The Quantization of Material Elementary Particles and Application to the Neutron and Proton

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Abstract

A previous mode of particle quantization is recalled. Its rules are formulated and applied to the explanation of the mass and magnetic moment of both nucleons. The mechanism of neutron decay $n^0 \longrightarrow p + e^- + \nu_e + W$ is described as the spontaneous transformation of its quantized structure (n^0) into that of the proton (p) with the emission of an electron.

Key words: mass quantum, neutron, proton, electron, spin, magnetic moment, charge, particle stability

1. PRELIMINARY

One of the most puzzling problems in elementary particle physics is the apparent disorder in the scale of masses. Many masses are known with an absolute error less than 1 MeV, and a number of them are even determined to a high degree of precision (five to seven significant figures).[1]

We do not believe that the quark model provides the ultimate solution to the problem of accurately predicting these masses. Not only are quarks not observable, the estimation of their presumed masses is so crude (20% uncertainty[1]) that one does not see how it could lead, for example, to the measured mass ratio[1] $m_p/m_e = 1836.152\,701\ (100)$.

The same may be said relative to the neutron and all the other stable particles. The nucleons pose the additional problem of their magnetic moments. The current theory calls them anomalous, because instead of one nuclear magneton (for the proton) and zero (for the neutron, which, owing to its electric neutrality and in agreement with the laws of quantum mechanics, should not possess such a moment), the experiments reveal quite different values, that is, $2.79 \ldots \mu_N$ and $-1.91 \ldots \mu_N$, respectively.

We claim that all these questions may be more satisfactorily answered in the frame of a model where mass is quantized. One of the authors[2] published such a model in order to explain quantitatively the masses and magnetic moments of nucleons. That quantization was further extended to other particles[3–5]; a later paper appeared about nucleons.[6] To our knowledge, treatises or reviews in English about the physics of particles make no mention of these papers; hence we have asked for a recall in *Physics Essays*. The present paper includes some additional information about mass quantization, and chiefly it discusses its philosophy.

The theory of mass quantization is based on a set of original rules. The formulation of these rules is rather intricate to cover the large number and the various properties of particles. For example, the fact that several particles are charged raises the interesting question of the origin of that charge. When a macroscopic conductor carries a net negative charge, one admits that this charge is caused by the presence of an excess of electrons on its surface. Nothing similar can be said to explain the charge of elementary particles. This is the reason why the new theory suggests a charge rule which applies to charged particles. Other rules are similarly associated with the various properties of the particles (spin, stability, etc.).

Although this set of rules may seem arbitrary, it will be recognized that it leads to so accurate a description of the elementary particles that its ability to explain the physical properties of both nucleons should no longer be ignored.

2. THE RULES OF PARTICLE QUANTIZATION

2.1 The Basic Rules

The quantum of mass (q.m.) is a mass equal to the electronic mass m_e at rest. It is not an electron, although it has a self-energy equal to $m_e c^2$.

2.1.1 Any material elementary particle is comprised of a determined association of q.m. called the "basic association" of the particle.
2.1.2 The basic association contains two or more quantum layers, each labeled by one of the integers $n = 1, 2, 3, 4, 5, 6, 7$.
2.1.3 The population of the layer of rank n is equal to $N = 16\ n^2$ q.m. It follows that the mass of the basic association of layers which characterizes a particle is equal to $\sum N = 16 \sum n^2$ q.m., the sum being extended to the various layers.
2.1.4 The basic association of some particles may be recurrent; this means that two or more layers may have the same quantum number n. (This rule plays no part in this paper, but will in other references that consider other particles like mesons.[4])

2.2 Complementary Rules

An elementary particle possesses some physical properties. We consider two of them.

2.2.1 Several particles have spin-1/2 (expressed in the unit h/2 π): the electron, neutron, proton, hyperons, and some other particles. *We claim that all particles with spin-1/2 have in their quantized structure a common property: besides their basic association of layers, they possess one supplementary quantum which is not integrated in a definite layer; it is additional to all layers.* In order to distinguish it from the other q.m., it is called "central" q.m. (the word "central" has no geometrical meaning).

We note that the electron is the only elementary particle with no quantum layer; however, it has a mass equal to 1 q.m. and a spin-1/2 owing to the presence of a central quantum.

2.2.2 The Concept of Mass Deviation

We call deviation of mass (in short, deviation) a determined number of q.m. that is added or subtracted to the basic association. It is related to one physical property of the particle. According to that definition, the central q.m. that is present in excess in the basic association is the deviation that characterizes all particles having spin-1/2. An elementary particle may be charged ($\pm\epsilon$) or neutral. We claim that its electric state is related to a well-defined mass deviation in excess or in deficiency. The electric state of particles is determined by the following rules.

2.2.3 *We claim that a layer is charged when it bears a group of 16 q.m. in excess or in deficiency.* This mass deviation is noted $+16$ or -16. The sign of the charge ϵ corresponding to the deviation $+16$ or -16 is peculiar to each charged particle; for example, the deviation $+16$ may confer the charge $-\epsilon$ to a particle and the charge $+\epsilon$ to another (the same for the deviation -16). One must thus distinguish the sign of the deviation 16 from the sign of the corresponding charge ϵ; in order to avoid confusion, when we speak of the sign of the deviation 16, the corresponding sign of ϵ will be written as a superscript, for example, $(144 + 16)^-$.

2.2.4 *A layer is also charged when it bears 1 q.m. or 3 q.m. in excess or in deficiency.* If a layer has a deviation of 2 q.m. in excess or in deficiency, it is neutral. The three deviations ±1, ±2, ±3 are called deviations of type 1 in order to distinguish them from the deviation of type 16. No deviation of type 1 other than ±1, ±2, ±3 exists. If a layer is charged by a deviation ±1 or ±3, the sign of the charge ϵ is also peculiar to the particle as it is for the deviation ±16. This rule may be expressed in another way: a deviation $+1$ charges the layer that bears it; a second deviation neutralizes the first, but a third deviation restores the charge (the same for -1, -2, -3).

2.2.5 Deviations of mixed types 1 and 16 may coexist. The associated charges may or not neutralize according to the following rules: a deviation of type 1 (1 q.m. or 3 q.m.) neutralizes a deviation of type 16, while a neutral deviation of type 1 (2 q.m.) does not. The only allowed mixed deviations are (±16 ±1), (±16 ±2), and (±16 ±3), the second being charged. The charge sign that is associated with mixed deviations is again peculiar to the particle considered.

In application of these rules, a particle is charged if one layer of its basic association bears the deviation ±16 or ±1 or ±3 or (±16 ±2). A particle is neutral in three cases: all layers of its basic association are regular (no deviation); one layer has a neutral deviation ±2 or (±16 ±1) or (±16 ±3); two layers of its basic association are charged with opposite signs; such a particle is an electric doublet. In such a case both charged layers are "adjacent" (their quantum numbers differ from one unit). An example is $(144 + 16)^-$, $(256 - 16)^+$, where the layer $n = 4$ has exchanged a group of 16 q.m. with the layer $n = 3$.

In summary, the charge of a particle is due to a particular deviation in its quantized structure, which may vary from one particle to another, although following the well-defined rules stated above.

2.2.6 (Various particles present another species of mass deviation in some of their layers. We call them deviations of type 8. They exist in the following variants: ±8, $|\pm 8 \pm 1|$, $|\pm 8 \pm 2|$, $|\pm 8 \pm 3|$ to the exclusion of any other. They are always neutral.) This note plays no part in this paper, which is devoted to nucleons; the rules in parentheses do not apply to them.

2.2.7 An antiparticle has the same basic association and the same deviations as its particle; the only difference is the reversed sign of the charge.

2.2.8 For every particle the quantized association of layers modified by the spin and charge deviations is called the "numerical association" of the particle; its "numerical" mass is therefore equal to an integer.

2.3 The Rule of Stability

Most elementary particles are essentially unstable, their lifetime being so short that it escapes any measurements. Their existence is indirectly established by the products of their decay, which are observable and measurable. The others have a free stable state, that is, a measurable lifetime. Besides the electron, the mass of which is equal to the mass quantum, the only particle that is indefinitely stable in the free state is the proton. It is natural to ascribe the stable state of a particle to a binding energy between its quantum layers and to admit, as one does in nuclear physics, that this binding entails a mass defect, $-\Delta$. The real mass of the particle is then equal to $m' = m - \Delta$, where m is the numerical mass defined above.

We claim that the mass deficiency $-\Delta$ of a particle with a stable state is given by $-\Delta = -M/784$ q.m., where M is a numerical mass, which is characteristic of the particle.

2.4 Remarks

The mass deficiency $-\Delta$ expressed in q.m. is not an integer. Because the central q.m. $+1$ of the particles with spin-1/2 has an integer value, it may not contribute to the numerical mass M that determines the mass deficiency $-\Delta$, for if it did contribute, it would become $(1 - 1/784)$. The same may be said for the charge deviations in excess $+1$ or $+3$ or $+16$ or $+|16 \pm 2|$ or for the neutral deviations in excess $+2$ or $+|16 \pm 1|$ or $+|16 \pm 3|$, which must remain an integer according to the rule of charge. The layer that bears a mass deviation in excess *may* or may not contribute to M; for example, the layer $(144 + 16)^-$ *may* contribute to M in the amount of 144 q.m. Obviously, the mass deviations in deficiency, which are charged or neutral, do not contribute to M; however, the layer that bears such a deviation may contribute to the stabilizing mass deficiency; for example, the layer $(256 - 16)^+$ *may* contribute in the amount of 240 q.m.

2.5 Commentary

One may ask what is the origin of the rules of this quantization. The goal of a physical theory is to establish, from assertions which are always more or less hypothetical, a logical synthesis of the experimental data that are known in connection with the considered field. The value of a physical theory is determined from the number of qualitative and quantitative data that it explains. Consequently, a physical theory is never valid *a priori*, but *a posteriori* in its inferences to the known data and eventually in new data that it foresees, if these are later confirmed by measurement. We shall show precisely how the new model agrees with the measurement of the masses and the magnetic moments of both nucleons.

The rules of particle quantization were introduced in Ref. 2 after a reflection about the data that were known at that time. They are maintained in this paper, except for some additional precision in the charge deviations as a result of the existence of increasingly accurate data.

We outline how to apply the rules of particle quantization to a given particle. First, one must determine its basic association, then its spin and charge deviations, and, finally, its mass deficiency, if it has a stable state. Each application of the rules offers a choice: the quantum numbers of the layers, the suitable charge deviations, and the characteristic numerical mass M that determines the mass deficiency. We acknowledge the choices to be correct if the experimental data are reached. This paper is exemplary on that account because it concerns the neutron and the proton, the masses, and the magnetic moments, which are known with the precision 10^{-7}. Such a procedure is not arbitrary, since it must be done in conformity with well defined rules. So this theory presents a new way of analyzing particles.

Moreover, the method establishes some correlations between various physical properties of particles; for example, we show that the mass of a particle depends on some properties (like spin, electric state, stable state), which require a very complete description of its quantized structure. This explains why our model can lead to measurements with a high degree of accuracy that, so far, the other theories have not yet reached.

2.6 The Quantum Numbers Associated with the Nucleons

The neutron and proton are commonly considered the two members of a unique energetic doublet: the neutron. Their masses differ by a little more than 1 MeV. In this quantization we claim that they are distinct particles; their basic association has the same mass, although their numerical structures differ. More precisely, the quantum numbers of their basic association are $n = 1, 2, 3, 4, 6, 7$ for n^0, and $n = 1, 2, 5, 6, 7$ for p, with their common numerical mass being 1840 q.m., since the mass of the layers $n = 3$, $n = 4$ together equals the mass 400 q.m. of the layer $n = 5$.

This first approach of the measured masses of the nucleons is correct with the precision 1.3×10^{-3} for n^0 and 2.1×10^{-3} for p. The mass deviations of n^0 and p will be specified below.

3. MASS OF THE NEUTRON

3.1 The Basic Association

According to Sec. 2.6, the basic association is written as

$$16 + 64 + 144 + 256 + 576 + 784 = 1840 \text{ q.m.} \tag{1}$$

3.2 Numerical Mass

The n^0 with spin-1/2 has numerical mass containing one additional central q.m. (Rule 2.2.1). Besides, n^0 has a negative magnetic moment; this property, unexplained to now, can be understood if n^0 is an electric doublet, that is, if its layers form two groups: the first one, with the charge $-\epsilon$ and spin-1/2, is responsible for the magnetic moment; the other has the charge $+\epsilon$. According to quantum mechanics, the intrinsic magnetic moment of n^0 is equal to $-\epsilon h/4\pi m_1 c$, where m_1 is the mass of the spinning magnetic group. This moment is computed below (Sec. 4). In agreement with what has been said in Secs. 2.2.3 and 2.2.5, the neutronic doublet follows from the exchange of a group of 16 q.m. between two adjacent layers; we claim that these layers are those that have the quantum numbers $n = 3$, $n = 4$; this will be found in agreement with the measured value of $M(n^0)$.

The numerical structure and mass of n^0 are, therefore,

$$1 + 16 + 64 + (144 + 16)^- + (256 - 16)^+ + 576 + 784 = 1841 \text{ q.m.} \tag{2}$$

3.3 Mass Defect of n^0

According to Rule 2.4 (Remarks), the central q.m. and the positive charged deviation +16 may not contribute to the numerical mass M that determines $-\Delta(n^0)$. Moreover, the layer $n = 7$ (784 q.m.) may not fully contribute to M, for the corresponding deficiency would be equal to $-784/784 = -1$ q.m., and this would charge the layer $n = 7$ (Rule 2.2.4). We conjecture that a group of 8 q.m. belonging to the layer $n = 7$ does not contribute to M. [Note: this group of 8 q.m., which does not contribute to M, remains present in the numerical mass 784 of the layer $n = 7$ and may not be confused with a deviation of type 8 (Point 2.2.6).] One finds

$$M = 1841 - (1 + 16 + 8) = 1816 \text{ q.m.}$$

According to Rule 2.4, one has

$$-\Delta(n^0) = -M/784 = -2.316\ 327 \text{ q.m.} \tag{3}$$

3.4 Actual Mass of n^0

$$m(n^0) = 1841 - \Delta(n^0) = 1838.683\ 673 \text{ q.m.} \tag{4}$$

The measured ratio $m(n^0)/m(e)$, that is, the value of $m(n^0)$ expressed in q.m., is 1838.683 649 (138); its precision of 7.5×10^{-8} agrees with the theoretical value derived from the rules.

4. MAGNETIC MOMENT OF THE NEUTRON

4.1 The neutron is neutral, yet it has a magnetic moment given by

$$M(n^0) = -1.913\ 042\ 75\ (45)\mu_N.$$

We explained in Sec. 3.2 that the reason for this is that the negative magnetic moment of n^0 is not determined by the whole mass of n^0, but only by the mass of its spinning magnetic group that bears the charge $-\epsilon$. The mass of n^0 must thus be distributed between its groups; we denote by m_1' the numerical mass of the spinning magnetic group and by m_2' that of the other group. We claim that the magnetic group contains the central quantum and all the "odd" quantum layers $n = 1, 3, 7$ of n^0. Its numerical mass is therefore given by

$$m_1' = 1 + 16 + (144 + 16)^- + 784 = 961^- \text{ q.m.} \tag{5}$$

The other group has the numerical mass

$$m_2' = 64 + (256 - 16)^+ + 576 = 880^+ \text{ q.m.}$$

According to quantum mechanics, the intrinsic magnetic moment of n^0 is equal to $-\epsilon h/4\pi m_1 c$; if we express it in the usual unit μ_N, called the nuclear magneton, defined by

$$1\,\mu_N = \epsilon h/4\pi m_p c,$$

where m_p is the mass of the proton, then the magnetic moment of n^0 becomes

$$M(n^0) = -(\epsilon h/4\pi m_1' c)/(\epsilon h/4\pi m_p c) = -m_p/m_1' \mu_N.$$

We find $M(n^0) \approx -1.910\,\mu_N$, which agrees with measurement with the precision of 10^{-3}.

4.2 The True Mass of the Spinning Magnetic Group of n^0

In order to get a better approximation, we must calculate the exact mass m_1 of the spinning magnetic group instead of its numerical mass m_1'. One has $m_1 = 961 - \Delta_1$ q.m., with $-\Delta_1$ the mass deficiency of this group. Similarly, calling $-\Delta_2$ the mass deficiency of the other group, one has $-\Delta_1 - \Delta_2 = -\Delta(n^0)$; for our goal it suffices to determine $-\Delta_1$.

In Sec. 3.3 it was shown that the total mass deficiency $-\Delta(n^0)$ is equal to $-M/784 = -(1841 - 1 - 16 - 8)/784$. We recall that the central quantum 1 and the charge deviation +16 may not contribute to M and that the layer $n = 7$ only contributes to M in the amount of $(784 - 8)$ q.m. Since the central quantum, the charged deviation +16, and the layer $n = 7$ are present in the spinning magnetic group of n^0, the numerical mass M of this group that determines its mass deficiency $-\Delta_1$ is equal to

$$M_1 = 961 - 1 - 16 - 8 = 936 \text{ q.m.}$$

One thus has

$$-\Delta_1 = -M_1/784 = -1.193\ 878 \text{ q.m.}$$

and

$$m_1 = 961 - \Delta_1 = 959.806\ 122 \text{ q.m.};$$

thus

$$M(n^0) = -m_p/m_1 = -1836.1527/m_1 = -1.913\ 045\ \mu_N,$$

which agrees with measurement to six significant figures.

It is possible to improve the theoretical value by considering that both groups are not independent from one another and that a "certain" kind of binding exists between them. The binding of all layers of n^0 corresponds to the mass deficiency $-\Delta(n^0)$ (cf. Sec. 3.3), which is responsible for the stable state of n^0. Since both groups of n^0 contain together all the layers, $-\Delta(n^0)$ is the mass deficiency of both groups together; of course, an additional binding between both groups may not modify $-\Delta(n^0)$, and, consequently, it may not modify the mass $M = 1816$ q.m. In fact, the rule of stability 2.4 determines the mass deficiency without specifying "how" this deficiency is distributed among the layers. This means that it is not necessary that each layer "itself" bears the deficiency that it determines. If one imagines that a "part" of the total deficiency $-\Delta(n^0)$ may be transferred from one group to the other, this exchange does not modify the value of $-\Delta(n^0)$, but establishes a kind of binding between both groups, since one of them bears a part of the mass deficiency that is determined by the other. Precisely, we claim that in the case of the neutron, one quantum belonging to the spinning magnetic group transfers its mass deficiency to the other group. So the mass deficiency $-\Delta(n^0)$ is conserved, but the numerical mass M_1 that determines the mass deficiency $-\Delta_1$ of the spinning magnetic group $-\Delta_1$ becomes

$$M_1 = (961 - 1 - 16 - 8 - 1) = 935 \text{ q.m.} \tag{6}$$

instead of 936 q.m. We calculate

$$-\Delta_1 = -935/784 = -1.192\ 602 \text{ q.m.}, \tag{7}$$

$$m_1 = 961 - \Delta_1 = 959.807\ 398 \text{ q.m.}, \tag{8}$$

$$M(n^0) = -m_p/m_1 = -1836.1527/m_1 = -1.913\ 043\ \mu_N, \tag{9}$$

in good agreement with measurement, $-1.913\ 043\ 08\ (54)\ \mu_N$.

5. PROCESS OF NEUTRON DECAY AND THE NUMERICAL STRUCTURE OF THE PROTON

The n^0 decays according to the mode $n^0 \rightarrow p + e^- + \nu_e + W$, where ν_e is the neutrino, and W is the kinetic energy of the emitted particles. This process conserves the spin-1/2 of n^0, with p inheriting it, e^- and ν_e being emitted with antiparallel spins-1/2.

From our viewpoint, this decay is the spontaneous transformation of the structure of n^0, that is, its numerical structure (2) modified by the mass deficiency $-\Delta(n^0)$, in another numerical structure, that is, that of p modified by the mass deficiency $-\Delta(p)$ which characterizes the emission $e^-\nu_e$. We first examine how the numerical structure of n^0 generates that of p. The neutron decay is a transitory process. In order to be clear, we split it in three simultaneous phases:

$$\text{(A)}\quad [1 + 16 + 64 + (144 + 16)^- + (256 - 16)^+ + 576 + 784] \longrightarrow [1 + 16 + 64 + 400 + 576 + 784]$$

The doublet formed by the layers $n = 3$, $n = 4$ combines in one layer $n = 5$. This essentially distinguishes p from n^0.

$$\text{(B)}\quad [1 + 16 + 400 + 576 + 784] \longrightarrow [1 + 16 + 64 + (400 - 16)^+ + (576 + 16)^- + 784]$$

A new doublet arises between the adjacent layers $n = 5$, $n = 6$; this doublet is called a "preprotonic doublet," since it will give rise to the proton.

$$\text{(C)}\quad [1 + 16 + 64 + (400 - 16)^+ + (576 + 16)^- + 784] \longrightarrow [1 + 16 + (64 + 1)^+ + (400 - |16 + 3|) + (576 + |16 + 1|) + 784] + 1^-$$

According to Rule 2.2.2, a charged particle possesses one charged layer. In fact, the layer $n = 6$ gains 1 q.m., while the layer $n = 5$ loses 3 q.m.: one q.m. is emitted in the form e^-; another is transferred to the layer $n = 6$, which is therefore neutralized in the form $(576 + |16 + 1|)$ (Rule 2.2.5); the third is transferred to the layer $n = 2$, which becomes charged in the form $(64 + 1)^+$ (Rule 2.2.4). Having lost 3 q.m., the layer $n = 5$ is neutralized in the form $(400 - |16 + 3|)$ (Rule 2.2.5). The numerical structure of p is thus

$$1 + 16 + (64 + 1)^{+} + (400 - |16 + 3|) + (576 + |16 + 1|) + 784 \quad (10)$$

with spin-1/2, charge $+\epsilon$, and numerical mass 1840 q.m., as a result of the lost quantum emitted in the form e^{-} (process C above).

6. MASS DEFECT $-\Delta(p)$

We have $m(p) = 1840 - \Delta(p)$. The mass deficiency results from the following deficiencies: when n^0 decays in p, p inherits the mass deficiency of n^0: $-\Delta(n^0) = -1816/784$ q.m. (cf. Point 3.3); in decaying, n^0 furnishes the emission energy W; this energy corresponds to a new mass deficiency denoted by $-\delta = -W/c^2$. We claim that the energy W is furnished by the set of odd layers $n = 1, 5, 7$ of the numerical structure $[1 + 16 + 64 + 400 + 576 + 784]$ which appeared in process A above. Its numerical mass is equal to 1200 q.m. The mass deficiency $-\delta$ is thus equal to (Rule 2.4)

$$-\delta = -1200/784. \quad (11)$$

The total mass deficiency of p is therefore equal to

$$-\Delta(p) = -\Delta(n^0) - \delta = -3016/784 = -3.846\ 939 \text{ q.m.} \quad (12)$$

7. THE ACTUAL MASS OF THE PROTON

Neglecting the very small mass $m(\nu_e)$ that is lost by n^0 when it decays, one has

$$m(p) = 1840 - \Delta(p) = 1836.153\ 061 \text{ q.m.} \quad (13)$$

The experimental value of the ratio $m(p)/m(e)$ is 1836.152 701 (100), the precision of which reaches 0.5×10^{-7}; the agreement with the theoretical value (13) reaches the precision 1.6×10^{-7}.

If we attribute the small difference to the fact that the neutrino rest mass has been neglected, we obtain

$$\begin{aligned} m(\nu_e) &= 1836.153\ 061 - 1836.152\ 701\ (100) \text{ q.m.} \\ &= (36 \pm 10) \times 10^{-5} \text{ q.m.} = (18 \pm 5) \times 10^{-5} \text{ MeV.} \quad (14) \end{aligned}$$

The rest mass $m(\nu_e)$ is unknown; the table of particles[1] gives $m(\nu_e) < 4.6 \times 10^{-5}$ MeV. The discrepancy is very likely ascribable to the overestimated accuracy of the experimental value of m_p/m_e.

7.1 Remarks

(1) The mass deficiency of p exceeds that of n^0 by a factor of $(-1 - \delta)$ q.m. It is natural to ascribe the perfect stability of p in the free state of its lower mass in regard to n^0.

(2) One might allege that in computing $-\Delta(n^0)$ (Sec. 3.3), one has claimed that the layer $n = 7$ of n^0 contributes $(784 - 8)$ q.m. to the mass deficiency of n^0, while in computing the mass deficiency $-\delta$ of p, the layer $n = 7$ contributes 784 q.m. There is no contradiction. In computing $-\Delta(n^0)$ one has admitted that the layer $n = 7$ contributes $(784 - 8)$ q.m., because in contributing 784 q.m., it would have been charged, and so n^0, too. Since p is derived from n^0, the layer $n = 7$ of p is derived from the layer $n = 7$ of n^0; having contributed $(784 - 8)$ in n^0, it may contribute 784 q.m. in p, for the total mass deficiency will be equal to $[(784 - 8) + 784]/784$, which is not an integer. The layer $n = 7$ is neutral in n^0 and remains so in p.

8. THE MAGNETIC MOMENT OF p

The $M(p)$ may be calculated quite similarly to $M(n^0)$. We claim that the layers of p form two groups like those of n^0. One group is the charged spinning magnetic group responsible for the magnetic moment $M(p)$, the other being neutral. The first group contains the even layers $n = 2$, $n = 6$ of p and the central quantum. The numerical structure and mass of the spinning magnetic group are written as

$$m_1' = 1 + (64 + 1)^{+}(576 + |16 + 1|) = 659^{+} \text{ q.m.,} \quad (15)$$

while we have for the other group

$$m_2' = 16 + (400 - |16 + 3|) + 784 = 1181 \text{ q.m.}$$

In a first approximation we find

$$M(p) = +m_p/m_1' = +1836.1527/m_1' = +2.786\ \mu_N,$$

which agrees with the experimental value with the precision of 2×10^{-3}.

In a second approximation we must determine the exact mass deficiency $-\Delta_1$ of the spinning magnetic group so that the mass of this group will have the value $m_1 = m_1' - \Delta_1$. The total mass deficiency $-\Delta(p) = [-\Delta(n^0) - \delta]$ is distributed between both groups, so that we have $-\Delta_1 - \Delta_2 = -\Delta(p)$.

For our goal it suffices to determine $-\Delta_1$. We claim that it is determined by the group $(16 + 400 + 784) = 1200$ q.m. which determines the mass deficiency $-\delta$, increased by a group of 16 q.m. present in the second group. So this mass deficiency of 16 q.m. is transferred from the second group to the spinning magnetic group, which establishes a binding between both groups of p. Thus the mass deficiency $-\Delta_1$ is determined from the numerical mass $M_1 = 1216$ q.m., and one has

$$-\Delta_1 = -M_1/784 = -1.551\ 020 \text{ q.m.}$$

The true mass m_1 of the spinning magnetic group of p is equal to

$$m_1 = m_1' - \Delta_1 = 657.448\ 980 \text{ q.m.,} \quad (16)$$

and we obtain

$$M(p) = +m_p/m_1 = +2.792\ 844\ 4\ \mu_N, \quad (17)$$

agreeing with the experimental value +2.792 844 4 (11) μ_N to seven significant figures.

9. CONCLUSIONS

9.1 This paper has presented an example of the application of the rules of particle quantization to nucleons. Their masses have been explained with the precision of 10^{-7} in assigning to n^0 the quantum numbers $n = 1, 2, 3, 4, 6, 7$ and to p the numbers $n = 1, 2, 5, 6, 7$. The deviations associated with the spin and the electric state of n^0 are 1 and ± 16 q.m.; those of p are 1, $-|16 + 3|$, and $+|16 + 1|$. All the layers of n^0 contribute to its mass deficiency $-\Delta(n^0)$ except $(1 + 16 + 8)$ q.m., which the rules exclude. The mass deficiency $-\Delta(p)$ contains $-\Delta(n^0)$ and an additional deficiency $-\delta$, which is equal to the deficiency of its odd layers (16 + 400 + 784) q.m.

The layers of the nucleon form two groups: one is the spinning magnetic group, responsible for the magnetic moment. Regarding n^0, this spinning group contains the central quantum associated with the spin and the odd layers $n = 1, 3, 7$, the layer $n = 3$ bearing the charge $-\epsilon$; for p it contains the central q.m. and the even layers $n = 2$, $n = 6$, with the layer $n = 2$ bearing the charge $+\epsilon$; so one retrieves the measured data $M(n^0)$ and $M(p)$ with the precision of 10^{-3}; from a suitable distribution of the mass deficiencies $-\Delta(n^0)$ and $-\Delta(p)$ between the groups, one is accurate within about six significant figures; in claiming a binding between both groups of each nucleon, realized by a transfer of a small mass deficiency from one group to the other, the precision of 10^{-6} of the measurements is effectively reached.

9.2 We believe that the existence of a mass quantum is a logical necessity of nature. A quantitative description of the physical world needs the adoption of four standards: length, time, mass, and electric charge, from which the various units of measure of all physical quantities are derived. What are these natural standards? Physics knows three of them: the speed of light in a vacuum c, the Planck constant h (or $h/2\pi$), and the elementary electric charge ϵ. The speed of light c is the upper limit of speed for matter and radiation, whereas $h/2\pi$ and ϵ are lower bounds for quanta. A fourth standard is needed in order to define the energy unit.(7) We propose that the electronic mass should play that part. Since it is the mass of the lightest material object, it naturally appears as the strongest candidate to be the quantum of mass. We note that some other forms of energy may have a value inferior to $m_e c^2$, for example, the energy $h\nu$ of a photon of low frequency, or the thermal energy of a molecule in a gas, but there is no objection to the existence of a quantum of material energy. Although m_e is the quantum of mass for material particles, it does not mean that we consider that the electron self-energy has no electromagnetic component.(8) Similarly, it is the whole mass of each elementary particle, including its eventual electromagnetic component, that is quantized according to the rules we have defined.

9.3 The notion of arithmetical parity plays an important part in this theory. The spinning magnetic group of n^0 is formed by its odd layers; however, the even layers form the magnetic group of p. In the case of p, the odd layers contribute to the additional mass deficiency $-\delta$, which corresponds to the emission energy of the electron-neutrino pair generated by neutron decay.

9.4 Our model expresses its rules in the most elementary mathematical formalism. Owing to that, it does not possess the seduction or the power of persuasion with which transcendental mathematical operators are credited. We ask, however, why nature would have excluded a modest formalism in making the large number and variety of elementary particles if it turns out to be sufficient? Quantum dynamics has succeeded in classifying the world of elementary particles, but it has failed to retrieve the accurately known experimental data. The interest in the present theory is therefore justified, unless someone establishes that the intervention of higher mathematics acting on hyperquantum quantities can reach a comparable efficiency.

9.5 The magnetic moments of the nucleons are not anomalous in this model; they are calculated on the basis of the classical formula $M = \epsilon h/4\pi mc$. The key to the problem is this: we do not consider that the whole mass of the particle contributes to M; only the mass of its spinning group does.

The magnetic moment of n^0 is, moreover, explained by considering n^0 as an electric doublet $(+\epsilon, -\epsilon)$. We point out, however, that the model does not introduce fractional charges like in quark theory. In fact, such fractional charges have never been observed.

9.6 Finally, it cannot be overemphasized that quantum dynamics only retrieves experimental data that are not accurately known (scattering data, heavy mesons mass spectra). But it fails when faced with high-precision measurements (masses and magnetic moments of stable particles). Precisely, the theory of mass quantization is able to fill that gap. The model can be extended to particles other than nucleons, for example, the hyperons,(4) the muon,(5) the mesons π,(5), K, and η.(5) The modes of disintegration may also be explained.(4,9)

Pursuing this investigation, one of the authors has shown that the knowledge of the quantized structure of the neutron can lead to conjecture on how neutrons have been generated as the original constituents of stars.(10) Their rapid decay has generated a plasma made of protons, electrons, and light nuclei. No comparable explanation exists about the creation of elementary particles, so that particle physics rejoins cosmology.

Received 13 September 1990.

Résumé

Un précédent mode de quantification des particules est rappelé. Ses règles sont énoncées et appliquées aux masses et aux moments magnétiques du neutron et du proton. Dans le cadre de cette quantification, le processus de désintégration $n^0 \rightarrow p + e^- + \nu_e + W$ du neutron est décrit comme la transformation spontanée d'une structure quantifiée (celle de n^0) en une autre (celle de p) avec émission d'un électron.

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