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Georges Sardin

► **To cite this version:**

Georges Sardin. About the symmetry of the deuteron structural charge density distribution. 2019. ⟨hal-01985930⟩

**HAL Id: hal-01985930**

**<https://hal.science/hal-01985930v1>**

Preprint submitted on 18 Jan 2019

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# **About the symmetry of the deuteron structural charge density distribution**

G. Sardin

## **Abstract**

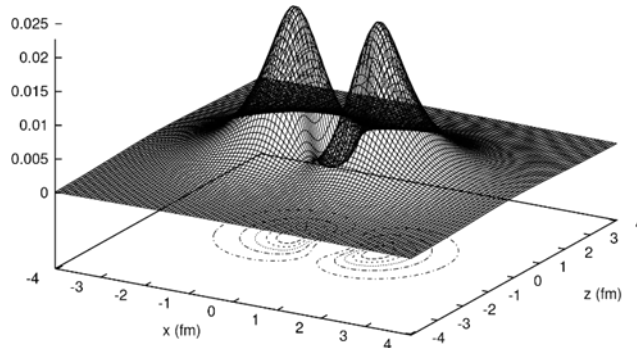
The distribution of the structural charge density of the deuteron is examined and its symmetry is analyzed on the basis of experimental data obtained from electron scattering experiments, in which the total symmetry of the deuteron structure is evidenced. Since according to the conventional nuclear model the deuteron is formed of a neutron and a proton, whose structural charge density is substantially different, it follows that the juxtaposition of the distribution of their charge density is asymmetrical, thus being in deep disagreement with that of the deuteron which is symmetrical. This incongruence is thus analyzed. The conventional model of a proton juxtaposed to a neutron is unable to provide a credible explanation of the symmetry of the deuteron charge distribution since it is composed of two different particles, one neutral and the other one charged, and with a highly dissimilar structural charge density. Consequently, an explanation for the structural symmetry of deuteron is proposed, based on a revised approach.

## **Introduction**

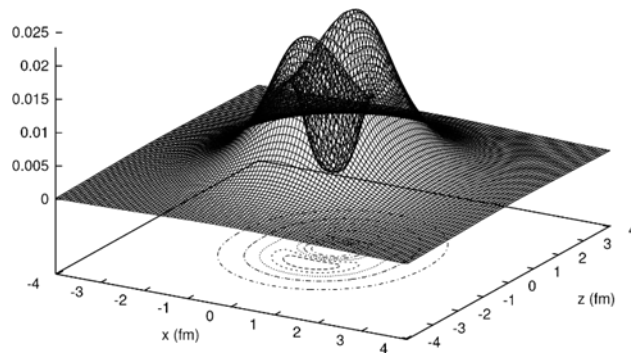
Here, the symmetry of the density distribution of the deuteron (fig.1, 2, 3) is examined by comparison with those of the neutron and the proton. Let us first consider the symmetry of the deuteron charge distribution in the context of the classical proton and neutron model as constituents of atomic nuclei [1- 8]. The conventional model of a proton juxtaposed to a neutron does not reliably account for the total symmetry of the deuteron charge distribution since it is composed of two different particles, whose structural charge density is deeply dissimilar (fig.5). It is therefore obvious that the conventional model is in default. In fact, such a model, without being retouched, is incompatible with the symmetry of the experimental distribution of the structural charge density of the deuteron given the dissymmetry of its two nucleons, one charged and one neutral.

## **1. The deuteron structural charge density distribution**

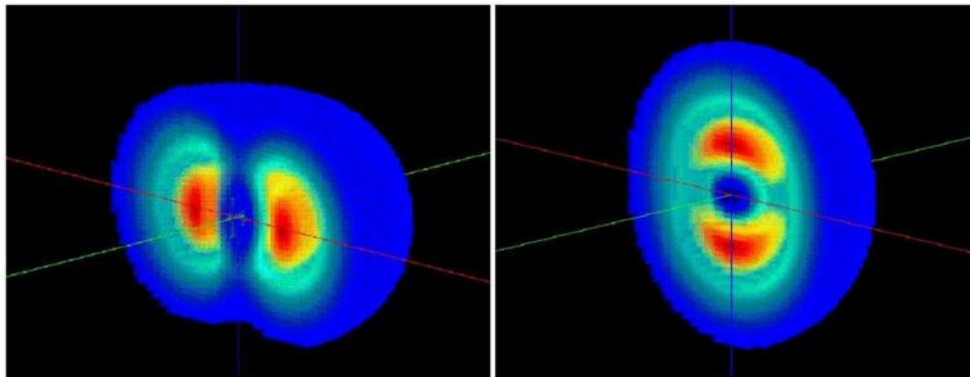
The symmetry of the deuteron charge distribution is inspected on the basis of the experimental data shown in the following pictures:



**Fig. 1:** Deuteron density  $\rho_M$  [ $\text{fm}^{-3}$ ] as a function of  $x, z$  for  $M = 0$  (fig. extracted from ref. [1])



**Fig. 2:** Deuteron density  $\rho_M$  [ $\text{fm}^{-3}$ ] as a function of  $x, z$  for  $M = \pm 1$  (fig. extracted from ref. [1])



**Fig. 3:** Deuteron densities in  $M = 0$  (left) and  $M = \pm 1$  (right) magnetic substates. The red spots correspond to the maximal nucleonic densities, while the dark volumes correspond to lower densities (outer surface is for 10% of maximal density) (fig. extracted from ref. [1])

The two picks from fig.1 and 2 are extremely identical, as well as the two parts from fig.3. Thus, the question is: can such structural symmetry of the deuteron be explained by the conventional neutron-proton representation of the deuteron without resorting to an excess of intellectual acrobatics? How a charged particle juxtaposed to a neutral particle could produce such a symmetry?

On fig.3 the two red zones, which correspond to the maximal nucleonic densities, are identical and thus cannot correspond to the asymmetrical union of a proton and a neutron. Instead they can easily be seen as two protons (red zones) wrapped within a “shell” (blue zone) formed by the orbital of an integer electric charge.

By deduction between the mass of the deuteron and that of two protons, the enveloping orbital would be in a quantum state of energy  $-0.931$  MeV. In effect, the structural energy of the deuteron is of  $1875.612928$  MeV, while that of the two protons is of  $2(938.2720813) = 1876.5441626$  MeV [9, 10], so the difference is of  $-0.9312346$  MeV. Since this energy has a negative value, it corresponds to a binding energy provided by the shell. Here we distinguish between bonding energy and dissociation energy. In effect, the disintegration energy into a proton and a neutron needs an extra energy of  $1.29$  MeV to form a neutron, so the energy of dissociation ends up being of  $2.22$  MeV, i.e.  $0.93$  MeV to brake the bond between the two protons plus  $1.29$  MeV for the shell to recombine with a single proton to form a neutron.

## **2. Incompatibility of the deuteron symmetrical charge distribution with the conventional model of the nucleus**

Let us first point out that the conventional model of elementary particles is unsuitable with the high symmetry of the deuteron charge distribution since it preserves the integrity of nucleons within the nucleus. So, in the deuteron a proton and a neutron are juxtaposed, which leads to an asymmetrical structure where a neutral particle is paired with a charged one.

Let us also point out another failure of the standard model. In fact, this model cannot provide a realistic explanation for the slight separation of the proton and the neutron in the deuteron, as evidenced in fig.3 and 7. It brings no reason for such separation since there is no repulsion between a neutral and a positive particle.

An important clue is provided by the fact that the potential between nucleons is repulsive at short distance. Note that no repulsion is expected between a proton and a neutron. This clearly indicates that this repulsive potential comes from the electrostatic repulsion between protons. On the other hand, they are bound by the enveloping cloud of negative charges (the “shell”) arising from the dissociation of neutrons. A quantum equilibrium is reached between the binding force and the dispersion force.

In view of these incongruities of the conventional neutron-proton model, let us briefly inspect the issue of the neutron and proton union in the deuteron. We know that the proton and the neutron are bound by the strong interaction. The question is: what is its true nature? Given its very short range it was interpreted by Yukawa as necessarily due to an exchange of a heavy particle whose range of interaction would be shorter as larger the mass.

Consequently, at the very beginning, the strong interaction has been interpreted as an exchange of the muon, just discovered. Very soon after, this interpretation was refuted in favor of an exchange of pions, which had been discovered by then. But as some experimental data resisted an adequate adjustment, some theorists proposed using a mixture of pions and kaons to obtain better fittings.

Currently, strong forces are rather interpreted from Quantum Chromo-Dynamics (QCD) as being mediated by a residual gluonic field, peripheral to the internal cohesive field of the nucleons.

However, since from the QCD, strong forces cannot be solved quantitatively due to extreme complexity, their quantitative evaluation keeps to be done using pion exchange. How much uncertainty and gradual variation of the official point of view! Can it be trusted after so many fancy occurrences? A consensus on the nature of the strong interaction is still far away.

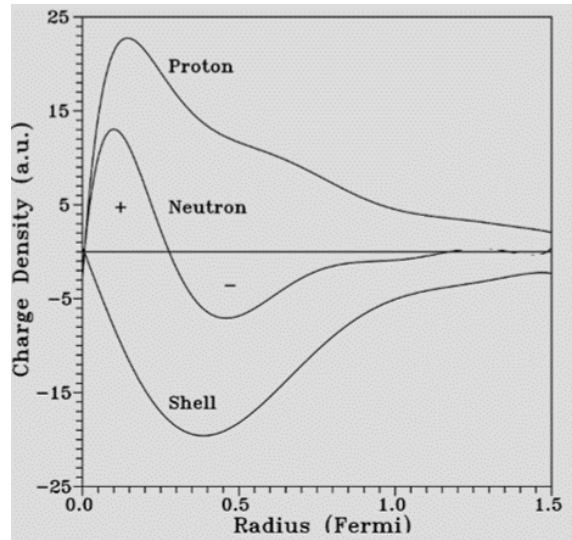
According to the QCD, the neutron would be composed of 3 quarks: two quarks "down" of electric charge  $1/3 q^-$  each one and a quark "up" of charge  $2/3 q^+$ , while the proton would be composed of a quark "down" of electric charge  $1/3 q^-$  and two quarks "up" of charge  $2/3 q^+$ . Since, according to the conventional model, the neutron and the proton preserve their individual structure in the nucleus, the structural symmetry of the deuteron cannot be explained from this model without resorting to a high dose of much risky mental acrobatics.

An essential difference with the QCD is that the neutron charged zones are not considered to be produced by fractional quark charges, but by integer electric charges  $q^+$  and  $q^-$ , as supported by the neutron decay into a proton and an electron, both with an integer electric charge. In addition, according to the QCD, the distribution of the proton charge density should have two peaks, one positive corresponding to the two  $2/3 q^+$  quarks and the other negative corresponding to the  $1/3 q^-$  quark. Moreover, the positive peak should be four times larger than the negative peak, which is incongruent with fig.4 showing only a positive part, but in contrast it is in full agreement with the model of the proton formed by one full positive charge. The fact that the proton has not two charge distributions, one positive and one negative, as the neutron, is clearly incoherent with their quark composition, since both having + and - quarks.

### **3. The neutron charge density distribution**

In our publication of 1999 on the fundamental principles of the structure of elementary particles [11], the graph relative to the neutron and proton charge distribution (fig.4) was already included, from which we deduced and represented the charge distribution of the negative component of the neutron ("the shell"). In addition, based on the decay of the neutron, it was deduced that its positive component ("the core") would simply be a proton. Moreover, since the distribution of the proton charge density has only one positive zone, it has been deduced that it is traced by a single positive integer charge.

Conversely, the graph (fig.4) shows that if the distribution of the charge density of the shell is then superposed to that of the proton, the distribution of the resulting charge density corresponds to that of the neutron, which is dual, showing a positive zone (+) in the first part of the radius and a negative zone (-) in its second part. It thus appears that the charge density of the shell overlaps that of the proton, since its maximum is at a radius greater than that of the proton. This is why they have been called "core" and "shell", and correspond respectively to the structural distribution of a positive charge forming a proton and to the spatial distribution of a negative charge forming a shell. On its side, the charge distribution of the proton has only one positive zone, traced by a single positive charge.

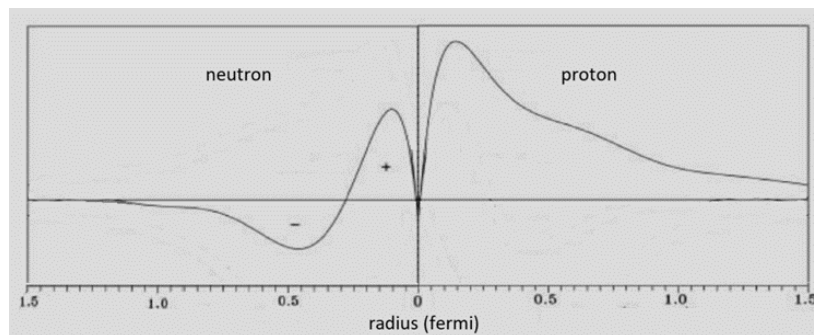


**Fig.4.** Distribution of the charge density of the proton and the neutron, as well as that of the shell deduced from the first two. [11, 12]

It can be seen that the charge distribution of the shell has a shape similar to that of the proton but inverted. Both have a maximum of about the same height but at a different radius, that of the proton being smaller than that of the shell. Therefore, it can be deduced that most of the shell covers the proton, since its maximum is more distant than that of the proton.

This explains the shape of the neutron charge distribution and why it has a positive part adjacent to a negative part, and also why their maximum and minimum have a lower height than the proton. The height of the charge distribution of the proton and that of the shell are both fixed by the electric charge which structures them and which has the same integer value but of opposite sign. This is in full coherence with the fig.5 presented here below.

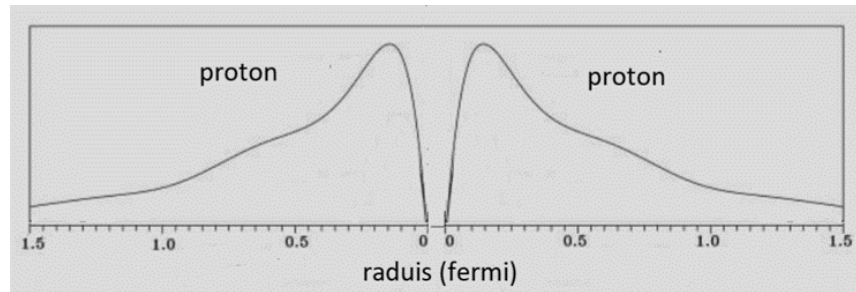
#### 4. The deuteron charge density according to the conventional model of a neutron adjacent to a proton



**Fig.5.** Graph derived from fig.4 in which the charge distribution of the neutron and the proton have been juxtaposed, according to the conventional representation of the deuteron in which the neutron and the proton are adjacent.

It is therefore obvious that according to the conventional model, in which the neutron preserves its structure in the atomic nucleus, the deuteron would not be symmetrical, which is in contradiction with the experimental results of fig.1, 2 and 3. Moreover the charge distribution of the neutron is in conflict with the two symmetrical peaks in fig.1 and 2, while one of them is assumed to correspond to a neutron, which is in formal disagreement with the neutron charge distribution of the fig.4, differing substantially from that of the proton as it has two zones, one positive and the other negative. So, the charge distribution of a neutron juxtaposed to a proton is asymmetric as shown in fig.5, which is in formal contradiction with the symmetry shown in fig.1, 2 and 3.

### 5. The deuteron charge density according to the orbital model of two juxtaposed protons

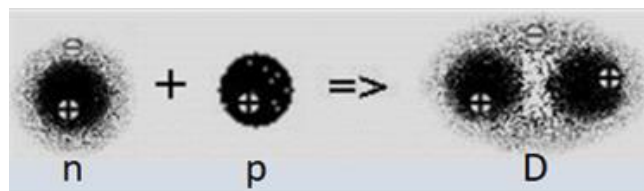


**Fig.6.** Structural charge distribution of two juxtaposed protons

In contrast, the charge distribution of two adjoin protons is symmetric as shown in fig.6. These two juxtaposed two-dimensional distributions of the electric charge of the proton are conformed to the three-dimensional distribution of the charge in fig.1 and 2, since it is evident that they show the same symmetry, corresponding to the charge distribution of two adjacent protons. This is a formal experimental proof that in the deuteron the neutron is dissociated into a proton and a negative electric charge wrapping then both protons. If the neutron would preserve its structure, the charge distribution of the deuteron could not be symmetrical.

It therefore appears clear that the charge distribution of the deuteron corresponds adequately to the model of the deuteron structure shown below in fig.7, which is symmetrical and therefore in agreement with fig.1, 2 and 6 and also coincides coherently with the charge density of fig.3. This symmetry cannot be obtained by the conventional model of a neutron juxtaposed to a proton, but only by two adjacent protons, enveloped in the distribution of the negative electric charge bonding them.

### 6. Deuteron structure according to the orbital model



**Fig.7.** Formation of the deuteron by sharing the neutron shell with a proton [11]

The binding force is provided by the distribution of the neutron peripheral charge (that is, the enveloping orbital) which, in the atomic nucleus, is shared with the adjacent protons. This is why the incorporation of neutrons is indispensable for the cohesion of the atomic nucleus. Since the neutron is considered to dissociate in the nucleus into a proton and a shell, it follows that the nucleus is composed exclusively of protons held together by the negative charges forming a bonding shell.

Thus, it follows that there are no neutrons in the atomic nucleus since in it they dissociate. Neutrons emitted during induced nuclear reactions or spontaneous nuclear disintegrations are considered to be formed at the very moment of their escape, by recombination of a proton with a negative charge of the binding shell of the atomic nucleus. This process of neutron formation from a proton is endothermic and requires 1.29 MeV, energy extracted from the cloud of negative charges wrapping the atomic nucleus. The inverse process of the neutron decay into a proton and an electron corresponds to the detachment of the neutron shell, resulting in a proton and the release of the shell, which then mutates to the electron structural quantum state, with emission of an antineutrino draining the surplus of energy at the time that it preserves the total spin.

From the conventional neutron-proton model, with the proton being charged and the neutron being neutral, it is clear that their charge distribution must differ, as it has been experimentally demonstrated, the proton having a single positive charge distribution while the neutron has two charge distributions, a positive at the center and a negative at the periphery, as shown in fig.4. These distributions accurately match with the proposed model.

From the standard model, how could the  $+2/3, +2/3, -1/3$  fractional charges of the proton give the same charge distribution as that of the neutron with instead  $+2/3, -1/3, -1/3$  fractional charges? How can it be explained without appealing to dubious arguments? Or as usual, what does not correspond with the QCD is ignored! Can we really believe that a charged particle, that is to say the proton, juxtaposed to a neutral particle, that is to say the neutron, could give such a symmetry of the structure of the deuteron?

Moreover, it should be noted that in the conventional representation, proton-proton and neutron-neutron nuclear structures should both be possible. Indeed, the cohesive force of the strong interaction is more than a hundred times stronger than the electrostatic repulsion, so a proton-proton bond should be possible. In addition, the neutron-neutron assembly being neutral should be even more easily formed due to the absence of repulsive forces. The conventional point of view has no real answer to these problems and must resort to highly artificial explanations, in a vain attempt to solve the issue.

According to the proposed model the proton-proton nuclear structure is not possible since the proton has no cohesive element. On its part, in the atomic nucleus the neutron-neutron union cannot be as well, because of the electrostatic repulsion of its two enveloping charges. To compensate for this repulsion between the electric charges of the shell, the incorporation of more protons is necessary, which is however limited by an excess of repulsion between protons, which entails the shell ending to be able of maintaining the cohesion of the protons when they are in excess. To recover the cohesion it is then necessary to incorporate more electric charges in the shell, and so on. The balance between the cohesive strength of the shell and the inner repulsion strength between its electric charges, plus the repulsion between protons, governs the stability of nuclei.

The spin  $1/2$  of the neutron implies that the spin of its shell is equal to 1 and antiparallel to the spin  $1/2$  of the proton. In addition, the fact that the deuteron has a spin 1 implies that its shell has retained the spin 1 of the neutron shell. The deuteron may also be seen as a neutron whose shell has incorporated a second proton, while preserving its spin 1. This implies the spins of the two protons to be antiparallel and so neutralizing each other, while the spin 1 of the shell is preserved. Instead, if the deuteron would have a spin 0 it would imply the spins of the two protons to be parallel, and that of the shell to have the opposite orientation, which in fact does not occur because the spin 0 of the deuteron is not observed, thus leading to the exclusive state antiparallel of the proton spin. The deuteron spin is determined from the hyperfine transition having a value of 1, and a positive parity. Since the quadrupole moment does not cancel out, it follows that the nucleus is not round, therefore it cannot be in a pure S state with an orbital angular momentum  $l = 0$ .

The proton radius has been re-evaluated recently (the proton radius puzzle), obtaining a value of 0.84087 Fm, about 4% lower than the previous value of 0.8775 Fm, and corresponding to the value of the root-mean-square radius of the proton obtained from spectroscopic measurements of a Lamb-shift transition frequency in the muonic hydrogen atom [9, 10]. Anyway these values of the proton radius can represent only an average value since the proton is not a rigid body in view that its structure corresponds to a density of charge which spatial distribution has an extension of the order of the Fm (Fig 4). It should also be mentioned that from the size of atomic nuclei, the nucleons occupy a volume having an average radius of about 1.4 Fm. If this average radius of the nucleons is compared to that of the proton of 0.84 Fm, this means that the protons are somewhat distant (about 1 Fm) between them, as might be expected due to their electrostatic repulsion.

In this context, one might ask at first sight why the deuteron does not dissociate into two protons and an electron. The reason is simple and comes from the fact that once broken the -0.93 MeV bond between the two protons, the dissociation of the deuteron into a neutron and a proton is more favorable than its dissociation into two protons and an electron because the first process requires an additional energy input of only 1.29 MeV, while the second requires 0.51 MeV for the electrical charge to transit to the electron state, plus an energy of at least about 3 MeV to escape from the electrostatic attraction of the two protons, a process which requires thus an energy higher ( $\sim 3.5$  MeV) than the energy required by the n p dissociation (2.22 MeV). Moreover, during the disintegration of the deuteron into neutron and proton, the spin 1 of the deuteron shell is preserved by the neutron shell. In the energetically unfavorable case of two protons and one electron decay, the conservation of total spin would also imply the emission of a neutrino.

Complementarily, the equivalent diffusion experiment with positrons should be compared to that performed with electrons. Actually, they represent two different interactions of the structural charge distribution of the neutron with two different incident particles, an electron in one case and its anti-particle in the other case. Given the mutual attraction between the negative charge of the deuteron shell and the positive charge of the incident positron, it is to be expected that these two charges of opposite sign could be annihilated into a gamma photon, thus releasing a proton and a neutron, plus a positron by dissociation of a virtual photon.

#### 4. Discussion

We have provided experimental evidence that there is no neutron in the atomic nucleus because of its dissociation into a proton and an enveloping negative charge, thus leading to a proton that adds to the adjacent protons. Neutrons are only protons covered by a shell formed by the distribution of a negative electric charge.

Considering that in the atomic nucleus the neutron dissociates into its two parts, namely a proton and a negative charge that spreads over all the protons present, acting as a binding carrier, it is therefore necessary to improve our understanding of the atomic nucleus because it does not contain neutrons. These can only be at the most regarded as virtual neutrons, since they are in a dissociated state. Neutrons are formed only when they escape from the nucleus by the recombination of a proton with an electrical charge of the nuclear bonding shell.

Aren't the two identical peaks of Fig.5 and 6 and the symmetry of Fig.7 better explained by a nucleus of two protons wrapped in a bonding orbital rather than a proton juxtaposed to a neutron? Will experimental data diverging from the standard standpoint be ignored forever? The conventional representation of deuteron based on a proton juxtaposed to a neutron cannot lead to such a total symmetry of the structure of the deuteron since one particle is charged and the other is neutral.

Since the discovery of the neutron in 1932 by James Chadwick, the model of the neutron-proton nucleus has been formally established without questioning the presence of the neutron in the nucleus, even knowing that it is unstable. Nobody deeply wondered why the neutron would become stable once in the nucleus. This was admitted without knowing why. No one put in doubt its presence, and no one thought that it would only get formed at its escape from the atomic nucleus. Nobody thought that the neutron could be a disguised proton, resulting from the fusion of a proton and an electron, fusion in which the proton preserves its identity but not the electron, whose structural charge distribution mutates to a different quantum state, and whose new charge distribution covers the proton.

How is it that nobody has thought about the possibility that the neutron would not be present in the nucleus, but that it would just be formed when ejected from the nucleus, by recombination of a proton with a negative charge of the nucleus shell? Nobody thought that atomic nuclei could simply be composed of protons wrapped in a cloud of electric charges that would bond them. In fact, the old proton-electron model was closer to reality than the afterward proton-neutron model, however it has been rejected due to the confusion between electric charge and electron, instead of considering the electron as a quantum state of the electric charge. When the electron is substituted by the electric charge the difficulties that motivated the rejection of the former e-p model disappear, since unlike the electron, the electric charge has neither mass, nor magnetic moment, nor spin, but these are provided by each specific quantum state it acquires. Thus the arguments regarding the spin of the nucleus and the excess of kinetic energy of the nuclear electrons making them unable to sustain the cohesion of the nucleus are no longer valid for the electric charge.

And besides, how come no one has thought of the possibility that the neutron is a composite particle containing at its center a core formed by a proton, and wrapped by a negative charge

forming a shell, since it dissociates into a proton and an electron. The emitted electron would come from the mutation of the neutron shell in detaching from its core proton, and the antineutrino would be emitted by the transition of the shell to its state of lower energy, from 1.29 MeV (structural energy of the neutron shell) at 0.51 MeV (structural energy of the electron). All this has been inhibited by the very fanciful composition of the neutron and the proton formulated by the QCD, including all hadrons, as well as by the gluonic nature of the strong interaction, equally far-fetched.

The inception in the 1920s of Quantum Mechanics and Heisenberg's indeterminacy principle led to the persuasion that electrons confined at the nuclear scale would have a kinetic energy overcoming the nuclear cohesion. Furthermore, some nuclei, such as e.g. the  $^{14}\text{N}$  has integer spin 1. In the nucleus model composed of protons and electrons, the  $^{14}\text{N}$  had 14 protons and 7 electrons, i.e. 21 entities of spin  $1/2$  and so the total spin would be half integer, in discrepancy with the experimental integer spin 1. These two arguments led to the rejection of the presence of electrons in the nucleus. Nevertheless, Rutherford maintained the subsistence of electrons by proposing that in the nucleus each electron would be bonded to a proton. The deficiency came from not having been able to differentiate between electron and electric charge, so his proposal could not be retained.

Consequently the e-p model has been rightly rejected but this is due to the confusion between electron and electric charge. The electric charge has no intrinsic mass, nor magnetic moment neither spin, but it gets a mutable extrinsic mass, magnetic moment and spin according the diverse quantum states it may acquire. For example, in its lowest quantum state represented by the electron it has a spin  $1/2$ , but in other quantum states such as e.g. the  $\mu^-$ ,  $\pi^-$ ,  $K^-$ ,  $p^-$ ,  $\Omega^-$ , etc. the electric charge has different mass, magnetic moment and spin. The point is that the extrinsic characteristics of the electric charge are quantized and mutable. Similarly, when the electric charge is incorporated into nuclei it may acquire different quantum states according to each specific nucleus.

However, a consequence of leaving behind the previous electron-proton nuclear model was the loss of the cohesive vehicle of the atomic nucleus represented by the electron, which required having to conceive another cohesion element for the new neutron-proton model, since without it they lack of cohesive power. This led to the then recently discovered muon being proposed as the cohesive vehicle between nucleons, which was later rejected in favor of the pion when discovered, and finally attributed to the gluons, of eight different types, fruits of the CDQ. However, the current introduction of the nuclear model q-p makes possible to recover the cohesion vehicle of the nucleus, lost when rejected the nuclear electron-proton model, but this time replacing the electron with the electric charge.

So, within this revised framework, the electric charge can be afresh incorporated to the nucleus, leading now to the q-p model, where q is the electric charge, not the electron. In the nucleus the electric charge can acquire diverse quantum states and it also act as bonding element between nuclear protons. Note that this q-p model is nonetheless somewhat approximate with the n-p model since the union of an electric charge with a proton gives a neutron, however in the nucleus the neutrons may only be seen as virtual neutrons since they are dissociated into a proton, and an electric charge in different quantum states according to each specific nucleus. Sometimes an electric charge recombines with a proton leading to a neutron that is expelled. Instead in the  $\beta$ -decay, a q- charge is expelled alone acquiring then the electron state, but according to the energy released it may rather transit to the higher muon state.

It is surprising to note that the electric charge is still today assimilated in a wrong and atavistic way to the electron, simply because it has been the first charged particle discovered and that of all of them it has the smallest mass, without realizing that the electron only corresponds to a specific quantum state of the electric charge. Unlike the electron, the electric charge has neither mass nor magnetic moment, but it gets them via each quantum state it can acquire. Each of the quantum states that the electric charge can reach defines a specific elementary particle, with its mass, magnetic moment, spin, and so on.

## Conclusions

We have demonstrated that in the deuteron, the neutron is dissociated into a positive charge distribution corresponding to a proton and a negative charge distribution that extends over the whole nucleus, and acts as a cohesive shell. Thus, the deuteron is in fact composed of two protons wrapped by the distribution of the negative electric charge, coming from the dissociation of the neutron. It is crucial not to confound the electric charge with the electron, which is a specific quantum state of the electric charge. In fact, all charged particles, such as the muon, the pion, the kaon, the proton, etc., correspond to different quantum states of the electric charge, each having a specific structural charge distribution defined by a wavefunction.

Obviously, something has not been wholly suitably conceived in regard to the atomic nucleus. In order to solve the problem, the structure of the neutron must be reconsidered. Consequently, the deuteron model should be revised in accordance with the experimental proofs here provided, supporting a two-proton nucleus and a cohesive shell. The great advantage of this model is that it offers a simple explanation of the nuclear cohesion, without calling for an exchange of imaginary gluons, but instead just resorting on the sharing of the long-known integer electric charge, which acts as a bonding carrier in accordance with the extended quantum state acquired. By extension, this model can be applied to all atomic nuclei and it can be considered that the neutron is always dissociated into a positive charge distribution corresponding to a proton and a negative charge distribution which extends over the whole nucleus, acting as a cohesive shell.

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