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Theoretical approach to the masses of the elementary fermions

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Abstract

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 $\sqrt{2} \exp(ix)$ if it corresponds to a space dimension or equal to $\sqrt{2} \exp(it)$ if it corresponds to a time dimension. The masses of fermions belonging to the first family of fermions are equal to integer powers of 2 (in $eV/c^2$) [1]. We make the hypothesis that the fermions of the 2nd and 3rd families are excited states of the fermions of the 1st family. Indeed, the fermions of the 2nd and 3rd families have masses equal to $2^n(p^2)/2$ where $n$ is an integer [1] calculated for the first family of fermions and $p$ is another integer. $p$ is an integer which corresponds to the excited states of the elementary wavefunctions (the energy of the excited elementary wave functions are equal to $p^2/2$; using normalized units).

Keywords:

I. Introduction

I make the assumption that our three-dimensional universe is embedded in a four dimensional euclidean space. Time is a function of the fourth dimension of this space [2–4]. If we apply this hypothesis to particle physics, we may say that elementary particles are four-dimensional, 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 [2].

To obtain the first family of fermions from the Standard Model (i.e. quark up, electron, electron neutrino) one may say that [5]:

- 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.

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

Straightforwardly, we make the following hypotheses:

- Spacetime has an underlying hypersquare array of edge length $\hbar$
- Elementary wave functions (in $(x, y, z, t)$ space) are eigenfunctions of a particle in a square potential (reduced parameters) $\sqrt{2} \exp(-ix)$ for space $\sqrt{2} \exp(-it)$ for time
- The eigenvalues of the elementary wave functions are equal to $p^2/2$ (with $p$ an integer number)

2. Masses of the electron, muon and tau

For electrons, we have

$$i\gamma^\mu \partial_\mu \psi = m\psi$$

(2)
The theoretical mass and experimental mass of an elementary particle are given. The Pauli matrices and Dirac matrices are introduced, and their properties are discussed. The Pauli matrices are half of all combinations, while the Dirac matrices represent infinitesimal rotations within the wavefunction. The number of eigenvalues for the ground state is calculated. The Dirac matrices are decomposed into prime numbers.

There are three possibilities of arranging \( \gamma_1, \gamma_2, \gamma_3 \) (the Dirac matrices) over \( x, y, \) and \( z \) (all space dimensions are equivalent) and one possibility to arrange \( \sigma_0 \) (temporal Pauli matrix; half of \( \gamma_0 \); because time does not go backward).

The large matrix \( M \) (equation (1)) containing all combinations has a dimension 9x4 + 2 = 38. We see that, with the coordinate vectors \( \sqrt{2} \text{exp}(-i\tau) \) and \( \sqrt{2} \text{exp}(i\tau) \) (eigenfunctions of a particle in a square potential), we have to multiply the modified Dirac equation by the Jacobian corresponding to these new coordinates. This Jacobian is equal to \( \sqrt{2^{38}} \) where 38 is the dimension of the large matrix [1]. We multiply the mass of the first particle of this family by the eigenvalues of the eigenfunctions of the particle.

We decompose the eigenvalues into prime numbers. The number of eigenvalues for the ground state (electron) is 38 (the dimension of the large matrix \( M \)). For the other particles, we take into account the spinor \((1,0)^T\) corresponding to the \( \sigma_0 \) Pauli matrix. So except for the electron, there are 37 eigenvalues for each particle.

- The mass of the electron is equal to \( 0.524 \text{MeV}/c^2 = 0.511 \text{MeV}/c^2 \)
- The mass of the muon is equal to \( 105.6 \text{MeV}/c^2 \)
- The mass of the tau is equal to \( 1.78 \text{GeV}/c^2 \)

The values in italic are the experimental masses [6].

We see that for the tau particle, one of the eigenvalues \( \frac{2^{19}}{c^2} \) is much larger than the others. This may explain the short lifetime of this particle.

The masses (theoretical and experimental) of the electron, muon and tau are summarized in Table 1.

### Table 1: Theoretical and experimental masses of the electron, muon and tau

<table>
<thead>
<tr>
<th>Particle</th>
<th>Theoretical mass ((eV/c^2))</th>
<th>Experimental mass ((eV/c^2)) [6]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron</td>
<td>(2^{19} = 0.524 \text{MeV}/c^2)</td>
<td>0.511 MeV/c²</td>
</tr>
<tr>
<td>Muon</td>
<td>(2^{19}.20^2/2 = 104.8 \text{MeV}/c^2)</td>
<td>105.6 MeV/c²</td>
</tr>
<tr>
<td>Tau</td>
<td>(2^{19}.82^2/2 = 1.76 \text{GeV}/c^2)</td>
<td>1.78 GeV/c²</td>
</tr>
</tbody>
</table>

3. **Masses of the quarks**

For quarks, we have

\[ i\gamma^\mu \partial_\mu \psi = m\psi \]

The Dirac matrices are representative of infinitesimal rotations within the wavefunction. Using combinatorial analysis we obtain equation (3) (using the fact that quarks are 3d [5] and that all space dimensions are equivalent).

There are three possibilities of arranging \( \gamma_1, \gamma_2, \gamma_3 \) (the Dirac matrices) over \( x, y, \) and \( z \) (all space dimensions are equivalent). There is one possibility to arrange \( \sigma_0 \)
Theoretical mass (962, 421, 221, 121, 212, 112, 332, 223, 113) Experimental mass (212, 213, 113, 112, 332, 223, 113)

We have to take into account the spinor (1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0) (3).

The values in italic are the experimental masses [6].

The theoretical and experimental masses of the quarks family are summarized in table 2.

The quark top has a mass equal to 212, 213, 113, 112, 332, 223, 113.

The quark strange has a mass equal to 212, 213, 113, 112, 332, 223, 113.

The quark bottom has a mass equal to 212, 213, 113, 112, 332, 223, 113.

The quark up has a mass equal to 212, 213, 113, 112, 332, 223, 113.

The quark down has a mass equal to 212, 213, 113, 112, 332, 223, 113.

We see that, with the coordinate vectors √2exp(-it) and √2exp(-ix) (eigenfunctions of the underlying hypersquare array), we have to multiply the modified Dirac equation by the Jacobian corresponding to these new coordinates. This Jacobian is equal to √22 where 42 is the dimension of the matrix [1].

We multiply the mass of the first particle of the quarks family by the eigenvalues of the eigenfunctions (of the particle). We decompose the eigenvalues into prime numbers. The number of eigenvalues for the ground state (quark up) is 42 (the dimension of the large matrix M, see equation (3)). For the other quarks, we take into account the spinor (1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0) Pauli matrices. So except for the quark up, there are 39 eigenvalues for each quark.

- The quark up has a mass equal to 212, 213, 113, 112, 332, 223, 113.
- The quark down has a mass equal to 212, 213, 113, 112, 332, 223, 113.
- The quark strange has a mass equal to 212, 213, 113, 112, 332, 223, 113.
- The quark bottom has a mass equal to 212, 213, 113, 112, 332, 223, 113.
- The quark top has a mass equal to 212, 213, 113, 112, 332, 223, 113.
- The quark up has a mass equal to 212, 213, 113, 112, 332, 223, 113.

Table 2: Theoretical and experimental masses of the quarks family.

<table>
<thead>
<tr>
<th>quark</th>
<th>Theoretical mass (eV/c^2)</th>
<th>Experimental mass (eV/c^2) [6]</th>
</tr>
</thead>
<tbody>
<tr>
<td>up</td>
<td>212 = 2.09MeV/c^2</td>
<td>2.2MeV/c^2</td>
</tr>
<tr>
<td>strange</td>
<td>212, 213, 113, 112, 332, 223, 113</td>
<td>96MeV/c^2</td>
</tr>
<tr>
<td>charm</td>
<td>212, 213, 113, 112, 332, 223, 113</td>
<td>84.9MeV/c^2</td>
</tr>
<tr>
<td>bottom</td>
<td>212, 213, 113, 112, 332, 223, 113</td>
<td>171.9GeV/c^2</td>
</tr>
</tbody>
</table>

4. Masses of the neutrinos

Up to now, there is no theoretical propagation equation for the neutrinos.
If we use the eigenvalues of the elementary wave functions like for quarks and electrons, muons and taus, we may write:

- The mass of the electron neutrino is equal to $2eV/c^2$.
- The mass of the muon neutrino is equal to $2 \times 412^2 = 412^2 eV/c^2 = 169 keV/c^2$.
- The mass of the tau neutrino is equal to $2 \times 3937^2 = 3937^2 eV/c^2 = 15.4 MeV/c^2$.

Hence, we found theoretical values of the masses of the neutrinos, which are in good agreement with the experimental masses.

5. Conclusion

We found the theoretical values of masses for all the elementary fermions (1st, 2nd and 3rd families of fermions). These theoretical masses are in good agreement with the experimental masses (the differences between theoretical and experimental masses are less than 10% except for the quarks down and strange). There is a possibility to analyze the symmetries of these particles and compare them to the symmetries of the Standard Model.

References