Theoretical approach in real space to the masses of protons and neutrons

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Theoretical approach in real space to the masses of protons and neutrons*

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Abstract

We make the hypothesis that our universe is threedimensional and curved, hence our universe may be embedded in a fourdimensional Euclidean space where the four dimensions are (x, y, z, t). The fourth dimension is time t which is treated like a spatial dimension. Straightforwardly, this Euclidean space has an underlying hypersquare array for which the edges have a width of one Planck length. The eigenfunctions of each edge of this array are $\sqrt{2}exp(ix_i)$ where $x_i = x, y, z$ or t. As previously published, the quarks are threedimensional in real space. The quark up has a mass of $2^{21}eV/c^2$ and the quark down $2^{22}eV/c^2$ (the quark down is an excited state of the quark up). Because the quark up is threedimensional (like the apex of a tetrahedron), each edge of the quark has an eigenvalue of $2^7 eV/c^2$. Let us consider that the color charge of the gluons are in fact the coordinates in real space (x: red; y:blue; z: green). The gluons have no mass so they have no temporal dimension. Each pair of quarks, share one gluon (the gluons interfere with the quarks edges).Gluons are bosons and quarks are fermions so for each edge of the underlying array (except the temporal edges) we calculate the ground states. In one proton or in one neutron, there are 3 gluons and 3 quarks; as only the temporal edges of the 3 quarks are not in the ground states and because the protons and neutrons obey the Schrödinger equation, the masses of the proton or neutron are equal to $2^{30}/\ln(\pi)eV/c^2 = 937MeV/c^2$. The difference between the masses of the proton and neutron comes from the difference between the experimental masses and the theoretical masses of quarks up and down. Straightforwardly, we found theoretical values of the masses of protons and neutrons within 2% of the experimental values of the masses of protons and neutrons.

Keywords: real space theory, theoretical mass of protons, theoretical mass of neutrons

1. Introduction

The masses of protons and neutrons remained a long time without a theoretical explanation to their value. Protons contain 2 quarks up and 1 quark down, while neutrons contain 1 quark up and 2 quarks down. There are also 3 gluons within protons and neutrons, these gluons carry the strong force. The experimental mass of protons is equal to $938.2720MeV/c^2$, while the experimental mass of neutrons is equal to $939.565MeV/c^2$.

Indeed, knowing the masses of quarks up and down and also knowing that the gluons have no mass, the mass of a proton (resp. neutron) cannot be explained by simply adding the masses of quarks up and down.

In order to give a theoretical explanation to the masses of protons and neutrons, I will use the same approach in real space than the calculation of the masses of the 3 families of elementary fermions [1–3].

I make the assumption that our threedimensional universe is embedded in a four dimensional euclidean space. Time is a function of the fourth dimension of this space [4–6]. Moreover,the following items have been found in previous articles [1–3] and will be used to calculate the masses of protons and neutrons:

- Calculation of particles masses in the (x,y,z,t) spacetime

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quark	Theoretical mass (eV/c^2) [1–3]	Experimental mass (eV/c^2) [7]
up	$2^{21} = 2.09Mev/c^2$	$2.2MeV/c^2$
down	$2^{21}.2^2/2 = 4.19MeV/c^2$	$4.7MeV/c^2$

Table 1: Theoretical and experimental masses of the quarks up and down.

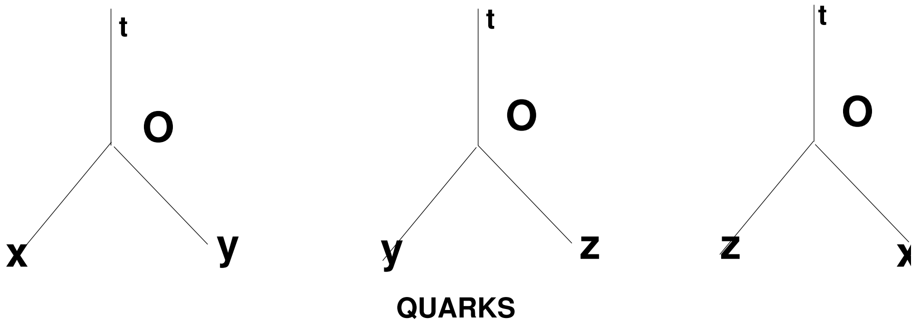

Figure 1: Geometry of quarks

- Time is equivalent to a space dimension (except that it is not possible to go backwards in time)

- Spacetime has an underlying hypersquare array of edge length $\hbar$

- Eigenfunctions (in (x, y, z, t) space) of this hypersquare array (reduced parameters) are $\sqrt{2}exp(ix)$ for space, $\sqrt{2}exp(it)$ for time (the eigenvalues of these eigenfunctions are equal to $\sqrt{2}$ in the ground states)

- Eigenvalues for excited states of these eigenfunctions equal to $p^2/2$ (with p an integer number)

With these items, we found the masses of the first family of elementary fermions which are equal to integer powers of 2 (in eV/c^2) [1–3]. The masses of elementary fermions which belong to the 2nd and 3rd family of fermions are excited states of the elementary fermions of the first family; thus these particles masses are multiplied by $p^2/2$ with respect to the masses of the first family of elementary fermions (with p an integer) [1–3].

In the following section, I will present the hypotheses for quarks, gluons and protons and neutrons. This leads to the theoretical value of the mass of protons which equals $937MeV/c^2$. The theoretical value of the mass of neutrons is found to be less than 2% larger than the experimental value.

2. Hypotheses

2.1. Quarks

I present here the hypotheses for quarks.

- quarks up and down are 3d [8]
- quarks are fermions
- quarks obey the Dirac equation
- the color charge of one quark for example (t, x, y) is blue, (t, x, z) is green and (t, y, z) is red (x: red; y:green ; z : blue)

Because the quark up is threedimensional (like the apex of a tetrahedron, see figure 1), each edge of the quark has an eigenvalue of $2^7 eV/c^2$ indeed the mass of the quark up is equal to $2^{21}eV/c^2$ (see table 1). The experimental masses of quarks up and quarks down are larger than the theoretically found values of their masses (see also table 1). This will explain the mass difference between protons and neutrons.

2.2. Gluons

I present here the hypotheses for gluons which carry the strong force within protons and neutrons nuclei.

- Gluons are 2d
- The gluons have no mass so they have no temporal dimension
- gluons are bosons

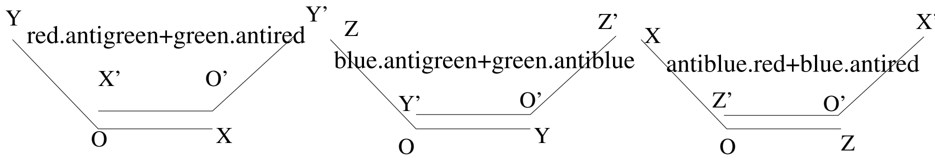

Figure 2: Geometry of gluons

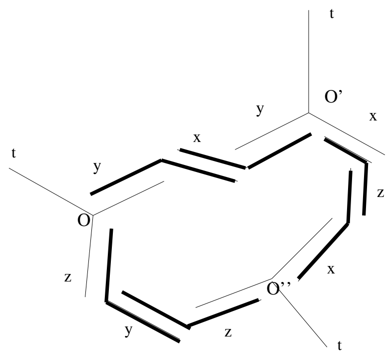

Figure 3: Geometry of protons or neutrons: thin lines represent quarks and bold lines represent gluons

- gluons obey the Klein-Gordon equation
- The color charge of gluons are in fact the coordinates in real space (x: red; y:green ; z : blue); see figure 2. For the coordinate x, red corresponds to a vector $\mathbf{OX}$ and antired to its opposite, the vector $\mathbf{X'O'}$. For coordinates y and z respectively , the same applies with $\mathbf{OY}$ (resp. $\mathbf{Y'O'}$) and $\mathbf{OZ}$ (resp. $\mathbf{Z'O'}$).

2.3. Protons and neutrons

Protons and neutrons obey the Schrödinger equation. The Schrödinger equation writes [9]:

$$\frac{\hbar^2}{2m}\nabla^2\psi(x, t = 0) = \frac{\hbar}{\omega}\frac{\partial^2}{\partial t^2}\psi(x = 0, t) \tag{1}$$

this leads to

$$\pi\psi(x, t = 0) = \psi(x = 0, t) \tag{2}$$

(in normalized units $m = 1$, $\hbar = 1$, $\omega = 2\pi\nu$ with the frequency $\nu = 1$) . This leads to

$$\pi \exp(ix) = \exp(it) \tag{3}$$

and finally to

$$x = t/\ln(\pi) \tag{4}$$

This last equation gives the relation between time t and spatial dimensions (for example x) when calculating the masses of protons and neutrons.

This relation is not valid for quarks as these last do not obey the Schrödinger equation but the Dirac equation. Because gluons have no mass, this relation is not valid when calculating the eigenvalues of gluons.

3. Calculations of the masses of protons and neutrons

In one proton or in one neutron, there are 3 gluons and 3 quarks. Each pair of quarks share one gluon (the gluons interfere with the quarks edges), see figure 3. The quarks are represented by thin lines and gluons by bold lines.

Gluons are bosons and quarks are fermions so each edge of the underlying array (except the temporal edges) is in the ground state because quarks and gluons interfere on these edges. The eigenvalue of each spatial edge of the quarks is equal to $\sqrt{2}eV/c^2$. There are 6 spatial edges of the quarks in one proton or one neutron (there are 6 thin segments within quarks with a spatial dimension: see figure 3). This gives a spatial eigenvalue equal to $\sqrt{2}^6 = 2^3 eV/c^2$ for the 3 quarks. The eigenvalue of each edge of gluons is also equal to $\sqrt{2}$ (each bold segment , within gluons, has an eigenvalue equal to $\sqrt{2}$, see figure 3). Because there are 4 edges within one gluon, each gluon has an eigenvalue equal to $\sqrt{2}^4 = 2^2 eV/c^2$. There are 3 gluons in one proton or one neutron so the eigenvalue for the 3 gluons is equal to $2^6 eV/c^2$.

Only the temporal edges of the 3 quarks are not in the ground states, moreover the temporal eigenvalues are equal to $(2^7)^3/\ln(\pi)$ (see section 2.1 and equation 4) because there are 3 temporal edges of the quarks: 3 thin segments in figure 3. So the masses of the proton or neutron are equal to $(2^7)^3.(2^6).(2^3)/\ln(\pi) = 2^{30}/\ln(\pi)eV/c^2 = 937MeV/c^2$ (we multiply all the eigenvalues of quarks and gluons). This value is close to the experimental values of the masses of protons and neutrons: $938.2720MeV/c^2$ for protons and $939.565MeV/c^2$ for neutrons.

Theoretically, protons and neutrons have the same mass. However, , the experimental mass of quarks up is equal to $2.2MeV/c^2$ and the experimental mass of quarks down is equal to $4.7MeV/c^2$ (see table 1). So, the experimental temporal edge for the quark up has an eigenvalue equal to $(2.2.10^6)^{1/3} = 130.059eV/c^2$ and the experimental temporal edge for the quark down has an eigenvalue equal to $(4.7.10^6/2)^{1/3} = 132.95eV/c^2$. So the mass ratio between protons (2 quarks up and 1 quark down) and neutrons (1 quark up and 2 quarks down) is equal to $130.059/132.95 = 0.978\%$.

4. Conclusion

We found theoretically the value of the mass of the proton which is equal to $937MeV/c^2$. This value equals the experimental value within 0.1 % . The theoretical value of the mass of the neutron is included between $937MeV/c^2$ and 937/0.978=958MeV/c^2 which equals the experimental mass within 1.02%.

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