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_μ = muon rest mass
m_{down} = down quark nude mass
m_{charm} = charm quark nude mass
α = fine-structure constant (atomic structure constant)
$F_{JMeV} = 1.602\,176\,564 \times 10^{-13} \dfrac{J}{MeV}$ (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

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

$$m_\mu = 105.6586\, MeV/c^2$$

2.2 Quarks

Table 1 shows the mass of the quarks [1]

Quark Name	Symbol (Particle)	Symbol (Antiparticle)	Mass Range (MeV/c^2) (source Wikipedia)	Mass (used in this paper) (MeV/c^2)
up	u	$\bar{u}$	1.5 - 3.3	3.06
down	d	$\bar{d}$	3.5 - 6.0	5.98
strange	s	$\bar{s}$	70 - 130	107.56
charm	c	$\bar{c}$	1,160 - 1,340	1236.86
bottom	b	$\bar{b}$	4,130 - 4,370	4494.99
top	t	$\bar{t}$	169,100 - 173,300	173,180

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

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

$$m_{down} = 1.066\,366\,008\,609 \times 10^{-29}\,Kg$$

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

$$m_{down} \approx 5.981\,874\,871\,MeV/c^2$$

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:

$$m_{charm} = 2.204\,906\,699\,970 \times 10^{-27}\,Kg$$

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

$$m_{charm} \approx 1236.862\,004\,MeV/c^2$$

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

$$\frac{m_{down}}{m_e} \approx \frac{5.98187\ MeV/c^2}{0.511\ MeV/c^2} \approx 11.7062 \tag{1}$$

$$\frac{m_{charm}}{m_\mu} \approx \frac{1236.86\ MeV/c^2}{105.6586\ MeV/c^2} \approx 11.7062 \tag{2}$$

Considering that

$$\frac{1}{\sqrt{\alpha}} = 11.706\,237\,61 \tag{3}$$

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

$$\frac{m_e}{m_\mu} = \frac{m_{down}}{m_{charm}} \tag{4}$$

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

$$m_e = \left(\frac{m_{down}}{m_{charm}} \right) m_\mu \tag{5}$$

(*) 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)

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

The result of this calculation is

$$m_e = 9.109\,382\,91\,x\,10^{-31}\,Kg \qquad \text{(R1)}$$

5. The Measured Mass of the Electron

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

$$m_{e\_\exp} = 9.109\,382\,91\,(40) \times 10^{-31}\,Kg \qquad \text{(CODATA 2010)}$$

It is also customary to express the mass in MeV/c^2

$$m_{e\_\exp} = 0.510\,999\,999\,MeV/c^2 \approx 0.511\,MeV/c^2$$

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

	Electron Mass (Kg)
Measured value $m_{e\_\exp}$ (CODATA 2010 [5])	$9.109\,382\,91\,(40) \times 10^{-31}$
Theoretical value m_e (Formula 5)	$9.109\,382\,91 \times 10^{-31}$

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

[1] Wikipedia, retrieved form *http: //en.wikipedia.org/wiki/List_of_particles*, (2013)
[2] K. Nakamura et al, *Live Particle Summary 'Quarks (u, d, s, c, b, t, b', t', Free)*. Particle Data Group, (2011).
[3] C. T. H. Davies et al, Precise Charm to Strange Mass Ratio and Light Quark Masses from Full Lattice QCD. Physical Review Letters, (2010).
[4] C. McNeile et al., Phys. Rev. D82 (2010) 034512.
[5] NIST 2010, *Fundamental Physical Constants—Extensive Listing,* retrieved from http: //physics.nist.gov/constants, (2010).
[6] R. A. Frino, *A Simple Formula Suggests a Profound Mass Relation between Quarks and Leptons*, (2014).