Spin-Charge-Family Theory Offers Understanding of Elementary Fields and Cosmological Observations

Short overview of the spin-charge-family theory and its achievements so far

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Some publications:

- *Phys. Lett.* **B 292**, 25-29 (**1992**), *J. Math. Phys.* **34**, 3731-3745 (**1993**), *Mod. Phys. Lett.* **A 10**, 587-595 (**1995**),
- *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)**1700046,
- *Phys. Rev.* **D 74** 073013-16 (**2006**),
- *New J. of Phys.* **10** (**2008**) 093002, arxiv:1412.5866,
- *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**, vol.121(2021)103890,
- Nucl. Phys. B, j.nuclphysb.2023.116326, Symmetry 2023,15,818-12-V2 94818, https:doi.org/10.3390/sym15040818

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More than **50 years ago** the **electroweak (and colour) standard model** offered an **elegant new step** in **understanding the origin of fermions and bosons** by **postulating for before the electroweak break**:

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.**

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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	$-\frac{1}{3}$
ν^i_R	1	weakless	0	colourless	0
e^i_R	1	weakless	-1	colourless	-1

Members of each of the $i = 1, 2, 3$ families, 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.

**

B.

- **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 needed for gauge invariance.

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- Three massless vector fields, the gauge fields of the three charges.

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 all are vectors **in** $d = (3+1)$, in the adjoint representations with respect to the weak, colour and hyper charges.

**

C.

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

  o carrying the weak charge $\pm\frac{1}{2}$ and the hyper charge $\mp\frac{1}{2}$.

  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**.

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- 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

D.

- There is the **gravitational field** in **d=(3+1)**.

o

- **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

The assumptions of the *standard model* remain unexplained.

- **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**,
- ...

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

- o It is obviously the time to make the new step beyond the *standard model*.

- o And to recognize whether the laws of nature are simple and elegant, answering all the questions without adding new terms to the action, or are like the approximate laws in the many body problems.

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

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

- **Work done so far on the spin-charge-family theory is promising.**

** We try to understand:

- What are elementary constituents and interactions among constituents in our Universe, in any universe?
- Are the elementary constituents of only one kind?
- Are the four observed interactions — gravitational, electromagnetic, weak and colour — of the common origin?
- Are the laws of "nature" simple and "elegant"?
- Are all the fermion and boson fields second quantized?

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- Can the postulates for the second quantized fermions and for the second quantized bosons be understood in equivalent way?
- Can the description of the internal space of fermions with the Clifford odd and of the internal space of bosons with the Clifford even algebra explain/replace the second quantization postulates?

- Is the space-time $(3+1)$? If yes, why $(3+1)$?
- If not $(3+1)$, may it be that the space-time is infinite?
- How has the space-time of our universe started?

- What is the matter and what the anti-matter?

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What questions should one ask to be able to find next steps beyond the *standard models* and to understand not yet understood phenomena?

- **o Where do family members originate?**
  o Where do charges of family members originate?
  o Why are the charges of family members so different?
  o Why have the left handed family members so different charges from the right handed ones?
- **o Where do families of family members originate?**
  o How many different families exist?
  o Why do family members – quarks and leptons – manifest so different properties if they all start as massless?

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- o **How are the origin of the scalar field (the Higgs's scalar) and the Yukawa couplings connected with the origin of families?**
  o **How many scalar fields determine properties of the so far** (and others possibly be) **observed fermions and masses of weak bosons?** (The Yukawa couplings certainly speak for the existence of several scalar fields with the properties of Higgs's scalar.)
- **Why is the Higgs's scalar**, or are all **scalar fields**, if there are several, **doublets with respect to the weak and the hyper charge?**
- **Do exist also scalar fields with the colour charge in the fundamental representation and where, if they are, do they manifest?**

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- Where do the **charges and correspondingly the so far** (and others possibly be) **observed vector gauge fields originate?**
- **Where** does the **dark matter originate?**
- **Where** does the **"ordinary" matter-antimatter asymmetry originate?**
- **Where** does the **dark energy originate?**
- What is the dimension of space? $(3+1)$?, $((d-1)+1)$?, ∞?
- **What** is the role of the **symmetries**– discrete, continuous, global and gauge – in our **universe, in "nature"?**
- And many others.

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My statement:

- An elegant trustworthy next step must offer answers to open questions in elementary particle physics and cosmology, explaining all the above questions:

  o The origin of the family members and the charges.
  o The origin of the families and their properties.
  o The origin of the scalar fields and their properties.
  o The origin of the vector fields and their properties.
  o The origin of the internal space of fermions and bosons and of their properties.
  o The origin of the dark matter.
  o The origin of the "ordinary" matter-antimatter asymmetry.

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My proposition:

Assuming:

- That the space-time is $d \geq (13+1)$,
- that the internal space of fermions is describable by the superposition of the Clifford odd products of γ^a,
- that the internal space of bosons is describable by the superposition of the Clifford even products of γ^a,
- that the second kind of the Clifford objects, $\tilde{\gamma}^a$, are used to denote the family quantum numbers of fermions,
- that the starting action for massless fermions and bosons assumes only one kind of fields, spin connections of two kinds, or, may be even better, the bosons with the internal space described by the Clifford even algebra,

then one has a chance to get answers on all the above questions.

o The **Spin-Charge-Family theory does offer the explanation for all the assumptions of the standard model**, **answering up to now several of the above cited open questions!**

o The **more effort is put into this theory, the more answers to the open questions in elementary particle physics and cosmology is the theory offering**.

o o I shall first make a short introduction into the **Spin-Charge-Family** theory.

o I shall report on **how does the odd Clifford algebra explain the second quantization postulates of Dirac.** Rev. article in JPPNP –2021 Progress in Particle and Nuclear Physics http://doi.org/10.1016.j.ppnp.2021.103890

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o I shall report on **how does the even Clifford algebra explain the second quantization of boson fields.** Nucl. Phys. B, https://doi.org/10.1016/ j.nuclphysb.2023.116326,[arXiv:2306.17167]

o I shall report on **how do fermion and boson fields behave in odd $d = (2n + 1)$ dimensional spaces.** Symmetry 2023,15,818-12-V2 94818, https:doi.org/10.3390/sym15040818, [arxiv.org/abs/2301.04466]

o o I shall make an **overview of achievements so far of** the **Spin-Charge-Family** theory.

- A brief introduction into the **spin-charge-family theory**.

- o There are **two kinds of the Clifford algebra objects in any d . I recognized that in Grassmann space.**

  J. of Math. Phys. **34** (1993) 3731

  θ^a**'s and** p^{θ}_a**'s**, $p^{\theta}_a = \frac{\partial}{\partial \theta_a}$
  with the property
  $(\theta^a)^\dagger = \eta^{aa} \frac{\partial}{\partial \theta_a}$.

  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** .

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

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

- **o the postulate**

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

with $(-)^{n_B} = +1, -1$, if B has a Clifford even or odd character, respectively, $|\psi_o >$ 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**.

- o It is convenient to write all the **"basis vectors" describing the internal space of either fermion fields or boson fields as products of nilpotents and projectors, which are eigenvectors of the chosen Cartan subalgebra**

$$S^{03}, S^{12}, S^{56}, \cdots, S^{d-1\;d}\,,$$
$$\tilde{S}^{03}, \tilde{S}^{12}, \tilde{S}^{56}, \cdots, \tilde{S}^{d-1\;d}\,,$$
$$\mathbf{S}^{ab} = S^{ab} + \tilde{S}^{ab}\,.$$

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

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

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

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

**

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

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

o

- γ^a **transforms** $\overset{ab}{(k)}$ **into** $\overset{ab}{[-k]}$, **never to** $\overset{ab}{[k]}$.
- $\tilde{\gamma}^a$ **transforms** $\overset{ab}{(k)}$ **into** $\overset{ab}{[k]}$, **never to** $\overset{ab}{[-k]}$.
- **There are the Clifford odd "basis vector", that is the "basis vector" with an odd number of nilpotents, at least one, the rest are projectors, such "basis vectors" anti-commute among themselves.** (They are superposition of odd products of γ^a.)
- **There are the Clifford even "basis vector", that is the "basis vector" with an even number of nilpotents, the rest are projectors, such "basis vectors" commute among themselves.** (They are superposition of even products of γ^a.)

o

- **In any even d there are two times $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ Clifford odd "basis vectors" offering description of fermions: $2^{\frac{d}{2}-1}$ families, each family with $2^{\frac{d}{2}-1}$ members, and the same number $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ of their Hermitian conjugated partners, appearing in a separate group.**

- **In any even d there are two times $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ Clifford even "basis vectors" offering description of bosons: They appear in two groups, each group with $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ members and with their Hermitian conjugated partners within the same group.**

- o Let us see how does one family of the Clifford odd "basis vector" in $d=(13+1)$ look like, if spins in $d=(13+1)$ are analysed with respect to the *standard model* groups.

  o Each of the nilpotent and projector is the eigenvector of one of the Cartan subalgebra eigenvectors:
  $S^{03} = \pm\frac{i}{2}, S^{12} = \pm\frac{1}{2}, ..., S^{13\,14} = \pm\frac{1}{2}$,
  and of: $\tilde{S}^{03} = \pm\frac{i}{2}, \tilde{S}^{12} = \pm\frac{1}{2}, ..., \tilde{S}^{13\,14} = \pm\frac{1}{2}$.

- o One irreducible representation of one family contains $2^{\frac{(13+1)}{2}-1}$ = 64 members which include all the family members, quarks and leptons with the right handed neutrinos included, as well as all the anti-members, antiquarks and antileptons, reachable by either S^{ab} (or by $\mathbb{C}_{\mathcal{N}}\ \mathcal{P}_{\mathcal{N}}$ on a family member).

Jour. of High Energy Phys. **04** (**2014**) 165
J. of Math. Phys. **34**, 3731 (**1993**),
Int. J. of Modern Phys. **A 9**, 1731 (**1994**),
J. of Math. Phys. **44** 4817 (**2003**), hep-th/030322.

S^{ab} generate **all the 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	$\mathbf{u_R^{c1}}$	$\overset{03}{(+i)}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**1**	$\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{6}$
2	u_R^{c1}	$\overset{03}{[-i]}\overset{12}{[-]} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**1**	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{6}$
3	d_R^{c1}	$\overset{03}{(+i)}\overset{12}{(+)} \mid \overset{56}{[-]}\overset{78}{[-]} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**1**	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{1}{6}$
4	$\mathbf{d_R^{c1}}$	$\overset{03}{[-i]}\overset{12}{[-]} \mid \overset{56}{[-]}\overset{78}{[-]} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**1**	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{1}{3}$	$\frac{1}{6}$
5	d_L^{c1}	$\overset{03}{[-i]}\overset{12}{(+)} \mid \overset{56}{[-]}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**-1**	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
6	$\mathbf{d_L^{c1}}$	$\overset{03}{(+i)}\overset{12}{[-]} \mid \overset{56}{[-]}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**-1**	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
7	$\mathbf{u_L^{c1}}$	$\overset{03}{[-i]}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{[-]} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**-1**	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$\frac{1}{6}$	$\frac{1}{6}$
8	u_L^{c1}	$\overset{03}{(+i)}\overset{12}{[-]} \mid \overset{56}{(+)}\overset{78}{[-]} \mid\mid \overset{9\,10}{(+)}\,\overset{11\,12}{(-)}\,\overset{13\,14}{(-)}$	**-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*.

S^{ab} generate **all the members of one family also leptons.** Here is the **eightplet** (represent. of $SO(7,1)$) **of leptons colour chargeless. The $SO(7,1)$ part is identical with the one of quarks, they differ in $SU(3) \times U(1)$ part, leading to different (Y, Q).**

i		$\|^a\psi_i>$	$\Gamma^{(3,1)}$	S^{12}	$\Gamma^{(4)}$	τ^{13}	τ^{23}	Y	Q
		Octet, $\Gamma^{(7,1)} = 1,\ \Gamma^{(6)} = -1,$ of leptons							
1	ν_R	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	0	0
2	ν_R	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \mid \stackrel{56}{(+)}\stackrel{78}{(+)} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	0	0
3	e_R	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \mid \stackrel{56}{[-]}\stackrel{78}{[-]} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	-1	-1
4	e_R	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \mid \stackrel{56}{[-]}\stackrel{78}{[-]} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	-1	-1
5	e_L	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \mid \stackrel{56}{[-]}\stackrel{78}{(+)} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{2}$	-1
6	e_L	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \mid \stackrel{56}{[-]}\stackrel{78}{(+)} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$-\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{2}$	-1
7	ν_L	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \mid \stackrel{56}{(+)}\stackrel{78}{[-]} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{2}$	0
8	ν_L	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \mid \stackrel{56}{(+)}\stackrel{78}{[-]} \parallel \stackrel{9\,10}{(+)}\ \stackrel{11\,12}{[+]}\ \stackrel{13\,14}{[+]}$	-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 all the anti-eightplet** (repres. of $SO(7,1)$) of **anti-quarks of the anti-colour charge bellonging to the same family of the Clifford odd basis vectors** .

i		$\|^a\psi_i>$	$\Gamma^{(3,1)}$	S^{12}	$\Gamma^{(4)}$	τ^{13}	τ^{23}	Y	τ^4
		Antioctet, $\Gamma^{(7,1)} = -1$, $\Gamma^{(6)} = 1$, of antiquarks							
33	$\bar{\mathbf{d}}^{\bar{c}1}_{\mathbf{L}}$	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \| \stackrel{56}{(+)}\stackrel{78}{(+)} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{6}$
34	$\bar{d}^{\bar{c}1}_{L}$	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \| \stackrel{56}{(+)}\stackrel{78}{(+)} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	-1	$-\frac{1}{2}$	1	0	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{6}$
35	$\bar{u}^{\bar{c}1}_{L}$	$\stackrel{03}{[-i]}\stackrel{12}{(+)} \| \stackrel{56}{[-]}\stackrel{78}{[-]} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	-1	$\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{2}{3}$	$-\frac{1}{6}$
36	$\bar{\mathbf{u}}^{\bar{c}1}_{\mathbf{L}}$	$\stackrel{03}{(+i)}\stackrel{12}{[-]} \| \stackrel{56}{[-]}\stackrel{78}{[-]} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	- 1	$-\frac{1}{2}$	1	0	$-\frac{1}{2}$	$-\frac{2}{3}$	$-\frac{1}{6}$
37	$\bar{\mathbf{d}}^{\bar{c}1}_{\mathbf{R}}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \| \stackrel{56}{(+)}\stackrel{78}{[-]} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$
38	$\bar{d}^{\bar{c}1}_{R}$	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \| \stackrel{56}{(+)}\stackrel{78}{[-]} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	1	$-\frac{1}{2}$	-1	$\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$
39	$\bar{u}^{\bar{c}1}_{R}$	$\stackrel{03}{(+i)}\stackrel{12}{(+)} \| \stackrel{56}{[-]}\stackrel{78}{(+)} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	1	$\frac{1}{2}$	-1	$-\frac{1}{2}$	0	$-\frac{1}{6}$	$-\frac{1}{6}$
40	$\bar{\mathbf{u}}^{\bar{c}1}_{\mathbf{R}}$	$\stackrel{03}{[-i]}\stackrel{12}{[-]} \| \stackrel{56}{[-]}\stackrel{78}{(+)} \|\| \stackrel{9\,10}{[-]}\;\stackrel{11\,12}{[+]}\;\stackrel{13\,14}{[+]}$	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 $\bar{\mathbf{d}}_{\mathbf{L}}$ of the 1^{st} row into $\bar{\mathbf{d}}_{\mathbf{R}}$ of the 5^{th} row, and $\bar{\mathbf{u}}_{\mathbf{L}}$ of the 4^{rd} row into $\bar{\mathbf{u}}_{\mathbf{R}}$ of the 8^{th} row.

- **o We discuss so far the internal space of fermions describing their internal space with Clifford odd "basis vectors".**

- **o The detailed study of the Clifford even "basis vectors", describing the internal space of bosons, together with the Clifford odd "basis vectors", describing the internal space of fermions was presented in the Workshop of this Forum one hour ago, when we made the first step in confronting the internal spaces, described by the Clifford odd and even "basis vectors", with those in strings theories.**

  NUPHB 994 (2023) 116326 , [arXiv: 2210.06256, physics.gen-ph V2]

  Symmetry 2023,15,818-12-V2 94818,
  https:doi.org/10.3390/sym15040818,
  [arxiv.org/abs/2301.04466]
  [arxiv:]

o

- **Let us write down the action.**
- **Fermions and bosons can exist even if they do not interact**, at least mathematically.
- **Describing their internal spaces we do not pay attention on their interactions. We treat them as free fields.**
- **Describing the properties of fermions and bosons as we observe, the interaction should be included**: **A simple and elegant one (this is how I "see nature"); demonstrating at low energies all the observed phenomena.**

I use in the spin-charge-family theory a simple action.
Fermions carry in $d=(13+1)$ only spins, two kinds of spins
(no charges, no family charges "put by hand")
and interact with the gauge gravitational fields.
γ^a, in a superposition of odd products, determine spins, charges and families of fermions. (In a superposition of even products, determine spins and charges of bosons).

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

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

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

**

We can write the action also by using "basis vectors" describing internal spaces of bosons, ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$, and fermions, $\hat{b}^{m\dagger}_{f}$:

- **For fermions we obtain**

$$
\begin{aligned}
\mathcal{A} &= \int d^d x\, E\, \frac{1}{2}\, (\bar{\psi}\, \gamma^a p_{0a} \psi) + h.c. + \\
\text{functions } \psi &\quad \text{are expressible with the superposition of} \\
\text{the Clifford odd} &\quad \text{"basis vectors" } \hat{\mathbf{b}}^{\mathbf{m}\dagger}_{\mathbf{f}} \text{ and continuously} \\
\text{differentiable} &\quad \text{functions in ordinary space } \phi^{\mathbf{m}}_{\mathbf{f}}(\mathbf{x}^{\mathbf{a}})\,, \\
\psi^{\mathbf{m}}_{\mathbf{f}} &= \hat{\mathbf{b}}^{\mathbf{m}\dagger}_{\mathbf{f}} *_T \phi^{\mathbf{m}}_{\mathbf{f}}(\mathbf{x}^{\mathbf{a}}) \\
p_{0a} &= f^{\alpha}{}_{a} p_{0\alpha} + \frac{1}{2E}\, \{p_{\alpha}, E f^{\alpha}{}_{a}\}_{-}\,, \\
p_{0\alpha} &= p_{\alpha} - \sum_{mf} {}^{\mathbf{I}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}}\, {}^{\mathbf{I}}\mathcal{C}^{\mathbf{m}}{}_{\mathbf{f}\alpha}(\mathbf{x}^{\mathbf{a}}) - \\
&\quad \sum_{mf} {}^{\mathbf{II}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}}\, {}^{\mathbf{II}}\mathcal{C}^{\mathbf{m}}{}_{\mathbf{f}\alpha}(\mathbf{x}^{\mathbf{a}})\,,
\end{aligned}
$$

**

- **For** **bosons** **we must replace** $\omega_{ca\alpha}$ **with** ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}\,{}^{I}\mathcal{C}^{m}{}_{f\alpha}$**, and** $\tilde{\omega}_{ca\alpha}$ **with** ${}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}\,{}^{II}\mathcal{C}^{m}{}_{f\alpha}$

$$
\begin{aligned}
{}^{I}R &= \frac{1}{2}\,\{f^{\alpha[a}f^{\beta b]}\,(\omega_{ab\alpha,\beta} - \omega_{ca\alpha}\,\omega^{c}{}_{b\beta})\} + h.c.\,, \\
\text{with}\,\omega_{ab\alpha} & \quad \text{replaced by superposition of } {}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}\,{}^{I}\mathcal{C}^{m}{}_{f\alpha}\,, \\
{}^{II}R &= ?\frac{1}{2}\,\{f^{\alpha[a}f^{\beta b]}\,(\tilde{\omega}_{ab\alpha,\beta} - \tilde{\omega}_{ca\alpha}\,\tilde{\omega}^{c}{}_{b\beta})\} + h.c.\,, \\
\text{with}\,\tilde{\omega}_{ab\alpha} & \quad \text{replaced by superposition of } {}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}\,{}^{II}\mathcal{C}^{m}{}_{f\alpha}\,.
\end{aligned}
$$

**

- **The "basis vectors" and correspondingly the creation operators for either the Clifford odd fermion fields or for the Clifford even boson fields in even and odd dimensional spaces are the newest achievements of the spin-charge-family theory.**

"How Clifford algebra helps understand second quantized quarks and leptons and corresponding vector and scalar boson fields, opening a new step beyond the standard model", Nucl. Phys. B, NUPHB 994 (2023) 116326 , [arXiv: 2210.06256, physics.gen-ph V2].
"Clifford odd and even objects in even and odd dimensional spaces", Symmetry 2023,15,818-12-V2 94818, https:doi.org/10.3390/sym15040818, [arxiv.org/abs/2301.04466] , https://www.mdpi.com/2073-8994/15/4/818 Manuscript ID: symmetry-2179313.

**

- The **Clifford algebra objects,** if used to describe the internal space — **"basis vectors"** — of **fermion** and **boson** fields, offer the explanation for the postulates of the usual **second quantization procedure.**
- The **internal space offers** a **finite** number of degrees of freedom for either **fermion "basis vectors": twice** $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ or for **boson "basis vectors": twice** $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ in $d(=2n)$-dimensional spaces .

It is the ordinary momentum or coordinate basis which offers the continuously infinite basis.

Progress in Particle and Nuclear Physics,
http://doi.org/10.1016.j.ppnp.2021.103890

Nucl. Phys. B, NUPHB 994 (2023) 116326 , [arXiv: 2210.06256, physics.gen-ph V2].
Symmetry 2023,15,818-12-V2 94818,
https:doi.org/10.3390/sym15040818, [arxiv.org/abs/2301.04466] ,
https://www.mdpi.com/2073-8994/15/4/818 Manuscript ID:

In what follows a short overview of the achievements of the *spin-charge-family* theory is presented.

- **The spin-charge-family explaining the observed properties of quarks and leptons and the vector and scalar boson fields, including the cosmological observations.**

**

We have discussed so far free fermion fields and boson fields in any even dimensional space, in particular in $d = (13+1)$.
We describe the internal space of fermion fields and also boson fields with the odd and even Clifford algebra elements, respectively.
The presentation of which were discussed in Workshop of this Forum.

- We learned that the family members of fermions, they are reachable by S^{ab}, distinguish in the eigenvalues of the Cartan subalgebra quantum numbers, and all the families, they are reachable by $\tilde{S}^{ab}$, are equivalent with respect to S^{ab}, they distinguish in the family quantum numbers.

**

Let us repeat:

- **The spin-charge-family theory assumes a simple starting action for fermions and bosons in $d \geq (13+1)$, with the gravity as the only gauge fields.**
- **It is the break of the starting symmetry which causes that fermion fields and gravitational fields manifest in $d = (3+1)$ as all the observed quarks and leptons and the corresponding vector and scalar gauge fields.**
- **C,P,T symmetries in $d = (3+1)$ follow from the symmetry in $d \geq (13+1)$.**

JHEP **04** (**2014**) 165,
Phys. Rev. **D 91** 065004 (2015),
J.of Mod. Physics **6** (2015) 2244,
Rev. article in
JPPNPhttp://doi.org/10.1016.j.ppnp.2021.103890 .
J. of Math. Phys. **34** (1993), 3731,
J. of Math. Phys. **43**, 5782 (2002) [hep-th/0111257].

o

In the spin-charge-family theory:

- **All** vector and **scalar gauge fields origin in gravity, explaining the origin of the vector and scalar gauge fields, which in the Standard model are assumed**, *Eur. Phys. J. C* **77** (2017) 231.

  o **Vector** and **scalar gauge fields 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].

- **If there are no spinor sources present, then either vector ($\vec{A}^A_m$, $m = 0, 1, 2, 3$) or scalar ($\vec{A}^A_s$, $s = 5, 6, .., d$) gauge fields are determined by vielbeins uniquely**.

- **o Spinors (fermions) interact correspondingly with**
  o the **vielbeins** and
  o the **two kinds of the spin connection fields**,
  Eur. Phys. J. C **77** (2017) 231.
- **o In** $d = (3+1)$ the **spin-connection fields**,
  together with the vielbeins,
  manifest either as
  o vector gauge fields with all the **charges** in the **adjoint representations** or as
  o scalar gauge fields with the **charges with respect to the space index** in the **"fundamental" representations** (what explains the assumed weak and hyper charges of the *standard model* for higgs scalars), and all the other **charges** in the **adjoint representations**, or as
  o tensor gravitational field.

o There are two kinds of scalar fields with respect to the space index $s \geq 5$ — manifesting in $d = (3+1)$:

- **A. Those** with **($s = 5, 6, 7, 8$)** (they carry zero **"spinor charge"**) **are doublets** with respect to the $SU(2)_I$ **(the weak) charge** and the **second** $SU(2)_{II}$ **charge (determining the hyper charge)**,
  forming two groups, each with four families.
  (**They are in the adjoint representations** with respect to the S^{ab} **and** $\tilde{S}^{ab}$).

  o These scalars, belonging to one of two groups, explain the Higgs's scalar and the Yukawa couplings .

  Scalars, belonging to the second of two groups, explain the the appearance of dark matter.

  o Phys. Rev. **D 91** (**2015**) 6, 065004

- **B. o Those** with **($s = 9, 10, ..d$)** are **colour triplets and antitriplets**.
  (**Also they are in the adjoint representations** with respect to the S^{ab} **and** $\tilde{S}^{ab}$).

  o These scalars transform antileptons into quarks, and antiquarks into quarks and back and correspondingly **contribute to matter-antimatter asymmetry of our universe and to proton decay**.

- **There are no additional scalar fields in the spin-charge-family theory**, if $d = (13 + 1)$.

  Phys. Rev. **D 91** (**2015**) 6, 065004
  J. of Mod. Phys. **6** (**2015**) 2244

o Breaking symmetry from M^{13+1} into $M^{7+1} \times M^6$ (and further) makes in $d = (3+1)$ observable vector and scalar gauge fields of massive quarks and leptons and (much more massive) dark matter.

- **o 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 charge in $d = (7+1)$.**
- **o Also all the boson fields, vector and scalar gauge 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, as we learned one hour ago.)

**

- We then let the $\mathcal{M}^{13+1}$ manifold to break into $\mathcal{M}^{7+1}$ $\times$ an almost S^6 sphere, with
- the Weyl equation, $m = (0,1,2,3,5,6,7,8)$ and $s = 9,10,\ldots 13,14$

$$
\begin{aligned}
&(\gamma^m p_m + \gamma^s p_{0s})\psi = 0\,,\\
&p_{0s} = f_s^{\sigma}(p_\sigma - \frac{1}{2}S^{ab}\omega_{ab\sigma} - \frac{1}{2}\tilde{S}^{ab}\tilde{\omega}_{ab\sigma}) + \frac{1}{2E}\{p_\sigma, f_s^{\sigma} E\}_-\,.
\end{aligned}
$$

- With the choice of the vielbein fields and the spin connection fields of both kinds, $\omega_{ab\alpha}$ and $\tilde{\omega}_{ab\alpha}$, one can achieve that the infinite surface $d = (9,10,11,\ldots,13,14)$ curls into an almost S^6 (with one hole with the substructure of $SU(3)\times U(1)$) with massless fermions in $d = (7+1)$.
- This is the project, not yet done. The simpler problem with breaking $\mathcal{M}^{5+1}$ manifold into $\mathcal{M}^{3+1}$ $\times$ an almost S^2 sphere with one hole is done, without and with families taking into account.

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

o 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 (let us repeat that 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**

o

- 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**.

** **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**.

o

- **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]

o

- **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**

**

- It is extremely encouraging for the spin-charge-family theory, that a simple starting action contains all the degrees of freedom observed at low energies, directly or indirectly, and that only

  o the break of manifold $M^{(13,1)}$ to $M^{(7,1)} \times M^{(6)}$ is needed so that the manifold $M^{(6)}$ makes an almost S^n sphere.

  o the condensate and

  o constant values of all the scalar fields with $s = (7, 8)$

  are needed that the 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,

  o the matter/antimatter asymmetry,

  o the triangle anomalies cancellation in the standard model

  Forts. der Physik, Prog.of Phys.) (2017) 1700046

**

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

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

IARD, J. Phys.: Conf. Ser. 845 01**2017** and the Refs. therein

**

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

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

Eur. Phys. J. C, **77** (2017) 231 and the refs. therein.

If there are no spinors present, the two spin connections are uniquely described by vielbeins $f^{\alpha}{}_{a}$.

o Fermions

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

$$
\begin{aligned}
\mathcal{L}_f \; = \;& \sum_{m=0,1,2,3} \bar{\psi}\gamma^m (p_m - \sum_{A,i} g^A \tau^{Ai} A^{Ai}_m)\psi + \\
& \{ \sum_{s=[7],[8]} \bar{\psi}\gamma^s p_{0s}\; \psi\} + \\
& \{ \sum_{s=[5],[6]} \bar{\psi}\gamma^s p_{0s}\; \psi + \\
& \sum_{t=[9],\dots[14]} \bar{\psi}\gamma^t p_{0t}\; \psi\} \,. \,,
\end{aligned}
$$

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

**

Covariant momenta

$$
\begin{aligned}
p_{0m} &= \{p_m - \sum_A g^A\, \vec{\tau}^A\, \vec{A}^A_m\} \\
\mathbf{m} \quad & n \quad (\mathbf{0}, \mathbf{1}, \mathbf{2}, \mathbf{3})\,, \\
p_{0s} &= f^{\sigma}_{s}\,[p_\sigma - \sum_A g^A\, \vec{\tau}^A\, \vec{A}^A_\sigma - \sum_A \tilde{g}^A\, \vec{\tilde{\tau}}^A\, \vec{\tilde{A}}^A_\sigma]\,, \\
\mathbf{s} &\in (\mathbf{7}, \mathbf{8})\,, \\
p_{0s} &= f^{\sigma}_{s}\,[p_\sigma - \sum_A g^A\, \vec{\tau}^A\, \vec{A}^A_\sigma - \sum_A \tilde{g}^A\, \vec{\tilde{\tau}}^A\, \vec{\tilde{A}}^A_\sigma]\,, \\
\mathbf{s} &\in (\mathbf{5}, \mathbf{6})\,, \\
p_{0t} &= f^{\sigma'}_{t}\,(p_{\sigma'} - \sum_A g^A\, \vec{\tau}^A\, \vec{A}^A_{\sigma'} - \sum_A \tilde{g}^A\, \vec{\tilde{\tau}}^A\, \vec{\tilde{A}}^A_{\sigma'})\,, \\
\mathbf{t} &\in (\mathbf{9}, \mathbf{10}, \mathbf{11}, \ldots, \mathbf{14})\,,
\end{aligned}
$$

**

$$
\begin{aligned}
A_s^{Ai} &= \sum_{a,b} c^{Ai}{}_{ab}\, \omega_{abs}\,, \\
A_t^{Ai} &= \sum_{a,b} c^{Ai}{}_{ab}\, \omega_{abt}\,, \\
\tilde{A}_s^{Ai} &= \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\, \tilde{\omega}_{abs}\,, \\
\tilde{A}_t^{Ai} &= \sum_{a,b} \tilde{c}^{Ai}{}_{ab}\, \tilde{\omega}_{abt}\,.
\end{aligned}
$$

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

- **o** τ^{Ai} represent the *standard model* charge groups — $SU(3)_c, SU(2)_w$ — the second $SU(2)_{II}$, the "spinor" charge $U(1)$, taking care of the hyper charge Y,
- **o** $\tilde{\tau}^{Ai}$ denote the family quantum numbers.

$$\mathbf{N}^{\mathbf{i}}_{(\mathbf{L},\mathbf{R})} : \; = \; \frac{1}{2}(S^{23} \pm iS^{01}, S^{31} \pm iS^{02}, S^{12} \pm iS^{03}),$$

$$\tau^{\mathbf{i}}_{(\mathbf{1},\mathbf{2})} : \; = \; \frac{1}{2}(S^{58} \mp S^{67}, \; S^{57} \pm S^{68}, \; S^{56} \mp S^{78}),$$

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

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

$$\mathbf{Y} := \; \tau^4 + \tau^{23},$$

$$\mathbf{Y}' := \; -\tau^4 \tan^2 \vartheta_2 + \tau^{23},$$

$$\mathbf{Q} := \; \tau^{13} + Y,$$

$$\mathbf{Q}' := \; -Y \tan^2 \vartheta_1 + \tau^{13},$$

and equivalently for family groups $\tilde{S}^{ab}$.

**

Breaks of symmetries
after starting with

o massless spinors (fermions) ,

o massles vielbeins and two kinds of the spin connection fields

We prove for a toy model that breaking symmetry in Kaluza-Klein theories can lead to massless fermions.

New J. Phys. 13, 103027, 2011.
J. Phys. A. Math. Theor. 45, 465401, 2012.
[arXiv:1205.1714], [arXiv:1312.541], [arXiv:hep-ph/0412208 p.64-84].
[arXiv:1302.4305], p. 157-166.

**

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

BREAK I

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

$\downarrow$

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

$\times \widetilde{\mathbf{SO}(1,7)}$

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

eight massless families

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

(devided into two groups)

BREAK II

$\downarrow$

The Standard Model like way of breaking

$\downarrow$

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

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

- **o The break from $SO(13,1)$ to $SO(7,1) \times SO(6)$, caused by the appearance of the condensate, leaves eight families ($2^{8/2-1} = 8$, determined by the symmetry of $\widetilde{SO}(1,7)$) massless. All the families are $\widetilde{SU}(3)$ chargeless.**
  Phys. Rev. **D**, 80.083534 (**2009**)

- **The appearance of the condensate of the two right handed neutrinos, coupled to spin 0, makes the boson gauge fields, with which the condensate interacts, massive.** These gauge fields are:

  o All the scalar gauge fields with the space index $s \geq 5$.

  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

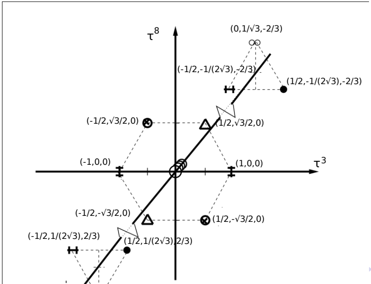
o The **condensate has spin** $S^{12} = 0,\ S^{03} = 0,$
weak charge $\vec{\tau}^{1} = 0$**, and**
$\vec{\tilde{\tau}}^{1} = 0,\ \tilde{Y} = 0,\ \tilde{Q} = 0,\ \vec{\tilde{N}}_{L} = 0.$

state	τ^{23}	τ^{4}	Y	Q	$\tilde{\tau}^{23}$	$\tilde{N}^{3}_{R}$	$\tilde{\tau}^{4}$
$\vert\nu^{\mathrm{VIII}}_{\mathbf{1R}} >_{1}\ \vert\nu^{\mathrm{VIII}}_{\mathbf{2R}} >_{2}$	1	-1	0	0	1	1	-1
$\vert\nu^{VIII}_{1R} >_{1}\ \vert e^{VIII}_{2R} >_{2}$	0	-1	-1	-1	1	1	-1
$\vert e^{VIII}_{1R} >_{1}\ \vert e^{VIII}_{2R} >_{2}$	-1	-1	-2	-2	1	1	-1

o Only the member on the first line $\vert\nu^{\mathrm{VIII}}_{\mathbf{1R}} >_{1}\ \vert\nu^{\mathrm{VIII}}_{\mathbf{2R}} >_{2}$ **gets non zero vacuum expectation value — by assumption.**

o Let us look at boson "basis vectors" as was already presented in the figure, which analyses ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$ with respect to Cartan subalgebra members (τ^3, τ^8, τ') in a toy model with $d = (5+1)$.

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 are the two triplets with non zero $\tau' = \pm\frac{2}{3}$, which transform leptons into quarks. They become massive.



o

- **Only 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** from
  $SO(1,3) \times SU(2)_I \times U(1)_I \times SU(3)$ to
  $SO(1,3) \times U(1) \times SU(3)$
  o **scalar fields with the space index** $s = (7,8)$ **obtain constant values and imaginary masses (nonzero vacuum expectation values)**,
  o **break correspondingly the weak and the hyper charge and change their own masses**.
  o **They leave massless** only the **colour, elm** and **gravity gauge fields.**
- **All the eight massless families gain masses**.

Also these is so far just assumed, waiting to be proven that scalar fields, together with boundary conditions, are spontaneously causing also this last breaks.

However, all the needed vector and scalar gauge fields, the fermion fields with all the observed properties, are already in the simple starting action, making the *spin-charge-family* **theory (at least so far) very promising**.

- o To the electroweak break several scalar fields, the gauge fields of two times $\widetilde{SU}(2) \times \widetilde{SU}(2)$ and three times singlets $U(1)$, contribute, all with the weak and the hyper charge of the *standard model* Higgs.
- o 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 twice $\widetilde{SU}(2) \times \widetilde{SU}(2)$.

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

- **o The mass matrices of each family member manifest the $\widetilde{SU}(2) \times \widetilde{SU}(2) \times U(1)$ symmetry, which — almost proven — remains unchanged in all loop corrections.**

[arXiv:1902.02691, arXiv:1902.10628]

- ** We studied on a toy model of $d = (5 + 1)$ conditions which lead after breaking symmetries to massless spinors chirally coupled to the Kaluza-Klein-like gauge field.

  New J. Phys. **13** (**2011**) 103027, 1-25,
  Int. J Mod. Phys. **A 29**, 1450124 (**2014**), 21 pages.

**

- **All the vector gauge fields**, A^{Ai}_{m}, $(m,n) = (0,1,2,3)$ **of the observed charges** $\tau^{Ai} = \sum_{s,t} c^{Ai}{}_{st}\, S^{st}$, **manifesting at the observable energies**, **have all the properties as assumed by the** ***standard model***.
- **They carry with respect to the space index** $m \in (0,1,2,3)$ **the vector degrees of freedom, while they have additional internal degrees of freedom** (τ^{Ai}) in **the adjoint representations**.
- **They origin as spin conection gauge fields** of S^{ab}: $A^{Ai}_{m} = \sum_{s,t} c^{Aist}\, \omega_{stm}$.
- $\mathcal{S}^{ab}$ **applies on indexes** (s,t,m) **as follows**

$$\mathcal{S}^{ab}\, \omega_{stm\ldots g} \;=\; i\,(\delta^{a}_{s}\, \omega^{b}{}_{tm\ldots g} - \delta^{b}_{s}\, \omega^{a}{}_{tm\ldots g})\,.$$

**

The action for vectors with respect to the space index $m=(0,1,2,3)$ origin in gravity

$$\int \mathbf{E}\, \mathbf{d^4x}\, \mathbf{d^{(d-4)}x}\, \alpha\, \mathbf{R^{(d)}} = \int \mathbf{d^4x}\, \{-\frac{1}{4} \mathbf{F^{Ai}}_{\mathbf{mn}}\, \mathbf{F^{Aimn}}\},$$

$$\mathbf{A^{Ai}}_{\mathbf{m}} = \sum_{\mathbf{s,t}} \mathbf{c^{Aist}}\, \omega_{\mathbf{stm}}\,.$$

Eur. Phys. J. C. **77** (**2017**) 231,

*

Also scalar fields
(there are doublets and triplets)
origin in gravity fields — they are spin connections and vielbeins —
with the space index $s \geq 5$,

Eur. Phys. J. C. **77** (**2017**) 231 ,
Phys. Rev. **D 91** (**2015**) 6, 065004,
J. of Mod. Physics **6** (**2015**) 2244.

**

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

o 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
$A^{Ai}_{\substack{78\\(-)}}$	$A^{Ai}_7 + iA^{Ai}_8$	$+\frac{1}{2}$	$-\frac{1}{2}$	0	0	0
$A^{Ai}_{\substack{56\\(-)}}$	$A^{Ai}_5 + iA^{Ai}_6$	$-\frac{1}{2}$	$-\frac{1}{2}$	0	0	-1
$A^{Ai}_{\substack{78\\(+)}}$	$A^{Ai}_7 - iA^{Ai}_8$	$-\frac{1}{2}$	$+\frac{1}{2}$	0	0	0
$A^{Ai}_{\substack{56\\(+)}}$	$A^{Ai}_5 - iA^{Ai}_6$	$+\frac{1}{2}$	$+\frac{1}{2}$	0	0	$+1$

o There are $A^{Ai}_{\substack{78\\(-)}}$ and $A^{Ai}_{\substack{78\\(+)}}$ 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.

- **o 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** $s = (9,\ldots,14)$.
- **o There are no additional scalars in the theory for d=(13+1)**.
- **All are massless.**
- All the scalars have the family and the family members quantum numbers in the **adjoint** representations.
- The properties of scalars are to be analyzed with respect to the generators of the corresponding subgroups, expressible with $\mathcal{S}^{ab}$, as it is the case of the vector gauge fields.
- It is the (**so far assumed**) **condensate, which makes those gauge fields, with which it interacts, massive**.
  o The condensate breaks the CP symmetry.

- **o The scalar condensate of two right handed neutrinos couple to**
  o the scalar and vector gauge fields, making some of them massive,
  o It does not interact with the weak charge $SU(2)_l$, **the hyper charge** $U(1)$, and **the colour** $SU(3)$ **charge gauge fields**, as well as the **gravity,**
  leaving them massless.

J. of Mod.Phys.**4** (**2013**) 823-847,
J. of Mod.Phys. **6** (**2015**) 2244-2247,
Phys Rev.**D 91**(**2015**)6,065004.

o 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:

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

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** $\tilde{\omega}_{abs'}$**.**

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

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

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

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

o Operators Y, Q and τ^{13}, applied on $(A_7^{Ai} \mp i\, A_8^{Ai})$

$$
\begin{aligned}
\boldsymbol{\tau^{13}}\,(A_7^{Ai} \mp i\, A_8^{Ai}) &= \pm\frac{1}{2}\,(A_7^{Ai} \mp i\, A_8^{Ai})\,,\\
\mathbf{Y}\,(A_7^{Ai} \mp i\, A_8^{Ai}) &= \mp\frac{1}{2}\,(A_7^{Ai} \mp i\, A_8^{Ai})\,,\\
\mathbf{Q}\,(A_7^{Ai} \mp i\, A_8^{Ai}) &= 0\,,
\end{aligned}
$$

manifest that **all $(A_7^{Ai} \mp i\, A_8^{Ai})$** 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:
$(A_7^{Ai} + iA_8^{Ai})$ **"dresses"** u_R, ν_R and $(A_7^{Ai} - iA_8^{Ai})$ **"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 $\tilde{\tau}^{13} = 0$, $\tilde{N}^3_L = 0$.

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

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

o

- 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 $\mathbf{n \geq 4}$ 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 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.**

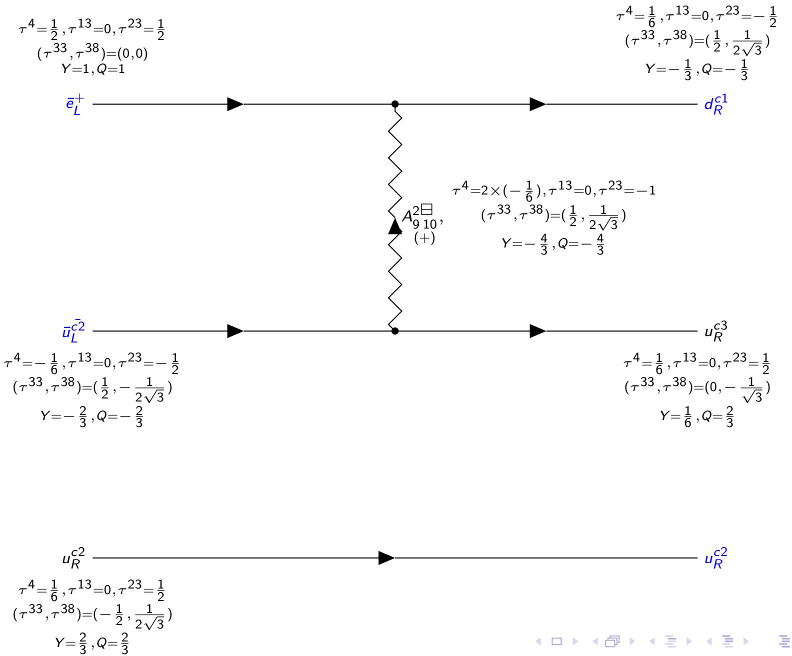
Matter-antimatter asymmetry

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 **chargeless 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 a chance to explain the matter-antimatter asymmetry**.

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

Dark matter

$d \to (d-4) + (3+1)$ **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

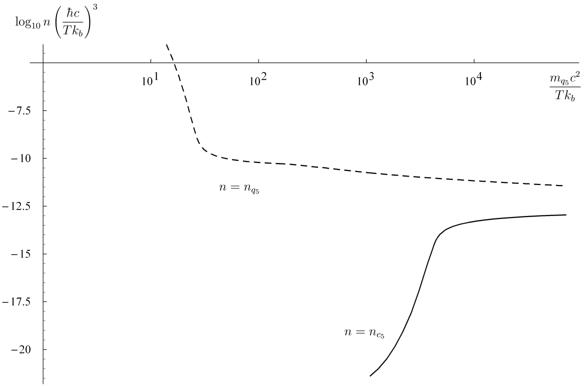


Figure: The dependence of the two number densities n_{q_5} (of the fifth family quarks) and n_{c_5} (of the fifth family clusters) as the function of $\frac{m_{q_5} c^2}{T k_b}$ is presented for the values $m_{q_5} c^2 = 71$ TeV, $\eta_{c_5} = \frac{1}{50}$ and $\eta_{(q\bar{q})_b} = 1$. We take $g^*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

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,..- ...

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

- **In the** *standard model* the **family members with all their properties**, the **families**, the **gauge vector fields**, the **scalar Higgs**, the **Yukawa couplings**, exist by the **assumption**.

- ** In the **spin-charge-family theory the appearance and all the properties of all these fields follow from the simple starting action** with **two kinds of spins** and with the **gravity only** .

  ** The theory offers the explanation for the **dark matter**.

  ** The theory offers the explanation for the **matter-antimatter asymmetry**.

  ** All the **scalar** and all the **vector** gauge fields are **directly or indirectly observable**.

- ** The **spin-charge-family theory even offers the creation and annihilation operators without postulation.**

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.

Concrete predictions:

- There are several scalar fields;
  o two triplets , o three singlets ,
  explaining higgss and Yukawa couplings,
  some of them will be observed at the LHC, JMP 6 (2015) 2244,
  Phys. Rev. D 91 (2015) 6, 065004.
- There is the fourth family, (weakly) coupled to the observed three, which will be observed at the LHC, New J. of Phys. 10 (2008) 093002.
- There is the dark matter with the predicted properties, Phys. Rev. D (2009) 80.083534.
- There is the ordinary matter/antimatter asymmetry explained and the proton decay predicted and explained, Phys. Rev. D 91 (2015) 6, 065004.

We recognize that:

- The **last data for mixing matrix of quarks are in better agreement with our prediction for the** 3×3 **submatrix elements of the** 4×4 **mixing matrix than the previous ones**.
- Our **fit to the last data predicts how will** the 3×3 **submatrix elements change** in the **next more accurate measurements**.
- **Masses** of the **fourth family lie much above the known three, masses of quarks are close to each other.**
- The1**larger are masses of the fourth family the larger are** $V_{u_1 d_4}$ **in comparison with** $V_{u_1 d_3}$ **and the more is valid that** $V_{u_2 d_4} < V_{u_1 d_4}$, $V_{u_3 d_4} < V_{u_1 d_4}$.
  The flavour changing neutral currents are correspondingly weaker.

- **Masses** of the **fifth family** **lie** **much above** **the known three and the** **predicted fourth family** **masses**.
- **Although the upper four families carry the weak (of two kinds) and the colour charge, these group of four families are completely decoupled from the lower four families up to the** $< 10^{16}$ **GeV, unless the breaks of symmetries recover**.
- **Baryons** **of the** **fifth family** **are heavy, forming small enough clusters with small enough scattering amplitude among themselves and with the ordinary matter to be the candidate for the** **dark matter**.
- **The "nuclear" force among them is different from the force among ordinary nucleons.**

- The **spin-charge-family theory is offering an explanation for** the **hierarchy problem**:
  The mass matrices of the two four families groups are almost democratic, causing spreading of the fermion masses from 10^{16} **GeV to** 10^{-8} **MeV**.

- **Using odd and even Clifford algebra objects** the **spin-charge-family theory is offering an explanation for** the **second quantization postulates for fermions and bosons, while describing the internal space of fermions with the Clifford odd anti-commuting "basis vectors" and the internal space of bosons with the Clifford even commuting "basis vectors" .**
- **When all the properties of** $\hat{b}^{m\dagger}_{f}$**, and their Hermitian conjugated partners,** $\hat{b}^{m}_{f}$**, as well as of** ${}^{I}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}}\,{}^{I}\mathcal{C}^{\mathbf{m}}_{\mathbf{f}\alpha}$ **will be understood we very probably will understood nature in** $d=(3+1)$ **much better.**

To summarize:

- I hope that I managed to convince you that I can answer 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 a lot of properties to derive.

Thank you for attendance.