How to present and interpret the Feynman diagrams in the theory describing fermion and boson fields in a unique way, in comparison with the Feynman diagrams so far presented and interpreted? :

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Although it looks like that we know almost everything about our Universe, due to the fact that the theories and models are to high extend supported, at least for very many observed properties in experiments and the cosmological observations,

it is also true that we do not know why and how the universe has started,

what caused the exponential grow of the size of the universe,

what is happening in the black holes,

we namely do not know how to treat the second quantized gravity, even if we almost are willing to accept that we know to treat fermions and their gauge fields.

- The Spin-Charge-Family theory,

  assuming the description of the internal spaces of fermions and bosons with the “basis vectors”, which are superposition of products of

  odd number of γ^a for fermions and

  even number of γ^a for bosons,

  offers an unique description of “basis vectors” of boson and fermion second quantized fields;

  Inspite of the differences from either the Dirac second quantization procedure, as well as from the Quantum Field Theory, the new one offers the explanation for all the observed fermions and bosons, without postulating the second quantization requirements, and does offer new predictions.

- **We shall point out the differences among all three ways of presenting internal spaces, leading to differences in all three ways of the quantum field theories.**

  This new one offers the same number of fermion and boson "basis vectors" defining the second quantized fields.

  If the internal space of fermion and boson second quantised fields, involved in creating our universe, has $d \geq (13+1)$

  and **the ordinary space is active in** $d = (3+1)$ **and no symmetry is broken**, **then both "basis vectors" have the same number of elements**.

- **Making a choice that all “basis vectors” are eigenvectors of the chosen Cartan subalgebra members**, and **arrange the “basis vectors” to be products** of **nilpotents and projectors then “basis vectors” of fermions have an odd number of nilpotents** , and **“basis vectors” of bosons have an even number of nilpotents** .
- **These description is elegant and simple to use.**
- **Analysing the “basis vectors” with respect to the symmetry they manifest in $d = (3+1)$, all the second quantized fermion fields observed in $d = (3+1)$, and all the second quantized boson fields observed in $d = (3+1)$, with the second quantized graviton fields included, can be described in an equivalent way.**

- There are the $2^{\frac{d}{2}-1}$ Clifford odd "basis vectors" appearing in $2^{\frac{d}{2}-1}$ families and the same number of their Hermitian conjugated partners, $2^{\frac{d}{2}-1}\times 2^{\frac{d}{2}-1}$, with the properties

$$\begin{aligned}\hat{\mathbf{b}}^{\mathbf{m}\dagger}_{\mathbf{f}} *_{\mathbf{A}} \hat{\mathbf{b}}^{\mathbf{m}`\dagger}_{\mathbf{f}`} &= 0\,, \quad \hat{\mathbf{b}}^{\mathbf{m}}_{\mathbf{f}} *_{\mathbf{A}} \hat{\mathbf{b}}^{\mathbf{m}`}_{\mathbf{f}`} = 0\,, \quad \hat{\mathbf{b}}^{\mathbf{m}}_{\mathbf{f}} *_{\mathbf{A}} \hat{\mathbf{b}}^{\mathbf{m}`\dagger}_{\mathbf{f}`} = \delta^{mm'}\delta_{ff`}\,, \\ \forall m, m', & \qquad f, f`\,.\end{aligned}$$

- There are $2^{\frac{d}{2}-1}\times 2^{\frac{d}{2}-1}$ Clifford even "basis vectors", ${}^{i}\hat{\mathcal{A}}^{m\dagger}_{f}$, i=I,II, appearing in two orthogonal groups, ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$, ${}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}$, with the properties

$$ {}^{\mathbf{I}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}} *_{\mathbf{A}} {}^{\mathbf{II}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}} = 0 = {}^{\mathbf{II}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}{}_{\cdot\mathbf{f}} *_{\mathbf{A}} {}^{\mathbf{I}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}}\,.$$

- The algebraic multiplication $*_A$ means

$$\begin{aligned}\overset{ab}{(\mathbf{k})}\overset{ab}{(-\mathbf{k})} &= \eta^{aa}\overset{ab}{[\mathbf{k}]}\,, \overset{ab}{[\mathbf{k}]}\overset{ab}{(\mathbf{k})} = \overset{ab}{(\mathbf{k})}\,, \overset{ab}{(\mathbf{k})}\overset{ab}{[-\mathbf{k}]} = \overset{ab}{(\mathbf{k})}\,, ** \\ \overset{ab}{(\mathbf{k})}\overset{ab}{[\mathbf{k}]} &= \mathbf{0}\,, \overset{ab}{[\mathbf{k}]}\overset{ab}{(-\mathbf{k})} = \mathbf{0}\,, \overset{ab}{[\mathbf{k}]}\overset{ab}{[-\mathbf{k}]} = \mathbf{0}\,, **\end{aligned}$$

Let us present general properties of fermion and boson fields' "basis vectors" in the suggested theory:

- The algebraic products, $*_A$, of two members of each of these two groups, ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$ and ${}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}$ have the property

$$ {}^{i}\hat{\mathcal{A}}^{m\dagger}_{f} \;*_A\; {}^{i}\hat{\mathcal{A}}^{m'\dagger}_{f`} \rightarrow \left\{ \begin{array}{r} {}^{i}\hat{\mathcal{A}}^{m\dagger}_{f`}\,, i=(I,II) \\ \text{or zero}\,. \end{array} \right. $$

- *The algebraic application, $*_A$, of the even "basis vectors" ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$ on the odd "basis vectors" $\hat{b}^{m'\dagger}_{f`}$*, we call this left multiplication, gives

$$ {}^{I}\hat{\mathcal{A}}^{m\dagger}_{f} \;*_A\; \hat{b}^{m'\dagger}_{f`} \rightarrow \left\{ \begin{array}{r} \hat{b}^{m\dagger}_{f`}\,, \\ \text{or zero}\,. \end{array} \right. $$

- *We find for the second group of boson fields, ${}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}$*,

$$ \hat{b}^{m\dagger}_{f} *_A {}^{II}\hat{\mathcal{A}}^{m'\dagger}_{f`} \rightarrow \left\{ \begin{array}{r} \hat{b}^{m\dagger}_{f``}\,, \\ \text{or zero}\,, \end{array} \right. $$

- The internal spaces of boson second-quantized fields can be written as the algebraic products of the odd "basis vectors" and their Hermitian conjugate partners:

$$
\begin{aligned}
{}^{I}\hat{\mathcal{A}}^{m\dagger}_{f} &= \hat{b}^{m'\dagger}_{f`} *_A (\hat{b}^{m''\dagger}_{f`})^\dagger \,, \\
{}^{II}\hat{\mathcal{A}}^{m\dagger}_{f} &= (\hat{b}^{m'\dagger}_{f`})^\dagger *_A \hat{b}^{m'\dagger}_{f`'} \,.
\end{aligned}
$$

Family members $\hat{b}^{m'\dagger}_{f`}$ of any family $f'$ generate in the algebraic product $\hat{b}^{m'\dagger}_{f`} *_A (\hat{b}^{m''\dagger}_{f`})^\dagger$ the same $2^{\frac{d}{2}-1}\times 2^{\frac{d}{2}-1}$ even "basis vectors" ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$.
Each family member m' generates in $(\hat{b}^{m'\dagger}_{f`})^\dagger *_A \hat{b}^{m'\dagger}_{f`'}$ the same $2^{\frac{d}{2}-1}\times 2^{\frac{d}{2}-1}$ even "basis vectors" ${}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}$.

- **Clifford even "basis vectors"**, having an even number of nilpotents, describe the internal space of **boson** fields. The **gluon** field, for example, ${}^{I}\hat{\mathcal{A}}^{\dagger}_{gl\; u_R^{c1}\to u_R^{c2}}$, which transforms the u_R^{c1} $(\tau^3=\frac{1}{2},\tau^8=\frac{1}{2\sqrt{3}})$ into u_R^{c2} $(\tau^3=-\frac{1}{2},\tau^8=\frac{1}{2\sqrt{3}})$ looks like: ${}^{I}\hat{\mathcal{A}}^{\dagger}_{gl\; u_R^{c1}\to u_R^{c2}}$
  $(\equiv \overset{03}{[+i]}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{[+]}\overset{9\,10}{(-)}\overset{11\,12}{(+)}\overset{13\,14}{[-]})$.
  If it algebraically multiplies on u_R^{c1}
  $(\equiv \overset{03}{(+i)}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{(+)}\overset{9\,10}{(+)}\overset{11\,12}{[-]}\overset{13\,14}{[-]})$ it follows

$$
{}^{I}\hat{\mathcal{A}}^{\dagger}_{gl\; u_R^{c1}\to u_R^{c2}}(\equiv \overset{03}{[+i]}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{[+]}\overset{9\,10}{(-)}\overset{11\,12}{(+)}\overset{13\,14}{[-]}) *_A
$$

$$
u_R^{c1\dagger}, (\equiv \overset{03}{(+i)}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{(+)}\overset{9\,10}{(+)}\overset{11\,12}{[-]}\overset{13\,14}{[-]}) \rightarrow
$$

$$
u_R^{c2\dagger}, (\equiv \overset{03}{(+i)}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{(+)}\overset{9\,10}{[-]}\overset{11\,12}{(+)}\overset{13\,14}{[-]}),
$$

$$
{}^{\mathbf{I}}\hat{\mathcal{A}}^{\dagger}_{\mathbf{gl\; u_R^{c1}\to u_R^{c2}}} = \mathbf{u_R^{c2\dagger}} *_{\mathbf{A}} (\mathbf{u_R^{c1\dagger}})^{\dagger},
$$

$$
{}^{I}\hat{\mathcal{A}}^{\dagger}_{gl\; u_R^{c2}\to u_R^{c1}}(\equiv \overset{03}{[+i]}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{[+]}\overset{9\,10}{(+)}\overset{11\,12}{(-)}\overset{13\,14}{[-]}) *_A u_R^{c2\dagger} \rightarrow u_R^{c1\dagger},
$$

$$
{}^{\mathbf{I}}\hat{\mathcal{A}}^{\dagger}_{\mathbf{gl\; u_R^{c2}\to u_R^{c1}}} = \mathbf{u_R^{c1\dagger}} *_{\mathbf{A}} (\mathbf{u_R^{c2\dagger}})^{\dagger}.
$$

- These gluons ${}^{I}\hat{\mathcal{A}}^{\dagger}_{gl\, u^{ci}_{R} \to u^{cj}_{R}} = u^{cj\dagger}_{R} *_{A} (u^{ci\dagger}_{R})^{\dagger}$ transform quarks of a particular colour charge to quarks of all the rest colour charges.
  Let us notice that they all are expressed as the algebraic product of a family member and one of the Hermitian conjugated partner.
- We can in an equivalent way express the weak boson ${}^{I}\hat{\mathcal{A}}^{\dagger}_{weak\, u^{ci}_{R} \to d^{ci}_{R}} = d^{ci\dagger}_{R} *_{A} (u^{ci\dagger}_{R})^{\dagger}$ transforming quarks of a particular weak charge to quarks of another weak charge (keeping the colour charges unchanged).

There is the second kind of the Clifford even "basis vectors", having as well an even number of nilpotents, and consequently commute, describing the internal space of boson fields; they are orthogonal to all ${}^{I}\hat{\mathcal{A}}^{\dagger m}_{f}$.

- They are called ${}^{II}\hat{\mathcal{A}}^{\dagger m}_{f}$.
  ${}^{II}\hat{\mathcal{A}}^{\dagger m}_{f}$ transform a family member of a particular family of fermions to the same family member of all the rest families of quarks and leptons and antiquarks and antileptons.
  Let $e^{-\dagger}_{L\uparrow f=1}$ be $(\equiv \stackrel{03}{[-i]}\stackrel{12}{[+]}\stackrel{56}{(-)}\stackrel{78}{(+)}\stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)})$, and $e^{-\dagger}_{L\uparrow f=2}$ be $(\equiv \stackrel{03}{(-)}\stackrel{12}{(+)}\stackrel{56}{(-)}\stackrel{78}{(+)}\stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)})$.
  It follows that ${}^{II}\hat{\mathcal{A}}^{\dagger m}_{f}$ apply fermions from the right hand side
  $e^{-\dagger}_{L\uparrow f=2}\;(\equiv \stackrel{03}{(-)}\stackrel{12}{(+)}\stackrel{56}{(-)}\stackrel{78}{(+)}\stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)}) \;*_A\; {}^{II}\hat{\mathcal{A}}^{\dagger m}_{f}$
  $(\equiv \stackrel{03}{(+)}\stackrel{12}{(-)}\stackrel{56}{[+]}\;\stackrel{78}{[-]}\stackrel{9\,10}{[-]}\stackrel{11\,12}{[-]}\;\stackrel{13\,14}{[-]}) \rightarrow e^{-\dagger}_{L\uparrow f=1}$
  $(\equiv \stackrel{03}{[-i]}\stackrel{12}{[+]}\stackrel{56}{(-)}\stackrel{78}{(+)}\stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)})$.

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

Also $^{II}\hat{\mathcal{A}}^{\dagger m}_{f}$ can be expressed as algebraic products of the Hermitian conjugate fermion fields and one of the Clifford odd "basis vector'.

- **photon** $^{II}\hat{\mathcal{A}}^{\dagger}_{phe^{-\dagger}e^{-}} = (e_L^{-\dagger})^{\dagger} *_A e_L^{-\dagger} =$
  photon $^{II}\hat{\mathcal{A}}^{\dagger}_{phe^{+\dagger}e^{+}} = (e_R^{+\dagger})^{\dagger} *_A e_R^{+\dagger}$
- **These photons are the same for all members of a family, quarks and leptons and antiquarks and antileptons.**

- The creation operators for either fermions or bosons must be defined as the tensor products, $*_T$, of both contributions, the "basis vectors" describing the internal space of fermions or bosons, and the basis in ordinary space-time in the momentum or coordinate representation.
  To the boson second quantised fields, we need to add the space index α.

$$
\begin{aligned}
&|\vec{p}>=\hat{b}^{\dagger}_{\vec{p}}\,|\,0_p\;>\,,\quad <\vec{p}\,|=<\,0_p\,|\,\hat{b}_{\vec{p}}\,,\\
&<\vec{p}\,|\,\vec{p}'>=\delta(\vec{p}-\vec{p}')=<\,0_p\,|\hat{b}_{\vec{p}}\,\hat{b}^{\dagger}_{\vec{p}'}\,|\,0_p\;>\,,\\
&<\,0_p\,|\hat{b}_{\vec{p}'}\,\hat{b}^{\dagger}_{\vec{p}}\,|\,0_p\;>=\delta(\vec{p}'-\vec{p})\,,\\
&<\vec{p}\,|\,\vec{x}>=<0_{\vec{p}}\,|\,\hat{b}_{\vec{p}}\,\hat{b}^{\dagger}_{\vec{x}}|0_{\vec{x}}\;>=(<0_{\vec{x}}\,|\,\hat{b}_{\vec{x}}\,\hat{b}^{\dagger}_{\vec{p}}\;|0_{\vec{p}}\;>)^{\dagger}\\
&<0_{\vec{p}}\,|\{\hat{b}_{\vec{p}}\,,\,\hat{b}^{\dagger}_{\vec{x}}\}_{-}|0_{\vec{x}}\;>=e^{i\vec{p}\cdot\vec{x}}\frac{1}{\sqrt{(2\pi)^{d-1}}}\,,\\
&\hat{\mathbf{b}}^{s\dagger}_{f}(\vec{x},x^0)=\sum_{m}\hat{b}^{m\dagger}_{f}\;*_T\int_{-\infty}^{+\infty}\frac{d^{d-1}p}{(\sqrt{2\pi})^{d-1}}\,c^{sm}{}_{f}\;(\vec{p})\;\hat{b}^{\dagger}_{\vec{p}}\,e^{-i(p^0x^0-\vec{p}\cdot\vec{x})}\,.\\
&{}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{fa}}(\vec{x},x^0)={}^{i}\hat{\mathcal{A}}^{m\dagger}_{f}\;*_T\int_{-\infty}^{+\infty}\frac{d^{d-1}p}{(\sqrt{2\pi})^{d-1}}\,{}^{i}\mathcal{C}^{m}{}_{fa}\,\hat{b}^{\dagger}_{\vec{p}}\,e^{-i(p^0x^0-\varepsilon\vec{p}\cdot\vec{x})}|_{p^0=|\vec{p}|}
\end{aligned}
$$

- All bosons "basis vectors", ${}^{I}\hat{\mathcal{A}}^{m\dagger}_{f}$ and ${}^{II}\hat{\mathcal{A}}^{m\dagger}_{f}$ (describing internal spaces of boson fields) are expressible as algebraic products of "basis vectors" and their Hermitian conjugated partners as $\hat{b}^{m'\dagger}_{f`} *_A (\hat{b}^{m''\dagger}_{f`'})^\dagger$ or as $(\hat{b}^{m'\dagger}_{f`})^\dagger *_A \hat{b}^{m''\dagger}_{f``}$.
- Knowing "basis vectors" of fermions appearing in families we know all the boson fields as well.

- **Let us see the so far observed differences between the Dirac second Quantized Fields of fermions and bosons, the Quantum Field Theory of fermions and bosons, and of the new proposal for the second quantized fields of fermions and bosons, in order to see whether the new proposal can offer any new insight into the quantum theory of fields.**
- The creation operators for either fermions, $\hat{\mathbf{b}}^{s\dagger}_{f}(\vec{x}, x^0)$, or bosons, ${}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{fa}}(\vec{x}, x^0)$, have already anticommuting properties – for fermions – and commuting properties for bosons, determined by the creation operators of the "basis vectors". **No postulates are needed**.
- **Families of "basis vectors" for fermions do not need to be postulated.** They do exist due to the existence of the irreducible representations.
- Interactions among fermions and bosons, among fermions (they are orthogonal) and within each of the two orthogonal kinds of bosons are determined by the corresponding "basis vectors".

- **Differences among Dirac theory, Quantum field theories and the present proposal continue.**
- Fermions and antifermions appear in the same families, they are equivalent members. No negative Dirac sea is needed. In the Quantum Field Theory instead of negative-energy fermions negative-frequency modes are suggested – antifermions have accordingly a positive energy.
- Knowing "basis vectors" of fermions, $\hat{\mathbf{b}}^{\mathbf{s}\dagger}_{\mathbf{f}}(\vec{x}, x^0)$, we can find "basis vectors" of all bosons, ${}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{fa}}(\vec{x}, x^0)$.
- Applying $\gamma^{\mathbf{a}}$ on **"basis vectors" of fermions** we generate a **"basis vectors" of bosons**: $\gamma^{\mathbf{a}} *_{\mathbf{A}} \hat{\mathbf{b}}^{\mathbf{m}\dagger}_{\mathbf{f}} \rightarrow {}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}}$.
- **There are in our proposal two kinds of boson fields**. The second kind is realized in the *standard model* with the Higgs field.
- The proposal treats **gravitons in an equivalent way as all the rest of the so far observed boson fields.** There is Lorentz covariance which must be fulfilled,which suggests this.

- General properties to point out differences between Dirac and Quantum Field Theory, and the here suggested proposal.

- Dirac and QFT use

  $\psi(x) = \int \frac{d^3p}{2Ep} \, (b_{\vec{p}} u_{\vec{p}} \, e^{-ip_a x^a} + d^{\dagger}_{\vec{p}} v_{\vec{p}} \, e^{ip_a x^a})$

  Dirac and QFT postulate the creation and annihilation anticommuting objects $b^{\dagger}_{\vec{p}}$, $b_{\vec{p}}$ and $d^{\dagger}_{\vec{p}}$, $d_{\vec{p}}$.

  Both frequency sectors are needed for Lorentz covariance and causal propagation.

- The new suggested proposal, having fermions and antifermions in the same family, while fermions and antifermions are related by $\mathbb{C}_{\mathcal{N}} \mathcal{P}^{(d-1)}_{\mathcal{N}}$, requires

  $\psi(x) = \int \frac{d^3p}{2E_p} [\hat{b}^{m\dagger}_{f} \, b^{\dagger}_{p} \, e^{-ipx} + (\mathbb{C}_{\mathcal{N}} \mathcal{P}^{(d-1)}_{\mathcal{N}} \, \hat{b}^{m\dagger}_{f} \, b^{\dagger}_{p}) \, e^{ipx}]$.

  With the discrete symmetries operator

$$\mathbb{C}_{\mathcal{N}} \mathcal{P}^{(d-1)}_{\mathcal{N}} \;=\; \gamma^0 \prod_{\Im \gamma^a, a=5,7,9,..,d} \gamma^a \, I_{\vec{x}_3} \,,$$

  with $I_{\vec{x}_3}$ applying on x^a leading to $(x^0, -x^1, -x^2, -x^3, x^5, .., x^d$

- **Two frequency sectors, following algebraically in the new proposal,** $\psi(x) = \int \frac{d^3p}{2E_p}[\hat{b}^{m\dagger}_f\, b^\dagger_p\, e^{-ipx} + (\mathbb{C}_{\mathcal{N}}\mathcal{P}^{(d-1)}_{\mathcal{N}}\,\hat{b}^{m\dagger}_f\, b^\dagger_p\, e^{-ipx})]$, as suggested by the Quantum Field Theory.

  The new proposal does not need to postulate creation and annihilation operators either for **fermions** or for bosons, the **"basis vectors" for fermions are already the creation operators and their Hermitian conjugated partners the annihilation operators.**

Like it is in the case $d = (5+1)$

$$
\begin{aligned}
&\text{fermion creation operator in d} = (5+1)\,,\\
&\text{for fermion with charge}\frac{1}{2}\text{and antifermion with charge} -\frac{1}{2}\\
p^0 &= |p^0|\\
\psi &= \beta \left(\left(\overset{03}{(+i)}\,\overset{12}{[+]}\,|\,\overset{56}{[+]} + \frac{p^1 + ip^2}{p^0 + p^3}\,\overset{03}{[-i]}\,\overset{12}{(-)}\,|\,\overset{56}{[+]} \right) \right) \cdot\\
& e^{-i(p^0 x^0 - \vec{p}\cdot\vec{x})}\,,\\
& -\beta \left(\left(\overset{03}{[-i]}\,\overset{12}{[+]}\,|\,\overset{56}{(-)} + \frac{p^1 + ip^2}{p^0 + p^3}\,\overset{03}{(+i)}\,\overset{12}{(-)}\,|\,\overset{56}{(-)} \right) \right) \cdot\\
& e^{-i(p^0 x^0 + \vec{p}\cdot\vec{x})}\,,
\end{aligned}
$$

The above superposition represents the contribution of any member of a family f and the contribution of the part obtained by the operator $(\mathbb{C}_{\mathcal{N}}\mathcal{P}^{(d-1)}$ on this member in the case $d = (5+1)$.

- The proposed fermion fields are Lorentz covariant. A general ψ, applying on a vacuum state, is a superposition of all possible $\hat{\mathbf{b}}^{s\dagger}_{f}(\vec{x})$

$$\hat{\mathbf{b}}^{s\dagger}_{f}(\vec{x}) \quad = \quad \sum_{m} c^{sm}{}_{f}(\vec{x})\ \hat{b}^{\dagger}_{\vec{x}} *_{T}\ \hat{b}^{m\dagger}_{f}\,.$$

Choosing the vacuum state

$$|\psi_{oc}> = \sum_{f=1}^{2^{\frac{d}{2}-1}} \hat{b}^{m}_{f}{}_{*_A}\hat{b}^{m\dagger}_{f}\,|\,1\ >,$$

for one of the members m, anyone of the odd irreducible representations f, it follows that the odd "basis vectors" obey the **Dirac postulates for the second quantized fermion**

- The algebraic structure of fermion fields, $\psi(x)$, with $2^{\frac{d}{2}-1}$ members in $2^{\frac{d}{2}-1}$ families, and the same number of their Hermitian conjugate partners have the properties:

$$\psi *_A \psi = 0, \quad \psi^\dagger *_A \psi^\dagger = 0, \quad \psi^\dagger *_A \psi \rightarrow {}^{II}\hat{\mathcal{A}}_a, \quad \psi *_A \psi^\dagger \rightarrow {}^{I}\hat{\mathcal{A}}_a,$$

$${}^{I}\hat{\mathcal{A}}_a *_A |\psi_{oc}> = 0\,, \quad {}^{II}\hat{\mathcal{A}}_a |\psi_{oc}> \neq 0\,.$$

- The creation operator for a free massless boson field in a coordinate representation is ${}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}\alpha}(\vec{x}, x^0) = {}^{i}\mathcal{C}^{m}{}_{f\alpha}(\vec{x}, x^0) \,*_T\, {}^{i}\hat{\mathcal{A}}^{m\dagger}_{f}$, $i = (I, II)$, with (f, m) equal on both sides of equation,The creation operator for a free massless boson field in a coordinate representation is

$$\begin{aligned}
{}^{\mathbf{i}}\hat{\mathcal{A}}^{\mathbf{m}\dagger}_{\mathbf{f}\alpha}(\vec{x}, x^0) &= {}^{i}\hat{\mathcal{A}}^{m\dagger}_{f} \,*_T \int_{-\infty}^{+\infty} \frac{d^{d-1}p}{(\sqrt{2\pi})^{d-1}}\, {}^{i}\mathcal{C}^{m}{}_{f\alpha}\, \hat{b}^{\dagger}_{\vec{p}}\, e^{-i(p^0x^0-\varepsilon\vec{p}\cdot\vec{x})}|_{p^0=|\vec{p}|} \\
&= {}^{i}\mathcal{C}^{m}{}_{f\alpha}(\vec{x})\, \hat{b}^{\dagger}_{\vec{x}}\, {}^{i}\hat{\mathcal{A}}^{m\dagger}_{f}\,, \\
i =& \ (I, II)\,. \qquad (1
\end{aligned}$$

On both sides of the equation the same indices (m, f) are meant.

- Covariant derivative of fermion fields, following from the "basis vectors" of the fermion and boson fields

$$D_a\psi = p_a\psi - {}^{I}\hat{\mathcal{A}}_a *_A \psi - \psi *_A {}^{II}\hat{\mathcal{A}}_a,$$

suggests the Lagrange density for fermions

$$\mathcal{L}_F(\psi) = \frac{1}{2}\left[\psi^\dagger *_A \gamma^0\gamma^a *_A D_a\psi + (D_a\psi)^\dagger *_A \gamma^0\gamma^a *_A \psi\right].$$

Considering a local Lorentz transformation in internal space

$$\psi \rightarrow \psi' = \Lambda\psi,$$

with

$$\Lambda(x) = e^{i\omega_{ab}(x)\mathcal{S}^{ab}},$$

we show that the fermion Lagrange density preserves its form under local Lorentz transformations.

The explicit form of the fermion equation becomes

$$\gamma^0\gamma^a\left(p_a\psi - {}^{I}\hat{\mathcal{A}}_a *_A \psi - \psi *_A {}^{II}\hat{\mathcal{A}}_a\right) = 0.$$

Since the algebra distinguishes two kinds of non interacting bosons,

$$ {}^{I}\mathcal{A}_a = \hat{b}^{m'\dagger}_{f`} *_A (\hat{b}^{m''\dagger}_{f`})^{\dagger}, \qquad {}^{II}\mathcal{A}_a = (\hat{b}^{m'\dagger}_{f`})^{\dagger} *_A \hat{b}^{m'\dagger}_{f`'} . $$

the bosonic Lagrange density separates naturally into two parts,

$$ \mathcal{L}_B = \mathcal{L}^{I}_B + \mathcal{L}^{II}_B. $$

Taking into account that each kind contains the kinetic term for the corresponding boson fields, and the self interacting term following we end up with the field strengths

$$ \begin{aligned} {}^{I}F_{ab} &= -i\,(p_a\,{}^{I}\mathcal{A}_b - p_b\,{}^{I}\mathcal{A}_a - \{{}^{I}\mathcal{A}_a, {}^{I}\mathcal{A}_b\}_-), \\ {}^{II}F_{ab} &= -i(p_a\,{}^{II}\mathcal{A}_b - p_b\,{}^{II}\mathcal{A}_a - \{{}^{II}\mathcal{A}_a, {}^{II}\mathcal{A}_b\}_-, \end{aligned} $$

and correspondingly with the bosonic Lagrange density

$$ \mathcal{L}_B = \frac{1}{4}\,{}^{I}F_{ab}\,{}^{I}F^{ab} + \frac{1}{4}\,{}^{II}F_{ab}\,{}^{II}F^{ab}. $$

The two bosonic sectors are mutually orthogonal, they do not interact in the bosonic part of the Lagrangian.

- **The interaction between the two sectors occurs only through fermions.**

The relations determined by properties of "basis vectors" for fermions and bosons.

- Fermions can interact only by exchanging bosons, and bosons of two different kinds can interact among themselves only by exchanging fermions.
-
$$
{}^{I}\hat{\mathcal{A}}^{m\dagger}_{f} *_A {}^{II}\hat{\mathcal{A}}^{m\dagger}_{f} \;\; = \;\; 0 = {}^{II}\hat{\mathcal{A}}^{m\dagger}{}_{\cdot f} *_A {}^{I}\hat{\mathcal{A}}^{m\dagger}_{f} \,.
$$
- The algebraic products, $*_A$, of two members of each of these two groups have the property
$$
{}^{i}\hat{\mathcal{A}}^{m\dagger}_{f} \;*_A\; {}^{i}\hat{\mathcal{A}}^{m'\dagger}_{f`} \rightarrow \left\{ \begin{array}{r} {}^{i}\hat{\mathcal{A}}^{m\dagger}_{f`}\,, i = (I, II) \\ \text{or zero}\,. \end{array} \right.
$$
-
$$
{}^{I}\hat{\mathcal{A}}^{m\dagger}_{f} \;*_A\; \hat{b}^{m'\dagger}_{f`} \rightarrow \left\{ \begin{array}{r} \hat{b}^{m\dagger}_{f`}\,, \\ \text{or zero}\,. \end{array} \right.
$$
-
$$
\hat{b}^{m\dagger}_{f} *_A {}^{II}\hat{\mathcal{A}}^{m'\dagger}_{f`} \rightarrow \left\{ \begin{array}{r} \hat{b}^{m\dagger}_{f``}\,, \\ \text{or zero}\,, \end{array} \right.
$$

We need to discuss the quantum vacuum for the proposed theory. Let us start with the quantum vacuum in the Dirac case and the Quantum Field Theory case.

- Quantum vacuum in the Dirac case requires the Dirac sea with negative energies, full of fermions, all over the space-time.
  The particle and antiparticle is the excitation of a particle and correspondingly a hole in the Dirac sea.

- Quantum vacuum in the Quantum Field Theory case represents the lowest-energy state of all quantum fields. All fields exist everywhere, also in the vacuum, Due to the uncertainty principle, the vacuum is full of fluctuations due to the uncertainty principle,

- The quantum vacuum in the **proposed theory represents the lowest-energy state of all quantum fields, like in the Quantum Field Theory** .
  All fermions exist everywhere, also in the vacuum state,which is generated from the ${}^{II}\hat{\mathcal{A}}^{m'\dagger}_{f'}$, with only projectors. Due to the uncertainty principle, the vacuum is full of fluctuations. The fermions on such a vacuum fulfil the Dirac postulates for the second quantized field without postulates.

- While Dirac and the Quantum Field Theory generate particle-antiparticle pairs by definition in every space-time point, in the proposed theory, particles and antiparticles exist in every family due to the description of the internal spaces of fermions and bosons, with odd (for fermions) and even (for bosons) number of nilpotents.

- In the proposed theory at each point of the space-time there exist momentumless fermion antifermion pairs, which applying on the vacuum state, generated by bosons of the second kind, give nonzero contributions.

- Let us look at the case that the internal space has $d = (13+1)$ dimensions, what offers the observed quarks and leptons and antiquarks and antileptoms – with the right-handed neutrinos and left-handed antineutrinos included – as well as all the observed boson fields, and several predictions.

  Let the photon ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}} (\equiv \stackrel{03}{[-]}\stackrel{12}{[+]} \mid \stackrel{56}{[+]}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{[-]}\,\stackrel{11\,12}{[-]}\,\stackrel{13\,14}{[-]})$ hits both, the electron $e^{-}_{L\uparrow}$ $(\equiv \stackrel{03}{[-i]}\stackrel{12}{[+]} \mid \stackrel{56}{(-)}\stackrel{78}{(+)} \mid\mid \stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)})$ and the positron $\bar{e}^{+}_{R\uparrow}$ $(\equiv \stackrel{03}{(+i)}\stackrel{12}{[+]} \mid \stackrel{56}{[+]}\stackrel{78}{[-]} \mid\mid \stackrel{9\,10}{[-]}\,\stackrel{11\,12}{[-]}\,\stackrel{13\,14}{[-]})$, in the vacuum.

Let be added that ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{R\uparrow})^{\dagger} *_A e^{-}_{R\uparrow}} = {}^{II}\hat{\mathcal{A}}^{\dagger}_{(u^{ci}_{L\uparrow})^{\dagger} *_A u^{ci}_{L\uparrow}}$, for any ci.

$${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{R\uparrow})^{\dagger} *_A e^{-}_{R\uparrow}} (\equiv \stackrel{03}{[-]}\stackrel{12}{[+]} \,|\, \stackrel{56}{[+]}\stackrel{78}{[-]} \,||\, \stackrel{9\,10}{[-]}\,\stackrel{11\,12}{[-]}\,\stackrel{13\,14}{[-]} = (e^{-}_{R\uparrow})^{\dagger} (\equiv \stackrel{03}{(+i)}\stackrel{12}{[+]} \,|\, \stackrel{56}{(-)}\stackrel{78}{[-]} \,||\, \stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)})^{\dagger} \,*_A\, e^{-}_{R\uparrow}.$$

The vacuum state is the same for all members of a family.

Let us see the figure in which a photon ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}}$ $(\equiv \stackrel{03}{[-]}\stackrel{12}{[+]} \,|\, \stackrel{56}{[+]}\stackrel{78}{[-]} \,||\, \stackrel{9\,10}{[-]}\,\stackrel{11\,12}{[-]}\,\stackrel{13\,14}{[-]})$ hits the electron $e^{-}_{L\uparrow}$ $(\equiv \stackrel{03}{[-i]}\stackrel{12}{[+]} \,|\, \stackrel{56}{(-)}\stackrel{78}{(+)} \,||\, \stackrel{9\,10}{(+)}\stackrel{11\,12}{(+)}\stackrel{13\,14}{(+)})$ and the positron $\bar{e}^{+}_{R\uparrow}$ $(\equiv \stackrel{03}{(+i)}\stackrel{12}{[+]} \,|\, \stackrel{56}{[+]}\stackrel{78}{[-]} \,||\, \stackrel{9\,10}{[-]}\,\stackrel{11\,12}{[-]}\,\stackrel{13\,14}{[-]})$, in the quantum vacuum, both from the right-hand side. The electron and the positron take away the photon's ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}}$ momentum.

The below diagram should not be interpreted as a stand alone physical process, but as an intermediate contribution entering the full amplitude.

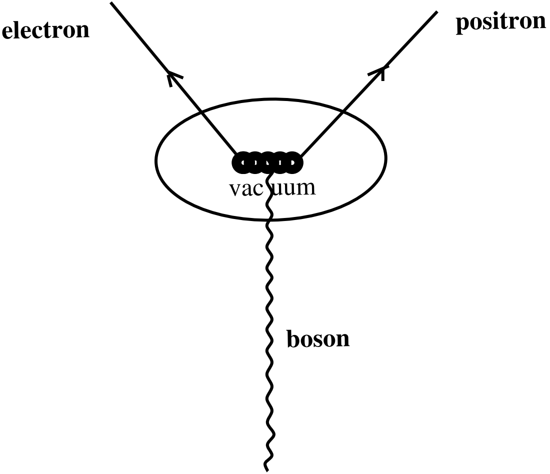
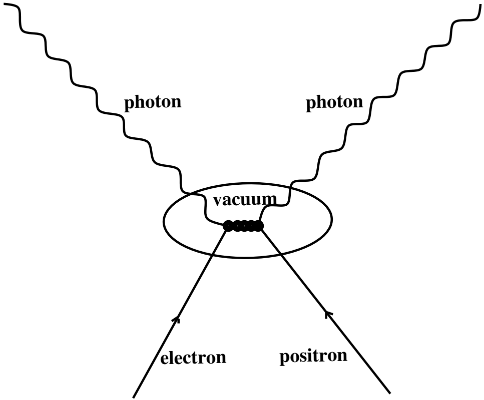


Figure: The creation of a fermion-antifermion pair. A photon – **boson** – $''\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}}$ $(\equiv \overset{03}{[-]}\overset{12}{[+]} \,|\, \overset{56}{[+]}\overset{78}{[-]} \,||\, \overset{9\,10}{[-]}\,\overset{11\,12}{[-]}\,\overset{13\,14}{[-]})$ hits the electron $e^{-}_{L\uparrow}$ $(\equiv \overset{03}{[-i]}\overset{12}{[+]} \,|\, \overset{56}{(-)}\overset{78}{(+)} \,||\, \overset{9\,10}{(+)}\overset{11\,12}{(+)}\overset{13\,14}{(+)})$ and the positron $\bar{e}^{+}_{R\uparrow}$ $(\equiv \overset{03}{(+i)}\overset{12}{[+]} \,|\, \overset{56}{[+]}\overset{78}{[-]} \,||\, \overset{9\,10}{[-]}\,\overset{11\,12}{[-]}\,\overset{13\,14}{[-]})$, in the quantum vacuum.

- The photon applies both fermions from the right-hand side. The electron and the positron take away the photon's ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^-_{L\uparrow})^{\dagger} *_A e^-_{L\uparrow}}$ momentum.
- Let us look in the proposed theory the annihilation of the electron-positron pair:
  An electron, $e^-_{L\uparrow}$, hits a photon ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^-_{L\uparrow})^{\dagger} *_A e^-_{L\uparrow}}$, and a positron, $\bar{e}^+_{R\uparrow}$, hits a photon, ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(\bar{e}^+_{R\uparrow})^{\dagger} *_A \bar{e}^+_{R\uparrow}}$ in the common vacuum.
  The electron and positron remain in the vacuum, while their momenta are taken away by the two photons of the second kind, ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^-_{L\uparrow})^{\dagger} *_A e^-_{L\uparrow}} = {}^{II}\hat{\mathcal{A}}^{\dagger}_{(\bar{e}^+_{R\uparrow})^{\dagger} *_A \bar{e}^+_{R\uparrow})}$.

The annihilation of the electron positron pair in the proposed theory. Both, electron and positron belong to the same family. Both move upwards.
(In the Dirac case positron moves backwards, and the Quantum Field Theory positron has a different phase what leaves many questions open.)



Although it looks like that the proposed theory explains most of Feynman diagrams in Quantum field theory in a different way but still in a comparable one, there are diagrams which disagree.

In the proposed theory there is the boson of the first kind with the "basis vector" ${}^{I}\hat{\mathcal{A}}^{\dagger}_{\bar{\nu}_{R\uparrow} *_A (e^{-}_{L\uparrow})^{\dagger}} = (\bar{\nu}_{R\uparrow} *_A (e^{-}_{L\uparrow})^{\dagger})$ (with the quantum numbers $\mathcal{S}^{03} = i$ and $\tau^4 = 1$, all the other quantum numbers are zero), which applies from the left-hand side on $e^{-}_{L\uparrow}$ (with $S^{03} = -\frac{i}{2}, S^{12} = \frac{1}{2}, \tau^{13} = -\frac{1}{2}, \tau^{23} = 0, \tau^4 = -\frac{1}{2}$) and transforms it to a antineutrino, $\bar{\nu}_{R\uparrow}$ (with $S^{03} = \frac{i}{2}, S^{12} = \frac{1}{2}, \tau^{13} = -\frac{1}{2}, \tau^{23} = 0, \tau^4 = \frac{1}{2}$), and a boson of the second kind ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}}$ (with all the quantum numbers equal zero).

$$[\bar{\nu}_{R\uparrow} *_A (e^{-}_{L\uparrow})^{\dagger}] *_A e^{-}_{L\uparrow} \to \bar{\nu}_{R\uparrow} *_A [(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}] \,.$$

The right-handed antineutrino, $\bar{\nu}_{R\uparrow}$, and the boson of a second kind share the momenta of ${}^{I}\hat{\mathcal{A}}^{\dagger}_{\bar{\nu}_{R\uparrow} *_A (e^{-}_{L\uparrow})^{\dagger}}$ and $e^{-}_{L\uparrow}$.

But this boson is not the weak boson.

If we want the weak boson to be involved, we suggest a two step process.
The first part is presented in the above figure:

A photon ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^-_{L\uparrow})^{\dagger} *_A e^-_{L\uparrow}}$ hits the electron $e^-_{L\uparrow}$ and the positron $\bar{e}^+_{R\uparrow}$ in the vacuum. The electron and the positron take away the photon's ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^-_{L\uparrow})^{\dagger} *_A e^-_{L\uparrow}}$ momentum.

In the second step the positron $\bar{e}^+_{R\uparrow}$, which has $\tau^{13} = \frac{1}{2}$, absorbs a photon ${}^{I}\hat{\mathcal{A}}^{\dagger}_{W^-} \equiv {}^{I}\hat{\mathcal{A}}^{\dagger}_{\bar{e}^+_{R\uparrow} \to \bar{\nu}_{R\uparrow}}$ and continues its path as an antineutrino $\bar{\nu}_{R\uparrow}$ moving like all fermions upwards in time.

This diagram, with the weak boson absorption included, and with all the particles and antiparticles moving upwards in time can represent what the usual diagrams might mean.

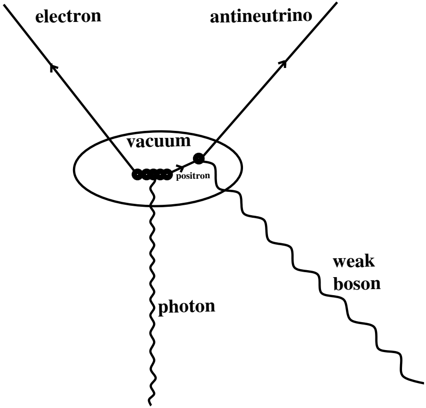


Figure: The creation of a electron-antineutrino pair: A photon ''$\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}}$ $(\equiv \overset{03}{[-]}\overset{12}{[+]} \mid \overset{56}{[+]}\overset{78}{[-]} \parallel \overset{9\,10}{[-]}\,\overset{11\,12}{[-]}\,\overset{13\,14}{[-]})$ hits the electron $e^{-}_{L\uparrow}$ $(\equiv \overset{03}{[-i]}\overset{12}{[+]} \mid \overset{56}{(-)}\overset{78}{(+)} \parallel \overset{9\,10}{(+)}\overset{11\,12}{(+)}\overset{13\,14}{(+)})$ and the positron $\bar{e}^{+}_{R\uparrow}$ $(\equiv \overset{03}{(+i)}\overset{12}{[+]} \mid \overset{56}{[+]}\overset{78}{[-]} \parallel \overset{9\,10}{[-]}\,\overset{11\,12}{[-]}\,\overset{13\,14}{[-]})$, in the quantum vacuum, both from the right-hand side. The weak boson hits positron from the left-hand side, transforming it to antineutrino.

The weak boson hits positron from the left-hand side, transforming it to antineutrino.

The two born photons, ${}^{I}\hat{\mathcal{A}}^{\dagger}_{e^{-}_{L\uparrow} *_A (e^{-}_{L\uparrow})^{\dagger}}$ and ${}^{I}\hat{\mathcal{A}}^{\dagger}_{\bar{e}^{+}_{R\uparrow} *_A (\bar{e}^{+}_{R\uparrow})^{\dagger}}$ remain momentumless in the vacuum, Eq. (**??**), the weak boson hits the positron (from the left-hand side, giving it the weak charge -1 and transforming it to the antineutrino. The electron and antineutrino take away the momentum of the photon ${}^{II}\hat{\mathcal{A}}^{\dagger}_{(e^{-}_{L\uparrow})^{\dagger} *_A e^{-}_{L\uparrow}}$ and the weak boson.

- Let us add that the Lorentz rotations work on both spaces, internal and ordinary space-time, only in $d = (3+1)$. In $d \geq 5$ only internal space contribute to the Lorentz rotations.

- **We are trying to understand the laws nature obeys.**
- **Describing the internal spaces of fermions and bosons with the "basis vectors" in $d = (13+1)$, while fermion and boson fields have non-zero momentum only in $d = (3+1)$ of the ordinary space-time, then we unify gravity and all the gauge fields**:

  $SO(3,1)$ of $SO(13,1)$ determines spins and handedness of gravitons, fermions, and antifermions,

  $SU(2) \times SU(2)$ of $SO(13,1)$ **determine two kinds of weak charges of fermions and bosons**,

  $SU(3) \times U(1)$ determine the **colour charges and the** $U(1)$ **charges of quarks and antiquarks and gluons**,
- **Photons' "basis vectors" are products of only projectors, with all spins and charges equal zero**,

- **Gravitons' "basis vectors"** **have two nilpotents only in $SO(3,1)$ part of $SO(13,1)$,**
- **Weak bosons' "basis vectors"** **have two nilpotents in $SU(2) \times SU(2)$ part of $SO(13,1)$,**
- **Gluons' "basis vectors"** **have two nilpotents in $SO(6)$ part of $SO(13,1)$.**
- **Fermions' "basis vectors" have odd number of nilpotents spread over $SO(13,1)$. They appear in families.**

- The proposed theory offers all the fermion and all the boson second quantized fields, with the scalar fields included, observed so far, no additional assumptions are needed,
- Explains the second postulates of Dirac,
- Offers the equivalent Feynman diagrams
- Makes several predictions, like: the existence of the right-handed neutrino and the left-handed antineutrino,
- The existence of new families, which explain the existence of the dark matter,
- The existence of new scalar fields, which explain the matter/antimatter asymmetry
- The existence of new scalar fields, which explain the inflation of the universe.

HERE STARTS UNIVERSE

- **Let us present graviton** ${}^{I}\hat{\mathcal{A}}^{\dagger}_{gr\; u^{c1}_{R\uparrow} \to u^{c1}_{R\downarrow}}$ **, which must leave all the charges of fermions, except the spin** (S^{03}, S^{12}) **in** $d = (3+1)$**, unchanged.**

$$
{}^{I}\hat{\mathcal{A}}^{\dagger}_{gr\; u^{c1\dagger}_{R\uparrow} \to u^{c1\dagger}_{R\downarrow}} (\equiv \overset{03}{(-i)}\overset{12}{(-)}\overset{56}{[+]}\overset{78}{[+]}\overset{9\,10}{[+]}\overset{11\,12}{[-]}\overset{13\,14}{[-]}) *_A
$$

$$
u^{c1\dagger}_{R\uparrow}, (\equiv \overset{03}{(+i)}\overset{12}{[+]}\overset{56}{[+]}\overset{78}{(+)}\overset{9\,10}{(+)}\overset{11\,12}{[-]}\overset{13\,14}{[-]}) \to
$$

$$
u^{c1\dagger}_{R\downarrow} (\equiv \overset{03}{[-i]}\overset{12}{(-)}\overset{56}{[+]}\overset{78}{(+)}\overset{9\,10}{(+)}\overset{11\,12}{[-]}\overset{13\,14}{[-]}),
$$

$$
\mathbf{{}^{I}\hat{\mathcal{A}}^{\dagger}_{gr\; u^{c1\dagger}_{R\uparrow} \to u^{c1\dagger}_{R\downarrow}}} = \mathbf{u^{c1\dagger}_{R\downarrow}} \; \mathbf{*_A} \; \mathbf{(u^{c1\dagger}_{R\uparrow})^{\dagger}},
$$

$$
{}^{I}\hat{\mathcal{A}}^{\dagger}_{gr\; u^{c1\dagger}_{R\downarrow} \to u^{c1\dagger}_{R\uparrow}} (\equiv \overset{03}{(+i)}\overset{12}{(+)}\overset{56}{[+]}\overset{78}{[+]}\overset{9\,10}{[+]}\overset{11\,12}{[-]}\overset{13\,14}{[-]}) *_A u^{c1\dagger}_{R\downarrow} \to u^{c1\dagger}_{R\uparrow},
$$

$$
\mathbf{{}^{I}\hat{\mathcal{A}}^{\dagger}_{gr\; u^{c1\dagger}_{R\downarrow} \to u^{c1\dagger}_{R\uparrow}}} = \mathbf{u^{c1\dagger}_{R\uparrow}} \; \mathbf{*_A} \; \mathbf{(u^{c1\dagger}_{R\downarrow})^{\dagger}}.
$$