# Round Table Discussions
# Next step beyond the *standard model* is to understand the origin of families.
# The *Spin-Charge-Family-Theory* is offering the mechanism for generating families

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The **Standard Model** was designed more than 35 years ago **offering an elegant next step in understanding the origin of fermions and bosons**.
**There are many open questions which the *Standard Model* leaves unanswered.**

**The most urgent to be answered if we want to understand the standard model assumptions and advise experimentalists what to measure are:**

- **What is the origin of families and their masses?**
  How many families there are at all?
- What is the **origin of the scalar fields (Higgs)?**
  Where do their masses (Higgs mass) and correspondingly the masses of the gauge fields originate?
- Where does the **dark matter** originate?

**There are also several other questions which need urgent answers:**

- What is the **origin of charges**, and correspondingly of **gauge fields**?
- Where does the **dark energy** originate?
- What is the dimension of the space? $(1+3)$?, $(1+(d-1))$? What is $d$? Why is the metric of space-time Minkowskian?
- How can all gauge fields, including gravity, be unified and consistently quantized?
- What is the role of the **symmetries**– discrete, continues, global and gauge – in Nature?
- What is the origin of **fermion-antifermion asymmetry**?
- What is the origin of fields which caused inflation? Can we formulate them in an unique way with all the fermionic and bosonic fields?
- How do **phase transitions** determine properties of fermions

It was the essential recognition of the **Standard Model** that

- there are **colour**, **weak and hyper charges**
- there are the **family members** (although one of them, right handed neutrino was been left out),
- there is **besides gauge fields connected with the charges** also the **scalar field with his nonzero vacuum expectation values**.

In the literature there are a lot of papers, advising experimentalists what should they measure and how should they do that to see the Higgs.
There are also a lot of papers, advising experimentalists how to observe the next step beyond the standard model.
There are a lot of papers of experimentalists explaining what they have succeeded to measure so far.

- **No signal** of the **Higgs** **up to several hundreds GeV, with small windows open up to this energy has been observed**.
- **No supersymmetric partners** up to the observed energies.
- **No new fermions** **up to this energy**.

**It is a negligible probability that any new physics can be predicted without knowing**

- **the mechanism responsible for the existence** of the **families**,
- **what the standard model effective Higgs is**,
- **what is the origin of the Yukawa couplings**,
- **how is the appearance of the scalar fields connected with the mass matrices of fermions**.

The **Spin-Charge-Family-Theory which I am proposing is offering the explanation for the existence of families, family members** and **for the appearance of mass matrices. It explains the existence of the scalar fields, their contribution to the mass matrices and to the masses of the gauge bosons**.

The **Higgs is an effective object, to which in this theory several scalar fields contribute**.

- **It predicts the fourth family to be possibly seen at the LHC.**
- **It predicts additional four families, the stable one of which is the candidate to form the dark matter.**
- **It predicts NO supersymmetry in the low energy regime.**

**In what does the Spin-Charge-Family-Theory differ from all the other proposals for understanding and explaining the assumption of the Standard Model?**

**The Spin-Charge-Family-Theory is not just assuming larger groups, or just assuming the one more family, or several new families.**

- **It offers the mechanism responsible for the appearance of families.**
- **It explains the origin of the mass matrices of family members.**
- **It explains the origin of the scalar fields and their manifestation as the effective Higgs.**
- **It explains the appearance of the charges**
- **unifying all the charges and all the gauge fields.**

## How is the Spin-Charge-Family-Theory offering a new way beyond the Standard Model?

- **Families and family members with the observed properties at the low energy regime appear in the Spin-Charge-Family-Theory due to the fact that spinors carry** (only) **two kinds of spin. (They carry no charges)**. The **Dirac spin takes care in** $d = 1 + 3$ **of the spin and the charges** of quarks and leptons, the **second kind of spin generates families**.
- **There is only gravity (vielbeins and gauge gravity fields connected with the two kinds of the spin) in a simple action in** $d = (1 + 13)$**. The action manifests** in $d = (1 + 3)$, after appropriate breaks of the starting symmetry, the **standard model action for fermions and gauge fields, with the scalar fields included**.

There are **two kinds of the Clifford algebra objects**:

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

$$\begin{aligned} \{\gamma^{\mathbf{a}}, \gamma^{\mathbf{b}}\}_+ &= \mathbf{2}\eta^{\mathbf{ab}} = \{\tilde{\gamma}^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_+, \\ \{\gamma^{\mathbf{a}}, \tilde{\gamma}^{\mathbf{b}}\}_+ &= 0, \end{aligned} \tag{1}$$

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

The **cross section** for the **fifth family neutrons** $\pi(r_{c_5})^2$:

$$\mathbf{10^{-8}}\mathrm{fm}^{\mathbf{2}} < \sigma_{\mathbf{c_5}} < \mathbf{10^{-6}}\mathrm{fm}^{\mathbf{2}}. \qquad (3)$$

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

- Our Sun's velocity: $v_S \approx (170 - 270)$ **km/s.**
- **Locally dark matter density $\rho_{dm}$ is known within a factor of 10** accurately:
  $\rho_{dm} = \rho_0 \, \varepsilon_\rho, \rho_0 = 0.3 GeV/(c^2 \, cm^3)$,
  we put $\frac{1}{3} < \varepsilon_\rho < 3$.
- The **local velocity of the dark matter clusters $\vec{v}_{dm}$ is unknown**, the estimations are **very model dependant**.
- The velocity of the Earth around the center of the galaxy is equal to: $\vec{v}_E = \vec{v}_S + \vec{v}_{ES}$,
  $v_{ES} = 30$ km/s,
  $\frac{\vec{v}_S \cdot \vec{v}_{ES}}{v_S \, v_{es}} \approx \cos\theta \sin\omega t, \theta = 60^0$.

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

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

- **We assume** $\sum_i \left|\vec{v_{dmi}} - \vec{v_S}\right| \rho_{dmi} = \varepsilon_{v_{dmS}} \varepsilon_\rho \, v_S \, \rho_0$, and correspondingly
- $\sum_i \vec{v}_{ES} \cdot \frac{\vec{v}_{dmi} - \vec{v}_S}{\left|\vec{v}_{dmi} - \vec{v}_S\right|} = v_{ES} \varepsilon_{v_{dmES}} \cos\theta \, \sin\omega t$, with $\omega$ for our Earth rotation around our Sun.
- We evaluate $\frac{1}{3} < \varepsilon_{v_{dmS}} < 3$ **and** $\frac{1}{3} < \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} < 3$.

**The cross section** for our heavy dark matter baryon $n_5$ to **elastically** scatter on an **ordinary nucleus** with $A$ nucleons in the Born approximation:

$\sigma_{c_5 A} = \frac{1}{\pi \hbar^2} < |M_{c_5 A}| >^2 \; m_A^2$,

$m_A \approx= m_{n_1} A^2 \cdots$ the mass of the ordinary nucleus,

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

- $\sigma_0 = 9 \, \pi r_{c_5}^2 \, \varepsilon_{\sigma_{nucl}}, \quad \frac{1}{30} < \varepsilon_{\sigma_{nucl}} < 30$, when the **"nuclear force"** dominates,
- $\sigma_0 = \frac{m_{n_1} G_F}{\sqrt{2\pi}} (\frac{A-Z}{A})^2 \varepsilon_{\sigma_{weak}}$ $(= (10^{-6} fm \frac{A-Z}{A})^2 \, \varepsilon_{\sigma_{weak}})$, $\varepsilon_{\sigma_{weak}} \approx 1$, when the **weak force** dominates ($m_{q_5} > 10^4$ TeV).
- The scattering cross section **among** our heavy neutral baryons $n_5$ is determined by the weak interaction: $\sigma_{c_5} \approx (10^{-6} \, \mathrm{fm})^2 \frac{m_{c_5}}{\mathrm{GeV}}$.

- Let us assume that the DAMA/NaI, CDMS, XENON100 and CoGeNT measure our heavy dark matter clusters.
- **We look for limitations these experiments might put on properties of our heavy family members.**
- Let an experiment has $N_A$ nuclei per kg with $A$ nucleons.
- At $v_{dmE} \approx 200$ km/s are the $3A$ scatters strongly bound in the nucleus, so that the whole nucleus with $A$ nucleons elastically scatters on a heavy dark matter cluster.
- The number of events per second ($R_A$) taking place in $N_A$ nuclei is equal to (the cross section is at these energies almost independent of the velocity) what follows

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

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

$\varepsilon = \varepsilon_\rho\,\varepsilon_{\mathbf{v_{dmES}}}\,\varepsilon_\sigma,$
$\mathbf{10^{-4}} < \varepsilon < \mathbf{10^{2}}$, for the "nuclear-like force" dominating
$\mathbf{10^{-2}} < \varepsilon < \mathbf{10^{1}}$, for the weak force dominating

Let $\varepsilon_{\mathbf{cut\,A}}$ determine the efficiency of a particular experiment to detect a dark matter cluster collision, then

$$\mathbf{R_{A\,exp}} \approx \mathbf{N_A}\,\mathbf{R_0}\,\mathbf{A^4}\,\varepsilon_{\mathbf{cut\,A}} = \mathbf{\Delta R_A}\varepsilon_{\mathbf{cut\,A}}\,\frac{\varepsilon_{\mathbf{v_{dmS}}}}{\varepsilon_{\mathbf{v_{dmES}}}}\,\frac{\mathbf{v_S}}{\mathbf{v_{ES}}\,\cos\theta}.$$

If DAMA/NaI is measuring our heavy family baryons (scattering mostly on $I$, $A_I = 127$, we neglect $Na$, with $A = 23$)

$$R_{I\,dama} \approx \Delta R_{dama} \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} \frac{v_S}{v_{SE}\ \cos 60^0},$$

most of unknowns are hidden in $\Delta R_{dama}$.

For Sun's velocities $v_S = 100, 170, 220, 270$ km/s we find $\frac{v_S}{v_{SE}\cos\theta} = 7, 10, 14, 18$ respectively.

DAMA/LIBRA (NaI) publishes $\Delta R_{I\,dama} = 0,052$ **counts per day and per kg of NaI.**

Then $R_{I\,dama} = 0,052 \frac{\varepsilon_{v_{dmS}}}{\varepsilon_{v_{dmES}}} \frac{v_S}{v_{SE}\cos\theta}$ counts per day and per kg.

**CDMS, XENON100, CoGeNT should then already measure our dark matter clustres.**

The experimets – XENON100, CoGeNT – seems to be close to measure something, but far from confirming annual modulation or even the DAMA/LIBRA experiment.

$\varepsilon$ might even be smaller (we are making now more precize evaluations), $\varepsilon = 10^{-4}$. Then CDMS, XENON100, CoGeNT experiments are still in agreement with the predictions that $n_5$ are at least the important part of the dark matter, but in this case our predictions would not explain the DAMA/LIBRA (NaI) experiment. Except if our fifth family quarks are lighter, around $10\,TeV$ or slightly lighter, as Maxim Yu. Khlopov assumed in his scenario.

Comparison of the CDMS and DAMA/LIBRA experiment

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

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

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

XENON100 should see 10 times more.