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# Masses of Neutrons and Protons from Quarks

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**Abstract:** This is a modified version of the article [1] by reducing the text and the number of formulas. Also, the formulas are prepared here: so that the WolframAlpha [2] software accepts the shorter formulas and performs the calculations of the down and up quarks mass. In the previous article, only an assessment was given. Ruđer Bošković's Theory and the assumption of quantum changes at Bošković's non-cohesive limit were used.

**Key words:** Planck, Bošković, quark, neutron, proton

## Introduction

Quote:

*In quantum chromodynamics, the modern theory of the nuclear force, most of the mass of protons and neutrons is explained by special relativity. The mass of a proton is about 80–100 times greater than the sum of the rest masses of the quarks that make it up, while the gluons have zero rest mass. [3]*

Instead of the previous one: here we apply Ruđer Bošković's view on forces in nature [4]:

## Quark mass growth

We use Bošković's limit of non-cohesion – R, (in my earlier articles it is a generalized radius). Also: the mass of the particle - m, Fundamental mass - mf = 1.088621711E-28 kg and the limit of non-cohesion - $R_f$ = 3.231309*10-15m, determined in [5, f 3b and 4]. The limit of non-cohesion, at which the repulsive and attractive forces are equal, is represented by formula (1):

$$R = R_f * \sqrt{m / m_f} \qquad (1)$$

Let's denote: $l_{pl}$ and $m_{pl}$ the Planck length and mass, $m_o$ – quark rest mass $R_o$ the initial non-cohesive radius. ***Let's assume a quantum action at the limit of non-cohesion, by which we get an increase in mass Δm, (2):***

$$\Delta m = \frac{\hbar}{c * R_0} = \frac{m_{pl} * l_{pl} * c}{c * R_0} = \frac{m_{pl} * l_{pl}}{R_0} \qquad (2)$$

That is: $$m - m_0 = m_{pl} * l_{pl}/\mathrm{R}_0 \quad (3)$$

Or: $$m = m_0\left[1 + m_{pl} * l_{pl}/(m_0 * R_0)\right] \quad (4)$$

The product in parentheses can take values greater than and less than 1, which means that there are values of mo and Ro where this term is 1, and it is a hypothetical fundamental particle [5, f 11], for which formula (5) is valid:

$$R_f * m_f = l_{pl} * m_{pl} = 3.517672636 * 10^{-43} kgm \quad (5)$$

Thus thanks to (5), we can write [4] in the form (6):

$$m = m_0\left[1 + m_f * R_f/(m_0 * R_0)\right] \quad (6)$$

Let's further simplify and generalize formula (6), using (1) we get (7):

$$m = m_{-1} * \left[1 + \left(m_f^3/m_{-1}^3\right)^{0.5}\right] \quad (7)$$

Where "-1" in the suffix: generally indicates the previous mass, not only the initial mass.

Let's simplify further: if we divide the masses by $m_f$, we get smaller dimensionless values:

$$x = m/m_f \quad (8)$$

Then (7) becomes: $$x = x_{-1} + x_{-1}^{-0.5} \quad (9)$$

***The hypothesis is that two applications of (9) for the up and down quark give the constituents of the proton, which according to particle physics are two up, one down quark and a gluon.*** Here it is virtual gluon - g, (10):

$$p = 2 * u_2 + d_2 + g \quad (10)$$

Where the mass of the virtual gluon is from [6, f. 5b and Table 1], g = 2.106425172 *10-31 kg, which if it is not correct, formula (10) will not be confirmed.

***With the hypothesis that the third iteration gives a neutron, we obtain from the second iteration by formula (11):***

$$n = u_2 + u_2^{-0.5} + 2 * \left(d_2 + d_2^{-0.5}\right) \quad (11)$$

If we include from (10): $d_2 = p - g - 2*u_2$, we get:

$$n = u_2 + u_2^{-0.5} + 2 * [p - g - 2 * u_2 + (p - g - 2 * u_2)^{-0.5}] \qquad (12)$$

Where only $u_2$ is unknown, which we calculate with WolframAlpha software: $u_2 = 5.5794515$ (see Table). According to (9), $u_2$ is also:

$$u_2 = 5.5794515 = u_0 + u_0^{-0.5} + (u_0 + u_0^{-0.5})^{-0.5} \qquad (13)$$

Gde je $u_o$ jedino nepoznato što u WolframAlpha daje četri rešenja ( $x = u_o$ ):

Where $u_o$ is the only unknown that in WolframAlpha gives four solutions ( $x = u_o$ ):

$x \approx 0.03844903813293423$

$x \approx 4.675841705447708$

Complex solutions

$x = -0.4783911936163934 - 0.8659230281627739\, i$

$x = -0.4783911936163934 + 0.8659230281627739\, i$

We will consider the first solution $u_o = 0.038449$:

Since from (10):

$$d_2 = p - g - 2 * u_2 = 4.2037455 \qquad (14)$$

Also, as for the up quark, by (9) we get (15):

$$d_2 = 4.2037455 = d_0 + d_0^{-0.5} + (d_0 + d_0^{-0.5})^{-0.5} \qquad (15)$$

Where $d_o$ is the only unknown that in WolframAlpha gives four solutions, and the first solution is: $d_o = 0.076915$. Let's show all in the following Table:

**Table Proton and Neutron from quarks using the previous formulas**

| **Name** | **$m_o$ [kg]** | **$x_o = m_o/m_f$** | **$x_1=x_o+x_o^{-0.5}$** | **$x_2=x_1+x_1^{-0.5}$** | **$x_3=x_2+x_2^{-0.5}$** |
|---|---|---|---|---|---|
| g - gluon | 2,10642517200E-31 | 0,00193495 | WolframA | formula (14) | |
| f-fund. č. | 1,08862171145E-28 | 1,00000000 | 2,0000000000 | 2,7071067812 | 3,3148880433 |
| d-donji k. | 8,37317614644E-30 | 0,07691539 | 3,6826468737 | 4,2037455400 | 4,6914781461 |
| u-gornji k. | 4,18564576958E-30 | 0,03844904 | 5,1382973662 | 5,5794515302 | 6,0028060936 |
| p-proton | 1,67262192369E-27 | **15,364583547** | **$2*u_2+d_2+g=$** | **15,364583547** | |
| n-neutron | 1,67492749804E-27 | **15,385762386** | | **$u_3+2*d_3=$** | **15,385762386** |
| **D = d/u** | **2,0004502548** | | masses [kg] | 1,67262192369E-27 | 1,67492749804E-27 |

=

Where red colored results are obtained by: WolframAlpha and brown with formula (14). Of course, by checking it can be shown that the same results will be obtained with formula (9), that is, with the formulas in the header.

If we multiply the values in the Table by $m_f$, we get the masses in [kg], for quarks (in the $m_o$ column) and the proton and neutron (bottom right), from where we see that they are the same as in the $m_o$ column, where the data is from [7]. Thus: the proposed hypotheses were confirmed. The mass ratio of the up and down quark D was also determined. Note that for g = 0, it is not possible to obtain the above results from [3].

# Conclusion

The rest mass of the up and down quarks and the formulas for the proton and neutron from the masses of the quarks are obtained;

It is shown that: there are 2 real and 2 complex solutions for the masses of up and down quarks at rest, which by applying (9) all give the masses of protons and neutrons;

The obtaining procedure and formulas explain why the masses of the proton and neutron are much greater than the rest mass of the quarks that make it up.

# References:


[1] Branko Zivlak, Masa Neutrona iz Masa Kvarkova, Kako? https://www.gsjournal.net/Science-Journals/Research%20Papers/View/8398

[2] https://www.wolframalpha.com/

[3] https://en.wikipedia.org/wiki/Proton

[4] Boscovich J. R.: (a) "Theoria philosophia naturalis redacta ad unicam legem virium in natura existentium", first (Wien, 1758) and second (Venetiis, 1763) edition in Latin language; (b) "A Theory of Natural Philosophy", in English, The M.I.T. Press, Massachusetts Institute of Technology, Cambridge, Massachusetts and London, England, first edition 1922, second edition 1966.

[5] Branko Zivlak, Fundamental Particle, https://vixra.org/abs/1312.0141

[6] Branko Zivlak, Од Бита До Бозона, https://www.gsjournal.net/Science-Journals/Essays-Mathematical%20Physics/Download/9051

[7] https:// CODATA Internationally recommended 2018 values of the of tehe Physical Fundamental Constants, https://physics.nist.gov/cuu/Constants/index.html