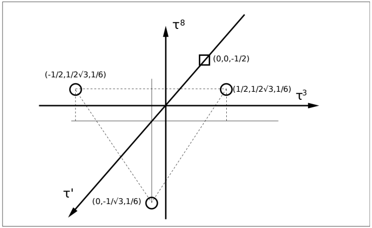
$$
\begin{aligned}
\mathbf{S} \;&=\; \int d^d x\, E\, \mathcal{L}_f + \\
&\quad\;\; \int d^d x\, E\, (\alpha\, R + \tilde{\alpha}\, \tilde{R})
\end{aligned}
$$

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

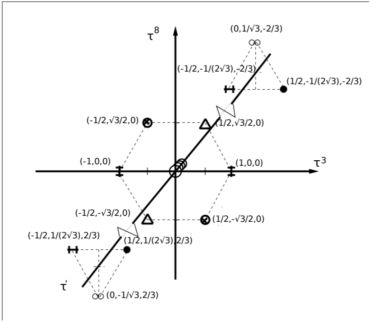
- **Looking for understanding nature with the Clifford odd and even "basis vectors",**
  I recognized that the internal spaces of the observed fermions can be described by the Clifford odd "basis vectors",
  and the internal spaces of the observed bosons can be described by the Clifford even "basis vectors".
- **Let us illustrate this recognition on a special case of** $d = (5+1)$,
  looking at the $SU(3) \times U(1)$ **sub-groups of the** $SO(5,1)$ **group (with the commuting operators** S^{03}, S^{12}, S^{56}**):**

$$\tau^3 := \quad \frac{1}{2}\,(-S^{1\,2} - iS^{0\,3})\,, \qquad \tau^8 = \frac{1}{2\sqrt{3}}(-iS^{0\,3} + S^{1\,2} - 2S^{5\,6})\,,$$
$$\tau' = -\frac{1}{3}(-iS^{0\,3} + S^{1\,2} + S^{5\,6})\,.$$

- In the **Clifford odd** part we find one **colour triplet of "basis vectors"** with $\tau' = \frac{1}{6}$ and **one colour singlet** with $\tau' = -\frac{1}{2}$, (representing, let say, only the colour part of **quarks and of the colourless leptons of one family**).



- The Clifford even "basis vectors" demonstrate: one sextet with $\tau' = 0$, four singlets with $(\tau^3 = 0, \tau^8 = 0, \tau' = 0)$, one triplet with $\tau' = \frac{2}{3}$ and one triplet with $\tau' = -\frac{2}{3}$.



If ${}^{I}\hat{\mathcal{A}}^{m}_{f}$, $\odot\odot$, with $(\tau^3 = 0, \tau^8 = -\frac{1}{\sqrt{3}}, \tau' = \frac{2}{3})$, applies on the Clifford odd "basis vector" with $(\tau^3 = 0, \tau^8 = 0, \tau' = -\frac{1}{2})$, $\square$, a singlet, transforms this singlet into Clifford odd "basis vector" with $(\tau^3 = 0, \tau^8 = -\frac{1}{\sqrt{3}}, \tau' = \frac{1}{6})$.

o SM

- **The *standard model* assumptions have been confirmed without offering surprises.**
- **The last unobserved field as a field, the Higgs's scalar, detected in June 2012, was confirmed in March 2013.**
- **The waves of the gravitational field were detected in February 2016 and again 2017. o SM**

There remain not understood phenomena within o SM

- The **Standard model assumptions need explanation, need next step.**

- **There are several cosmological observations which do not look to be explainable within the standard model, like**

  o The **existence of the dark matter**

  o The **matter/antimatter asymmetry in the universe**

  o The **need for the** *dark energy*

- the **observed dimension of space time**,
- the **quantization of the gravitational field since all systems are to my understanding second quantized**,
- ...

- o SM The Standard model assumptions have in the literature several explanations, but with **many new not explained assumptions.**

- The Spin-Charge-Family theory offers the explanation for
  i. all the assumptions of the *standard model*,
  ii. for many observed phenomena:
  ii.a. the **dark matter**,
  ii.b. the **matter-antimatter asymmetry**,
  ii.c. **others observed phenomena**,
  iii. explaining the Dirac's postulates for the **second quantized fermion** and **second quantized boson** fields,
  iv. **making several predictions.**

  Is the Spin-Charge-Family theory the right next step beyond both standard models?

In the literature all the internal spaces are described by using groups.

- Quarks and leptons and antiquarks and antileptons are postulated separately.
- NO explanation for the existence of the families of quarks and leptons can be found, which would not just assume the family groups.
- Several extensions of the standard model are, however, proposed, like:

  0 The $SU(3)$ group is assumed to describe, not to explain, the existence of three families.

  0 Like the Higgs's scalar charges are in the fundamental representations of the groups.

- **The most popular are the SU(5) and SO(10) grand unified theories unifying all the charges.**

  o But the **spin** (the handedness) **is obviously connected with the (weak and the hyper) charges, what these theories do "by hand" as it does the standard model, and the appearance of families is not explained.**

- **Supersymmetric theories, assuming the existence of bosons with the charges of quarks and leptons and fermions with the charges of the gauge vector fields,**

  although having several nice properties but not explaining the appearance of families (except again by assuming larger groups), are not, to my understanding, the right next step beyond the standard model.

o The **Spin-Charge-Family theory does offer the explanation for all the assumptions of the standard model**,

o **For the observed properties of quarks and leptons and antiquarks and antileptons** ,

o **For the vector and scalar gauge fields** ,

o **explaining** the **second quantization postulates** for **fermions and bosons.**

o **Let us see how does** the **break of the starting symmetry** $SO(13,1)$, **leading to the observed properties of quarks and leptons and antiquarks and antileptons and to observed vector and scalars , go.**

o **Let me tell the concrete predictions so far made**.

Breaking symmetry from M^{13+1} into $M^{7+1} \times M^{6}$

- **We start with the massless solutions of the Weyl equation in $d = (13+1)$ with the "basis vectors", described by the odd Clifford algebra objects, determining the internal space of fermions.**
- **With the spin (or the total angular momentum) in extra dimensions, $d > (7+1)$, determining** the **colour** $SU(3)$ **and** the **"fermion charge"** τ **in** $d = (7+1)$.
- **Also all the boson fields are in $d = (13+1)$ massless free fields with the "basis vectors", described by** the **even Clifford algebra objects, determining the internal space of bosons.**

Condensate

- **The (assumed so far, waiting to be derived how does this spontaneously appear) scalar condensate of two right handed neutrinos with the family quantum numbers of the upper four families (there are two four family groups in the theory)**, appearing $\approx 10^{16}$ GeV or higher,

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

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

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

  o Before the electroweak break all the so far observed vector gauge fields are massless.

  Phys. Rev. **D 91** (**2015**) 6, 065004,
  J. of Mod. Phys. **6** (**2015**) 2244,
  J. Phys.: Conf.Ser. 845 01, **IARD 2017**

The **condensate has spin** $S^{12} = 0$, $S^{03} = 0$,
weak charge $\vec{\tau}^{1} = 0$, **and**
$\vec{\tilde{\tau}}^{1} = 0$, $\tilde{Y} = 0$, $\tilde{Q} = 0$, $\vec{\tilde{N}}_L = 0$.

state	τ^{23}	τ^{4}	Y	Q	$\tilde{\tau}^{23}$	$\tilde{N}^{3}_{R}$	$\tilde{\tau}^{4}$
$\lvert\nu^{VIII}_{1R} >_1 \, \lvert\nu^{VIII}_{2R} >_2$	1	-1	0	0	1	1	-1
$\lvert\nu^{VIII}_{1R} >_1 \, \lvert e^{VIII}_{2R} >_2$	0	-1	-1	-1	1	1	-1
$\lvert e^{VIII}_{1R} >_1 \, \lvert e^{VIII}_{2R} >_2$	-1	-1	-2	-2	1	1	-1

- The vector fields, **which do not couple to the condensate and remain massless, are:**

  o the hyper charge vector field.

  o the weak vector fields,

  o the colour vector fields,

  o the gravity fields.

  The $SU(2)_{II}$ symmetry breaks due to the **condensate**, leaving the **hyper charge unbroken**.

S^{ab} generate **all the 64 members of one family**. The **eightplet** (represent. of $SO(7,1)$) **of quarks of a particular colour charge.** **All are Clifford odd "basis vectors"** .

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

Nonzero vacuum expectation values of scalars

— waiting to be shown how does such an event, making the masses of the scalar gauge fields imaginary, appear in the spin-charge-family spontaneously.

- **The scalar fields with the space index $(7, 8)$, gaining nonzero vacuum expectation values**, a constant values, **cause the electroweak break**,

  o **breaking the weak and the hyper charge,**

  o **changing their own masses**,

  o **bringing masses to the weak bosons**,

  o **bringing masses to the families of quarks and leptons**.

  Phys. Rev. **D 91** (**2015**) 6, 065004,
  J. Phys.: Conf.Ser. 845 01 **IARD 2017**,
  Eur. Phys. J.C. **77** (2017) 231 [arXiv:1604.00675],
  J. of Mod. Phys. **6** (**2015**) 2244, [arXiv:1502.06786, arXiv:1409.4981]

- **The only gauge fields which do not couple to these scalars and remain massless are**

  o electromagnetic,

  o colour vector gauge fields,

  o gravity.

- **There are two times four decoupled massive families of quarks and leptons after the electroweak break**:

  o There are the observed three families among the **lower four, the fourth to be observed**.

  o The stable among the upper four families form the **dark matter**.

  Phys. Rev. **D 80**, 083534 (**2009**),
  Phys. Rev. **D 91** (**2015**) 6, 065004,
  J. Phys.: Conf.Ser. 845 01, **IARD 2017**

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

BREAK I

at $\mathsf{E} \geq 10^{16}\mathsf{GeV}$

$\downarrow$

$\mathsf{SO}(1,7) \times$ $\times \widetilde{\mathsf{SO}(1,7)}$ $\qquad$ $\mathsf{U}(1) \times$ $\qquad$ $\mathsf{SU}(3)$

$\swarrow$ $\qquad$ $\searrow$

eight massless families

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

(devided into two groups)

BREAK II

$\downarrow$

The Standard Model like way of breaking

$\downarrow$

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

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

- **It is really encouraging for the spin-charge-family theory, that a simple starting action contains all the fermions, all the corresponding vector gauge fields and all the scalar fields observed at low energies.**
- There are **two breaks of the manifold** $M^{(13,1)}$ **needed**:

  o At high energies — $\geq 10^{16}$ **GeV — from** $M^{(13,1)}$ **to** $M^{(7,1)} \times M^{(6)}$. **The condensate of two right handed neutrinos with the weak charge zero, the second** $SU(2)$ **charge equal to** 1**, with the"fermion charge"** -1**,** $\tilde{\tau}^{13} = 1$**,** $\tilde{\tau}^{4} = -1$**,** $\tilde{N}^{3}_{R} = 1$**) can do this break, making all the boson fields not observed at low energies very heavy.**

  o At the electroweak break scalar fields with the space index $(7,8)$ **give masses to twice four families of quarks and leptons and anti-quarks and anti-leptons and to weak bosons.**

The Spin-Charge-Family theory explains

o all the assumptions of the standard model, with the gauge fields, scalar fields, families of fermions, masses of fermions and of bosons included,

o explaining also the dark matter, *Phys. Rev. D* **80**, 083534 (2009), 1-16,

o the matter/antimatter asymmetry, *Phys. Rev.* **D 91** (2015) 065004

o the triangle anomalies cancellation in the standard model (Forts. der Physik, Prog.of Phys.) (2017) 1700046)

and...

Fermions

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

$$
\begin{aligned}
\mathcal{L}_f &= \bar{\psi}\gamma^m (p_m - \sum_{A,i} g^A \tau^{Ai} A^{Ai}_m)\psi + \quad (m = 0,1,2,3) \\
&\quad \{ \sum_{s=[7],[8]} \bar{\psi}\gamma^s p_{0s}\, \psi\} + \ (\text{mass by Higgs}\, \tau^{13} = \pm\frac{1}{2}, Y = \mp\frac{1}{2}) \\
&\quad \{ \sum_{s=[5],[6]} \bar{\psi}\gamma^s p_{0s}\, \psi + \quad (\text{scalar doublets}) \\
&\quad \sum_{t=[9],\dots[14]} \bar{\psi}\gamma^t p_{0t}\, \psi\} \quad (\text{scalar triplets}) \\
&\quad + \text{the rest}\ ,\ ,
\end{aligned}
$$

J. of Mod. Phys. **4** (**2013**) 823

Covariant momenta and bosons

$$
\begin{aligned}
p_{0m} &= \{p_m - \sum_A g^A \vec{\tau}^A \tilde{\mathbf{A}}^{\mathbf{A}}_{\mathbf{m}}\}\,, \quad \mathbf{A}^{\mathbf{Ai}}_{\mathbf{m}} = \sum_{\mathbf{a},\mathbf{b}} \mathbf{c}^{\mathbf{Ai}}{}_{\mathbf{ab}}\, \omega_{\mathbf{abm}}\,,\\
\mathbf{m} &\in (\mathbf{0},\mathbf{1},\mathbf{2},\mathbf{3})\,,\\
p_{0s} &= f^{\sigma}_{s}[p_\sigma - \sum_A g^A \vec{\tau}^A \tilde{\mathbf{A}}^{\mathbf{A}}_{\sigma} - \sum_A \tilde{g}^A \vec{\tilde{\tau}}^A \tilde{\tilde{\mathbf{A}}}^{\mathbf{A}}_{\sigma}]\,,\\
\mathbf{s} &\in (\mathbf{7},\mathbf{8})\,,\\
p_{0s} &= f^{\sigma}_{s}[p_\sigma - \sum_A g^A \vec{\tau}^A \tilde{\mathbf{A}}^{\mathbf{A}}_{\sigma} - \sum_A \tilde{g}^A \vec{\tilde{\tau}}^A \tilde{\tilde{\mathbf{A}}}^{\mathbf{A}}_{\sigma}]\,,\\
\mathbf{s} &\in (\mathbf{5},\mathbf{6})\,,\\
p_{0t} &= f^{\sigma'}_{t}(p_{\sigma'} - \sum_A g^A \vec{\tau}^A \tilde{\mathbf{A}}^{\mathbf{A}}_{\sigma'} - \sum_A \tilde{g}^A \vec{\tilde{\tau}}^A \tilde{\tilde{\mathbf{A}}}^{\mathbf{A}}_{\sigma'})\,,\\
\mathbf{t} &\in (\mathbf{9},\mathbf{10},\mathbf{11},\ldots,\mathbf{14})\,,\\
\mathbf{A}^{\mathbf{Ai}}_{\sigma} &= \sum_{a,b} c^{Ai}{}_{ab}\, \omega_{\mathbf{ab}\sigma}\,, \quad \tilde{\mathbf{A}}^{\mathbf{Ai}}_{\sigma} = \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\, \tilde{\omega}_{\mathbf{ab}\sigma}\,,
\end{aligned}
$$

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

- τ^{Ai} **represent the charge groups, following from** $SO(13,1)$ **—** $SU(3)_c, SU(2)_w$ **as in the** *standard model* **— the second** $SU(2)_{II}$**, the "spinor" charge** $U(1)$**, taking care of the hyper charge of the** *standard model* $Y = \tau^{23} + \tau^4$,
- $\tilde{\tau}^{Ai}$ **denote the family quantum numbers.**

New J. Phys. 13, 103027, 2011.
J. Phys. A. Math. Theor. 45, 465401, 2012.

- **The break from $SO(13,1)$ to $SO(7,1) \times SO(6)$, made by the appearance of the condensate, leaves eight massless families of quarks and leptons and antiquarks and antileptons**,
- **Makes the boson gauge fields, with which the condensate interacts, massive**. These gauge fields are:

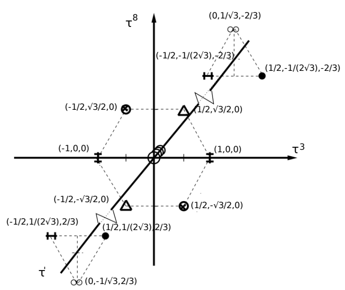
o All the **scalar gauge fields which couple to the condensate**.

o The vector ($m \leq 3$) gauge fields with the Y' **charges — the superposition of** $SU(2)_{II}$ and $U(1)_{II}$ **charges**.

J. Phys.: Conf. Ser. 845 (**2017**) 012017

Let us look at **boson "basis vectors"** presented in a toy model, which analyses ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$ with respect to Cartan subalgebra members (τ^3, τ^8, τ').

There are
one sextet with $\tau' = 0$,
four singlets with $(\tau^3 = 0, \tau^8 = 0, \tau' = 0)$,
one triplet with $\tau' = \frac{2}{3}$ and one triplet with $\tau' = -\frac{2}{3}$.
The only ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$ which couple to condensate in this toy model are the two triplets with $\tau' = \pm\frac{2}{3}$, **transforming leptons** into **quarks**. **These two triplests** become massive.



- The **colour, elm, weak and hyper** **vector gauge fields do not interact with the condensate and remain massless**. J. of Mod. Physics **6** (**2015**) 2244

At the electroweak break (caused by the scalar fields)

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

break to

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

o Scalar fields, higgses with the space index $s = (7,8)$ **manifesting the symmetry of either**
$\widetilde{SU}(2)_L \times \widetilde{SU}(2)_I \times U(1)$
or $\widetilde{SU}(2)_R \times \widetilde{SU}(2)_{II} \times U(1)$
obtain constant values and imaginary masses (nonzero vacuum expectation values),

o breaking correspondingly the **weak** and the **hyper charge Y** , **and changing their own masses**.

o They leave massless only the **colour, elm** and **gravity gauge fields.**

Twice four massless families of quarks and leptons and antiquarks and antileptons gain masses.

- **Several scalar fields carry the weak and the hyper charge of the *standard model* higgs.**
- **They carry besides the weak and the hyper charge either**

  o the family members quantum numbers originating in (Q,Q',Y') or

  o the family quantum numbers originating in $\widetilde{SU}(2)_L \times \widetilde{SU}(2)_I$ or $\widetilde{SU}(2)_R \times \widetilde{SU}(2)_{II}$.

  J. of Mod. Physics **6** (**2015**) 2244.

- **The mass matrices of each family member manifest the** $\widetilde{SU}(2)_{L,R} \times \widetilde{SU}(2)_{I,II} \times U(1)$ **symmetry**.

[arXiv:1902.02691, arXiv:1902.10628]

- **Several scalar gauge fields with the space index (s,t,s') = (7,8), origin in the spin connection fields, either $\tilde{\omega}_{abs}$ or $\omega_{s'ts}$:**

  o There are twice two triplets, the scalar gauge fields with the family quantum numbers ($\tilde{\tau}^{Ai} = \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\, \tilde{S}^{ab}$) and

  o three singlets with the family members quantum numbers (Q,Q',Y'), the gauge fields of S^{st}.
- **They are all doublets with respect to the space index (5,6,7,8).**
- **They have all the rest quantum numbers determined by the adjoint representations.**
- **They explain at the so far observable energies the Higgs's scalar** and **the Yukawa couplings.**

J. of Mod. Physics **6** (**2015**) 2244. [arXiv:1902.02691, arXiv:1902.10628]

The two **doublets**, determining the properties of the **Higgs's scalar** and the **Yukawa couplings**, are:

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

There are $A^{Ai}_{\frac{78}{(-)}}$ and $A^{Ai}_{\frac{78}{(+)}}$ which gain **nonzero vacuum expectation values** at the **electroweak break**.

Index Ai determines the **family** ($\tilde{\tau}^{Ai}$) quantum numbers and the **family members (Q,Q',Y')** quantum numbers, both are in adjoint representations.

Scalars with s=(7,8), which gain nonzero vacuum expectation values, break the weak and the hyper symmetry, while conserving the electromagnetic and colour charge:

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

Ai denotes:

o family quantum numbers

($\tilde{\tilde{\tau}}^{1}$, $\tilde{\tilde{N}}_{L}$) quantum numbers of the first group of four families and

($\tilde{\tilde{\tau}}^{2}$, $\tilde{\tilde{N}}_{R}$)) quantum numbers of the second group of four families.

o And family members quantum numbers (Q, Q', Y')

A^{Ai}_s **are expressible with either** $\omega_{sts'}$ **or** $\tilde{\omega}_{abs'}$**.**

$$
\begin{aligned}
\tilde{\tilde{\mathbf{A}}}^{\mathbf{1}}_{\mathbf{s}} &= (\tilde{\omega}_{\mathbf{58s}} - \tilde{\omega}_{\mathbf{67s}}, \tilde{\omega}_{\mathbf{57s}} + \tilde{\omega}_{\mathbf{68s}}, \tilde{\omega}_{\mathbf{56s}} - \tilde{\omega}_{\mathbf{78s}})\,, \\
\tilde{\tilde{\mathbf{A}}}^{\mathbf{2}}_{\mathbf{s}} &= (\tilde{\omega}_{\mathbf{58s}} + \tilde{\omega}_{\mathbf{67s}}, \tilde{\omega}_{\mathbf{57s}} - \tilde{\omega}_{\mathbf{68s}}, \tilde{\omega}_{\mathbf{56s}} + \tilde{\omega}_{\mathbf{78s}})\,, \\
\tilde{\tilde{\mathbf{A}}}^{\mathbf{N}}_{\mathbf{Ls}} &= (\tilde{\omega}_{\mathbf{23s}} + \mathbf{i}\tilde{\omega}_{\mathbf{01s}}, \tilde{\omega}_{\mathbf{31s}} + \mathbf{i}\tilde{\omega}_{\mathbf{02s}}, \tilde{\omega}_{\mathbf{12}}\mathbf{s} + \tilde{\omega}_{\mathbf{03s}})\,, \\
\tilde{\tilde{\mathbf{A}}}^{\mathbf{N}}_{\mathbf{Rs}} &= (\tilde{\omega}_{\mathbf{23s}} - \mathbf{i}\tilde{\omega}_{\mathbf{01s}}, \tilde{\omega}_{\mathbf{31s}} - \mathbf{i}\tilde{\omega}_{\mathbf{02s}}, \tilde{\omega}_{\mathbf{12}}\mathbf{s} - \mathbf{i}\tilde{\omega}_{\mathbf{03s}})\,, \\
A^{Q}_{s} &= \omega_{56s} - (\omega_{9\,10s} + \omega_{11\,12s} + \omega_{13\,14s})\,, \\
A^{Y}_{s} &= (\omega_{56s} + \omega_{78s}) - (\omega_{9\,10s} + \omega_{11\,12s} + \omega_{13\,14s}) \\
A^{4}_{s} &= -(\omega_{9\,10s} + \omega_{11\,12s} + \omega_{13\,14s})\,.
\end{aligned}
$$

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

$$\mathcal{L}_M = \sum_{s=(7,8),Ai} \bar{\psi}\,\gamma^s\,(-\tau^{Ai}\,A^{Ai}_s\,)\psi =$$
$$-\bar{\psi}\,\{\,\overset{78}{(+)}\,\tau^{Ai}\,(A^{Ai}_7 - i\,A^{Ai}_8) + \overset{78}{(-)}\,\tau^{Ai}\,(A^{Ai}_7 + i\,A^{Ai}_8)\,\}\psi\ ,$$

$$\overset{78}{(\pm)} = \frac{1}{2}\,(\gamma^7 \pm\, i\,\gamma^8\,)\,, \quad A^{Ai}_{\overset{78}{(\pm)}} := (A^{Ai}_7 \mp i\,A^{Ai}_8)\,.$$

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

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

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

Ai determines:

either

o the **Q,Q',Y' charges** of the **family members**

or

o family charges ($\vec{\tilde{\tau}}^{\tilde{1}}, \vec{\tilde{N}}_L$), **transforming a family member of one family into the same family member of another family,**

manifesting in each group of four families the

$\widetilde{SU}(2) \times \widetilde{SU}(2) \times U(1)$

symmetry.

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

	$\tilde{N}^3_R = 0, \quad \tilde{\tau}^{23} = 0$		$\tilde{N}^3_R = 0, \quad \tilde{\tau}^{23} = 0$	$\tilde{\tau}^{13}$	$\tilde{N}^3_L$
$u^{c1}_{R\,1}$	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\vert\stackrel{56}{[+]}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,1}$	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\vert\stackrel{56}{[+]}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$-\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,2}$	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\vert\stackrel{56}{[+]}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,2}$	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\vert\stackrel{56}{[+]}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$-\frac{1}{2}$	$\frac{1}{2}$
$u^{c1}_{R\,3}$	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\vert\stackrel{56}{(+)}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,3}$	$\stackrel{03}{(+i)}\stackrel{12}{[+]}\vert\stackrel{56}{(+)}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,4}$	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\vert\stackrel{56}{(+)}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,4}$	$\stackrel{03}{[+i]}\stackrel{12}{(+)}\vert\stackrel{56}{(+)}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$\frac{1}{2}$	$\frac{1}{2}$
	$\tilde{N}^3_L = 0, \quad \tilde{\tau}^{13} = 0$		$\tilde{N}^3_L = 0, \quad \tilde{\tau}^{13} = 0$	$\tilde{\tau}^{23}$	$\tilde{N}^3_R$
$u^{c1}_{R\,5}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\vert\stackrel{56}{(+)}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,5}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\vert\stackrel{56}{(+)}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$-\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,6}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\vert\stackrel{56}{[+]}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,6}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)}\vert\stackrel{56}{[+]}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$-\frac{1}{2}$	$\frac{1}{2}$
$u^{c1}_{R\,7}$	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\vert\stackrel{56}{(+)}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,7}$	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\vert\stackrel{56}{(+)}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$\frac{1}{2}$	$-\frac{1}{2}$
$u^{c1}_{R\,8}$	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\vert\stackrel{56}{[+]}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}$	$\nu_{R\,8}$	$\stackrel{03}{[+i]}\stackrel{12}{[+]}\vert\stackrel{56}{[+]}\stackrel{78}{[+]}\Vert\stackrel{9\,10}{(+)}\;\stackrel{11\,12}{(+)}\;\stackrel{13\,14}{(+)}$	$\frac{1}{2}$	$\frac{1}{2}$

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

- Scalars with the weak and the hyper charge $(\mp\frac{1}{2},\pm\frac{1}{2})$ determine masses of **all** the **family members** α of the **lower four families**, ν_R **of the lower four families have nonzero** $Y' := -\tau^4 + \tau^{23}$ and interact **with the scalar field** $(A^{Y'}_{(\pm)}, \vec{\tilde{A}}^{\tilde{1}}_{(\pm)}, \vec{\tilde{A}}^{\tilde{N}_L}_{(\pm)})$.
- **The group of the lower four families** manifest the $\widetilde{SU}(2)_{\widetilde{SO}(1,3)} \times \widetilde{SU}(2)_{\widetilde{SO}(4)} \times U(1)$ **symmetry** (also after all loop corrections).

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

[arXiv:1412.5866], [arXiv:1902.02691], [arXiv:1902.10628]

We made calculations, treating quarks and leptons in equivalent way, as required by the "spin-charge-family" theory. Although

- any **(n-1)x (n-1)** submatrix of an unitary **n x n** matrix determines the **nxn** matrix for **n** $\geq$ **4** uniquely,
- the **measured mixing matrix elements** of the **3 x 3** submatrix **are not yet accurate enough even for quarks to predict the masses** m_4 **of the fourth family members**.
  o We can say, taking into account the data for the mixing matrices and masses, that m_4 **quark masses might be any in the interval (300** $< m_4 <$ **1000) GeV or even above**. Other experiments require that m_4 are above 1000 GeV.
- **Assuming masses** m_4 **we can predict mixing matrices**.

Results are presented for two choices of $m_{u_4} = m_{d_4}$, [arxiv:1412.5866]:

- 1. $m_{u_4} = 700$ GeV, $m_{d_4} =$ **700** GeV.....new_1
- 2. $m_{u_4} = 1\,200$ GeV, $m_{d_4} =$ **1 200** GeV.....new_2

$|V_{(ud)}| =$

exp_n	0.97425 ± 0.00022	0.2253 ± 0.0008	0.00413 ± 0.00049	
new_1	0.97423(4)	0.22539(7)	0.00299	**0.00776(1)**
new_2	0.97423[5]	0.22538[42]	0.00299	**0.00793[466]**
exp_n	0.225 ± 0.008	0.986 ± 0.016	0.0411 ± 0.0013	
new_1	0.22534(3)	0.97335	0.04245(6)	**0.00349(60)**
new_2	0.22531[5]	0.97336[5]	0.04248	**0.00002[216]**
exp_n	0.0084 ± 0.0006	0.0400 ± 0.0027	1.021 ± 0.032	
new_1	0.00667(6)	0.04203(4)	0.99909	**0.00038**
new_2	0.00667	0.04206[5]	0.99909	**0.00024[21]**
new_1	**0.00677(60)**	**0.00517(26)**	**0.00020**	**0.99996**
new_2	**0.00773**	**0.00178**	**0.00022**	**0.99997[9]**

One can see what
B. Belfatto, R. Beradze, Z. Berezhiani, required in [arXiv:1906.02714v1], that
$V_{u_1 d_4} > V_{u_1 d_3}$, $V_{u_2 d_4} < V_{u_1 d_4}$, and $V_{u_3 d_4} < V_{u_1 d_4}$, ,
what is just happening in my theory.
The newest experimental data, PDG, (P A Zyla at al, Prog. Theor. and Exp. Phys., Vol. 2020, Issue 8, Aug. 2020, 083C01) have not yet been used to fit mass matrix of Eq. (1).

- o The **matrix elements V_{CKM} depend strongly on the accuracy of the experimental 3 x 3 submatrix**.
  o **Calculated 3 x 3 submatrix of 4 x 4 $\mathbf{V_{CKM}}$ depends on the m_{4th} family masses, but not much**.
  o $V_{u_i d_4}$, $V_{d_i u_4}$ **do not depend strongly on** the m_{4th} **family masses** and **are obviously very small**.
- **The higher are the fourth family members masses, the closer are the mass matrices to the democratic matrices for either quarks or leptons, as expected.**
- **The higher are the fourth family members masses, the better are conditions**
  $V_{u_1 d_4} > V_{u_1 d_3}$ **,**
  $V_{u_2 d_4} < V_{u_1 d_4}$ **, and**
  $V_{u_3 d_4} < V_{u_1 d_4}$
  fulfilled.

- **The stable family of the upper four families group is the candidate to form the Dark Matter.**
- **Masses of the upper four families are influenced :**
  o **by the** $\widetilde{SU}(2)_{II\,\widetilde{SO}(3,1)} \times \widetilde{SU}(2)_{II\,\widetilde{SO}(4)}$ **scalar fields with the corresponding family quantum numbers,**
  o **by the scalars** $(A^{Q}_{\substack{78\\(\mp)}}, A^{Q'}_{\substack{78\\(\mp)}}, A^{Y'}_{\substack{78\\(\mp)}})$, and
  o **by the condensate of the two** ν_R **of the upper four families.**

Dark matter

$d \rightarrow (d-4) + (3+1)$ **before (or at least at) the electroweak break.**

- We follow the evolution of the universe, in particular the abundance of the fifth family members - the candidates for the dark matter in the universe.
- We estimate the behaviour of our stable heavy family quarks and anti-quarks in the expanding universe by solving the system of Boltzmann equations.
- We follow the clustering of the fifth family quarks and antiquarks into the fifth family baryons through the colour phase transition.
- The mass of the fifth family members is determined from the today dark matter density.

Phys. Rev. **D** (**2009**) 80.083534

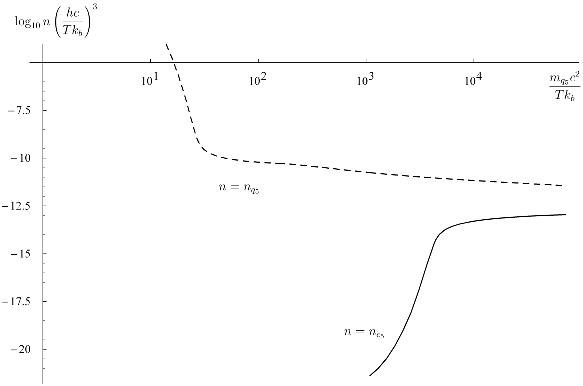


Figure: The dependence of the two number densities n_{q_5} (of the fifth family quarks) and n_{c_5} (of the fifth family clusters) as the function of $\frac{m_{q_5} c^2}{T k_b}$ is presented for the values $m_{q_5} c^2 = 71$ TeV, $\eta_{c_5} = \frac{1}{50}$ and $\eta_{(q\bar{q})_b} = 1$. We take $g^*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

We estimated from following the fifth family members in the expanding universe:

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

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

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

We estimate from the scattering of the fifth family members on the ordinary matter on our Earth, on the direct measurements - DAMA, CDMS,..- ...

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

Matter-antimatter asymmetry

- **There are besides doublets, with the space index** $s = (5, 6, 7, 8)$, as well **triplets and anti-triplets, with respect to the space index** $s = (9, \ldots, 14)$.
- **There are no additional scalars in the theory for d=(13+1)**.
- **All the scalars have the family and the family members quantum numbers in** the **adjoint** representations.
- It is the (**so far assumed**) the **condensate**, **which makes those gauge fields — vector or scalar — with which it interacts, massive**.

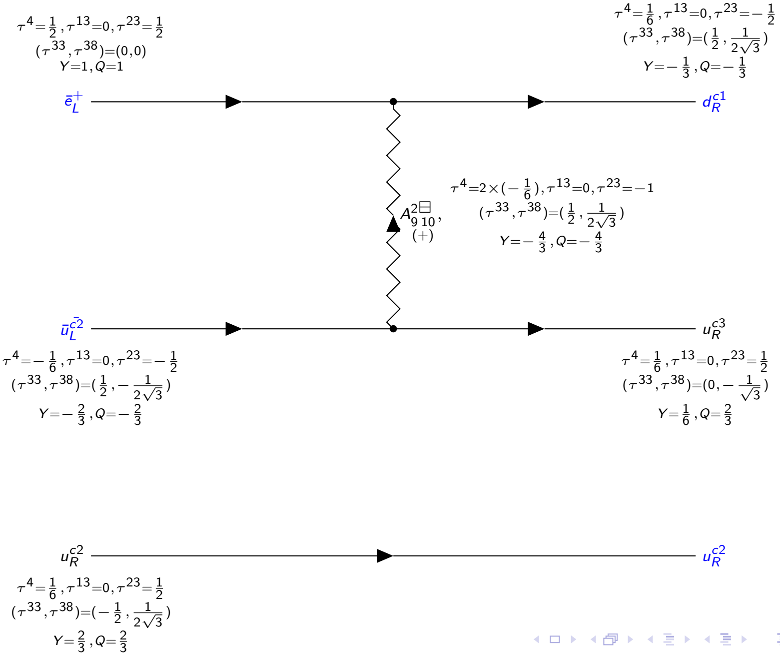
  o **The condensate breaks the CP symmetry**.

There are also triplet and anti-triplet scalars, $s = (9, .., d)$**:,**

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

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

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



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

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

In the expanding universe, fulfilling the Sakharov request for appropriate non-thermal equilibrium, **these triplet scalars have offer explanation for the matter-antimatter asymmetry**.

The opposite transition makes the proton decay.
These processes seem to explain the lepton number non conservation.

In the standard model the **family members with all their properties**,

the **families**,

the **vector gauge fields**,

the **scalar Higgs**, the **Yukawa couplings**,

exist by the **assumption**.

In the **spin-charge-family theory the appearance of all** the **standard model fields before the electroweak break, as well as their properties follow from**

the **simple starting action in** $d = 13 + 1$

with **fermions carrying two kinds of spins no charges**,

interacting with the **gravity only;**

the **vielbeins** (**the gauge fields of momenta**),

and the **two kinds of the spin connection fields,**

(**the gauge fields of** S^{ab} **and** $\tilde{S}^{ab}$).

The internal spaces of fermions and bosons are **described by the Clifford algebra objects**.

The theory offers the explanation for the :

- **o** **dark matter**, the stable of the upper four families does this .
- **o** **matter-antimatter asymmetry**, the **condensate** (breaking the CP symmetry), and the massive **triplet scalars** do that,
- **o** all **scalar** and all **vector** gauge fields are **directly or indirectly observable**.
- **o** definition of the **creation and annihilation operators** without postulating their anti-commutativity or commutativity,
- **o** Fadeev-Popov ghosts which appear in odd-dimensional spaces.

The spin-charge-family theory explains also many other properties, which are not explainable in the standard model, like "miraculous" non-anomalous triangle Feynman diagrams.

The more work is put into the spin-charge-family theory the more explanations for the phenomena follow.

To summarize:

- I hope that I managed to convince you that the **spin-charge-family theory** **answers many open questions of particle physics and cosmology.**
  The more work is put into this theory the more observed phenomenas I can explain and the predictions offer.
- **The collaborators are very welcome!**
- **There are namely still a lot of properties to derive and explain and understand:**
  o Are equations of motion of elementary fields simple end elegant? as it is in the spin-charge-family theory?
  o Does nature choose the Clifford algebra to describe the internal degres of freedom of fermion and **boson fields?**
  o Are all the systems second quantized, with the Black holes included? Can my way help to second quantize gravity?
- **There are many calculations still needed.**