Correlation of Nucleon Mass with Lepton Mass

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One of the key questions of elementary particles physics is the mass relation between leptons and nucleons or quarks. Leptons in many hadron decays and interactions show a typical energy of 53 MeV. Explicit numbers of these electrons accommodated in a quark fit the observed mass and charges of quarks and nucleons. The model further is shown to have exactly and only three different variations for quarks, the colors.

The success of QED and QCD in describing interactions of elementary particles and in predicting results of measurements performed with quantum-wave particles is unquestioned. Still missing, however, is a physical description or model of the elementary properties, e.g. the "color" of a quark or the "charge" of a quark or of an electron. A quantum reality[1] is searched for which could e.g. reduce the number of elementary constants (now approx. 20) or reduce the number of elementary forces. If it could solely be achieved to correlate properties like masses of the electron and nucleons, it would be regarded as major progress[2,3].

There are some models to unify leptons and quarks by a preon or rishon model. The "rishon" model of H. Harari[4] tried to explain all elementary particles as compositions of three rishons and their antirishons. A similar preon - model of Salam and Pati[5] consists of “somons”, “flavons” and “chromons” with several variations and electrical charges between +/-1/2 and +/- 1/6. These models, however, open a new and complicated "particle zoo" instead of simplifying physics. Both models have not overcome the "mass paradox", i.e. that the sum of all rishon/preon masses does not fit to the sum of the constituents plus the corresponding binding energy.

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A clue for a step towards a correlation between hadrons and leptons could be certain particle reactions, where electrons and even neutrinos of up to 53 MeV are produced[6] - e.g. the pion/myon decay. Usually it is denied that nucleons or mesons really "contain" electrons[7], but these high energy leptons have little in common with charge clouds that form the orbit around a hydrogen atom. A highly energetic and agitated state is expected to be the result of the decay of the two-quark pion. What, if nucleons and pions really contain 53 MeV leptons? It is remarkable that eighteen times 53 MeV approximately gives the nucleon mass.

Quark and Nucleon mass

As a working hypothesis for the structure of a quark a single spherical quantum wave is assumed. It should have a mass of around 300 MeV, a spin, show exactly three different configurations, the "colors", and should exhibit the well known +/-1/3 or -/+ 2/3 charges. A single quark then would be an unstable rotating (spin) spherical wave aggregate; two of them should form the relatively stable pions. Three of them each form the proton with 938 MeV and the neutron with 940 MeV. The particle decays and reactions of course would have to be the ones successfully described by QCD and QFT.

The nucleon consists of three quarks. 3 times 6 = 18 of these 53 MeV leptons amount to 954 MeV which is very close to the proton mass; six 53 MeV leptons therefore might generate or inhabit one quark of 318 MeV, e.g. orbiting each other in the spherical wave. In an atomic nucleus, 8 MeV are necessary for removing one nucleon[8]. Applying this binding energy also to a quark, this would give a total binding energy of 2 * 8 MeV to remove two of three quarks. 954 MeV minus binding energy now should give the nucleon mass:

$$\mathbf{6 * 3 * 53\ MeV - 2 * 8\ MeV = 938\ MeV - qed.}$$

The free neutron, as it is unstable, simply would have to have a slightly smaller binding energy of 7 MeV per quark to yield the observed 940 MeV.

This approach for the first time would correlate lepton mass with nucleon mass. The question is, why and how exactly six lepton orbits should be accommodated in the quark. The poles of a spherical wave are crossed diagonally by one lepton each and this scheme can be applied to every crossover of a meridian crossing the equator or another meridian as shown in Fig. 1. Exactly and only six different and independent orbits of this type can be drawn in and are given as single, double and triple lines and as solid or broken lines, respectively, comparable to the Pauli Exclusion Principle.

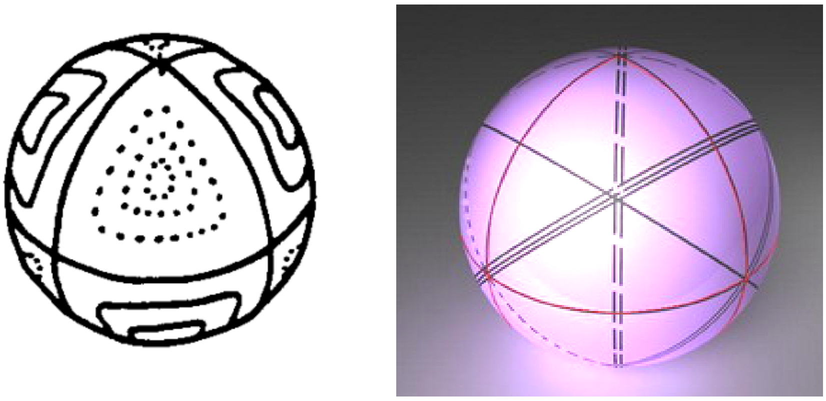

Fig. 1: The quark as spherical wave. Left: quantum wave by Herbert[10]; right: spherical wave occupied with six individual orbits

If each of these orbits is occupied with only one lepton they form a quark. Filling each orbit with a lepton pair with antiparallel spin, then twelve leptons minus binding energy would give a two-quark particle with much higher stability, e.g. a pion. The two-quark pions, e.g. the u-d-bar, then consist of 2*6 = twelve high energy leptons. The pion mass of only 135 to 140 MeVs hardly fits into the 318 MeV scheme per quark - they should have a mass of 636 MeV minus some binding energy. But three quarks perfectly form the stable nucleon with a reasonable binding energy; hence the naked quark is completely unstable and never has been observed alone. A two quark pion is fully charge- and spin compensated and therefore it is relatively stable. Höfling[9] attributes the total spin compensation to spin 0 to a very high binding energy between the two quarks and explains the low pion mass in this way, too. The simplest second generation particles - the negative and positive myons - have a mass of 106 MeVs, exactly twice that of the high energy nucleus electron.

Quark partial charges and colors

To account for the quark charges of -1/3 and +2/3 of the elementary charge it was tried to find a scheme where the electric charge of these particles could be formed by a composite, which contains common fractions of the total electrical field ranging from - 2/3 over - 1/3 to + 1/3 and +2/3 charges. The system then accommodates the seven possibilities from -3/3 to + 3/3, as given in table 1:

e^-	u-bar	d-quark	neutral	d-bar	up-quark	e^+
-3/3	-2/3	-1/3	0	+1/3	+2/3	+3/3

Table 1 Scheme of leptons and quarks sorted by their charges

The simplest spherical wave to fit these seven variations is the same sphere as in Fig. 1 divided into 8 quadrants by two meridians and one equator. This version of the wave function often is shown as agitated state of a spherical quantum wave - e.g. as described by Herbert[10].

The -1/3 and + 2/3 charges can be built with the common factor of +/-1/6 elementary charge per quadrant. The $1/6^{th}$ charge also is a component of the model of Salam and Pati[11]. A sphere with three positive and five negative 1/6 charged quadrants has a total balance of 3/6 -5/6 = -2/6 = -1/3, which corresponds to the charge of the down-quark. A sphere with 2 negative and 6 positive quadrants has 6/6 -2/6 = 4/6 = + 2/3 charge and relates to the up-quark charge. An antiquark easily is identified as having e.g. five positive and three negative quadrants to form the anti-down-quark or d-bar. Two positive and six negative fields can then form the -2/3 charge of the anti-u / u-bar.

This result with a well known oscillation state of a spherical wave now would have to account for the three colors of the quarks. There are many possible permutations how the eight quadrants can be polarized in groups of six positive and two negative or three positive and five negative quadrants. A simple scheme consisting of a table of the 8 quadrants of the down quark was drawn, where every possible combination of 3+ and 5- segments is indicated. Table 2 represents the first combinations. The upper row shows the "northern" hemisphere opened like a world map, the lower row the "southern" hemisphere. Imagining a ball with three positive fields on the northern hemisphere, number 2 and number 3 are equal to number 1 by rotation, no. 5 equals no.1, looking on the pole, too and so on.

1	2	3	4	5	**6**	7	....	**14**
+ + + -	+ + - +	+ - + +	- + + +	+ + - -	+ - + -	+ - - +	....	+ - + -
- - - -	- - - -	- - - -	- - - -	+ - - -	+ - - -	+ - - -	....	- + - -

Table. 2: The first possible combinations of segment polarities of the d-quark.

It is found that only three different versions of the down quark exist, all variations can be rotated into one of the marked three arrangements of table 2. The bold marked variations cannot be derived by rotation or symmetry from each other.

Fig. 2 shows the three – dimensional schematic of the identified d-quark versions.

Fig. 2: The three possible configurations of the Down – Quark.

The same procedure was performed on the up-quark with two "-" and six "+" fields. Again, only three variations were found, which cover all possible permutations of the 2/6 quark.

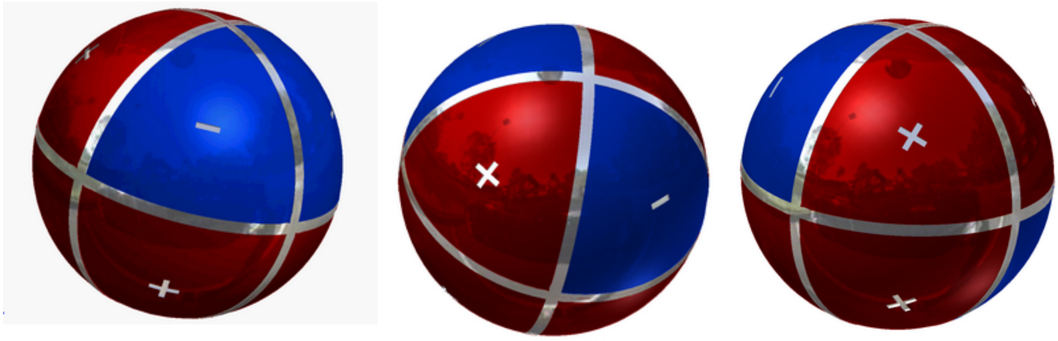

Fig. 3: The three possible configurations of the Up-Quark.

These three and only variations can be christened red, green and blue and perfectly match the three different colors in which the quarks are known. With these three variations the current model easily can explain the three colors of the quarks in QCD. The colors were originally introduced to avoid a violation of the Pauli Exclusion Principle and can now be simplified from a theoretically required, abstract quantum number to a real variation of quadrant polarity distribution. With this success of the concept to explain charges and colors, one quark can be regarded as sphere of waves with eight quadrants with specific polarities of 1/6 e each.

The other combinations of field distributions of the eight quadrant spheres now consist of:

Number pos. 1/6th charges	1	2	3	4	5	6	7
number neg. 1/6th charges	7	6	5	4	3	2	1
charge	- 6/6	- 4/6	- 2/6	0	+ 2/6	+ 2/3	+ 6/6
Resulting charge	- 1	- 2/3	- 1/3	0	+ 1/3	+ 2/3	+ 1
particle/quark - type	e^-	u-bar	d	ν	d-bar	u	e^+

Table 3: first generation particles

The simplicity of this scheme is appalling. With all variations of a simple agitated state of a spherical wave, the basic elementary particles - as taking part in hadron reactions - can be described. With a 1:7 ratio of positive and negative quadrants, even an electron- and a positron - like quark can be identified. It is not assumed that the normal state of the free electron always is of this type, but definitively a state of the spherical quantum wave the electron could obtain at high energies can be composed in this way. The neutrino also is known to be emitted with energies up to 53 MeV. The +4/6 -4/6 sphere then could be called a neutrino-like quark. It should also be able to emit photons until it achieves the "hardly visible" status known as neutrino.

These quark-like leptons are emitted as highly energetic beta - particles from the nucleus in a decay process. They stepwise achieve lower energetic states by photon emission until they can be regarded as "normal" free leptons. This radiation is observed as the Cerencov radiation[12]. The process can be visualized as in Fig. 4:

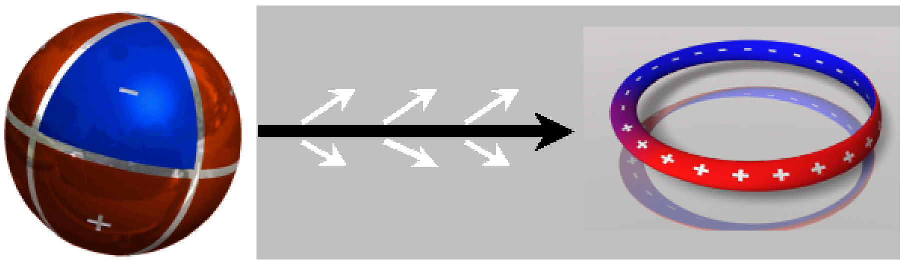

Fig. 4 Schematic decay of the 7/1 or positron quark into the free positron

Nucleon Composition

These quantum wave spheres now should form the known particles. The proton (uud) would consist of:

Particle	u	+	u	+	d	=	charge = + 1
+ charged quadrants	6/6	+	6/6	+	3/6	=	15/6
- charged quadrants	-2/6	-	2/6	-	5/6	=	-9/6
sum charge						=	**1**

The partial charge balance of the neutron n = udd would be:

particle	u	+	d	+	d		charge = 0
+ charged quadrants	6/6	+	3/6	+	3/6	=	+12/6
- charged quadrants	-2/6	-	5/6	-	5/6	=	-12/6
sum charge						=	**0**

Open is still, in which manner the three quark spheres interact to form a nucleon. Three spheres grouped together by electrostatic forces do not fit to the extremely strong color forces observed - and the single quarks never have been observed alone.

Within the proton and the neutron the distribution of the electric field and the corresponding magnetic field should be visible depending on the radius and it should represent the different kind of quarks and their spin. The internal charge distribution of the nucleons found in the 50ies by Hofstadter et al. [13,14] would suggest three spheres nested one within the other and thus continue the self – similar structure of the electron shell of the atom, the shell – like structure of atomic nuclei to a shell structure of the nucleons themselves.

There are six 53 MeV leptons per quark, as only six different stable orbits per sphere are possible. A total of six leptons passing 4 fields per revolution gives 24 fields. The proton consists of 3 quarks with 8 quadrants each, i.e. 24 fields, too, which could in some way account for the high stability of the proton. Of these 24 fields there are 15 positively and 9 negatively charged quadrants. There is a balance of +15 - 9 = 6 positive fields in excess. As the total proton charge is + 1 e, the assumed charge per quadrant of 1/6 e per field is confirmed. The fractional charge per quadrant could be interpreted like in quantum mechanics, where charge often is supposed to be shielded by virtual electron positron pairs. Due to the high energy of the particles concerned, the shielding should be significant and yield the 1/6 total visible charge per quadrant of the quark. The orbiting leptons also could partly compensate the fields of each other[11], so that the average field gives one sixth e per quadrant.

Example reactions

The reactions or decay processes of elementary particles shall - of course - be met by the model. One of the best known examples is the decay of the free neutron[15]:

	n		→		p^+		+	e^-	+	ν_e
u	d	d	→	u	u	d	+	e^-	+	ν_e
+6/6	+3/6	+3/6	→	+6/6	+6/6	+3/6	+	1/6	+	-4/6
-3/6	-5/6	-5/6	→	-2/6	-2/6	-5/6	-	7/6	+	+4/6
	+12/6		→		+15/6		+		(-3/6)	
	-12/6		→		- 9/6		-		(+3/6)	

This is not only a charge balance fitting accidentally or by implication, but quantitatively gives the positive charge balance and the negative balance. Additionally, the model shows the necessity for the reaction to emit the neutrino for the individual charge balance of each polarity.

The proton--> neutron reaction in nuclear fusion is:

u	→	d	+	e^+	+	ν_e
6/6	→	3/6	+	7/6	+	(-4/6)
- 2/6	→	- 5/6	-	1/6	–	(+4/6)

Again, the charge balance per polarity is met and the neutrino emission is predicted as necessary not only for momentum conservation, but also for lepton charge conservation.

One example reaction already mentioned is the decay of a (140 MeV plus impulse) pion (u d-bar) into a myon (106 MeV) and a myon - neutrino and the subsequent myon decay into a positron, an anti - myon – neutrino and an electron - neutrino (overall reaction):

u	+	d-bar	→	ν_μ	+	ν_μ-bar	+	ν_e	+	e^+
+6/6	+	5/6	→	+4/6	+	(-4/6)	+	4/6	+	7/6
-2/6	-	3/6	→	-4/6	-	(+4/6)	-	4/6	-	1/6

The positron charge here is identified as +7/6 and -1/6 quark type particle. The antineutrino has to be added with inverted polarities to account for the charge and spin balance and the total balance perfectly matches. It is confirmed again that a beta particle resulting from a nuclear or high energy particle reaction can be described as a agitated spherical wave with -/+ 7/6 and +/-1/6 charge and that a high energy neutrino can be described as +4/6 and -4/6 = neutral quark. The law of charge conservation obviously is valid also for the 1/6th charge fields for each polarity separately.

Outlook for quantum mechanics

This approach correlates lepton mass with nucleon mass. It also reveals the historical difficulties, as not the ratio of (0.51/938) MeV, but a very specific high energy state of the lepton of (53/938) MeV is relevant. We have a model that accounts for the 1/3 charges and the three colors of the quarks with a well known and simple state of a spherical wave with different field polarities in eight quadrants. Higher generation leptons and quarks are presumed to be excited states of first generation leptons and quarks, as also postulated by Harari, ref. [16].

The charge of the quark is the sum of the electromagnetic field components of high energy leptons in eight quadrants. It is postulated that the constituents of the quark – the above mentioned high energy electrons and positrons – on their orbits within the quark have their fraction of the total charge located in one quadrant field of the sphere and the remaining fields compensate each other inside or on the backside of the sphere. All first generation particles relevant in hadron reactions can be derived from the possible variations of the polarity. The neutrino-quark is identified as particle of a structure equivalent to the nucleon electron. Its occurrence is demanded also for local charge balance, not only for momentum conservation.

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