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A Novelty Solution to the Neutron Anomaly (An Anomalous Neutron or "Dark"?)

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Abstract

To explain the anomaly ($\tau_b \neq \tau_f$) of the neutron lifetime τ in some experiments, in "bottle" τ_b and in "beam" τ_f, we resort to an anomalous form of the neutron n_a. This form belongs to one of two different states of the structure of the quark configurations making up the neutron (nucleon): first, an ordinary form Ψ_o, while the second is an "anomalous" form Ψ_a, difficult to detect and decay. If the ordinary configuration is present in everyone nuclear processes, to strong and weak interactions, and in diffusion processes, the anomalous form can emerge, in casual way and probabilistic, in some processes of fusion with production of neutrons and can be highlighted in some experiments as those in "bottle" and in "beam", see the anomaly of the neutron lifetime. We show that the anomalous form Ψ_a can be highlighted in the coupling between a dipoles' lattice of virtual bosons W and the neutron (nucleon) because the neutron into anomalous configuration does not decays. Finally, we interpret the anomalous neutron as a "dark" neutron, presenting, so, the dark matter as an anomalous form of hadron matter.

Keywords

Anomaly, Anomalous Neutron, Dark Neutron, Geometric Structure, Discrepancy, Bosons' Lattice, Weak Decay

1. Introduction

Along the path of knowledge of physical reality, a phenomenon can occur that cannot be explained by an already existing physical model. This could be the case of the free neutron decay anomaly. For some time, researchers have been trying to measure the lifetime of the neutron with extreme precision. Since 2005, the decays in two different instrumental apparatuses, "in the bottle" and "in

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beam", have been compared, but have produced different values: a discrepancy of about 8 - 9 seconds between the two types of experiments. When these "anomalies" occur in a definitive way, it becomes appropriate to introduce a new resolving element, a premise for a new descriptive paradigm of physical reality. Our innovative proposal is the introduction in the neutron physics of a particular physical condition, in correspondence to a "no ordinary" internal structure of quarks: in this state the neutron is difficult to detect, and its decay shows remarkable delay or do not happen. This aspect would explain the experimental value of the discrepancy between the two lifetimes. Just in (sect. 2.1) we report the experimental values of the two lifetimes [1]-[7] which are connected to the number n of neutron detected. In sect. 2.2 we have examined, the suggestion of B. Fornal and B. Grinstein (F-G) [8], which interpret the neutron "anomaly" by hypothesizing the presence of a dark particle χ among the decay products. In sect. 2.3, we show that the discrepancy $(d_r)_{exp}$ could be a consequence of two different methods of counting the decayed neutrons. Instead of the χ particle, the difference in the counting could reveal presence of a "anomalous" neutron, which we do not detect in the "in bottle" experiment, sect. 2.4. The presence of two different types of neutrons (ordinary and anomalous) could be justified, see sect. 3.1, by a different internal structure of the quarks that make up them: we indicate this as "structure hypothesis" of the nucleon. The diffusion experiments ($e + p$), which highlight three center of diffusion (three quarks), determine the first structure of proton (see the parton model [9] [10] [11]), indicated as structure state Ψ_1. This structure is more suitable to describe a proton in interaction or inside a nucleus, see the EMC effect in nuclear physics [12], where the cross-section of a free nucleon is different from the bounded nucleon, see sect. 3.2. Instead, in polarization experiments of the proton spin [13], we can think of highlight the second structure Ψ_2, which is more suitable for describing in QM a wave-particle (proton) in movement. In sect. 3.2 one highlights that the Ψ_2 structure allows, in a simple way, of understand and resolve the problems of proton momentum and spin. We define the first (Ψ_1) of these two structures as "anomalous" in free neutrons $(\Psi_1 \equiv \Psi_a)_{free}$, since it is difficult to detect and decayless, while the second (Ψ_2) can have two eigenstates: the first is "ordinary" $(\Psi_2 \equiv \Psi_o)_{free}$., the second is also "anomalous" and degenerated $[(\Psi_{2'} \equiv \Psi_a), (\Psi_{2''} \equiv \Psi_a)]$. In sect. 3.3, one presents the representation at matrix of the configurations of the two nucleon structures. In sect. 4.1 one underlines the "transformation" action of W-bosons on the quarks in the β-decays. This can happen, thanks to the W boson which would operate on nucleons through the combined action of a "pair" (W^+, W^-) or lattice {W}. In this way, we introduce, see sect. 4.2, in the theory of interactions the possibility that an intermediary agent can manifest itself as a lattice-field, see the pion decay, where the application of {W} simplifies the decay. All this determines a new descriptive "paradigm" of interactions, which implies, in its turn, a deepening of the way of seeing the particles: the interaction agent as lattice. In sect. 4.2, we describe then the coupling between the two structures, the {W} lattice and that of the neutron and, in general, of the nucleon, see also sect. 3.3. Thus, the two forms, the ordinary and anomalous one, are highlighted, both in the neutron and in the proton, showing that the anomalous one decay with difficulty but could also not decay (sect. 4.2). Once it has been established that nucleons are particles with an internal structure, we proceed, see sect. 5.1, to the "theoretical" calculation of the relative value of the discrepancy $(d_r)_{th}$ in the fusion reaction $(D + T) \to He + n + \gamma$ [1], in the case in which an anomalous neutron n_a could also form. The almost "coincidence" of the numerical values of the two indices $(d_r)_{th} \approx (d_r)_{exp}$ is immediately revealed. This shows that the hypothesis of an anomalous neutron can be consistent with the experimental data and an alternative to the hypothesis of the dark F-G particle. Finally, see sect. 5.2, the aspects of no decay of the anomalous neutron, no interaction in an electromagnetic way and difficulty interacting in a strong way, induce us to assert that the anomalous neutron has difficulty being detected and this last aspect recalls us to a "dark" particle. Furthermore, it should be noted that to understand the association anomalous-dark is necessary to formulate the conjecture that even quarks have a geometric structure resulting from an elastic coupling between quantum oscillators. This allows us to understand how an anomalous form of nucleon can originate and how it cannot annihilate itself with the respective antiparticle. This last aspect can cause dark matter and antimatter (ordinary and dark) to aggregate and coexist in galactic halos: in this way, the enigma of the disappearance of antimatter in this universe is solved. In conclusion, the presence of the anomaly has made it possible to detect that dark matter and ordinary matter are two sides of the same coin: the matter.

2. The Discrepancy between Lifetime in Neutron Decay

2.1. The Anomaly of the Neutron Decay

In their article [8], F-G try to explain the reason for the discrepancy in the values of the lifetime τ of the neutrons obtained in two different experimental situations: "*free*" neutrons in a beam (N_f) [1] [2] [3] and neutrons (N_b) confined in a container called "bottle" [4] [5] [6] [7]. In the first method of measure, that of the beam, the number of decays of the free neutron n_f by protons resulting from the β decays are counted n_p, to measure the neutron lifetime $\tau_{\text{beam}} \equiv \tau_f$, with $n_f = n_p$. In beam, F-G report the average value $\tau_f = (887.7 \pm 1.2_{[\text{stat}]})\ s$, see the works [1] [2] [3]. In the second method of measure (in bottle) of the neutron lifetime τ_{bottle}, suitably cooled neutrons are stored in the container for a Δt time comparable to their lifetime; after, the remaining neutrons are counted (n_{rb}) using the mathematical function $\exp(-t/\tau_n)$, during the next their decay. The average from the five experiments in the bottle, see F-G [8], included in the PDG world average is $\tau_{\text{bottle}} \equiv \tau_b = (879.6 \pm 0.6)\ s$. Besides, we have also considered the newest work by Gonzalez *et al.* [7], where the neutron lifetime in bottle is $\tau_b = (877.75 \pm 0.28)\ s$. The expectation was to detect in the two experiments the same lifetime $(\tau_b = \tau_f)$; instead, the opposite was experimentally verified $(\tau_b < \tau_f)$. The experimental relationship that links the lifetime τ and the number of decays n is $\tau \propto$

$1/n$. The discrepancy is: $[(\tau_b < \tau_f) \Leftrightarrow (n_b > n_f)]$.

2.2. The Hypothesis of a Dark Decay Channel in (F-G)

Thanks to the experiment of Gonzalez *et al.* the possibility that one of the two measurement modes is subject to a very large systematic error is excluded: thus, a discrepancy exists. (F-G) argue that the discrepancy is the consequence of a neutron decay in a dark matter (DM) particle χ_d. One between dark decays channels more probable can be: $[n \to \chi_d + \gamma]$, with γ (photon) and χ_d as dark fermion. From the various calculations a mass particle $m(\chi_d)$ emerges which is less than a few MeV with respect to the neutron one, that is (937.90) MeV < m_χ < (938.78) MeV, thus placing itself so between the proton and the neutron. The attempt of F-G of proposing a dark decay of neutron is a "hypothesis" that, however, goes beyond the standard model (SM) [8], see the Lagrangian (L), which here we show in a way schematized:

$$L = \left(\underline{u}d\Phi + \Phi^{*}\underline{\chi}d + \underline{Q}l\Phi^{*} + \underline{Q}Q\Phi + H.c\right) - M_{\Phi}^{2}\left|\Phi\right|^{2} - m_{\chi}\left(\chi\underline{\chi}\right) \quad (1)$$

With the field: $(u,d)_{neutron\ quark}$, $Q_{leptoquark}$, Φ_{scalar}, χ_{dark}, $l_{leptone}$, see Figure 1.

Note, from Figure 1, the particle Φ acts on the quarks (d, d, u), transforming them into the particle χ, accompanied either by a gamma ray γ. This transformation of the quarks and gluons connected to Φ is something "unclear". In fact, we underline that, the dark particle χ can be produced only if one admits a sort unclear "fusion" between quark and gluons, which happens inside the neutron and is mediated by Φ-field. If we follow yet the working hypothesis of F-G, we should admit then a mediating hypothetic "fifth force" that would transform a quark q into χ and vice versa ($q \Leftrightarrow \Phi \Leftrightarrow \chi$). At any rate, the transformation process of the ($n \to \chi$) would be so given always by the action of the Φ-field, which, nevertheless, is always a "vague" field or not well specified by the same authors F-G. Besides, developing the idea of dark decay without specifying the nature of the intermediary agent, see Φ, is a weak idea: a phenomenon (the anomaly) cannot be explained by resorting to a particle unknown in nature χ_d (not yet observed) which in turn it would be produced by an equally unknown reaction (see the intermediary agent Φ). The explanation of the anomaly given by F-G through the production of a dark particle is epistemologically weak. In truth, this is precisely the double basic problem of the dark matter hypothesis:

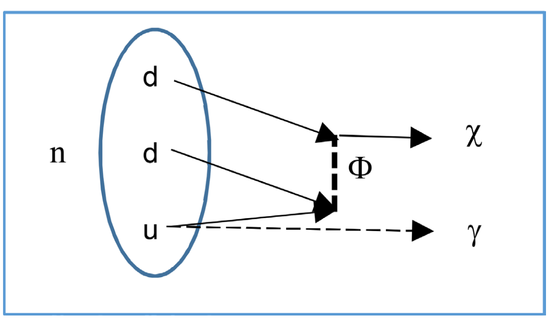

Figure 1. Dark decay in ($\chi + \gamma$) of the neutron.

not knowing neither the form of dark matter nor what transformation (intermediary agent) generates it.

2.3. Examination of the Experiments

The comparison between the two experiments, the bottle and beam, takes place if we assume that $[N_b = N_f = N]_{initial}$ where N is the initial number of neutrons in both experiments, see in "bottle" (N_b) and in "beam" (N_f). Since the neutrons in bottle are ultra-cold or have a very large wavelength compared to that of the wall nucleons then can be considered as "*frees*". This would imply that the number of decays of the neutron in the bottle would be equal to that of the beam ($n_b = n_f$) or the equal lifetimes ($\tau_b = \tau_f$); it would follow ($\tau_b = \tau_f$) ⇔ ($n_b = n_f$). We then ask us because the experimental results give ($\tau_b < \tau_f$). We consider the difference $[\Delta\tau_n = (<\tau_f> - <\tau_b>)]$, see the anomaly, and calculate $(\Delta\tau_n/<\tau_f>)$, which represents the value of "relative discrepancy" d_r. We take as a reference value of neutron lifetime in the bottle that is obtained by the average of values τ_b (Gonzalez) [7] and τ_b (Fornel) [8]*:* $<\tau_b> = [(\tau_b(G) + \tau_b(F))/2)] = (878.68)\ s$; in the beam, we consider the average value quoted by F-G, but relative to the experiment of Yue [5], $[\tau_f = (887.7 \pm 1.2_{[stat]})s]$. The experimental value of relative discrepancy is:

$$\left(d_r\right)_{exp} = \Delta\tau_n \Big/ \left\langle \tau_f \right\rangle = \left(887.7 - 878.68\right) \big/ 887.7 \approx 0.0102 \tag{2}$$

The two authors (F-G) find a Branching fraction (Br) of reaction ($n \to p$ + other) of about 99%, while the remaining 1% probability would be for another type of decay or in general of another possible reaction. Different scenarios there would be in the case of "dark" decay channel (case A) and in the case of other reactions, but not dark particles (case B). If we did not accept case A then the case B would remain and thus, we should look for an explanation of the discrepancy that includes something "anomalous" in the neutron and its decay. Note that still no gamma photons have been observed in experiments in bottle, also if we have always the experimental confirmation that is $[n_b > n_f]$. In this case, the hypothesis B would become very interesting.

2.4. Another Possible Origin of the Discrepancy

Pending other experiments that confirm the F-G hypothesis, we could think of another possible explanation for the discrepancy: the presence of an "anomalous" neutron n_a with delayed decay or, in extremis, also decay less (case B) and therefore not be detectable in the bottle. Let us remember that F-G find that the difference in mass between χ and the neutron n is a few MeV and therefore our conjecture of an anomalous neutron could be compatible with the calculations made by F-G, within the same error ranges, if this has a slightly lower mass to that of the "ordinary" neutron n_o: $[m(n_a) \approx m(n_o)]$. Note, in the bottle experiment, an operation is performed that is not carried out in beam: after a time Δt_b, see sect. 2.3, in which the decays of the neutrons introduced into the bottle take place, the neutrons remaining in the bottle n_{rb} are counted by a neutron absorber

A_n. In this case, an experimenter thinks the neutrons that have had the decays during the time Δt_b in the bottle will be n_b or [N-n_{rb} = n_b]. Note this is an indirect measure. Instead, in beam, n_p protons from n_n decays of free neutrons are detected for a certain time of observation Δt_f. This is a direct measure. The experimenter then states that [n_p = n_f] is the number of neutron decays n_n in the beam. The two different experiments are conducted in such a way that the observation times of the neutron decays are as if they were the same: ($\Delta t_f = \Delta t_b$). The possible origin of an anomalous neutron $n(a)$ could take place during a fusion reactions and fission e.g., in the fusion reaction ($D + T \rightarrow He + n$) one could have also ($D + T \rightarrow He + n(a)$). Just this reaction is that producing the neutron beam used in the mentioned experiments (from the Los Alamos Neutron Science Center's proton-beam-driven solid deuterium UCN source, Ref. [1]). Therefore, in the initial number N of neutrons inserted in the two different instruments, beam and bottle, there will also be present, in equal numbers, the n_a anomalous neutrons that is $(n_a)_f = (n_a)_b$, where n_a is now the number of anomalous neutrons. The effective neutrons are ($N - n_a = N^\circ$) both in the beam and in the bottle: $(N^\circ)_b = (N^\circ)_f$. Therefore in beam it is [$(N^\circ)_f - n_p = \underline{n}_{rf}$]. However, the experimenter associates a certain amount of Deuton mass (M_D) and Tritium (M_T) to production of a certain amount of neutrons N: (X_D, Y_T) $\Leftrightarrow N$. The possible production of anomalous neutrons at present is not considered in the literature, so the experimenter believes that they are N effective ordinary neutrons n_o and does all the calculations with this number N. In beam, an experimenter, therefore, puts in his calculations: [$N - n_p = n_{rf}$]. But n_{rf} is only an "apparent" number: it is not the true number of ordinary neutrons left in the beam. The true number of ordinary neutrons in the beam will be indicated with $\underline{n}_{rf}$. Note that ($n_{rf} > \underline{n}_{rf}$) because $N > N^\circ$. In fact, we find also:

$$\left[n_{rf} = N - n_p = \left(N^\circ + n_a\right) - n_p = \left(N^\circ - n_p\right) + n_a = \underline{n}_{rf} + n_a\right] \rightarrow \left[n_{rf} > \underline{n}_{rf}\right] \quad (3)$$

In the bottle, the anomalous neutrons are not detected by the absorber A_n, therefore they do not appear in n_{rb}. The experimenter detects n_{rb} neutrons and states that [$N - n_{rb} = n_b$], where n_b should be for him the number of the effective neutrons. But the number n_b is apparent while n_{rb} experimental is true. Also in the bottle experiment, the experimenter does not know that would be $(N^\circ)_b - n_{rb} = \underline{n}_b$. The experimenters did their utmost to make the experiment in the bottle "identical" (in the development of the beta decay) to that of the beam, so we might think that it should be observed [$n_{rb} = \underline{n}_{rf}$]. Note that here we have an equality between two true numbers. However, if we replace n_b with ($N - n_{rb}$) then we will apparently have that:

$$\left\{N - n_b = n_{rb} = \underline{n}_{rf} = n_{rf} - n_a = \left(N - n_p\right) - n_a\right\} \Rightarrow \left\{n_b = n_p + n_a\right\} \quad (4)$$

It follows that the experimenter, by its experimental way, will find a neutron number in the bottle greater than that in the beam ($n_b > n_f$), thus incorrectly determining an anomaly in the lifetime of the neutron. All this is a consequence of the fact that the existence of the "anomalous" neutron both in the bottle and in the beam is not considered. Therefore, the anomaly (discrepancy) could reveal the existence of an anomalous neutron.

3. The Anomalous Nucleon

3.1. The Hypothesis of Double Structure of Nucleon

The hypothesis of the anomalous neutron n_a cannot involve the "nature" of the neutron, but the internal "structure" of its quarks. We introduce so the possibility that the neutron can have two structure forms: the first is defined as "ordinary" while the second is defined as "anomalous" because difficult to decay (often even decayless) and detect. The idea of a different structure in the nucleons would imply a different spatial arrangement of the internal quarks. Literature always references the "internal motion" of quarks [10] [11] when calculating their orbital angular momentum [14], using the "parton" model (QPM) [10] and that of Lattice QCD, see Ref. [15] [16]. Even if there is a good agreement between the theoretical predictions of QPM and QCD and the experimental data concerning the cross section, the "Structure" Functions [17], the other kinematic parameters as the orbital angular momentum and energy, however, no additional information is given on the spatial structure of quarks distribution. The QPM merely maintains in the DIS [18] [19] experiments on the proton, that three free "partons" are detected within it, see the "scaling" of the structure functions $F(x_B)$, and confined to remain at its inside [17]. The attempt to physically express the proton is reduced to seeing it as a "material object" made of three point-like quarks immersed in a "*sea*" [20] [21] of quark-antiquark pairs which in turn are immersed in a "sea" of gluons [22] [23]: this representation is not free from doubts and questions. To avoid problems of a representative nature, the researchers opted mainly for the development of a purely mathematical model of the structure of a nucleon. Instead, we will look for a "physical" representation of the nucleon structure and, through this, explain some experimental results, such as the value of proton total spin, the momentum global of the proton and the anomaly of neutron decay. To represent the spatial configurations of the quark's orbital motions with more descriptive details one could refer to the dynamics aspects more elementary already described in the (QPM) and QCD. Precisely, both models predict the dualistic behavior of the "Asymptotic Freedom" (AF) at a mutual short distance of quarks and their "Hadronization" at a long distance (see $V(r) \approx (\ldots + kr)$) [15], while only in the QCD the color gauge field of gluons leads to admit a mutual "confinement", see the shielding of color charge [24]. Note the "Asymptotic Freedom" behavior in the QPM shows a Form Factor F(Q) compatible with an exponential distribution of electric charge [$\rho(r) \equiv \exp(-ar)$], in which the quarks could be located with more probability at "centre" [10] [11]. The two behaviors are a consequence of a "reduction" process from the no-local state $\Psi(p,e)$ of the physics system electron-proton to the local state ($\Psi \rightarrow \Psi_i$), where the proton shows a corpuscle aspect given by the three quarks seen as diffusion centres, see the reaction ($e + p$). Note that if the "confinement" of quarks happens when they are away from each other, then when the quarks reciprocally are near, we could locate them at the "centre" of the nucleon. The synthesis of these aspects could be by the following "indicative" and intuitive illustration, see Figure 2, reported only in various didactic literature:

In this "geometric" structure, we must assign an oscillator motion, see the QM, and rotational to any quark. The configuration (seen as a structure state Ψ_1) can well describe a proton inside a nucleus, because the quarks spread themselves spatially inside to proton, in a way that they can become of "valence" and, thus, bind to other nucleons into the nucleus [25]. In this case, the quarks go toward the outside or the outskirts to tie themselves to the quarks of other nuclei. In this configuration, the valence quarks are, therefore, binding agents and have a corpuscle aspect (in fact they are diffraction centres) and, thus, also the proton. The same happens in the neutron. Instead, in the case of free nucleons, the quarks, with no more valence bonds, go toward the "centre", where are asymptotically frees and they can spatially locate along the same line of oscillation as "three beads connected by springs". Therefore, we think that the configuration of Figure 2 cannot "appropriately" describe free nucleons to which one can associate an undulatory behavior (wave-nucleon) so as the Quantum Mechanics (QM) states. We are thus induced to search for another configuration of quarks which may describe the nucleon propagation as "oscillations" of a plane wave, see the eigenstate of moment p_x (k_x) propagating along an X-line of quantum oscillators of the nucleonic field. This configuration might be, seen always in an intuitive way an indicative, the following, see Figure 3.

Where g_i are the bounding gluons, (s_p, s_n) are the proton spins and neutron, (k_p, k_n) are the wave-vectors and (u, d) is the wave-function pair of quarks. Note

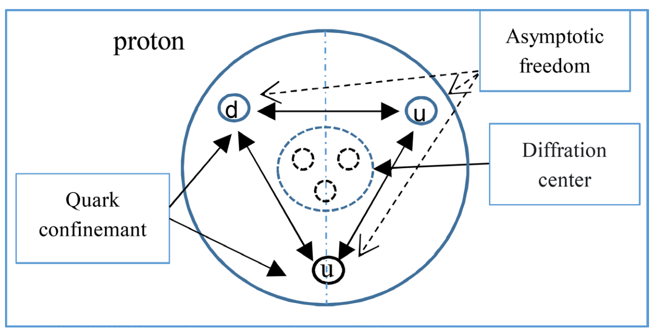

Figure 2. Quark configuration in parton model and in QCD.

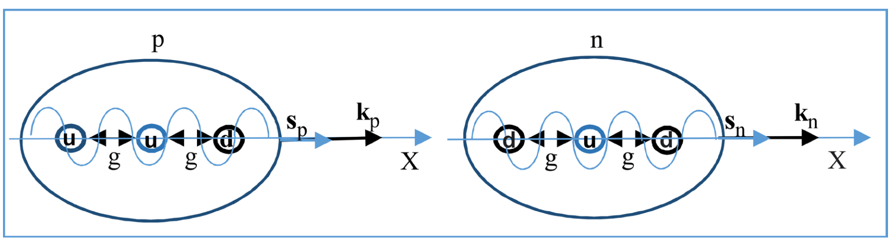

Figure 3. Propagation of wave-nucleons in moment eigenstates (k_p, k_n).

that, in the case of β-decay of both nucleons, one transforms into the other, excluding the decay of the "inner" quark. We will say that these two configurations are then reciprocally compatible with β-decay. Recall that the total moment p_{tot} is the sum of the moments p_i assigned to all the constituents of the system, quarks, and gluons. Then it is needed to consider that the system of oscillators along the proton propagation line X (in an eigenstate of the moment), see **Figure 3**, is unique both for the quanta of the fields (u, d) and for those of the gluon field: this is possible if the respective wavelength λ_i are "commensurable" ($\lambda_g/\lambda_q = p_g/p_q = n$), where ($\lambda_q$, λ_g) are the wavelengths of quarks and gluons, and n is an inter number (n = 1, 2, …). In this case, we can think, in accordance with the QM, that the wave functions of the quarks (Ψ_u, Ψ_d) and gluons B_{gi} "interpenetrate" reciprocally as if the gluon field is a "waveguide" of the fermion quarks. Note the proton configuration of **Figure 3** could happen when there is an "external" electric field E that accelerates the proton with all its quarks, which so arrange along the E-field lines. This placement along the field lines (or replacement) can happen also for the "electrically neutral" neutron because the quarks having the same an electric charge, see the magnetic moment of the neutron.

3.2. The Questions of Momentum and Spin of Quarks and Gluon

The intuitive representation of **Figure 3** helps us to understand in a way very simpler some problematic physical aspects of nucleons described by QCD [15] and QPM [10] [11]. According to the field theory, the waves associated with these oscillations carry a moment. For each wave packet of quarks and gluons, we will have $\{p_q = \Sigma_i(hk_i), p_g = \Sigma_j(hk_j)\}$. Note that to the proton we can always assign a wave packet. For plane-wave it is $\{p_q = (hk_q), p_g = (hk_g)\}$. For the interpenetration of the waves, we will have that ($\lambda_g/\lambda_q = p_g/p_q = n$) (*). In this way, the total moment of the proton (eigenstate p_p) will be given by:

$$p_p = \Sigma_q\left(p_q\right) + \Sigma_g\left(p_g\right) \tag{5}$$

Note, in **Figure 3**, that:

- the quark oscillations and gluons are polarized along the spin axis coincident to that of propagation X.
- this configuration is coherent with the quark's confinement and the Asymptotic Freedom because the gluons are like "springs" with elastic force $F_{(x\to 0)} \approx k_{el}\, x$.
- this configuration is compatible with the experimental observations on the momentum p of QPM, where emerges the connection [23] between p_q and p_g:

$$\Sigma_q\left(p_q\right) = (1/3)\, p_p\,,\quad \Sigma_q\left(p_g\right) = 2\Sigma_q\left(p_q\right) \tag{6}$$

In fact, in an intuitive and approximate way, see **Figure 4**, each quark q_i has side two side gluons of "valence" (g', g'') which connect it to the other quarks q_j.

Note that the number of gluons is $N(g) = 6$ while that of quarks is $N(q) = 3$. If the addition property of the momentum of a compound system is the sum of the

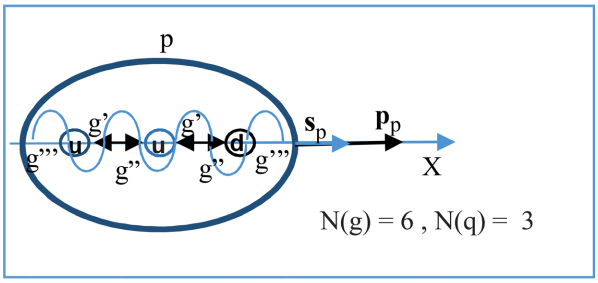

Figure 4. Structure of quarks and gluons of proton in first approximation.

momentum of the constituents, we will have, see the Equation (5) and (*), that:

$$p_p = \Sigma_q\left(p_q\right) + \Sigma_g\left(p_g\right) = 3p_q + 6p_g = 3p_q + 6np_q = \left(3+6n\right)p_q \tag{7}$$

With $p_{q1} = p_{q2} = p_{q3} = p_q$, the same is for gluons: $p_{gi} = p_g$.

It follows: $p_q = (1/3)\Sigma_q(p_q)$, $\Sigma_g(p_g) = 6p_g$. Note in Equation (7) that:

If $n = 1 \rightarrow p_p = 9p_q = 9(1/3)\ [\Sigma_q(p_q)] = 3\Sigma_q(p_q) \rightarrow \Sigma_q(p_q) = (1/3)p_p$

This result is coincident to one of Equation (6a).

If $n = 1 \rightarrow p_g = np_q = p_q$ it follows $\Sigma_g(p_g) = 6p_g = 6p_q = 2(3p_q) = 2\Sigma_q(p_q)$.

Note this result is coincident with that of Equation (6b). This last proposal, see **Figure 3**, could find consensus in the experimental activity of recent years [23] [24] [25] [26], which investigates the momentum p and spin s of the proton by the QCD model, and which undermines the structure of the proton, so as is seen by the QPM, see **Figure 2**. In fact, in the series of spin state polarization experiments, see the Ref. [23], the researchers are oriented towards a slightly different representation from that of the QPM. It was believed before (in QPM) that the spin of the proton coincided with the spin of the unpaired quark, however, measurements in experiments with non-polarized protons [27], showed that quarks can contribute as fermions up to 25% to the total spin of the proton. We recall that the fundamental baryons composed by (u,d) have: $s_q(\Psi_{spinor}) = [(\pm 1/2)_N, \pm 3(1/2)_\Delta]_{(25\%)}$. Following, D. de Florian and collaborators, see Ref. [23], they claim, from the analysis of the experimental data of the RHIC, to have found: "*evidence for a nonvanishing polarization of gluons* (in direction of the proton spin)…*and a significant contribution of gluon spin to the proton spin…*" Rojo's group [28] thus calculated that the gluons probably contribute about half (50%) to the proton global spin. The polarization would thus allow each gluon with a spin equal to 1, to contribute to constituting the missing part of the spin of the proton, according to its orientation. All this, in our opinion, can also demonstrate a polarization of the quark oscillations, see the gluons in **Figure 4**, along the propagation axis of the proton with spin polarized precisely along this axis. In this case, the "orbital" motions of quarks could be "squashed" around the propagation axis (the quarks go to align along the spin) and contribute at least 25% to the global spin of the nucleon. Considering these experimental aspects, we can then conjecture a possible representation of the arrangement of quarks within a "spin-polarized" proton, which however takes into consideration the wave aspects associated with the proton in its whole, that is, in its quarks and gluons. Note, already we have proposed this in the representation for the two nucleons of **Figure 3**. We point out this configuration of the internal structure of the proton as state Ψ_2. It is thus noted, in the light of the experimental data (see RHIC in [23]) just described, that we could make the following proposal:

$$s_p = \pm\frac{1}{2} \Leftrightarrow \left\{ s_q\left(\Psi_{spin}\right) = \left[\pm\frac{1}{2}, \pm 3\frac{1}{2}\right]_{(25\%)}, s_g\left(G_{vect}\right) = \mp 1_{(50\%)}, s_q\left(J_{orb}\right) = \pm 1_{(25\%)} \right\} \quad (8)$$

One can guess that the proton spin must be given by sum of the spins of individual field, which compose the proton and propagate all in the same direction: $[\boldsymbol{s}_p = \boldsymbol{s}_q + \boldsymbol{s}_g]$. Where s_q is given by $[\boldsymbol{s}_q = \boldsymbol{s}_{q(orbital)} + \boldsymbol{s}_{q(spinor)}]$, while $[\boldsymbol{s}_g = \boldsymbol{s}_{g(boson)}]$. In the Ψ_2 proton structure, we can suppose $[\boldsymbol{s}_{q(orb)} = 0]$ and $[\boldsymbol{s}_{g(bos)} = \boldsymbol{s}_{g(inside)} + \boldsymbol{s}_{g(outside)}]$, with $\left[s_{g(in)} = s'_g + s''_g = 0\right]$ and $\left[s_{g(out)} = s^{*\prime}_g + s^{*\prime\prime}_g = \mp 1\right]$ because the external gluons belong to "waveguide" field; we have $[s_{g(boson)} = s_{g(in)} + s_{g(out)} = s_{g(out)} = μ1]$. Therefore, we have:

$$\left[\boldsymbol{s}_p\left(\Psi_2\right) = \boldsymbol{s}_q + \boldsymbol{s}_g = \boldsymbol{s}_{q(spinor)} + \boldsymbol{s}_{g(boson)} \rightarrow s_p\left(\Psi_2\right) = \pm(1/2) \mp 1\right]_{\Psi_2} \quad (9)$$

In nucleon we have $[\boldsymbol{s}_p = \boldsymbol{s}_q + \boldsymbol{s}_g = \boldsymbol{s}_{q(spinor)} + \boldsymbol{s}_{g(boson)} \rightarrow s_p = \pm(1/2)$ μ $1 = \pm(1/2)]$.

In baryon Δ we have $[s_p = \pm(3/2)]$.

If $[s_{q(orb)} \neq 0]$ in Ψ_1 structure eigenstate of nucleon, then we could have: $[s_{q(orbital)} = \pm 1]$; in this case we will have:

$$\left\{ \boldsymbol{s}_p = \boldsymbol{s}_q + \boldsymbol{s}_g = \left(\boldsymbol{s}_{q(orb)} + s_{q(spin)}\right)_q + \boldsymbol{s}_{g(bos)} \rightarrow s_p = \left[(\pm 1) + \left(\pm\frac{1}{2}\right)\right]_q + (\mp 1)_g = \pm\frac{1}{2} \right\}.$$

Thus, we can conjecture that $[s_{orb} \equiv J_{orb}(μ1)]_q$ is always opposite to the spin of gluons s_g (± 1) and two quarks of three would have opposite spins (exactly the couples $(u, u)_p$ and $(d, d)_n$). Comparing the two configurations, see **Figure 2** and **Figure 3**, or two states (Ψ_1, Ψ_2), the proton (nucleon) would thus appear "dual" in structure and an "observation" operation on it could induce it to exhibit one of the two states of the spatial configuration of the quarks: $\Psi_N \equiv (\Psi_1, \Psi_2)_N$. The two different geometric arrangements highlight so two states of the nucleon characterized by the same quantum numbers but by two different behaviors in the interaction and decay processes: all of this is pointed out as "Structure Hypothesis". We assign the first structure Ψ_1, see **Figure 4**, to nucleons participating in "interactions" inside a nucleus. We assign the second structure Ψ_2, see **Figure 3**, to free nucleons that propagate in space (moving with respect to the Reference System of the Laboratory, S_{lab}) or in the scattering process, see the diffusion $(e + p)$. Therefore, we could state that the quarks, inside a nucleus, re-place themselves in relation to the bonds with other nucleons $(\Psi_2 \rightarrow \Psi_1)$. The above is not new in the panorama of experiments on the internal structure of nucleons: the EMC effect [12] has been known for some time: "*the quarks that make up protons and neutrons in atomic nuclei behave differently than the quarks that make up free protons and neutrons*". Just in Ref. [17] the researchers studied the relationship between the cross sections for a nucleon bound in a nucleus and that of a free nucleon. Experimentally, they found that $\sigma(n)_N/\sigma(n)_f \neq 1$, where $\sigma(n)_N$ is the cross-section of the nucleon, which is bound to at the nucleus, while $\sigma(n)_f$ is the free nucleon one. This confirms the Structure Hypothesis, and then, in interaction processes, we have that the nucleon, in each case, collapses in one of the two possible states (Ψ_1, Ψ_2). Note, besides, the Ψ_2 structure could be assumed by the proton (nucleon) consequent to an observation of spin polarization. We could conjecture that in processes where the nucleon binds to other nucleons, it is into state Ψ_1, while in processes where it "detaches" from a nucleus, the nucleon presents itself into state Ψ_2.

3.3. The Structure Matrices of Nucleon

Note that the eigenstate Ψ_2 of **Figure 3** can have three distinct configurations relative to the position of the quarks (u, d): $\{(u, d, u)_1, [(u, u, d)_{2'}, (d, u, u)_{2''}]\}$; where two of these $[(u, u, d), (d, u, u)]$ are degenerate into the location of the two oscillators (u, u). Then, we could associate a column-matrix to each configuration. The same would be for the neutron. We will therefore have the following matrices in the nucleon in Ψ_2-state:

$$N\left(\Psi_2\right) \equiv \left\{ \begin{pmatrix} d \\ u \\ d \end{pmatrix}_n, \left[\begin{pmatrix} d \\ d \\ u \end{pmatrix}_{n'}, \begin{pmatrix} u \\ d \\ d \end{pmatrix}_{n''} \right] \right\}_n, \quad \left\{ \begin{pmatrix} u \\ d \\ u \end{pmatrix}_p, \left[\begin{pmatrix} d \\ u \\ u \end{pmatrix}_{p'}, \begin{pmatrix} u \\ u \\ d \end{pmatrix}_{p''} \right] \right\}_p \tag{10}$$

We note that in Ψ_1 -state the exchange of place of the quarks does not cancel the "spherical" symmetry (invariance for rotations), instead, in Ψ_2 -state the exchange of place cannot be invariant because there are two "outside" quarks and one "inside". This can have repercussions on interaction phenomena, especially when the spin is different in various configurations [29]. Thus, in general, we might think that in weak interactions, where W bosons are involved, different states of polarizations of the neutron could affect its behavior, even in the β-decay. In Ref. [13], at RHIC, according to the data, collisions between two protons whose spins are aligned occur with a different frequency from that which characterizes collisions of particles with spin in opposite directions. As we will see in the next section, then the spin directions could be important also in β-decay, where the W-boson are involved. In conclusion, we might think that there could be differences in behaviors between the three configurations [Ψ_{2n}, ($\Psi_{2n'}$, $\Psi_{2n''}$)] or eigenstates of Ψ_2 -state, so even between two structure states (Ψ_1, Ψ_2). In fact, if we take in consideration the eigenstates $(\Psi_2)_n \equiv (d, u, d)$ and $(\Psi_2)_{n'} \equiv (d, d, u)$, see **Figure 3**, in a free neutron, see Equation 10, then we will have as decay, in **Figure 5**:

Here we distinguish two configurations in Ψ_2 where g_o are the outside gluons that can be used for strong interactions with other quarks of other hadrons, while g_i are the inside gluons that bind the internal quarks of the neutron. We will say, "intuitively", that two d-quarks, in the first configuration, are less "committed" in internal bonds than u-quark and, therefore, may have fewer "constraints" of energetic nature for decay, see the nucleus. In the second configuration, one only *d*-quark is less "committed", and, thus, available to decay. In general, regarding β-decay, we define:

- "open" the configuration in which there are at least two peripheral ("external") quarks, that is linked to a single quark.
- "semi-open" the configuration in which there is only one peripheral quark.
- "not open" in which each of the three quarks is bound to the other.

If the quark is peripheral, it is more likely to transform for decay into the other quark of the pair (u, d). The Ψ_2 (*d, u, d*) is "open" to the β-decay, while Ψ_2 (*d, d, u*) is "semi-open". So the Ψ_2 (*d, d, u*) has a probability minor than Ψ_2 (*d, u, d*) in β-decay. In the Ψ_1-state, each quark is related to the other two, see **Figure 6**.

Even if the figure is only an intuitive (but indicative) and formal representation (could we better say didactic?), we can define this structure as "not open" (to β-decay) because each *d*-quark, with respect to the Ψ_2-structure, is "bonded" to other quarks. In probabilistic terms, we believe that the Ψ_2-structure is more likely to β-decay than the Ψ_1-structure. As we have already said, the Ψ_1-structure could be more suitable than Ψ_2 to describe bound states of the neutron, and, as we well know, a bound neutron in a nucleus does not decay, while if free it does. Having so introduced a structure in a neutron, one could then have the possibility of differentiating its behavior related to decay. In fact, the discrepancy of the neutron lifetime could be explained if to a neutron one associates some different structures: that "open", "semi-open" and "not open". The transition from a bound state to a free state involves the transition from the state with structure Ψ_1 to that with structure Ψ_2. The times, once a neutron emerges from a (strong) nuclear reaction are analogous to those of strong interactions, because the passage

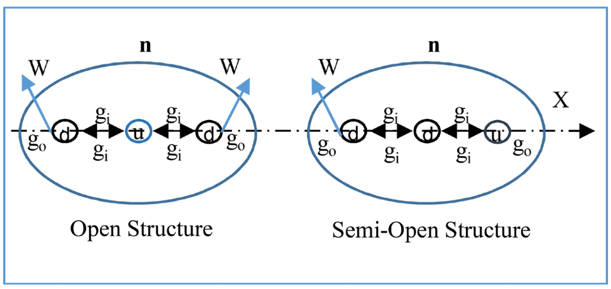

Figure 5. Possible decays in two different structures of Ψ_2.

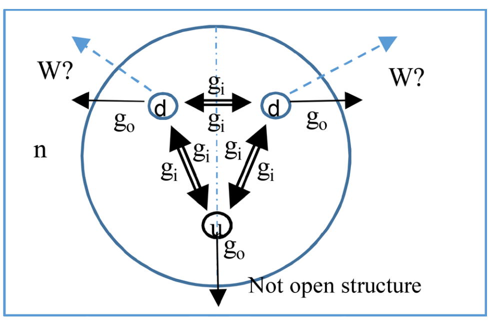

Figure 6. Unlikely decay in "not open" structure Ψ_1.

of quarks, no longer valence, from the periphery to the center is "forced" by the gluons. However, we do not deny the possibility that there are delays in the transition times determined by some, for the moment, unspecified cause. In this case, we will have a free neutron but in aΨ_1-state: $\Psi_1 \to (\Psi_1)_{free}$. All these aspects push us to talk about a structure anomaly of the free neutron. We can speak of an anomaly also in the case that a neutron emerges, in a neutron production process, with a structure given by the two "semi-open" configurations ($\Psi_{2n'}$, $\Psi_{2n''}$). For what we have just said, to "not-open" state Ψ_1 we can then associate the same matrices of the degenerate state ($\Psi_{2n'}$, $\Psi_{2n''}$); note that in state Ψ_1 there is an "invariance" for permutations of places of quarks (degenerate states), see **Figure 5**, like in the states ($\Psi_{2n'}$, $\Psi_{2n''}$). In this case, the matrices for the structure Ψ_1 are:

$$n(\Psi_1) \equiv \left[\begin{pmatrix} d \\ d \\ u \end{pmatrix}_{n'}, \begin{pmatrix} u \\ d \\ d \end{pmatrix}_{n''} \right]_n \tag{11}$$

Therefore, we speak about an ordinary neutron n_o as also an anomalous neutron n_a. We have so established a correspondence between the matrices and the configurations of the two structures of the neutron. In this way, the order of the writing of quarks in a matrix points out a quarks' configuration. We will have so that:

$$\begin{gathered} \left\{ \Psi_a \left((\Psi_1)_f, \Psi_{2n'} \right) \Leftrightarrow \left[n_a(u,d,d), n_a(d,d,u) \right] \right\}, \\ \left\{ \left[\Psi_o(n) \equiv (\Psi_2)_f \right] \Leftrightarrow \left[n_o(d,u,d) \right] \right\} \end{gathered} \tag{12}$$

At proton, we can also assign an ordinary structure $\Psi_o(p)$ as also an anomalous $\Psi_a(p)$. However, regarding β-decay, the proton could be non-symmetrical with respect to the neutron regarding the shape of the matrices that describe it. In fact, note that a β-decay of the ordinary neutron in "open" configuration (d,u,d), see **Figure 5**, transforms it into a proton with configuration (u,u,d) or (d,u,u), which, looking at the correspondent matrices of the neutron, one could say that are "semi-open" configurations. It follows that the indicatives matrices associated with each nucleon could be different in the two characteristics of "anomalous". If we look at the structures of **Figure 2** (neutron) and **Figure 6** (proton), we can argue that they represent two nucleons "not-open" to β-decay, as happens for bonded nucleons into a nucleus. All these aspects induce us to think that in β-decay there is no symmetry of configurations between neutron and proton. At this point, we think that it is necessary to deepen the β-decay of the nucleons or the relation between W-bosons and nucleons. We could think that the difference in neutron decay between two structures, could be further "accentuated" if even to the W boson one associates a physical state at more "structures": the coupling between two structure-systems would be more complex than the coupling between a structure (the nucleon) and a "point-like" particle, the W boson, but it could better highlight the presence of the anomalous neutron.

4. The Lattice {W}

4.1. The Lattice {W} of Bosons W±

The different nucleon structures that may have different behavior in β-decay, and therefore in weak interactions, lead us to review the very meaning of "decay" of the d-quark: ($d \to W^- + u$). The phenomenological theory of interactions [10] [11] [29] does not explain why a "point-like" particle (d-quark) decays spontaneously: therefore, becomes difficult to describe the β-decay as the emission of a W-radiation and consequent transformation of the d-quark in a u-quark; idem for ($u \to W^+ + d$). To have radiation emission we must consider structures such as atoms and nuclei or accelerating electrons. QED describes the bremsstrahlung radiation [10] [11] as ($e + \gamma_v \to e + \gamma_r$), where γ_v is a virtual photon of an external electric field E and γ_r is a real photon. Note the electron remains unchanged because it is point-like. But we ask ourselves in the β-decay why the d-quark emits the W-radiation and at the same time transforms itself into a u-quark. To accept the decay, it needs to think that "something" intervenes in the d-quark transformation into a u-quark: we think of an "agent" Φ, see **Figure 7**. In this case, the structure of the nucleon N changes and consequently also its matrix representation:

Now, we could believe that the same W-boson is the agent in question ($\Phi \equiv W$) and that it operates by coupling between its field oscillators and those of the d-quark. The action of "transformation" of d-quark into u-quark by $W^{\pm}$ can be formally expressed as: ($W^+ \otimes d \to u$), where $\otimes$ is the coupling operation, for the moment expressed only in formal terms. We would also have the other case ($W^- \otimes u \to d$). To talk about "transformation" constitutes a change of perspective in the theoretical treatment of the interactions between elementary particles. By recalling the matrices of Equation (10) we can see the transformation of a matrix into another through the action of W, expressed in matrix form, that transforms the elements of the matrices, see **Figure 8**, ($n \to N$), where N can be a nucleon ordinary as also anomalous. The change of perspective implies that we do not consider the following usual form of interaction Hamiltonian H_{int} in the pion decay [11] [29]:

$$H_{int}(W) = \frac{g}{2\sqrt{2}}\left\{\left\{\left[\bar{u}\gamma_\mu(1+\gamma_5)d\right]W_\alpha^+ + \left[\bar{\mu}\gamma_\mu(1+\gamma_5)\nu\right]W_\alpha^+\right\} + \left\{\left[u\gamma_\mu(1+\gamma_5)\bar{d}\right]W_\alpha + \left[\mu\gamma_\mu(1+\gamma_5)\bar{\nu}\right]W_\alpha\right\}\right\} \tag{13}$$

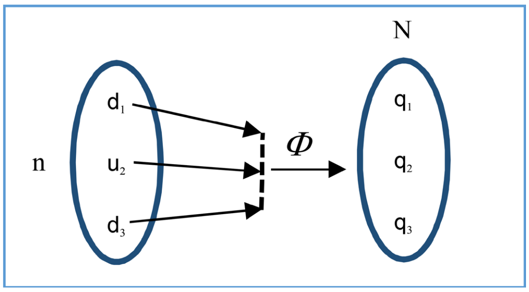

Figure 7. Hypothesis of a transition $n \to N$.

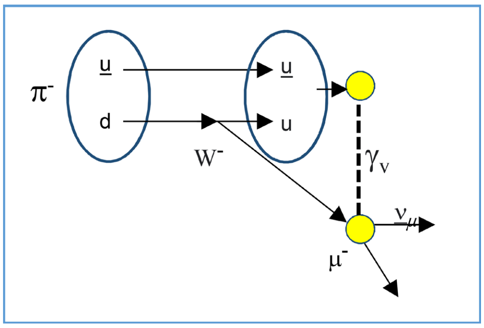

Figure 8. Representative diagram of the pion decay.

where (u, d, μ, ν) are wave functions expressed by the creation and annihilation operators of Fermions $\left[\left(b_0, b_0^+\right)_{Fermi}\right]$ while (W) is the wave functions by operators $\left[\left(a_0, a_0^+\right)_{Bose}\right]$. In the case of pion decay, the phenomenon is usually described through the following diagram, see **Figure 8**:

We can give the following formal description with matrices:

$$\begin{pmatrix} u \\ d \end{pmatrix} = \begin{pmatrix} \underline{u} \\ d \to u + W^- \end{pmatrix} \to \begin{pmatrix} \underline{u} \\ u \end{pmatrix} + W^- \to \left(\gamma_v + W^-\right) \to \left(W^-\right)_\gamma \to \begin{pmatrix} \mu \\ \underline{\nu}_\mu \end{pmatrix} \tag{14}$$

Note the pair (u, $\underline{u}$) annihilates and produces a virtual photon (γ_v), which couples with the W⁻ boson before decaying. This description is now replaced by a new description in which agent W transforms the d-quark: ($W^+ \otimes d \to u$). Looking to **Figure 7**, note that if $N = n'$(neutron) then the Φ-agent operates by double action: Φ ($u_2 \to d_2$, $d_3 \to u_3$), that is $\Phi \equiv$ (W^+, W^-), obtaining [$N = n' =$ (d_1, d_2, u_3)], see also the matrices in Equation (11). In a new perspective, we could treat the β-decay with two coupled bosons (W^+, W^-): so, one introduces the concept of "lattice" {W} ≡ (W^+, W^-). Therefore, as happens to electrons, surrounded by a virtual cloud of photons, or also to nucleons, surrounded by a virtual cloud of pions, then we could also state that quarks are surrounded by a cloud of virtual dipoles of bosons $W^{\neq}$, as well as, obviously, by a cloud of gluons. Recall that the Z-boson is a combination of boson "pair" (W^+, W^-), see [30]. The lattice {W} aspect one finds again in the last experiments to CERN (see ATLAS experiments), see Ref. [31], as interpretation of the pair annihilation (q, $\underline{q}$) in processes ($p\underline{p}$), that is: [($p + p$) → ($\gamma + \gamma$) → (W^+, W^-)]. Note that at high energies, the intensity of the weak interaction tends to approach that of the electromagnetic interactions (see the processes of annihilation and creation of pairs). So, considering the lattice hypothesis {W}, we state that: [($p + p$) → ($\gamma + \gamma$) → (W^+, W^-)] ≡ [(q,$\underline{q}$) →{W})]. In this case, the π-pion decay can be described in the following way: the W^+ boson couples with d-quark and transforms it into a u-quark, with the consequence of having an annihilation (u, $\underline{u}$) followed by emission of a γ-virtual ray, which is absorbed by W^- boson, now decoupled from the W^+; this absorption induces the free W^- boson to pass from the virtual state to the real one in which it decays (as a damped oscillator) in a pair (μ, $\underline{\nu}_\mu$) or, rarely, in (e, $\underline{\nu}_e$) pair. Therefore, we have, **Figure 9**:

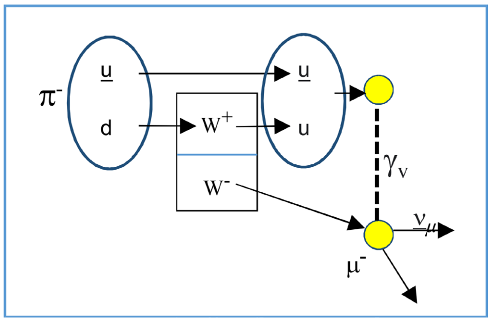

Figure 9. Representative diagram of decay by lattice {*W*}.

Now, we can use the same formal description of the Equation (14):

$$\begin{pmatrix}W^+\\W^-\end{pmatrix}\otimes\begin{pmatrix}\underline{u}\\d\end{pmatrix}=\begin{pmatrix}W^+\otimes\underline{u}\to\underline{d}\\W^-\otimes d\to d+W^-\end{pmatrix}\to\begin{pmatrix}\underline{d}\otimes d\\W^-\end{pmatrix}\to\begin{pmatrix}\gamma\\W^-\end{pmatrix}\to\left(W^-\right)_\gamma\to\begin{pmatrix}l^-\\\underline{\nu}\end{pmatrix} \quad (15)$$

where we have expressed in matrix form the pion and the lattice-structure {*W*}; here, again the term (⊗) formally represents the action of the *W* operator-field on the quarks of the pion. When two structures (*W, π*) or (*W, N*) reciprocally couple (the oscillations of their respective field oscillators couple) it becomes important so how the respective components couplings. To varying the dislocation of internal components of one of the two structures, there might be a difference in the physical behaviour of the overall structure. Then, in the mutual coupling between the quantum oscillators of fields (that is $[(a, a^+)_W \otimes (b, b^+)_d]$, the order of the couplings becomes important. If we express the fields (*W, π*) or (*W, N*) with matrices, then a hypothesis on these structures might be that to connect a particular order of the matrix elements to a given structure, see the Equation (10): consequently, if we change the order of the elements of a matrix, the coupling between the two particles could change and thus also the conclusive result. This hypothesis is physically valid if the phenomena, foretold by it, are experimentally verified, see the next section about the decay anomaly. From the theoretical point of view, one can intuit that there could be physical equivalence between the Feynman diagrams with *W*-bosons and the *W* lattice because the first constitutes already a lattice of propagators [11] [29]. Obviously, the description through {*W*} does not eliminate the Weinberg-Higgs mechanism that builds the weak interaction mediated by the vector boson *W*. We can so accept the use of lattice {W} to describe both the pion decay, see **Figure 9**, and that of the neutron.

4.2. The Coupling between the Lattice {W} and the Nucleon

Now, we need to consider the action of the {*W*} lattice on the structure of the nucleons. To describe the coupling of the lattice {*W*} with a nucleon *N*, we must adapt the representative matrix $(W)_{2\times1}$, see Equation (15), to the matrix of the nucleon $(N)_{3\times1}$: to the lattice {*W*} we need to assign a column matrix $(W)_{3\times1}$ with three elements. To two bosons (W^+, W^-) it needs to add a third element which must be a "neutral" element or correspond to a transformation action of "identity". We could then consider the identity operator *I*. We pass then to take into consideration all the possible configurations of the matrix $(W)_{3\times 1}$:

$$\{W\} \equiv \left\{ \begin{pmatrix} W^{\pm} \\ I \\ W^{\mp} \end{pmatrix}, \begin{pmatrix} W^{\pm} \\ W^{\mp} \\ I \end{pmatrix}, \begin{pmatrix} I \\ W^{\pm} \\ W^{\mp} \end{pmatrix} \right\} \tag{16}$$

Here also, there are two equivalent structures (W') or degenerate forms of the lattice $\{W\}$. We could analyse all the possible cases of coupling of structures $(W^{\pm}) \otimes (N)$; however, for now, we take those configurations consistent to the phenomenology of the beta decay of the nucleon. An aspect relevant is the spin one. In a nucleon the couple of identic quarks, $(u, u)_p$ and $(d, d)_n$, cannot have the quarks with parallel spins because they are fermions. Therefore, the application of W in a nucleon is conditioned by spin: ($W^{\pm}_{\downarrow\uparrow} \otimes q^{\mp}_{\uparrow\downarrow} \to q'_{\downarrow\uparrow}$ with $q' \neq q$), ($W^{\pm}_{\downarrow\uparrow} \otimes q^{\pm}_{\uparrow\downarrow} \to W^{\pm}_{\downarrow\uparrow} \otimes q^{\pm}_{\uparrow\downarrow}$). Besides, one must have: $\{W\} \equiv \left(W^{\pm}_{\downarrow\uparrow},\ W^{\pm}_{\uparrow\downarrow}\right)$. That is the two W-Bosons in the lattice $\{W\}$ are in a state of quantum entanglement and no-local and could act like a scalar because the two W-boson have opposite spins: in this way, one could simplify the renormalization question of massive vector bosons, see the sect. 4.1. All this needs to be deepened. Therefore, we now introduce in matrices of nucleons and W-bosons the orientation of the spin vector. Let us look for the couplings between column matrices that correctly describe the beta decay. We quickly find, see Equation (10), that:

$$\begin{pmatrix} (W^{+})_{\uparrow\downarrow} \\ I \\ (W^{-})_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} d_{\downarrow} \\ u_{\uparrow\downarrow} \\ d_{\uparrow} \end{pmatrix}_{n_o} = \begin{pmatrix} (W^{+})_{\uparrow} \otimes d_{\downarrow} \\ I \otimes u_{\uparrow\downarrow} \\ (W^{-})_{\downarrow} \otimes d_{\uparrow} \end{pmatrix} = \begin{pmatrix} u_{\downarrow} \\ u_{\uparrow} \\ (W^{-})_{\downarrow} \otimes d_{\uparrow} \end{pmatrix} = \left[(W^{-})_{\downarrow} + \begin{pmatrix} u_{\downarrow} \\ u_{\uparrow} \\ d_{\uparrow} \end{pmatrix}_{p} \right] \tag{17}$$
$$= (p)_{\uparrow} + (W^{-})_{\downarrow} = \left[p + \left(l^{-}, \bar{\nu}\right) \right]$$

The $\underline{\otimes}$-operation cannot transform the d-quark. Note this configuration $p\,(u, u, d)$ is compatible with the beta decay of the neutron. If the configuration (d, u, d) represents the "ordinary" neutron n_o, by Equation (17) we can suppose that the configuration (u, u, d) could just be that of the ordinary proton p_o, see the sect. 3.3. We denote by $\{W\}_n$ the lattice structure $\{W\}$ which is compatible with the neutron decay. It follows: $(W^{\pm})_n \otimes n_o = [p_o + (l, \nu)]$. Now, we apply the matrix $(W)_n$ to the matrix of the anomalous neutron n_a, see the Equation (11):

$$\begin{gathered} \begin{pmatrix} (W^{+})_{\uparrow\downarrow} \\ I \\ (W^{-})_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} d_{\downarrow} \\ d_{\uparrow} \\ u_{\downarrow\uparrow} \end{pmatrix}_{n_a} = \begin{pmatrix} (W^{+})_{\uparrow} \otimes d_{\downarrow} \\ I \otimes d_{\uparrow} \\ (W^{-})_{\downarrow} \otimes u_{\uparrow} \end{pmatrix} = \begin{pmatrix} u_{\uparrow} \\ d_{\uparrow} \\ d_{\downarrow} \end{pmatrix}_{n_a}, \\ \begin{pmatrix} (W^{-})_{\uparrow\downarrow} \\ I \\ (W^{+})_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} d_{\downarrow} \\ d_{\uparrow} \\ u_{\downarrow\uparrow} \end{pmatrix}_{n_a} = \begin{pmatrix} d_{\downarrow} \\ d_{\uparrow} \\ u_{\downarrow\uparrow} \end{pmatrix}_{n_a} \end{gathered} \tag{18}$$

Note the application of the lattice $\{W\}_n$ to this configuration n_a of the neutron does not determine any decay. We write $(W^{\pm})_n \otimes n_a = n_a$ and say that the ordinary structure of $\{W\}_n$ does not induce the decay of the n_a anomalous neutron. The column matrix associated to the proton p of the Equation (17) should be that of the ordinary proton p_o. We can verify this if by $\{W\}_n$ applied to $p(u, u, d)$ one obtains the β-decay of "ordinary" proton. It follows:

$$\begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_\downarrow \\ u_\uparrow \\ d_{\uparrow\downarrow} \end{pmatrix}_{p_o(\gamma)} = \begin{pmatrix} (W^-)_\uparrow \otimes u_\downarrow \\ I \otimes u_\uparrow \\ (W^+)_\downarrow \otimes d_\uparrow \end{pmatrix}_\gamma = \begin{pmatrix} d_\uparrow \\ u_\uparrow \\ u_\downarrow \end{pmatrix}_\gamma \tag{19}$$

Note that here the application of $\{W\}_n$ is an "identity" operation: in fact, we have obtained again the same excited proton. However, we could suppose that the action of γ -photon on the proton reduces all quarks in one of spin eigenstates $(u_\downarrow, u_\uparrow, d_\downarrow)$:

$$\begin{aligned} \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_{\downarrow\uparrow} \\ u_{\uparrow\downarrow} \\ d_{\uparrow\downarrow} \end{pmatrix}_{p_o(\gamma)} &= \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \left[\gamma \otimes \begin{pmatrix} u_{\downarrow\uparrow} \\ u_{\uparrow\downarrow} \\ d_{\uparrow\downarrow} \end{pmatrix}_{p_o} \right] = \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_\downarrow \\ u_\uparrow \\ d_\downarrow \end{pmatrix}_\gamma \\ &= \begin{pmatrix} (W^-)_{\uparrow\downarrow} \otimes u_\downarrow \\ I \underline{\otimes} u_\uparrow \\ (W^+)_{\downarrow\uparrow} \otimes d_\downarrow \end{pmatrix}_\gamma = \begin{pmatrix} (W^-)_\uparrow \otimes u_\downarrow \\ u_\uparrow \\ (W^+)_\downarrow \otimes d_\downarrow \end{pmatrix}_\gamma = \left[(W^+)_\downarrow + \begin{pmatrix} d_\uparrow \\ u_\uparrow \\ d_\downarrow \end{pmatrix} \right] \\ &= (W^+)_\downarrow + (n_o)_\uparrow = \left[n_o + (l^+, \nu_l) \right] \end{aligned} \tag{20}$$

Note that when the lattice $\{W\}$ reduces itself in the pair $(W^+_{\downarrow\uparrow},\ W^-_{\uparrow\downarrow})$, the spin "action" of u-quark ($\downarrow$) on the $W^-_{\downarrow\uparrow}$ induces the reduction $(W^-_{\downarrow,\uparrow} \to W^-_\uparrow)$ and one has $(W^-)_\uparrow \otimes u^+_\downarrow \to d_\uparrow$. Simultaneously, one has the reaction $(W^+)_\downarrow \otimes d^-_\downarrow \to (W^+)_\downarrow + d_\downarrow$. Note that W-boson cannot couple with d-quark because have the same spin direction. So, the (W^-)-boson, decupled from (W^+), will be free and can decay in a leptonic pair. In another spin eigenstate $(u_\downarrow, u_\uparrow, d_\uparrow)$ one cannot have decay but only an identity transformation:

$$\begin{aligned} \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_\downarrow \\ u_\uparrow \\ d_{\uparrow\downarrow} \end{pmatrix}_{p_o(\gamma)} &= \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \left[\gamma \otimes \begin{pmatrix} u_\downarrow \\ u_\uparrow \\ d_{\uparrow\downarrow} \end{pmatrix}_{p_o(\gamma)} \right] \\ &= \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_\downarrow \\ u_\uparrow \\ d_\uparrow \end{pmatrix}_\gamma \\ &= \begin{pmatrix} (W^-)_{\uparrow\downarrow} \otimes u_\downarrow \\ I \underline{\otimes} u_\uparrow \\ (W^+)_{\downarrow\uparrow} \otimes d_\uparrow \end{pmatrix}_\gamma = \begin{pmatrix} (W^-)_\uparrow \otimes u_\downarrow \\ u_\uparrow \\ (W^+)_\downarrow \otimes d_\uparrow \end{pmatrix}_\gamma = \begin{pmatrix} d_\uparrow \\ u_\uparrow \\ u_\downarrow \end{pmatrix} \end{aligned} \tag{21}$$

Therefore, we have shown that the matrix associated with the "ordinary" proton is $p_o(u, u, d)$. We ask us if one can speak of an "anomalous" proton, with matrix $p_a(u, d, u)$; from the Equation (20), one has:

$$\begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_{\downarrow\uparrow} \\ d_{\uparrow\downarrow} \\ u_{\uparrow\downarrow} \end{pmatrix}_{p_a(\gamma)} = \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \left[\gamma \otimes \begin{pmatrix} u_{\downarrow\uparrow} \\ d_{\uparrow\downarrow} \\ u_{\uparrow\downarrow} \end{pmatrix}_{p_a} \right] = \begin{pmatrix} (W^-)_{\uparrow\downarrow} \\ I \\ (W^+)_{\downarrow\uparrow} \end{pmatrix} \otimes \begin{pmatrix} u_{\downarrow} \\ d_{\downarrow} \\ u_{\uparrow} \end{pmatrix}_{\gamma}$$
$$= \begin{pmatrix} (W^-)_{\uparrow\downarrow} \otimes u_{\downarrow} \\ I \otimes d_{\downarrow} \\ (W^+)_{\downarrow\uparrow} \otimes u_{\uparrow} \end{pmatrix}_{\gamma} = \begin{pmatrix} (W^-)_{\uparrow} \otimes u_{\downarrow} \\ d_{\downarrow} \\ (W^+)_{\downarrow} \otimes u_{\uparrow} \end{pmatrix}_{\gamma} = \left[(W^+)_{\downarrow} + \begin{pmatrix} d_{\uparrow} \\ d_{\downarrow} \\ u_{\uparrow} \end{pmatrix} \right] \quad (22)$$
$$= (W^+)_{\downarrow} + (n_a)_{\uparrow} = \left[n_a + (l^+, \nu_l) \right]$$

If we assumed the "anomalous proton" p_a can be excited by γ-ray, then it could decay into an anomalous neutron. If the experiment does not detect the difference between ordinary neutron and anomalous, the same for the proton, then we cannot distinguish the decay of ordinary proton from that anomalous. Recall the two structures (Ψ_1, Ψ_2) in neutrons so as in the protons (nucleons), we must assign to proton the following correspondences: $[p_a\,(u, d, u)] \Leftrightarrow (\Psi_1)_f \equiv \Psi_a(p)$, $[p_o\,(d, u, u), p_o\,(u, u, d)] \Leftrightarrow (\Psi_2)_f \equiv \Psi_o(p)$.

In synthesis, for the nucleons, we can have:

$$N \equiv \left\{ \begin{pmatrix} d \\ u \\ d \end{pmatrix}_{n_o}, \left[\begin{pmatrix} d \\ d \\ u \end{pmatrix}_{n'_a}, \begin{pmatrix} u \\ d \\ d \end{pmatrix}_{n''_a} \right] \right\}_n, \quad \left\{ \begin{pmatrix} u \\ d \\ u \end{pmatrix}_{p_a}, \left[\begin{pmatrix} d \\ u \\ u \end{pmatrix}_{p'_o}, \begin{pmatrix} u \\ u \\ d \end{pmatrix}_{p''_o} \right] \right\}_p \quad (23)$$

As already said before, we do not take into consideration the other possible combinations of the two structures because they move away from the phenomena of the beta decay of the neutron dealt with in the bottled and beam experiences. In conclusion, from the Equation (10), we derive that the nucleonic matter (hadronic in general) would appear in two forms (states): "ordinary" and "anomalous". The latter could generate the anomaly found in the decay of the free neutron. Conversely, the anomaly found in the decay of the free neutron could confirm the existence of an anomalous "form" of structure in free neutrons.

5. The Anomalous Neutron

5.1. Calculation of the Theoretical Value of $(d_r)_{th}$ Relative Discrepancy

Considering the hypotheses made in this article relating to the hypothesized structure of the lattice W and of the neutron, it is now possible to calculate the theoretical value of discrepancy relative $(d_r)_{th} = (\Delta\tau/\tau_f)$, index of the anomaly of the neutron decay. If this value approaches the one determined experimentally then the hypothesis of structure acquires significance. For the moment, we specify that the born of anomalous neutron n_a can occur by some fusion processes: for example, the reaction $D + T \rightarrow He + n_o$. In this process [1] there is the possibility of have an anomalous neutron $[n(\Psi_a) = n_a]$, with configurations $[(d, d, u)$

or (u, d, d)]: $D + T \to He + n_a$. Something it happens: in the first phase of reaction $(D + T)$ an agent Θ can act in quarks of nucleons of the physics system $\{D + T\}$ in a way that an anomalous neutron can take form. The field Θ could be an interaction field that "relocates" the quarks changing so the nucleon structure from $(\Psi_o \to \Psi_a)$, see the Equation (23). In this case, we could think the same gluons (g_i), "recombine" the quarks: $[\Theta_g \otimes (d_1, u_1, d_2) \to (d_1, d_2, u_1)]$. The neutron, instead of emerging in eigenstateΨ_2, emerges in an anomalous state Ψ_a, see the sect. 3.3. We consider the system $(D + T)$, see Equation (11): $D = n(d_1, u_1, d_2) + p(u_2, u_3, d_3)$, $T = [n(d_4, u_4, d_5) + n(d_6, u_5, d_7)] + p(u_6, u_7, d_8)$.

In sect. 3.3 we have stated that the nucleons have the structure Ψ_1 inside a nucleus, in this case into the Deuton and Tritium. Since in the reaction $(D + T) \to He + n$ an only neutron emerges we will have one only probability of emerging for anomalous neutron n_a, about all the possible combinations that give an ordinary neutron in the reaction $(D + T) \to He + n$. This combination $n_a = [(d, d, u), (u, d, d)]$ is degenerate and, therefore, it has a weight of double probability value with respect to all the possible combinations. All possible "neutral" combinations N_c between the d-quark pair $(d_i, d_j)_{(i \neq j)}$ with u_k-quark can be calculated: $N_{C(d,u,d)} \equiv [(d_i \otimes u_j \otimes d_k]_{(i \neq k)}$ where $\otimes$ is now tensorial product, with $(i, j) = (1, \ldots, 8)$ and $k = (1, \ldots, 7)$. This calculus has been already made in a paper, see the ref. [32], in which the anomalous neutron presents itself as a geometric structure of coupled quantum oscillators, which is different from that of the ordinary neutron. In this case, the two geometric structures (G_o, G_a), see Figure 5 and Figure 9 in ref. [32], can be mitted in correlation to the two matrices, as that of the ordinary neutron Ψ_o and anomalous Ψ_a: $[G_o \Leftrightarrow n_o(d, u, d), (G_a) \Leftrightarrow n_a(d, d, u)]$. The number of combinations or ordinary configurations $N_{C(d,u,d)} \equiv [(d_i \otimes u_j \otimes d_k]_{(i \neq k)}$ can be given so:

$$N_c(d,u,d) = \sum_{k=1}^{7} u_k \left[\sum_{\substack{i=1 \\ i>j}}^{8} d_i \left(\sum_{j=i}^{8} d_j \right) \right] = 196$$

In the case of an emission of an anomalous neutron (d, d, u) at degenerate aspect we will have two possibilities on the (196) combinations. Then the probability $P(n_a)$ of having "two" n_a is:

$$P(n_a) = N(n_a)/N(n_o) = 2/196 = 0.0102040816326531 \approx 0.0102$$

The number (0.0102) coincides with the experimental discrepancy $(d_r)_{exp}$, reported in the sect. 2.3, up to the fourth decimal place: $[(d_r)_{th} \approx (d_r)_{exp},]$. Reversing the reasoning just made, we could say that the relative value of the discrepancy found by the experimenters (0.0102) is a consequence of the possibility of having an anomalous neutron in the $(D + T)$ fusion reaction. We have so shown that a valid alternative hypothesis to that of F-G (the dark particle χ), could be to consider the possibility of the existence of an anomalous neutron that determines a difference in the values of the lifetime, relative to two different experiments, such as those of the "bottle" and the "beam".

5.2. The Some "Bold" Conjectures

If in next future, the researchers do not detect the gamma photons in experiments in bottle and in DIS experiments would have confirmation of the double structure of nucleons, then the hypothesis of the anomalous neutron would become even more interesting. If a physicist follows this last hypothesis, in front him of different scenarios would open: to see again the hadrons' physics and the internal structure of the nucleon, and, lastly, the possibility, due to the characteristics of anomalous nucleons, see the sect. 3.3 and 4.1 and Equation (23), that the "anomalous" matter could be in relation to the "dark" matter. Recall that the anomalous neutron in a lattice {W} does not decay, see Equation (18), and does not interact electromagnetically: the anomalous neutrons could so tie together and originate a galactic halo, see the primordial phase of universe evolution. To have a more convincing relation [anomalous ⇔ dark] one would need to find also that the anomalous hadron matter interacts very but very "weakly" with other ordinary hadrons. Besides, if we recall the work of F-G in which they find a difference in mass between χ and the "ordinary" neutron n_o of few MeV, then the relation [anomalous ⇔ dark] could be confirmed only if [$m(n_a) \approx m(n_o)$]. Thus, if we have an anomalous neutron which no decay, not interacts electromagnetically, not interacts with other ordinary hadrons and [$m(n_a) \approx m(n_o)$], then one could propose the following "bold" conjecture: the anomalous neutron is also a dark neutron [32]. However, we must note that the "anomalous" structure of the state (Ψ_a) does not give us indications about its mass less than that of the ordinary neutron nor does it indicate how difficult it is for it to interact with other hadrons. Therefore, to pass from the idea of an anomalous neutron to that of a dark neutron, it is necessary to add "something" more to the basic hypothesis of this study, what that the existence of the different configurations of the quarks inside a nucleon. More information beyond that of the "dual" structure of the neutron (in general of the nucleon) is missing. One of these might be that of consider in the state Ψ_a the possibility that there is a particular geometric configuration (or dislocation) of the internal quarks which makes the neutron as "dark". There are some already published works where the authors attempt to "geometrically" represent the anomalous structure of the quarks into a nucleon: the anomalous geometric configuration of quarks would prevent the neutron from interacting and decaying but does not would prevent to it the formation of a tie to other anomalous neutrons and to give so origin to aggregations of anomalous matter, with properties very similar to that of dark matter. In these works, see Ref. [33] [34] [35] [36], the innovative idea of a "geometric" structure of quarks inside a nucleon originated from a "hypothesis of structure" also on the quarks: this other "bold" conjecture admits one only physical possibility to not falling into certain physical contradictions, deriving from the basic hypothesis of the particles' theory which wants these to be point-like. This possibility would be that to purpose the quarks as geometric structures of coupled quantum oscillators: the oscillators couple forming "golden" triangles. Recall that field theory dictates that the fields are a set of coupled oscillators: it must thus be considered that a particular coupling of the field oscillators, with a geometric (golden) configuration, can propagate along a field line, or propagation axis. The authors of this article point out that the "golden" hypothesis of quarks can very well be considered as an alternative hypothesis to the basic hypothesis of string theory, a theory that does not yet have definitive experimental results for its complete acceptance. Thanks to the golden geometric structure of quarks one can so also build that of nucleons. By means of this geometric structure of quarks is possible to also build the "dark" form of the two nucleons and even that of the pion [37]. Just in a previous study, see Ref. [32], the authors gave the geometric shape Γ_o of the ordinary neutron n_0 and that Γ_d of a "dark" neutron n_d, and also calculated that $[m(n_d) < m(n_o)]$ and $[m(n_a) \approx m(n_o)]$. By means of geometric structure Γ_d, is possible to comprehend because the dark neutron does not decay and has many difficulties interacting in a strong way whit other ordinary hadrons [32]. The conjecture of a geometric representation of quarks and hadrons having different configurations, see the states (Ψ_o, Ψ_a), push us to formulate the idea that dark matter and ordinary one are two different aspects of the hadronic "matter", where each of them is necessary to other, see the gravitational origin of galaxies. If one knows the "geometric" structure of the quarks inside a nucleon [33] [34] [35], then one could have indications to deduce the probability [32] that an anomalous neutron, now dark neutron, is emitted in the reaction $(D + T) \rightarrow He + n_a$, see the Equation (25). In fact, the authors, in the assemblage of the nucleons of the system $(D + T)$, showed the possible couplings between the quarks that give the structure of the anomalous (dark) neutron, and found that the theoretical relative discrepancy $(d_r)_{th}$ is almost equal to the one experimental $[(d_r)_{th} \approx (d_r)_{exp},]$, see the value (0.0102). Although a free dark neutron (and dark pion) does not interact with other hadrons, its geometric shape allows it, physical certain conditions, to aggregate with another dark neutron, as if they were two pieces of a puzzle. This aspect reminds us of chemistry: a chemical compound is formed only for the physical conditions of molecules to which the component elementary atoms are subjected. Then, the dark geometric structure allows the aggregation of dark matter into "clusters" of dark neutrons interspersed with dark neutral pions. An important consequence of the anomalous geometric form of nucleons, see Ref. [32], could be given by the paradoxical aspect that dark matter does not annihilate with ordinary antimatter nor dark antimatter: the respective geometric shapes fit together but do not-annihilate, see geometric figures in Figure 5 and Figure 8 in Ref. [32]. Note in these figures that the configurations of ordinary antineutron $\underline{n}_o(\underline{d}_1, \underline{u}_1, \underline{d}_2)$, geometrically symmetric to the ordinary neutron one, and the anomalous one $n_d(d_3, d_4, u_2)$ have the $\underline{u}_1$-quark no geometrically correspondent to u_1-quark (the quarks stay no in the same axis of propagation X), therefore they do not can annihilate. This aspect determines that the $\underline{n}_o$ and n_d cannot annihilate. In Ref. [32] the authors have shown that clusters of ordinary antimatter aggregated with dark antimatter and dark matter can so be originated: this would solve the enigma of the disappearance of antimatter in this universe. The antimatter would be so trapped in the galactic halos. The aggregations of dark matter with dark antimatter and ordinary antimatter, in the first phases of universe evolution, converged in slow and cold densities of "matter", which by the rotational dynamics of the proto galaxies have been centrifuged outwards [38] of these, determining so the halos of "dark" matter, detected in astronomic observations. At the present time, the galactic halos would be made up of enormous aggregations of dark matter and dark antimatter, in which matter, and ordinary antimatter are wedged inside.

6. Conclusion

The presence of the anomaly has made it possible to detect that dark matter and ordinary matter are two sides of the same coin: matter. This was possible because we moved from a perspective of point-like particles, see the quanta of quantum fields, to a perspective of particles as structures of oscillators coupled with geometric form. This shift in perspective opens the way to a new descriptive paradigm in particle physics (the new physics?). We could so speak of a second attempt at the geometrization of physics: if the first concerned the geometrization of Space-Time, the second is that of the geometrization of particle fields.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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