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The Empirical Rule for Calculating the Electric Charge of Elementary Particles

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Abstract

The empirical rule for calculation of electric charges of the elementary particles is offered. The given rule contains two parameters: full number of colors N_c of which color of the given particle is formed and a color index L - number of colors which the given particle possesses. The offered rule allows calculating electric charges of all elementary particles - leptons, quarks and intermediate vector bosons.

Keywords: *Elementary Particles, Leptons, Quarks, Intermediate Vector Bosons*

1. Introduction

As is well known [1] without antiparticles experimentally opened 12 fermions (6 leptons and 6 quarks) and 4 intermediate vector boson: carrier of strong interactions (gluon-g), carrier of electromagnetic interactions (photon -γ), and carriers of weak interactions (the neutral weak boson Z^0 and charged weak bosons $W^{\pm}$, which are the antiparticles to each other). All these particles are elementary, *i.e.,* at the present level of knowledge they do not consist of more elementary particles. Symbols designations and electric charges Q (in units of elementary charge) of these particles are shown in **Table 1**.

In this paper we propose a generalized empirical rule for calculating the electric charges of all elementary particles - leptons, quarks and intermediate vector bosons.

2. Some Preliminary Remarks

As far as we know, currently there is no generalized rule for calculating the charge of all elementary particles, *i.e.* quarks, leptons and intermediate bosons. There is only a generalized formula of Gell-Mann-Nishidzhimy [2], whereby the electric charge of quark (in units of elementary charge) is expressed through the internal quantum numbers

$$Q = I_z + (B+S+C-b+t) \tag{1}$$

which define the so-called flavor quark. Here, I_z - the projection of the isotopic spin I, B - baryon number, S - strangeness, C - charm, b - beauty, t - the truth quark. Doubled value of the second term $Y = B + S + C - b + t$ is called hypercharge. The values of quantum numbers and the resulting electric charge of quarks are given in **Table 2**.

In the electroweak theory introduces the concept of "weak hypercharge" Y^w distinguishing leptons left and right helicity. At the same time $Y_L^w = -1$ for the "left" leptons and $Y_R^w = -2$ for the "right" leptons. Such introduction of the weak hypercharge and the assumption

Table 1. Elementary particles

Particles		Symbols designations			Q
Leptons	upper row	ν_e	ν_μ	ν_τ	0
	bottom row	e	μ	τ	–1
Quarks	upper row	u	c	t	+2/3
	bottom row	d	s	b	–1/3
Bosons	upper row		γ, Z^0		0
	bottom row		g		0
			W		±1

Table 2. Characteristics of quarks

Aroma of quark	B	I	I_z	S	C	b	t	Q
u	1/3	1/2	+1/2	0	0	0	0	2/3
d	1/3	1/2	–1/2	0	0	0	0	1/3
c	1/3	0	0	0	1	0	0	2/3
s	1/3	0	0	-1	0	0	0	–1/3
t	1/3	0	0	0	0	0	1	2/3
b	1/3	0	0	0	0	1	0	–1/3

that the isotopic spin $I = 1/2$ for the "left" lepton and $I = 0$ for the "right" lepton can be used to calculate the charge leptons the same formula as for hadrons:

$$Q = I_z^w + \frac{Y^w}{2}, \tag{2}$$

where I_z^w — the third component "of the weak isotopic spin" of the "left" leptons ($I_z = -1/2$ for e_L^- and $I_z = 1/2$ for ν_{eL}).

In [3] proposed a formula whereby the electric charge of quark (in units of elementary charge) is expressed through the number of colors N_c:

$$Q = \frac{1}{2}\left(\frac{1}{N_c} \pm 1\right), \tag{3}$$

where the plus sign corresponds to the upper line of quarks (*u, c, t*) and the minus sign corresponds to the bottom line of quarks (*d, s, b*). Given $N_c = 3$ we obtain $Q = +2/3$ for quarks of upper line and $Q = -1/3$ for quarks of bottom line.

3. Proposal Rule

The Formula (3) allows calculating of electric charges only for quarks. We propose a generalized rule that the electric charge of quarks, leptons and intermediate bosons is expressed in terms of the number of colors N_c (which make up the color of a given particle), the color index L (number of colors which the given particle possesses) and is given (in units of elementary charge) by the formula:

$$Q = \frac{N_c - 3}{6} + \frac{1}{2}\left(\frac{L}{1 - L + N_c} \pm 1\right). \tag{4}$$

Here, L- is a certain color index, which is set $L = 1$ in the presence of one color, $L = 2$ in the presence of two color and L=0 in the absence of color of the particles. Plus sign corresponds to quarks and leptons of the upper line ($u, c, t, \nu_e, \nu_\mu, \nu_\tau$), and the minus sign corresponds to quarks and leptons of the bottom line (d, s, b, e, μ, τ). If we assume that the leptons are colorless, *i.e.* for them $L = 0$ and $N_c = 0$, then from Formula (4) we obtain $Q = 0$ for leptons the upper line (plus sign) and $Q = -1$ for leptons bottom line (minus sign). For quarks $L = 1$ and $N_c = 3$. In this Formula (4) coincides with Formula (3) and for the charge of quarks we obtain the above values.

Equation (4) also allows us to calculate the electric charges of the intermediate vector bosons γ, Z^0, W^- and g. When $L = 0$ and $N_c = 0$ Formula (4) gives the value of $Q = 0$ and $Q = -1$, respectively for the intermediate bosons γ, Z^0 (plus sign) and W^- (minus sign). A gluon electric charge $Q = 0$ is obtained from (4) with the sign "minus" in parenthesis, if we assume that $L = 2$ and $N_c = 3$, since the gluon is not one, but two color index.

In conclusion, we note that the electrical charges antileptons, quarks and W^+ boson can also be calculated by Formula (4), taken with opposite sign.

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