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The masses of the first family of fermions and of the Higgs boson are equal to integer powers of 2

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Abstract

We noticed that the first family of fermions and the Higgs boson have masses which are equal to integer powers of 2 in eV/c^2 units (i.e. in the Planck length units). We made the hypothesis that, if spacetime is composed of small hypercubes of one Planck length edge, it exists elementary wavefunctions which are equal to $\sqrt{2}\exp(ikx_i)$ if it corresponds to a space dimension or equal to $\sqrt{2}\exp(i\omega t)$ if it corresponds to a time dimension. By using the Dirac propagation equation and combinatorics we showed that the electron has a mass of $2^{19}eV/c^2$, the quark has a mass of $2^{21}eV/c^2$ and the electron neutrino has a mass of $2eV/c^2$. Finally, the Higgs boson is showed to have a mass of $2^{37}eV/c^2$

Keywords:
theoretical masses of elementary particles, fourdimensional space, real space theory

1. Introduction

I make the assumption that our threedimensional universe is embedded in a four dimensional euclidean space. Time is a function of the fourth dimension of this space [1–3]. If we apply this hypothesis to particle physics, we may say that elementary particles are fourdimensional, threedimensional and twodimensional.

The coordinates (x, y, z, t) are not orthonormal. Indeed, time t evolves as $log(r)$ where r is the comoving distance in cosmology [1].

Let us make the additional assumption that for each of these four dimensions there are functions like $exp(ikx_i)$ with $(x_i = x, y, z, t)$ which vibrate (like in string theory). So, our reasoning is simply the description of how to distribute these functions in the fourdimensional space. In the following, the reasoning applies in real space.

A previous paper of mine (see [5]) predicts that the Higgs potential in real space is a hypercubic box in our fourdimensional space.

To obtain the first family of fermions from the Standard Model (i.e. quark up, electron, electron neutrino) one may say that:

- the electron is fourdimensional (t, x, y, z)
- the quark is three dimensional (t, x, y).
- finally, the electronic neutrino is twodimensional (t, x) and x, y and z are equivalent. It is only due to an equivalent propagation equation to the Fermi Dirac equation that when this neutrino propagates, there are infinitesimal rotations between the characteristic coordinates (leading to flavor oscillations).

To obtain the remaining fermions (elementary particles), one has to modify the quantum number n (similar to the quantum number during oscillation in a hypercubic box). Thus, the remaining fermions of the Standard Model may be seen as excited states of the first fermion family.

So, we made a classification of elementary particles with respect to their dimensions [4]. To verify these conclusions, we analyze here the masses of the first family of fermions.

One may remark that the masses of the first family of fermions (elementary particles) and of the Higgs boson are integer powers of 2 if expressed in eV/c^2. For details on these masses, see table I.

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Name	measured mass in eV/c^2	2^n
Electron	$\approx 511.10^3$	$2^{19} \approx 524.10^3$
Quark up	$\approx 2.3.10^6$	$2^{21} \approx 2.1.10^6$
Electron neutrino	≈ 2	2^1
Higgs boson	$\approx 126.10^9$	$2^{37} \approx 137.10^9$

Table 1: Masses of the first family of fermions and of the Higgs boson

In order to explain this property, let us analyze the Dirac equation which is the propagation equation of part of the first family of fermions (except the electron neutrino).

The Dirac equation may be written:

$$i\gamma^\mu \partial_\mu \psi - m\psi = 0 \tag{1}$$

with ψ the wavefunction, m the mass of the fermion and with the Dirac matrices:

$$\gamma^0 = \begin{pmatrix} I_2 & 0 \\ 0 & -I_2 \end{pmatrix}, \tag{2}$$

$$\gamma^1 = \begin{pmatrix} 0 & \sigma_x \\ -\sigma_x & 0 \end{pmatrix}, \tag{3}$$

$$\gamma^2 = \begin{pmatrix} 0 & \sigma_y \\ -\sigma_y & 0 \end{pmatrix}, \tag{4}$$

$$\gamma^3 = \begin{pmatrix} 0 & \sigma_z \\ -\sigma_z & 0 \end{pmatrix}, \tag{5}$$

where σ_ν are the Pauli matrices.

On a mathematical point of view, the Dirac matrices are representative of infinitesimal rotations within the wavefunction of a given elementary particle.

Let us make two hypotheses: first, the elementary wave function corresponds to the eigenfunction of a square potential with dimensions corresponding to the Planck length (we take $\hbar = 1$ here). This first hypothesis leads to elementary eigenfunctions which are equal to $\sqrt{2}\exp(ikx_i)$ if the eigenfunction corresponds to a space dimension or equal to $\sqrt{2}\exp(i\omega t)$ if the eigenfunction corresponds to a temporal dimension.

2. Mass of the electron

Following Olivi-Tran and Gottiniaux [4], the electron is fourdimensional. So, the wavefunction has four subcomponents which may be seen also as wavefunctions. In order to get the mass of the electron, let us analyze the Dirac equation which may be rewritten:

$$i\gamma^\mu \partial_\mu \psi = m\psi \tag{6}$$

A hint is to write equation (6) with the use of one unique matrix M containing all Dirac matrices. Moreover, one has to take into account the fact that this large matrix has to contain all possible combinations of Dirac matrices . Hence, we modify the Dirac equation by putting more constraints: all space dimensions have to be equivalent and time cannot go backwards.

$$iM\partial_\mu \psi = m\psi \tag{7}$$

Thus there are 3 possibilities of arranging $\gamma^1, \gamma^2, \gamma^3$; all space dimensions are thus equivalent. Because time cannot go backwards, we take into account half of the matrix γ_0 which is equal to the Pauli matrix σ_0. The large matrix M containing all combinations of γ^μ matrices over x, y and z is then:

$$\begin{pmatrix} \gamma_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \gamma_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \gamma_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \gamma_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \gamma_1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \gamma_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \gamma_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \sigma_0 \end{pmatrix} \tag{8}$$

We see that, if we work with the coordinate vectors ($\sqrt{2}\exp(ikx_i)$, $\sqrt{2}\exp(i\omega t)$), we have to multiply the l.h.s of the modified Dirac equation (7) by the Jacobian corresponding to these new coordinates. This Jacobian is equal to $\sqrt{2}^N$ where N is the dimension of the large matrix M.

The modified dirac equation (7) may be reduced to the dirac equation (6). So, the eigenfunctions of the modified Dirac equation may be found by making permutations of x, y and z in the eigenfunctions of the Dirac equation: this means that x, y, z are equivalent.

So the large matrix containing all combinations of γ^μ has a dimension of $4X3X3 + 2 = 38$:i.e. 38X38. The eigenvalue of the Dirac equation is equal to 1, so the eigenvalue m of the modified Dirac equation is equal to $m = \sqrt{2}^{38} = 2^{19} eV/c^2$.

Finally, if one deals with eV/c^2 units, the theoretical mass of the electron is equal to $2^{19} eV/c^2 \approx 524 keV$ (the measured mass of the electron is $511 keV$).

3. Mass of the quark up

Following Olivi-Tran and Gottiniaux [4], the quark up is threedimensional. So, the wavefunction has three

subcomponents which may be seen also as wavefunctions. In order to get the mass of the quark up, let us analyze the Dirac equation which may be rewritten:

$$i\gamma^{\mu}\partial_{\mu}\psi = mc\psi \tag{9}$$

A hint is to write equation (9) with the use of one unique matrix M containing all Dirac matrices. Moreover, one has to take into account the fact that this large matrix has to contain all possible combinations of Dirac matrices over x, y and z. Hence, we modify the Dirac equation by putting more constraints: all space dimensions have to be equivalent and time cannot go backwards.

$$iM\partial_{\mu}\psi = m\psi \tag{10}$$

Thus there are 3 possibilities of arranging $\gamma^1, \gamma^2, \gamma^3$; all space dimensions are equivalent. Because time cannot go backwards, we take into account half of the matrix γ_0 which is equal to the Pauli matrix σ_0, for each pair of matrices γ_{μ}. The large matrix M containing all combinations of γ^{μ} matrices is then band diagonal with this band diagonal equal to:

$$(\gamma_1, \gamma_2, \gamma_3, \sigma_0, \gamma_2, \gamma_3, \gamma_1, \sigma_0, \gamma_3, \gamma_1, \gamma_2, \sigma_0) \tag{11}$$

If all space dimensions are equivalent this leads to all possible combinations of γ^{μ}, σ^0. Equation (10) may be reduced to the Dirac equation (9) if one takes into account that the solutions of the Dirac are equivalent by making permutations of x, y and z.

So the large matrix containing all combinations has a dimension of $3X3X4 + 3X2 = 42$.

We see that, if we work with the coordinate vectors ($\sqrt{2}\exp(ikx_i)$, $\sqrt{2}\exp(i\omega t)$), we have to multiply the l.h.s of the modified Dirac equation by the Jacobian corresponding to these new coordinates. This Jacobian is equal to $\sqrt{2}^N$ where N is the dimension of the large matrix M (i.e. 42).

The eigenvalue of the Dirac equation is equal to 1, so the eigenvalue m of the modified Dirac equation is equal to $m = \sqrt{2}^{42} = 2^{21} eV/c^2$.

Finally, if one deals with eV/c^2 units, the mass of the quark up is equal to $2^{21} eV/c^2 \approx 2.1 MeV$ (the measured mass of the quark up is $2.3 MeV$).

4. Mass of the electron neutrino

Following Olivi-Tran [4], the electron neutrino is twodimensional: one temporal dimension and one spatial dimension. Up to now, there is no existing theoretical propagation equation for the neutrinos. Let us make the hypothesis that all space dimensions are equivalent: as the electron neutrino has only one spatial dimension, there is no 'rotations' between different spatial dimensions (as for the electron and the quark). In the propagation equation for neutrino, there would be no Dirac matrices and only two subeigenfunctions would come into account: one for space the other for time.

A theoretical propagation function for the neutrino would then use 2 subfunctions $\sqrt{2}\exp(i\omega t)$ and $\sqrt{2}\exp(ikx)$. So the mass of the electron neutrino would be $m = \sqrt{2}^2 = 2eV/c^2$ (the measured mass of the electron neutrino is $\approx 2eV$).

5. Mass of the Higgs boson

In a previous paper, Olivi-Tran [5] showed that the Higgs field corresponds to the solution of the massless Klein-Gordon propagation equation coupled to a hypercubic fourdimensional potential. The first family of fermions acquire mass by interacting with the Higgs field.

The Higgs field gives mass to the previous fermions and is fourdimensional. The Higgs potential has to be able to contain a combination of electron, quark up and electron neutrino.

In order to contain all the previous combinations, the resulting combination of the coordinate vectors $\sqrt{2}\exp(ikx_i)$ for spatial dimensions has a norm equal to 2^{18} (electron : combinations over x, y, z) multiplied by 2^{18} (quark up : combinations over $(x, y); (y, z)$ and (x, z)) ; the electron neutrino is included in these last. The resulting combination is 2 for the temporal dimension (coordinate vector $\sqrt{2}\exp(i\omega t)$ identical for all 3 fermions)

So, if we make the hypothesis that the Higgs field is a combination of the field corresponding to the electron, the quark up and the electron neutrino, the mass of the Higgs boson would be equal to $2^{18}.2^{18}.2 = 2^{37} eV/c^2 \approx 137 GeV$ (the measured mass of the Higgs boson is $126 GeV$).

6. Conclusion

The masses of the first family of fermions and of the Higgs boson are integer powers of 2 within experimental errors. As what I wrote in the introduction [4], other fermions are excited states of the first family and thus they do not follow the same rule regarding their masses. Now, one has to analyze the masses of the W and Z bosons which maybe can be found theoretically with the same reasonings.

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