# How far has so far the Spin-Charge-Family theory succeeded to offer the explanation for the observed phenomena: The Standard Model assumptions, the matter-antimatter asymmetry, the appearance of the Dark Matter, the second quantized fermion fields...., making several predictions

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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**), *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,

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**:

**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.**

| $\alpha$ name | hand-edness $-4iS^{03}S^{12}$ | weak charge $\tau^{13}$ | 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 | $-\frac{1}{3}$ |
| $\nu^i_L$ | $-1$ | $\frac{1}{2}$ | $-\frac{1}{2}$ | 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 the $i = 1, 2, 3$ families, $i = 1, 2, 3$ 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**.

## Gauge fields before the electroweak break

- 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 $\mp\frac{1}{2}$ — as it would be in the **fundamental representation of the groups**,
  **o** gaining at some step **a "nonzero vacuum expectation values"**, 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**.

- 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 $\mathbf{d=(3+1)}$.

- **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.**

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

- **I am proposing the *spin-charge-family* theory,** which **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 fermions**,

  **iv.** **making several predictions.**

  **Is this the right next step beyond both** *standard models?*

**

**There are namely many other phenomena not yet understood, like:**

- the **dark energy**,
- the **observed dimension of space time**,
- the **quantization of the gravitational field**,
- ...

- **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?**
- **Can the elementary constituent be of only one kind? Are the four observed interactions — gravitational, elektromagnetic, weak and colour — of the common origin?**
- **Is the space-time the so far observed $(3+1)$? 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?**

**Obviously it is the time to make the next step beyond both standard models.**

**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?**

- **o How is 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?**

- 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? $(3+1)$?, $((d-1)+1)$?, $\infty$?
- **What** is the role of the **symmetries**– discrete, continuous, global and gauge – in our **universe, in Nature?**
- And many others.

My statement:

- An elegant trustworthy next step must offer answers to several open questions, explaining:
  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 dark matter.
  o The origin of the "ordinary" matter-antimatter asymmetry.

**My statement continues:**

- **There exist not yet observed families, gauge vector and scalar gauge fields.**
- **Dimension of space is larger than** 4 (very probably infinite).
- **Inventing a next step which covers one of the open questions**, **might be of a help but can hardly show the right next step in understanding nature.**

In the literature NO explanation for the existence of the families can be found, which would not just assume the family groups.
Several extensions of the standard model are, however, proposed, like:

- The $SU(3)$ group is assumed to describe – not explain – the existence of three families.
  Like the Higgs's scalar charges are in the fundamental representations of the groups, also the Yukawas are assumed to emerge from the scalar fields, in the fundamental representation of the $SU(3)$ group.

- **SU(5) and SO(10) grand unified theories are proposed, unifying all the charges.** 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**, **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 I shall first make a short introduction into** the **Spin-Charge-Family theory.**

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

**o I shall report on how does the odd Clifford algebra explain the second quantization postulates of Dirac.**
[arXiv:1802.05554v1v2, arXiv:1802.05554v4, arXiv:1902.10628].

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

- **Spinors carry** in $d \geq (13+1)$ **two kinds of spin, no charges**, *Phys. Rev.* **D 91** 065004 (2015), *J.of Mod. Physics* **6** (2015) 2244.

  **o** The **Dirac spin** $(\gamma^a)$ in $d = (13+1)$ **describes** in $d = (3+1)$ **spin** and **ALL the charges of quarks and leptons**, **left and right handed, explaining all the assumptions about the charges and the handedness of the** *standard model J. of Math. Phys.* **34** (1993), 3731, *J. of Math. Phys.* **43**, 5782 (2002) [hep-th/0111257].

  **o** The **second kind** of **spin** $(\tilde{\gamma}^a)$ **describes FAMILIES, explaining the origin of families and their number**, *J. of Math. Phys.* **44** 4817 (2003) [hep-th/0303224].

  **o** There is **NO third kind of spin.**

- **C,P,T symmetries in** $d = (3+1)$ **follow from the C,P,T symmetry in** $d \geq (13+1)$. (*JHEP* **04** (**2014**) 165)

- **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 They 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**.

- **Spinors interact correspondingly with**
  o the vielbeins and
  o the **two kinds of the spin connection fields**, *Eur. Phys. J. C* **77** (2017) 231.
- **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** and all the other **charges** in the **adjoint representations** or as
  o **tensor gravitational field**.

**There are two kinds of scalar fields with respect to the space index** $s$:

- **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)**. They are in the **adjoint representations** with respect to the **family** and the **family members charges**.

**o These scalars explain the Higgs's scalar and the Yukawa couplings**.

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

- **Those** with twice the "spinor charge" of a quark and $(s = 9, 10, ..d)$ are **colour triplets. Also they are in the adjoint representations** with respect to the **family** and the **family members charges**.

  **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

## 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 **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 appear in the** *spin-charge-family* **spontaneously**.

- **The scalar fields with the space index $(7, 8)$, gaining nonzero vacuum expectation 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**

- **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 the**

  **o condensate** and

  **o nonzero vacuum expectation 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) **and...**

**The spin-charge-family theory is a kind of a Kaluza-Klein-like theory, but with two kinds of spins.**

**In *d*-dimensional space there are fermions with two kinds of spins and gravity, represented by two spin connection and vielbein gauge fields.**

J. of Mod. Phys. **4** (2013) 823,
Phys. Rev. **D 91** (2015) 6, 065004,
J. of Mod. Phys. **6** (2015) 2244 [arxiv:1409.4981],
IARD, J. Phys.: Conf. Ser. 845 (2017) 012017 [arXiv:1607.01618]/v2],
Eur. Phys. J.C. **77** (2017) 231,
Forts. der Physik, Prog. of Phys.) (2017) 1700046

Comparing the spin-charge-family and the unifying theories, with the Kaluza-Klein like theories included.

- The $SO(10)$ must be put into $SO(13,1)$,
- allowing only gravity as gauge fields,
- recognizing that there are two kinds of the Clifford algebra objects
  o one explaining spins and charges of fermions,
  o the second one explaining families of fermions.

This would be the first step towards the spin-charge-family theory, if assuming as well the simple starting action for fermions and gauge fields.

At low energies the simple starting action for fermions and gravity manifest all the observed degrees of freedom — quarks and leptons antiquarks and antileptons, the observed gauge vector and scalar fields — so that nothing in addition is needed.

- One has to recognize:
- that the scalar gauge fields are of two kinds due to the two kinds of the Clifford algebra objects,
- offering the explanation for several so far observed phenomena,
  o for the masses of fermions and weak bosons,
  o for the appearance of the matter-antimatter asymmetry in the universe,
  o for the appearance of the dark matter,
  o and for several other phenomena.
- One must also demonstrate that breaking symmetry can steel lead to (almost) massless fermions,
- proving this, making several predictions.

- **No assumptions for the group contents of fermions to represent spins, charges and families are needed, what other theories must make.**
- **In addition, as I shall discuss in this talk, the theory offers the second quantized fields, explaining the Dirac postulates.**

**A short look "inside" the spin-charge-family theory.**

**There are only two kinds of the Clifford algebra objects in any d**:

- The **Dirac $\gamma^a$ operators** (used by Dirac 90 years ago).
- The **second one: $\tilde{\gamma}^a$**, which I recognized in the Grassmann space.
- **The two kinds form two independent spaces**.

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

**The postulate**

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

where $(-)^{n_B} = +1, -1$, when the object $B$ has a Clifford even or odd character, respectively, and $|\psi_o>$ is a vacuum state on which the operators $\gamma^a$ **apply**,
**reduces the Clifford space for the factor of two**, while the operators $\tilde{\gamma}^a\tilde{\gamma}^b$ define the **family quantum numbers**.

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

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

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

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

My **recognition:**

- If $\gamma^a$ **are used to describe the spin and the charges of spinors,**
  $\tilde{\gamma}^a$ **- since it must be used or it must be explained why it does not manifest - it must be used to describe families of spinors**.

Phys. Lett. **B 292**, 25-29 (**1992**),
J. Math. Phys. **34**, 3731-3745 (**1993**),
Mod. Phys. Lett. **A 10**, 587-595 (**1995**)

A simple action for **a spinor which carries in** $d = (13+1)$ **only two kinds of spins (no charges)** and for the **gauge gravitational fields**, **with which spinors interact:**

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

▶

$$\mathcal{L}_f = \frac{1}{2}(\bar{\psi} \, \gamma^a p_{0a} \psi) + h.c.$$

$$p_{0a} = f^{\alpha}{}_a p_{0\alpha} + \frac{1}{2E} \{p_\alpha, E f^{\alpha}{}_a\}_-$$

$$\mathbf{p}_{0\alpha} = \mathbf{p}_\alpha - \frac{\mathbf{1}}{\mathbf{2}} \mathbf{S}^{\mathbf{ab}} \omega_{\mathbf{ab}\alpha} - \frac{\mathbf{1}}{\mathbf{2}} \tilde{\mathbf{S}}^{\mathbf{ab}} \tilde{\omega}_{\mathbf{ab}\alpha}$$

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

- **The only internal degrees of freedom of spinors (fermions) are the two kinds of the spin.**
- **The only gauge fields are the gravitational ones – vielbeins and the two kinds of spin connections.**
- **Both, $\gamma^a$ and $\tilde{\gamma}^a$, transform as vectors in $d$,**

  **and correspondingly also $f^{\alpha}{}_{a}\,\omega_{bc\alpha}$ and $f^{\alpha}{}_{a}\,\tilde{\omega}_{bc\alpha}$ transform as tensors with respect to the flat index $a$.**

**

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

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

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

**

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

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

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 $f^{\alpha}{}_{a}$.**

## Fermions

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

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

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

## Covariant momenta

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

$$
\begin{aligned}
\mathsf{A}_{\mathsf{s}}^{\mathsf{Ai}} &= \sum_{\mathsf{a,b}} \mathsf{c}^{\mathsf{Ai}}{}_{\mathsf{ab}}\, \omega_{\mathsf{abs}} \,, \\
\mathsf{A}_{\mathsf{t}}^{\mathsf{Ai}} &= \sum_{\mathsf{a,b}} \mathsf{c}^{\mathsf{Ai}}{}_{\mathsf{ab}}\, \omega_{\mathsf{abt}} \,, \\
\tilde{\mathsf{A}}_{\mathsf{s}}^{\mathsf{Ai}} &= \sum_{\mathsf{a,b}} \tilde{\mathsf{c}}^{\mathsf{Ai}}{}_{\mathsf{ab}}\, \tilde{\omega}_{\mathsf{abs}} \,, \\
\tilde{\mathsf{A}}_{\mathsf{t}}^{\mathsf{Ai}} &= \sum_{\mathsf{a,b}} \tilde{\mathsf{c}}^{\mathsf{Ai}}{}_{\mathsf{ab}}\, \tilde{\omega}_{\mathsf{abt}} \,.
\end{aligned}
$$

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

- **o** $\tau^{Ai}$ 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.

$$\begin{aligned}
\mathbf{N}^{\mathbf{i}}_{(\mathbf{L},\mathbf{R})} :&= \frac{1}{2}(S^{23} \pm i S^{01}, S^{31} \pm i S^{02}, S^{12} \pm i S^{03})\,,\\
\tau^{\mathbf{i}}_{(\mathbf{1},\mathbf{2})} :&= \frac{1}{2}(S^{58} \mp S^{67},\, S^{57} \pm S^{68},\, S^{56} \mp S^{78})\,,\\
\tau^{\mathbf{i}}_{\mathbf{3}} :=&\ \frac{1}{2}\,\{S^{9\,12} - S^{10\,11}\,, S^{9\,11} + S^{10\,12},\, S^{9\,10} - S^{11\,12},\\
&S^{9\,14} - S^{10\,13},\, S^{9\,13} + S^{10\,14}\,, S^{11\,14} - S^{12\,13}\,,\\
&S^{11\,13} + S^{12\,14},\, \frac{1}{\sqrt{3}}(S^{9\,10} + S^{11\,12} - 2S^{13\,14})\}\,,\\
\tau^{4} :=&\ -\frac{1}{3}(S^{9\,10} + S^{11\,12} + S^{13\,14})\,,\\
\mathbf{Y} :=&\ \tau^{4} + \tau^{23}\,,\\
\mathbf{Y'} :=&\ -\tau^{4}\tan^2\vartheta_2 + \tau^{23}\,,\\
\mathbf{Q} :=&\ \tau^{13} + Y\,,\\
\mathbf{Q'} :=&\ -Y\tan^2\vartheta_1 + \tau^{13}\,,
\end{aligned}$$

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

**Breaks of symmetries**
**after starting with**

**o massless spinors (fermions) ,**

**o 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**

$\downarrow$

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

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

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)

- **Both breaks leave 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

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 | $\tau^{23}$ | $\tau^4$ | $Y$ | $Q$ | $\tilde{\tau}^{23}$ | $\tilde{N}_R^3$ | $\tilde{\tau}^4$ |
|---|---|---|---|---|---|---|---|
| $\boldsymbol{\vert\nu^{VIII}_{1R} >_1 \vert\nu^{VIII}_{2R} >_2}$ | 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 | $-1$ |

- 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 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.**

**But all the needed degrees of freedom are already in the simple starting action, looking so far very promising**.

- **To the electroweak break several scalar fields, the gauge fields of twice** $\widetilde{SU}(2) \times \widetilde{SU}(2)$ **and three** $\times U(1)$ **, contribute, all with 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 twice** $\widetilde{SU}(2) \times \widetilde{SU}(2)$.

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

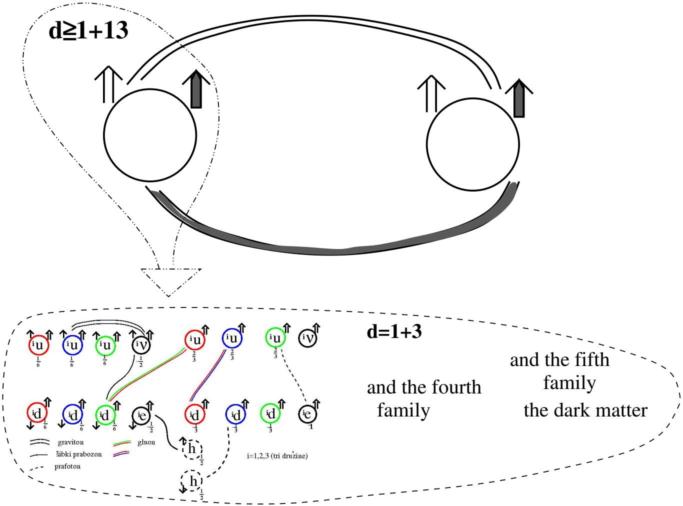
- **The mass matrices of each family member manifest the $\widetilde{SU}(2) \times \widetilde{SU}(2) \times U(1)$ symmetry, which remains unchanged in all loop corrections**,

  **while repetitions of the nonzero vacuum expectation values of the scalar fields, together with loop corrections, both in all orders, give a controllable change of this symmetry.**

[arXiv:1902.02691, arXiv:1902.10628]

- We studied on a toy model of $d = (1 + 5)$ 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.


d≧1+13
d=1+3
and the fourth family
and the fifth family
the dark matter
graviton
šibki prabozon
prafoton
gluon
i=1,2,3 (tri družine)

**

**Families of quarks and leptons and antiquarks and antileptons**

**Our technique to represent spinors is elegant.**

- J. of Math. Phys. **34**, 3731 (1993),
- Int. J. of Modern Phys. **A 9**, 1731 (1994),
- J. of Math. Phys. **36**, 1593 (1995),
- J. of Math. Phys. **43**, 5782-5803 (2002), hep-th/0111257,
- J. of Math. Phys. **44** 4817 (2003), hep-th/0303224,
- J. of High Ener. Phys. **04** (2014) 165, arxiv:1212.2362v2.

**The spinors states are created out of**

**nilpotents** $\overset{ab}{(\pm i)}$ and **projectors** $\overset{ab}{[\pm i]}$

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

with $\gamma^a$ which are usual **Dirac operators in** $d$**-dimensional space**.

J. of Math. Phys. **34**, 3731 (1993),
Int. J. of Modern Phys. **A 9**, 1731 (1994),
J. of Math. Phys. **43**, 5782-5803 (2002)

**Nilpotents** $\overset{ab}{(\pm i)}$ and **projectors** $\overset{ab}{[\pm i]}$ **are chosen to be eigensates of the Cartan subalgebra of** $S^{ab}$ and $\tilde{S}^{ab}$.

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

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

- One **Weyl representation** of one **family contains** all the **family members** with the **right handed neutrinos included**. It includes also **antimembers, 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

- There are $2^{(7+1)/2-1} = 8$ **families**, which decouple into **twice four families**, with the quantum numbers $(\tilde{\tau}^{2i},\ \tilde{N}^i_R)$ and $(\tilde{\tau}^{1i},\ \tilde{N}^i_L)$, respectively.

  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

| i | | $\vert^a\psi_i >$ | $\Gamma^{(3,1)}$ | $S^{12}$ | $\Gamma^{(4)}$ | $\tau^{13}$ | $\tau^{23}$ | $Y$ | $\tau^4$ |
|---|---|---|---|---|---|---|---|---|---|
| | | Octet, $\Gamma^{(7,1)}=1,\ \Gamma^{(6)}=-1,$ of quarks | | | | | | | |
| 1 | $\mathbf{u}_{\mathbf{R}}^{\mathbf{c1}}$ | $\stackrel{03}{(+i)}\stackrel{12}{(+)}\vert\stackrel{56}{(+)}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$ | **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 | $\mathbf{d}_{\mathbf{R}}^{\mathbf{c1}}$ | $\stackrel{03}{[-i]}\stackrel{12}{[-]}\vert\stackrel{56}{[-]}\stackrel{78}{[-]}\Vert\stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$ | **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 | $\mathbf{d}_{\mathbf{L}}^{\mathbf{c1}}$ | $\stackrel{03}{(+i)}\stackrel{12}{[-]}\vert\stackrel{56}{[-]}\stackrel{78}{(+)}\Vert\stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$ | **-1** | $-\frac{1}{2}$ | -1 | $-\frac{1}{2}$ | 0 | $\frac{1}{6}$ | $\frac{1}{6}$ |
| 7 | $\mathbf{u}_{\mathbf{L}}^{\mathbf{c1}}$ | $\stackrel{03}{[-i]}\stackrel{12}{(+)}\vert\stackrel{56}{(+)}\stackrel{78}{[-]}\Vert\stackrel{9\,10}{(+)}\stackrel{11\,12}{(-)}\stackrel{13\,14}{(-)}$ | **-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 | $\frac{1}{6}$ | $\frac{1}{6}$ |

$\gamma^0\gamma^7$ 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 $\gamma^0$ do in the Stan. model.

The **anti-eightplet** (repres. of $SO(7,1)$) of **anti-quarks** of the anti-colour charge, reachable by either $S^{ab}$ or $\mathbb{C}_{\mathcal{N}}\mathcal{P}_{\mathcal{N}}^{(d-1)}$:

| i | | $\|^a\psi_i>$ | $\Gamma^{(3,1)}$ | $S^{12}$ | $\Gamma^{(4)}$ | $\tau^{13}$ | $\tau^{23}$ | $Y$ | $\tau^4$ |
|---|---|---|---|---|---|---|---|---|---|
| | | Antioctet, $\Gamma^{(7,1)}=-1$, $\Gamma^{(6)}=1$, of antiquarks | | | | | | | |
| 33 | $\bar{\mathbf{d}}^{\bar{c}1}_{\mathbf{L}}$ | 03 12 56 78 9 1011 1213 14<br>$[-i](+) \mid (+)(+) \mid\mid [-]\ [+]\ [+]$ | -1 | $\frac{1}{2}$ | 1 | 0 | $\frac{1}{2}$ | $\frac{1}{3}$ | $-\frac{1}{6}$ |
| 34 | $\bar{d}^{\bar{c}1}_{L}$ | 03 12 56 78 9 1011 1213 14<br>$(+i)[-] \mid (+)(+) \mid\mid [-]\ [+]\ [+]$ | -1 | $-\frac{1}{2}$ | 1 | 0 | $\frac{1}{2}$ | $\frac{1}{3}$ | $-\frac{1}{6}$ |
| 35 | $\bar{u}^{\bar{c}1}_{L}$ | 03 12 56 78 9 1011 1213 14<br>$[-i](+) \mid [-][-] \mid\mid [-]\ [+]\ [+]$ | -1 | $\frac{1}{2}$ | 1 | 0 | $-\frac{1}{2}$ | $-\frac{2}{3}$ | $-\frac{1}{6}$ |
| 36 | $\bar{\mathbf{u}}^{\bar{c}1}_{\mathbf{L}}$ | 03 12 56 78 9 1011 1213 14<br>$(+i)[-] \mid [-][-] \mid\mid [-]\ [+]\ [+]$ | - 1 | $-\frac{1}{2}$ | 1 | 0 | $-\frac{1}{2}$ | $-\frac{2}{3}$ | $-\frac{1}{6}$ |
| 37 | $\bar{\mathbf{d}}^{\bar{c}1}_{\mathbf{R}}$ | 03 12 56 78 9 1011 1213 14<br>$(+i)(+) \mid (+)[-] \mid\mid [-]\ [+]\ [+]$ | 1 | $\frac{1}{2}$ | -1 | $\frac{1}{2}$ | 0 | $-\frac{1}{6}$ | $-\frac{1}{6}$ |
| 38 | $\bar{d}^{\bar{c}1}_{R}$ | 03 12 56 78 9 1011 1213 14<br>$[-i][-] \mid (+)[-] \mid\mid [-]\ [+]\ [+]$ | 1 | $-\frac{1}{2}$ | -1 | $\frac{1}{2}$ | 0 | $-\frac{1}{6}$ | $-\frac{1}{6}$ |
| 39 | $\bar{u}^{\bar{c}1}_{R}$ | 03 12 56 78 9 1011 1213 14<br>$(+i)(+) \mid [-](+) \mid\mid [-]\ [+]\ [+]$ | 1 | $\frac{1}{2}$ | -1 | $-\frac{1}{2}$ | 0 | $-\frac{1}{6}$ | $-\frac{1}{6}$ |
| 40 | $\bar{\mathbf{u}}^{\bar{c}1}_{\mathbf{R}}$ | 03 12 56 78 9 1011 1213 14<br>$[-i][-] \mid [-](+) \mid\mid [-]\ [+]\ [+]$ | 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.

## New way of second quantization of fermion fields in the odd Clifford algebra manifesting families and family members of quarks and leptons and antiquarks and antileptons
## Explaining the Dirac postulates for second quantized fermions.

Any family irreducible Lorentz representation of the odd Clifford algebra of SO(13,1) includes 64 members—all the quarks and the leptons, the antiquarks and the antileptons, left and right handed, with spin up and spin down—with the following properties:

- Quarks distinguish from leptons only in the SU(3)$\times$ U(1) subgroup of the group SO(13,1)
- The SO(7,1) subgroup with 8 elements is the same for quarks and leptons, and the same for antiquarks and antileptons.
- The Hermitian conjugated representation belong to another odd irreducible representation of the group SO(13,1).

- **Defining the creation operator in the internal space:**
  $u^{c1\dagger}_{\uparrow R} \Leftrightarrow b^{1\dagger}_1 := \overset{03}{(+i)}\overset{12}{(+)} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\overset{11\,12}{(-)}\overset{13\,14}{(-)}$,
- **its Hermitian conjugated partner is**
  $u^{c1}_{\uparrow R} \Leftrightarrow (\mathbf{b}^{1\dagger}_{\mathbf{1}})^{\dagger} = \overset{\mathbf{13\,14}}{(+)}\overset{\mathbf{11\,12}}{(+)}\overset{\mathbf{9\,10}}{(-)} \mid\mid \overset{\mathbf{78}}{(-)}\overset{\mathbf{56}}{(-)} \mid \overset{\mathbf{12}}{(-)}\overset{\mathbf{03}}{(-\mathbf{i})}$,
- $u^{c1\dagger}_{\downarrow R} \Leftrightarrow b^{1\dagger}_2 := \overset{03}{[-i]}\overset{12}{[-]} \mid \overset{56}{(+)}\overset{78}{(+)} \mid\mid \overset{9\,10}{(+)}\overset{11\,12}{(-)}\overset{13\,14}{(-)}$, and
- $\hat{b}^{1}_{2} := \overset{13\,14}{(+)}\overset{11\,12}{(+)}\overset{9\,10}{(-)} \mid\mid \overset{78}{(-)}\overset{56}{(-)} \mid \overset{12}{[-]}\overset{03}{[-i]}$,
- $\cdots\cdots$
- $\cdots\cdots$ .

**Creation and Hermitian conjugated partners, operating on a vacuum state**

- $|\psi_o> = \overset{\mathbf{03}}{[-\mathbf{i}]}\overset{\mathbf{12}}{[-]}\overset{\mathbf{56}}{[-]}\cdots\overset{\mathbf{13\,14}}{[-]}\;|\mathbf{0}>$
- **define fermion states—quarks and leptons and antiquarks and antileptons—of one of 8 families.**

One finds the following anti-commutation relations for a fermion fields, which represent **"basis vectors" in internal space** determining properties of the observed **quarks and leptons** ($i = (u^{f,\uparrow,\downarrow}_{R,L}, d^{f,\uparrow,\downarrow}_{R,L}, \nu^{f,\uparrow,\downarrow}_{R,L}, e^{f,\uparrow,\downarrow}_{R,L})$)
and **anti-quarks and anti-leptons** ,
**with the family quantum number** $f$.

- $\{\mathbf{b}^{\mathbf{f}}_{\mathbf{i}}, \mathbf{b}^{\mathbf{f}'\dagger}_{\mathbf{k}}\}_{*_{\mathbf{A}}+}|\psi_{\mathbf{o}}> = \delta^{\mathbf{f}\,\mathbf{f}'}\,\delta^{\mathbf{i}}_{\mathbf{k}}\;|\psi_{\mathbf{o}}>$,
- $\{\mathbf{b}^{\mathbf{f}}_{\mathbf{i}}, \mathbf{b}^{\mathbf{f}'}_{\mathbf{k}}\}_{*_{\mathbf{A}}+}|\psi_{\mathbf{o}}> = 0\cdot|\psi_{\mathbf{o}}>$ ,
- $\{\mathbf{b}^{\mathbf{f}\dagger}_{\mathbf{i}}, \mathbf{b}^{\mathbf{f}'\dagger}_{\mathbf{k}}\}_{*_{\mathbf{A}}+}|\psi_{\mathbf{o}}> = 0\cdot|\psi_{\mathbf{o}}>$ ,
- $\mathbf{b}^{\mathbf{f}}_{\mathbf{i}} *_{\mathbf{A}} |\psi_{\mathbf{o}}> = 0\cdot|\psi_{\mathbf{o}}>$,
- $\mathbf{b}^{\mathbf{f}\dagger}_{\mathbf{i}} *_{\mathbf{A}} |\psi_{\mathbf{o}}> = |\psi^{\mathbf{f}}_{\mathbf{i}}>$

[ arXiv:1802.05554v1], [arXiv:1802.05554v4], [arXiv:1902.10628]

- **There are $2^{\frac{d}{2}-1}$ different "basis vectors" for each of $2^{\frac{d}{2}-1}$ families in d-dimensional space, if there is no break of symmetries.**
- **They are defined for any momentum $(p^0, \vec{p})$ in any dimension $d$.**
- **The "basis vectors" manifest in $d = (3+1)$ space spins, charges and families, but not yet include the momentum space.**

**The superposition of "basis vectors" of particular family can be chosen so that it solves the equations of motion for, let us choose, free massless fermions.**

$$\begin{aligned} \mathcal{A} &= \int \mathbf{d^d x}\, \frac{\mathbf{1}}{\mathbf{2}}\, (\psi^{\dagger}\gamma^{\mathbf{0}}\,\gamma^{\mathbf{a}}\mathbf{p_a}\psi) + \mathbf{h.c.}\,, \\ \gamma^{\mathbf{a}}\mathbf{p_a}|\psi> &= \mathbf{0}\,, \end{aligned}$$

The plane wave solution $s$ for $p^a = (p^0, p^1, p^2, p^3, 0, 0, \cdots, 0)$, for a particular family, charge and right handedness, for example, is the superposition $\hat{b}^{s,ch,f\dagger}(\vec{p})$

- $\hat{b}^{s,ch,f\dagger}(\vec{p}) = (\alpha^{\mathbf{s,ch,s}}_{\uparrow}(\tilde{\mathbf{p}})\ \hat{\mathbf{b}}^{\mathbf{ch,f}\dagger}_{\uparrow} + \beta^{\mathbf{s,ch,s}}_{\downarrow}(\tilde{\mathbf{p}})\ \hat{\mathbf{b}}^{\mathbf{ch,f}\dagger}_{\downarrow})$ $\mathbf{e}^{-\mathbf{i}(\mathbf{p_0 x^0} - \tilde{\mathbf{p}}\cdot\mathbf{x^p})}$ , $\mathbf{p^0} = |\tilde{\mathbf{p}}|\,,$

$$|\psi^{\mathbf{s,ch,f}}(\tilde{\mathbf{p}})> \;=\; \hat{\mathbf{b}}^{s,ch,f\dagger}(\vec{p})|_{p^0=|\vec{p}|} *_A |\psi_o>\,,$$

- A general solution in d-dimensional space where **s** denotes different orthonormal solutions of the equations of motion in $d$

$$\hat{\mathbf{b}}^{s,f\dagger}(\tilde{\mathbf{p}}) = \sum_{\mathbf{i}} \mathbf{c}^{sf}{}_{\mathbf{i}}(\tilde{\mathbf{p}})\, \mathbf{b}^{f\dagger}_{\mathbf{i}}\,,$$

- while we have in $x$ representation

$$|\psi^{sf}(\tilde{\mathbf{x}},\mathbf{t})> = \int_{-\infty}^{+\infty} \frac{dp^{d-1}}{(\sqrt{2\pi})^{d-1}} \sum_{m} \alpha^{f}_{sm}(\vec{p})\cdot \mathbf{e}^{\mathbf{i}\tilde{\mathbf{p}}\cdot\tilde{\mathbf{x}}}\, \hat{\mathbf{b}}^{\mathbf{f}}_{\mathbf{m}}$$

$$= \sum_{m} \hat{\mathbf{b}}^{\mathbf{f}}_{\mathbf{m}}\, \alpha^{\mathbf{f}}_{\mathbf{sm}}\, (-\mathbf{i}\frac{\partial}{\partial\tilde{\mathbf{x}}})\ \delta(\tilde{\mathbf{x}})$$

$$\delta(\tilde{\mathbf{x}}) = \int_{-\infty}^{+\infty} \frac{dp^{d-1}}{(\sqrt{2\pi})^{d-1}}\, e^{i\vec{p}\cdot\vec{x}}$$

- There are $2^{\frac{d}{2}-1}$ **different "basis vectors"** $\hat{b}^{f}_{m}$ **for each of** $2^{\frac{d}{2}-1}$ **families**.
  **Together** $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ **"basis vectors", defining on the vacuum state the corresponding single particle "basis states".**

- For $p^a = (p^0, p^1, p^2, p^3, 0, 0, \cdots, 0)$, when spin in $d \geq 6$ determines charges in $d = (3+1)$ we have correspondingly

$$
\begin{aligned}
|\psi^{\mathbf{s,ch,f}}(\tilde{\mathbf{x}}, \mathbf{t}) > &= \int_{-\infty}^{+\infty} \frac{dp^{d-1}}{(\sqrt{2\pi})^{d-1}} \sum_m \alpha^{fch}_{sm}\,(\vec{p}) \cdot \mathbf{e}^{\mathbf{i}\tilde{\mathbf{p}}\cdot\tilde{\mathbf{x}}}\, \hat{\mathbf{b}}^{\mathbf{fch}}_{\mathbf{m}} \\
&= \sum_m \hat{\mathbf{b}}^{\mathbf{fch}}_{\mathbf{m}}\, \alpha^{\mathbf{fch}}_{\mathbf{sm}}\,(-\mathbf{i}\frac{\partial}{\partial\tilde{\mathbf{x}}})\ \delta(\tilde{\mathbf{x}}) \\
\delta(\tilde{\mathbf{x}}) &= \int_{-\infty}^{+\infty} \frac{dp^{d-1}}{(\sqrt{2\pi})^{d-1}}\, e^{i\vec{p}\cdot\vec{x}}
\end{aligned}
$$

- We can have for each momentum $\tilde{\mathbf{p}}$ a tensor products of two single particle states, of three single particle states, up to $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ single particle states (if there is no break of symmetry).
- A tensor product of $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ single particle states of all possible ($\infty$ many) momenta $\vec{p}$, $|p^0| = |\vec{p}|$, form the Hilbert space of all possible Slater determinants with no state occupied, with one state — any one — occupied and all the rest unoccupied, with two states occupied, up to all the $2^{\frac{d}{2}-1} \times 2^{\frac{d}{2}-1}$ states occupied.
- The Hilbert space $\mathcal{H}_{\tilde{\mathbf{p}}}$ of a particular momentum $\tilde{\mathbf{p}}$ consists correspondingly of $2^{2^{d-2}}$ "Slater determinants", since the "Slater determinant" can have no occupied state, one occupied state, two occupied states, up to $2^{d-2}$ occupied states, respectively.

- **The total Hilbert space $\mathcal{H}$ is the infinite product ($\otimes_{\mathbf{N}}$)** of $\mathcal{H}_{\tilde{\mathbf{p}}}$:
  $\mathcal{H} = \prod_{\tilde{\mathbf{p}}}^{\infty} \otimes_{\mathbf{N}} \mathcal{H}_{\tilde{\mathbf{p}}}$,
  **where the product ($\otimes_{\mathbf{N}}$) is to point out that Clifford odd objects $\hat{\mathbf{b}}^{\mathbf{f}\dagger}_{\mathbf{m}}$** and $\hat{\mathbf{b}}^{\mathbf{f}\dagger}_{\mathbf{m}'}$ **keep to anticommute in superposition** $\hat{\mathbf{b}}^{\mathbf{sf}\dagger}_{\mathbf{tot}}(\tilde{\mathbf{p}})$ and $\hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'}_{\mathbf{tot}}(\tilde{\mathbf{p}}')$

$$\hat{\mathbf{b}}^{\mathbf{sf}\dagger}_{\mathbf{tot}}(\tilde{\mathbf{p}}) *_T \hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'}_{\mathbf{tot}}(\tilde{\mathbf{p}}') = - \hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'}_{\mathbf{tot}}(\tilde{\mathbf{p}}') *_T \hat{\mathbf{b}}^{\mathbf{sf}\dagger}_{\mathbf{tot}}(\tilde{\mathbf{p}}) , \quad \vec{p} \neq \vec{p}' ,$$

  **where both represent either solutions or the Hermitian conjugated solutions of equation of motion for different** $\tilde{\mathbf{p}}$, $\vec{p} \neq \vec{p}'$ **and** $\mathbf{p}^0 = |\tilde{\mathbf{p}}|$ **in both cases.**
- **for $\vec{p} = \vec{p}'$ it follows**

$$\{\hat{\mathbf{b}}^{\mathbf{sf}\dagger}_{\mathbf{tot}}(\tilde{\mathbf{p}}) , \hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'}_{\mathbf{tot}}(\tilde{\mathbf{p}}')\}_{*_{\mathbf{A}}+} |\psi_o> = \delta^{\mathbf{ff}'} \delta^{\mathbf{ss}'} \delta(\tilde{\mathbf{p}} - \tilde{\mathbf{p}}') |\psi_o> .$$

- **Correspondingly the Clifford odd creation and annihilation operators fulfill the anticommutation relations**

$$\begin{aligned}
\{\hat{\mathbf{b}}^{\mathbf{sf}\dagger}{}_{\mathbf{tot}}(\tilde{\mathbf{p}}), \hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'\dagger}{}_{\mathbf{tot}}(\tilde{\mathbf{p}}\,')\}_{*_{\mathbf{T}}+}\,\mathcal{H} &= \mathbf{0}\,,\\
\{\hat{\mathbf{b}}^{\mathbf{sf}}{}_{\mathbf{tot}}(\tilde{\mathbf{p}}), \hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'}{}_{\mathbf{tot}}(\tilde{\mathbf{p}}\,')\}_{*_{\mathbf{T}}+}\,\mathcal{H} &= \mathbf{0}\,,\\
\{\hat{\mathbf{b}}^{\mathbf{sf}}{}_{\mathbf{tot}}(\tilde{\mathbf{p}}), \hat{\mathbf{b}}^{\mathbf{s}'\mathbf{f}'\dagger}{}_{\mathbf{tot}}(\tilde{\mathbf{p}}\,')\}_{*_{\mathbf{T}}+}\,\mathcal{H} &= \delta^{\mathbf{ss}'}\delta^{\mathbf{ff}'}\delta(\vec{p}-\vec{p'})\,\mathcal{H}\,,
\end{aligned}$$

**for any $\vec{p}$ and any $\vec{p'}$.**

- We can represent $\mathcal{H}_{\tilde{\mathbf{p}}}$ as follows

$$\begin{aligned}
&|0_{1p}, 0_{2p}, 0_{3p}, \dots, 0_{2^{d-2}p} > |_1 \quad ,\\
&|1_{1p}, 0_{2p}, 0_{3p}, \dots, 0_{2^{d-2}p} > |_2 \quad ,\\
&|0_{1p}, 1_{2p}, 0_{3p}, \dots, 0_{2^{d-2}p} > |_3 \quad ,\\
&|0_{1p}, 0_{2p}, 1_{3p}, \dots, 0_{2^{d-2}p} > |_4 \quad ,\\
&\vdots\\
&|1_{1p}, 1_{2p}, 0_{3p}, \dots, 0_{2^{d-2}p} > |_{2^{d-2}+2} \quad ,\\
&\vdots
\end{aligned}$$

**To define the whole Hilbert space $\mathcal{H}$ these Slater determinants must be repeated for $\infty$ number of $\tilde{\mathbf{p}}$.**

Let us compare the above second quantization procedure, describing internal space of fermions with the odd Clifford algebra objects, with the second quantization procedure proposed by Dirac, where he creation operators and correspondingly their Hermitian conjugate operators are assumed.

$$\psi_{\mathbf{i}}(\mathbf{t}, \tilde{\mathbf{x}}) = \sum_{\mathbf{p},\mathbf{i}} \hat{\mathbf{a}}^{\dagger}_{\mathbf{i}}(\mathbf{p})\, \mathbf{v}(\tilde{\mathbf{p}}, \mathbf{i})\, \mathbf{e}^{-\mathbf{p}_{\mathbf{a}}\mathbf{x}^{\mathbf{a}}}).$$

$v(\vec{p}, i)$ determine solutions of equations of motion for a particular $\mathbf{e}^{-\mathbf{p}_{\mathbf{a}}\mathbf{x}^{\mathbf{a}}}$.

Creation operators $\hat{\mathbf{a}}^{\dagger}_{\mathbf{i}}(\mathbf{p})$ are in the Dirac case assumed, together with the (assumed) Hermitian conjugate operator, to fill the anticommutation relation.

In the spin-charge-family theory the creation operators appear by themselves from the odd Clifford objects, representing — applied on the vacuum state $|\psi_o>$ — fermion states.

- The **anticommutation relations for creation operators and their Hermitian conjugated partners in the Dirac case** in $d = (3+1)$ **for spin** $(\uparrow, \downarrow)$ and **right and left handedness** $(\pm\mathbf{1}$, respectively)

$$\begin{aligned}\{\hat{\mathbf{a}}^{\dagger}_{i}(\vec{p}_k), \hat{\mathbf{a}}^{\dagger}_{j}(\vec{p}_l)\}_{*_T+} &= 0 = \{\hat{\mathbf{a}}_{i}(\vec{p}_k), \hat{\mathbf{a}}_{j}(\vec{p}_l)\}_{*_T+}\,,\\ \{\hat{\mathbf{a}}_{i}(\vec{p}_k), \hat{\mathbf{a}}^{\dagger}_{j}(\vec{p}_l)\}_{*_T+} &= \delta_{ij}\delta_{\vec{p}_k\vec{p}_l}\,,\end{aligned}$$

in the case of massless fermions and discretized momenta for a fermion in a box.

- To be able to compare the spin-charge-family theory creation operators for this particular case of $d = (3+1)$, we make a choice of the creation operators representing

spin $\uparrow$ and right handedness, $\hat{b}^{\dagger}_1 := \stackrel{03}{[+i]}\stackrel{12}{(+)}$,

and spin $\downarrow$ and right handedness, $\hat{b}^{\dagger}_2 := \stackrel{03}{(-i)}\stackrel{12}{[-]}$,

and we not pay attention on charges (which in spin-charge-family theory originate in $d \geq 6$) and families. This is in Dirac quantization introduced by corresponding groups.

- In the spin-charge-family case the creation operators $\hat{b}^{\dagger}_{i}, i = (1,2)$ originate in "basis vectors" determining the internal degrees of freedom in the internal space of fermions.
- Solutions of the Weyl equation – the Dirac equation for massless fermions – are superposition of both "basis vectors" for particular $\vec{p}$, $|p^0| = |\vec{p}|$
$\hat{\mathbf{b}}^{s\dagger}_{tot}(\vec{p}) = \alpha^s\,(\vec{p})\;\hat{b}^{\dagger}_{1} + \beta^{s\;s}\,(\vec{p})\;\hat{b}^{\dagger}_{2}$.
- Let us introduce the corresponding creation operators also for the Dirac case on the same stage already, that is on the stage of "basi vectors".
We define for the Dirac case two new creation operators. $a^{\dagger}_{i}$ and $\hat{\mathbf{a}}^{\dagger}_{i}$, $(i = (1,2)$ representing spin $(\uparrow, \downarrow)$, respectively) as follows

$$\hat{b}^{\dagger}_{1} := \overset{03}{[+i]}\overset{12}{(+)} \quad \text{to be related to} \quad \hat{\mathbf{a}}^{\dagger}_{1} := \begin{pmatrix} 1 \\ 0 \end{pmatrix} \cdot a^{\dagger}_{1}\,,$$

$$\hat{b}^{\dagger}_{2} := \overset{03}{(-i)}\overset{12}{[-]} \quad \text{to be related to} \quad \hat{\mathbf{a}}^{\dagger}_{2} := \begin{pmatrix} 0 \\ 1 \end{pmatrix} \cdot a^{\dagger}_{2}\,,$$

- The Hermitian conjugated partners are correspondingly

$$\hat{b}_1 := -\stackrel{03}{[+i]}\stackrel{12}{(-)} \quad \text{to be related to} \quad \hat{\mathbf{a}}_1 := (1\,0)\cdot a_1\,,$$

$$\hat{b}_2 := \stackrel{03}{(+i)}\stackrel{12}{[-]} \quad \text{to be related to} \quad \hat{\mathbf{a}}_2 := (0\,1)\cdot a_2\,,$$

- Let us define the superposition of both creation operators $\hat{\mathbf{a}}^{\dagger}_i$, $i = (1,2)$, **which do not depend on momentum** $p^a$,

$\hat{\mathbf{a}}^{s\dagger}_{tot}(\vec{p}_k) := \alpha^s_1(\vec{p}_k)\,\hat{\mathbf{a}}^{\dagger}_1 + \alpha^s_2(\vec{p}_k)\,\hat{\mathbf{a}}^{\dagger}_2 = \sum_i \hat{\mathbf{a}}^{\dagger}_i(\vec{p}_k) v^s_i(\vec{p}_k)$

with coefficients $\alpha^s_i(\vec{p}_k)$, $i = (1,2)$,
chosen so that the superposition solves the equation of motion for a "plane wave" $e^{-i(p^0 x^0 - \vec{p}_k\cdot\vec{x})}$, where $|\vec{p_k}| = |p^0|$, determine

$\sum_i \hat{\mathbf{a}}^{\dagger}_i(\vec{p}_k) v^s_i(\vec{p}_k)$ in the Dirac case.

- $\psi^s(\vec{x},t) = \int_{-\infty}^{+\infty} d^3p \; \hat{\mathbf{b}}^{s\dagger}_{\mathbf{tot}}\,(\tilde{\mathbf{p}})\, e^{-i(p^0 x^0 - \vec{p}_k\cdot\vec{x})}$

  **to be related to**

  $$\psi^s(\vec{x},t) = \int_{-\infty}^{+\infty} d^3p \; \hat{\mathbf{a}}^{s\dagger}_{\mathbf{tot}}\,(\tilde{\mathbf{p}})\, e^{-i(p^0 x^0 - \vec{p}_k\cdot\vec{x})}.$$

**The odd Clifford algebra offers the explanation for the Dirac's postulates for the second quantized fermions. It explains:**

- **The appearance of the finite number of the internal degrees of freedom of fermions.**
- **The anticommutation relations among the creation and annihilation operators, creating the single fermion states.**
- **The infinite degrees of freedom of creation operators due to infinite dimensional ordinary space.**
- **The tensor products of Clifford odd creation operators explains the Hilbert space of the second quantized fermions.**

- **It is worthwhile to notice that "nature could make a choice" of Grassmann rather than Clifford space:**
  **o Also in Grassmann space, namely, one finds the anticommutation relations needed for a fermion field.**
  **o But in this case spinors would have spins and charges in adjoint representations** with respect to particular subgroups.
  **o And no families would appear.**

**Vector gauge fields origin in gravity**,
**in vielbeins and two kinds of the spin connection fields**,
**the gauge fields of $S^{ab}$ and $\tilde{S}^{ab}$**

**

- **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** $(\tau^{Ai})$ 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**

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

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

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*

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

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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.**

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

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

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

- **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 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**.

- **The scalar condensate of two right handed neutrinos couple to**
  **o all the scalar and vector gauge fields, making 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.

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:

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

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

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

The **mass term**, appearing in the **starting action**, is ($p_s$, 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 $\tau^{13}$, 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"** $u_R, \nu_R$ 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** measures:

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 $\nu_R$ (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 $\tilde{\tau}^{23} = 0$, $\tilde{N}_R^3 = 0$, the second four families have $\tilde{\tau}^{13} = 0$, $\tilde{N}_L^3 = 0$.

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

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

- Scalars with the weak and the hyper charge $(\mp\frac{1}{2}, \pm\frac{1}{2})$ determine masses of **all** the **family members** $\alpha$ of the **lower four families**, $\nu_R$ **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.....$new_2$

$|V_{(ud)}| =$

| | | | | |
|---|---|---|---|---|
| $exp_n$ | $0.97425 \pm 0.00022$ | $0.2253 \pm 0.0008$ | $0.00413 \pm 0.00049$ | |
| $new_1$ | 0.97423(4) | 0.22539(7) | 0.00299 | **0.00776(1)** |
| $new_2$ | 0.97423[5] | 0.22538[42] | 0.00299 | **0.00793[466]** |
| $exp_n$ | $0.225 \pm 0.008$ | $0.986 \pm 0.016$ | $0.0411 \pm 0.0013$ | |
| $new_1$ | 0.22534(3) | 0.97335 | 0.04245(6) | **0.00349(60)** |
| $new_2$ | 0.22531[5] | 0.97336[5] | 0.04248 | **0.00002[216]** |
| $exp_n$ | $0.0084 \pm 0.0006$ | $0.0400 \pm 0.0027$ | $1.021 \pm 0.032$ | |
| $new_1$ | 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.**

- **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** $\nu_R$ **of the upper four families.**

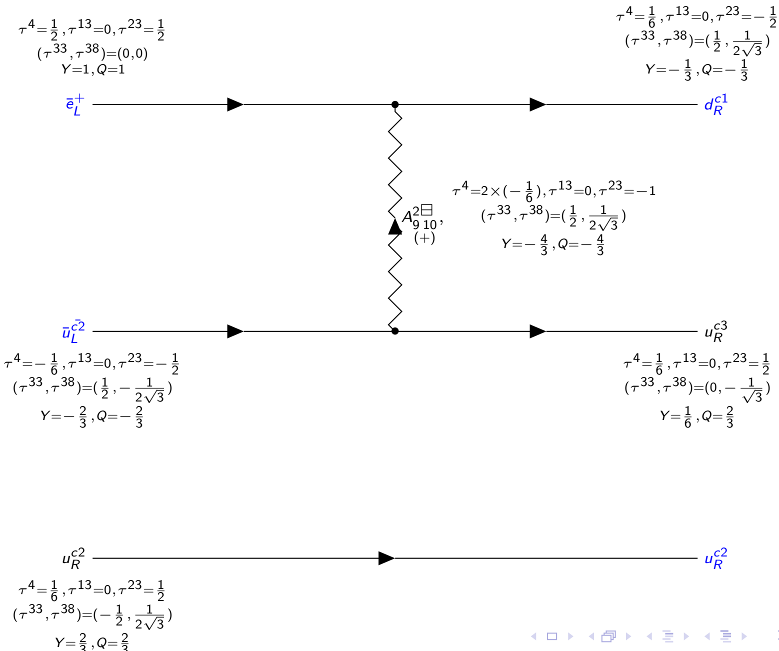
# Matter-antimatter asymmetry

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

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

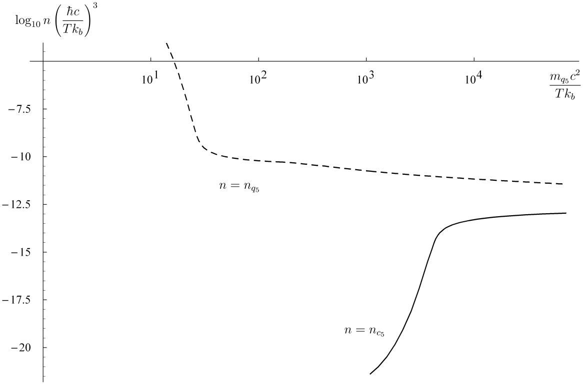



Figure: The dependence of the two number densities $n_{q_5}$ (of the fifth family quarks) and $n_{c_5}$ (of the fifth family clusters) as the function of $\frac{m_{q_5} c^2}{T k_b}$ is presented for the values $m_{q_5} c^2 = 71$ TeV, $\eta_{c_5} = \frac{1}{50}$ and $\eta_{(q\bar{q})_b} = 1$. We take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

**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,..- ...**

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

- **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** $3 \times 3$ **submatrix elements of the** $4 \times 4$ **mixing matrix than the previous ones**.
- Our **fit to the last data predicts how will** the $3 \times 3$ **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**.

**To summarize:**

- I hope that I managed to convince you that I can answer many open questions of particle physics and cosmology.
- The collaborators are very welcome!
- There are namely a lot of properties to derive.