The Mass of the Electron
(Draft Version)

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Abstract

A formula for the mass of the electron is obtained postulating that the ratio between the mass of the electron to the mass of the muon equals the ratio between the mass of the down quark to the mass of the charm quark. The values of the quark masses used in this formula fall into the experimental limits published by reference [1].

Keywords: Lepton, quark, electron, muon, down quark, charm quark, naked mass, generations of matter, fine-structure constant, NIST, CODATA.

1. Nomenclature

The following are the symbols for the constants I shall use in this paper

\[ m_e \] = electron rest mass
\[ m_\mu \] = muon rest mass
\[ m_{\text{down}} \] = down quark nude mass
\[ m_{\text{charm}} \] = charm quark nude mass
\[ \alpha \] = fine-structure constant (atomic structure constant)
\[ F_{JMeV} = 1.602176564 \times 10^{-13} \frac{J}{MeV} \] (conversion factor)

2. The Masses of Leptons and Quarks

2.1 Leptons

The only leptons we refer to in this paper are the electron and the muon. The value of the muon rest mass, according to (CODATA 2010 [4]), is

\[ m_\mu = 1.883 \, 531 \, 475 \, (96) \times 10^{-28} \, Kg \] (CODATA 2010)

\[ m_\mu = 105.6586 \, MeV/c^2 \]

2.2 Quarks

Table 1 shows the mass of the quarks [1]
The last column of Table 1 shows two of the masses (in red) used in this paper. The masses shown in this column can be considered “calibrated” masses. It is worthy to observe that the mass of the down quark and the mass of the charm quark fall within the limits shown in the mass range column.

Down quark:
According Nakamura et al [2], the mass of the down quark is between 4.1-5.7 $MeV/c^2$
According Davies [3] the mass of the down quark is approximately 4.8 $MeV/c^2$

The value for the naked mass of the down quark we shall adopt will be

$$m_{down} = 1.066 \times 10^{-29} Kg$$

Considering the conversion factor, $F_{JMeV}$, we can express this mass as

$$m_{down} \approx 5.981 \times 10^{-27} MeV/c^2$$

Charm quark:
According Nakamura et al [1], the mass of the charm quark is 1.29+0.05-0.11 $GeV/c^2$
According to McNeile [4] the mass of the charm quark is 1273 (6) $MeV/c^2$

We shall adopt the following naked mass for the charm quark:

$$m_{charm} = 2.204 \times 10^{-27} Kg$$

Considering the conversion factor, $F_{JMeV}$, we can express this mass as

$$m_{charm} \approx 1236.862 \times 10^{-27} MeV/c^2$$

Table 1: The mass of quarks. The masses shown in red are the ones used in this paper.

<table>
<thead>
<tr>
<th>Quark Name</th>
<th>Symbol (Particle)</th>
<th>Symbol (Antiparticle)</th>
<th>Mass Range ($MeV/c^2$) (source Wikipedia)</th>
<th>Mass (used in this paper) ($MeV/c^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>up</td>
<td>$u$</td>
<td>$\bar{u}$</td>
<td>1.5 - 3.3</td>
<td>3.06</td>
</tr>
<tr>
<td>down</td>
<td>$d$</td>
<td>$\bar{d}$</td>
<td>3.5 - 6.0</td>
<td>5.98</td>
</tr>
<tr>
<td>strange</td>
<td>$s$</td>
<td>$\bar{s}$</td>
<td>70 - 130</td>
<td>107.56</td>
</tr>
<tr>
<td>charm</td>
<td>$c$</td>
<td>$\bar{c}$</td>
<td>1,160 - 1,340</td>
<td>1236.86</td>
</tr>
<tr>
<td>bottom</td>
<td>$b$</td>
<td>$\bar{b}$</td>
<td>4,130 - 4,370</td>
<td>4494.99</td>
</tr>
<tr>
<td>top</td>
<td>$t$</td>
<td>$\bar{t}$</td>
<td>169,100 - 173,300</td>
<td>173,180</td>
</tr>
</tbody>
</table>
3. The Formula for the Mass of the Electron

I shall derive a formula for the mass of the electron from the following two “calibrated” ratios

\[
\frac{m_{\text{down}}}{m_e} \approx \frac{5.98187 \text{ MeV/} c^{2}}{0.511 \text{ MeV/} c^{2}} \approx 11.7062 \quad (1)
\]

\[
\frac{m_{\text{charm}}}{m_\mu} \approx \frac{1236.86 \text{ MeV/} c^{2}}{105.6586 \text{ MeV/} c^{2}} \approx 11.7062 \quad (2)
\]

Considering that

\[
\frac{1}{\sqrt{\alpha}} = 11.70623761 \quad (3)
\]

According to “calibrated” expressions (1) and (2) I shall postulate that:

**Postulate**

the ratio between the mass of the electron to the mass of the muon equals the ratio between the mass of the down quark to the mass of the charm quark.

Mathematically this means that

\[
\frac{m_e}{m_\mu} = \frac{m_{\text{down}}}{m_{\text{charm}}} \quad (4)
\]

This formula is proposed as a true law of nature (not as a numeric formula). It is worthy to remark the symmetry shown by equation (4): the electron and the muon are the heaviest leptons of generations 1 and 2, respectively (*), while the down quark and the charm quark are the heaviest quarks from generations 1 and 2, respectively.

Solving equation (4) for \( m_e \) we can calculate the mass of the electron. The final equation is

\[
m_e = \left( \frac{m_{\text{down}}}{m_{\text{charm}}} \right) m_\mu \quad (5)
\]

(*) The electron neutrino and the muon neutrino are the lightest leptons of generations 1 and 2, respectively.
4. Calculation

Let us calculate the mass of the electron from equation (5)

\[ m_e = \left( \frac{1.066\ 366\ 008\ 609 \times 10^{-29}}{2.204\ 906\ 699\ 970 \times 10^{-27}} \right) \times 1.883\ 531\ 475 \times 10^{-28} \text{Kg} \]

The result of this calculation is

\[ m_e = 9.109\ 382\ 91 \times 10^{-31} \text{Kg} \]  \hspace{1cm} (R1)

5. The Measured Mass of the Electron

According to NIST [5], the measured value for the rest mass of the electron is

\[ m_{e\_exp} = 9.109\ 382\ 91(40) \times 10^{-31} \text{Kg} \]  \hspace{1cm} (CODATA 2010)

It is also customary to express the mass in \( \text{MeV} / c^2 \)

\[ m_{e\_exp} = 0.510\ 999\ 999\ \text{MeV} / c^2 \approx 0.511\ \text{MeV} / c^2 \]

6. Mass Comparison

Let us compare the theoretical value calculated in section 4 with the experimental counterpart from section 5. The following table contains both values to make the comparison easier

<table>
<thead>
<tr>
<th>Electron Mass (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured value ( m_{e_exp} ) (CODATA 2010 [5])</td>
</tr>
<tr>
<td>Theoretical value ( m_e ) (Formula 5)</td>
</tr>
</tbody>
</table>

Table 2: Comparison table.
4. Conclusions

The equation proposed in this paper involves the mass of four particles: two particles from generation 1 (the electron and the down quark) and two from generation 2 (the muon and the charm quark).

According to the values for the mass of the down quark, charm quark and muon, conclude that formula (5) reproduces the observed mass of the electron very accurately. (accurate to, at least, 8 decimal places). Formula (5) tells us that there is a profound mass relationship between quarks and leptons. I have already found a very accurate mass relationship between leptons and quarks when I proposed the formula for the mass difference between the neutron and the proton (A Simple Formula Suggests a Profound Mass Relation between Quarks and Leptons [6]). In conclusion, this researches reinforces the existence of a mass relationship between leptons and quarks.

REFERENCES
[2] K. Nakamura et al, Live Particle Summary 'Quarks (u, d, s, c, b, t, b', t', Free).
   Particle Data Group, (2011).