**MAJORANA PARTICLE IS A**

**NEUTRAL SELF-CONJUGATED ELECTRON**

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**ABSTRACT**

With the neutron decay, a proton and an electron ($e^-$) are emitted. The energy gap, which should be offset by the emission of a 3rd particle, is randomly included between 0.511 and 0.7828 MeV. These values correspond to those of a more or less accelerated electron, but not those of a neutrino, which mass is considered to be ≤ 0.01 electronic masses. Pauli and Fermi hypothesized that this 3rd particle should be free of electric charge and provided with the same mass and spin of an electron. Such requests may be fully met by an electron, but without electric charge: a neutral electron (e°), equally safeguarding all Conservation Laws.

If we analyze the properties of this possible particle, they seem to coincide with those attributed to the *Majorana Spynor* or *Fermion*: that is, a massive particle, free of electric charge, *self-conjugated*, i.e. it identifies with its antiparticle (with the exception of the spin: antiparallel): ↓e° ≡ ē°↑

**INTRODUCTION**

Ettore Majorana wrote his latest work inspired by Dirac equation: 'Symmetric Theory of Electron and Positron'. In the abstract He states: "Making use of a new quantization process, the meaning of Dirac equations is somewhat modified and there is no longer any reason to speak of negative-energy states nor to assume, for any other types of particles, especially neutral ones, the existence of antiparticles, corresponding to the "holes" of negative energy "[1]. Klein states: the *negative energy states,* emerged from the interpretation of Dirac electron's equation wave, *repelled* not only Majorana, but other physicists too, above all Pauli and Heisenberg [2]. We report the Dirac wave equation for the electron [3][4]:

$$[\, Y^{\mu} (I\, \delta/\delta x^{\mu} - eA_{\mu}(x)) + m]\ \Psi(x) = 0 \qquad (1).$$

With reference to this equation Wilczek states: "It describes the behavior of the wave function $\Psi(x)$. It has 4 components: $\Psi_{e\uparrow}(x), \Psi_{e\downarrow}(x), \Psi_{p\uparrow}(x), \Psi_{p\downarrow}(x)$. Each of them is a function whose value depends on the space and time, as indicated by the *argument*($x$). Dirac considered these values complex numbers, which square magnitude gives an opportunity to find the kind of corresponding particle: up spin electron, down spin electron, up spin positron or down spin positron, at the space- time given point. In modern interpretation the values are operators which create electrons or destroy positrons. $\mu$ *should* have a value of 0,1,2,3, representing the time and the 3 directions of space, and add up the contributions of all values. The derivative $\delta/\delta x°$ measures how quickly the wave function changes over time, while others derivatives measure how quickly it changes in different spatial directions. $A(x)$ fields are the electromagnetic potentials. They specify the electric and magnetic field felt by the electron. The electron charge is -e. It specifies the intensity of its response to those fields. The mass of the electron is $m$. Dirac's innovation was to introduce Y matrices. A spectacular result was the prediction that there had to exist a new particle with the same mass of the electron, but of opposite charge, and able to annihilate an electron transforming it into pure energy. Now the *bad news*: Dirac's equation has four components; that is, it contains 4 separate wave functions, to describe the electrons. Two components have an attractive and direct interpretation, describing the two possible directions of the spin of an electron. The other two, on the contrary, showed several problems. In fact the two extra equations contain solutions with *negative energy* (and with both spin directions) "[5]. Majorana writes: "We limit ourselves to the description of a quantization procedures for the matter-waves, which is the only important case for applications, at present; this method appears as a natural generalization of the Jordan-Wigner method, and it allows not only to cast the electron-positron theory into a symmetric form, but also to construct an essentially new theory for particles not endowed with an electric charge (neutrons and the hypothetical neutrinos). Even through it is perhaps not yet possible to ask experiments to decide between the new theory and a simple extension of the Dirac equations to neutral particles, one should keep in mind that the new theory introduces a smaller number of hypothetical entities, in this yet unexplored field "[1]. Majorana adds: "It is well known that one can eliminate the imaginary unit(*i*) from the Dirac equations with no external field:

$$[W/c + (\alpha,p) + \beta mc]\Psi = 0 \qquad (2),$$

with an appropriate choice of the operators $\alpha$ and $\beta$ (and this can be done in a relativistically invariant fashion). We shall, in fact, refer to a system of intrinsic coordinates such as to make eq. (2) real, keeping explicitly in mind that the formulae we shall derive are not valid, without suitable modification, in a more general coordinate system. Denoting, as usual, with $\sigma_x$, $\sigma_y$, $\sigma_z$ and $\rho_1$, $\rho_2$, $\rho_3$ two independent sets of Pauli matrices, we set:

$$\alpha_x = \rho_1\ \sigma_x; \quad \alpha_y = \rho_3; \quad \alpha_z = \rho_1\ \sigma_z; \quad \beta = -\rho_1\ \sigma_y; \qquad (3);$$

dividing eqs. (3) by $-h/2\pi i$ and defining $\beta' = -i\ \beta$, $\mu = 2\pi$ mc/h, we obtain the real equations:

$$[1/c\ \delta/\delta t\ -(\alpha, grad) + \beta'\ \mu]\ \Psi = 0 \qquad (4).$$

As a consequence, eq.(2) separates into two independent set of equations, one for the real and one for the imaginary part of $\Psi$. We set $\Psi = U + iV$ and consider the real equations (4) as acting on $U$ :

$$[1/c\ \delta/\delta t\ -(\alpha, grad) + \beta'\ \mu\ ]\ U = 0 \qquad (5).$$

The latter equations, by themselves, i.e. without the similar equations involving $V$, can be derived from the *variational principle*"[1,Majorana]. It is of considerable importance to highlight this Majorana record with reference to Eq.(5). Majorana says: "The behaviour of $U$ under space reflection can be conveniently defined keeping into account that a simultaneous change of sign of $U$ has no physical significance, as already implied by other reasons. In our scheme:

$$U'(q) = RU(-q) \qquad (6),$$

with $R = i\ \rho_1\ \sigma_y$ and $R^2 = -1$. Similarly, for a time reflection:

$$U'(q,t) = i\rho_2\ U(q,-t) \qquad (7).$$

It is remarkable, however, that the part of formalism which refers to $U$ (or $V$) can be considered, in itself, as the theoretical descriptions of some material system, in conformity with the general methods of quantum mechanics. The fact that this reduced formalism cannot be applied to the description of positive and negative electrons may well be attributed to the presence of the electric charge, and it does not invalidate the statement that, at the present level of knowledge, equations related to the *anti-commutability relations* constitute the simplest theoretical representation of neutral particles. The advantage of this procedure, with respect to the elementary interpretation of the Dirac equations, is that there is now no need to assume the existence of antineutrons or antineutrinos "[1] meant as distinct particles from the respective anti-particles[6]. Adds Majorana: "in the place of massless quanta, we have particles with a finite rest mass and also for them we have two available polarization states. In the present case, as in the case of the electromagnetic radiation, the half-quanta of rest energy and momentum are present, except that they appear with the opposite sign, in apparent connection with the different statistic. They do not constitute a specific difficulty, and they must be considered simply as additive constants, with no physical significance. Similarly to the case of light quanta, it is not possible to describe with eigenfunctions the states of such particles. In the present case, however, the presence of a rest mass allows one to consider the *non relativistic approximation*, where all the motions of elementary quantum mechanics apply, obviously. The non relativistic approximation may be useful primarily in the case of the heavy particles (neutrons)"[1].

**DISCUSSION**

Edoardo Amaldi too, like Majorana, one of *the boys of via Panisperna* (as well as the first chief of the CERN in Geneve), writes: "Dirac relativistic theory, which led to the prediction of the positron and a little later confirmed by the experience, is based on Dirac equation which is completely symmetrical to the sign of the charge of the considered fermion; but this symmetry is partly lost in the subsequent development of the theory that describes the vacuum as a situation in which all the states of negative energy are occupied, as well as all the free positive energy. The excitement of a fermion from one of the negative state energy to a positive one leaves a gap with positive energy, which can be interpreted as the anti-fermion. In this way the process of excitation of a fermion, from a state of negative energy to one of positive energy, is equivalent to the creation of a couple fermion-antifermion. This asymmetric approach brings as a consequence also the need to erase, without any *sound justification of principle*, some infinite constants due to negative energy states, as, for example, the electric charge density. These drawbacks are avoided in the theory proposed by Majorana, in which he proposes a new representation of the Dirac matrices $\Upsilon\mu$ ($\mu$ = 1,2,3,4), which has the following properties: **1)**Unlike what happens in the original Dirac's representation, in Majorana's representation the 4 $\Upsilon_\mu$ matrices have the same reality properties of the four-vector $\chi_\mu \equiv r, ict$; or, if one takes all the real space-time coordinates, associated with a pseudo-Euclidean metric, all four are real. **2)** In this representation, Dirac's equation relating to a free fermion is with real coefficients, thus its solutions are broken into a real part and an imaginary one, each of them meets separately the mentioned equation. But each of these real solutions, just as a consequence of its reality, has two very important properties: the first is that it gives rise to a quadruple vector with zero electric charge. It follows that the real solutions of Dirac's equation must correspond to fermions free of both electric charge and magnetic moment. The second result of the reality of the fermionic field $\Psi$ is that the corresponding field operator must be Hermitian, so that its degrees of freedom are halved and there is no more distinction between fermion and antifermion. Majorana in his work suggested that the neutron or neutrino, or both particles, were corpuscles of this type that is neutral corpuscles identified with the corresponding anticorpuscles. **3)** Examing Dirac's equation related to a fermion placed in an electromagnetic field, written in Majorana representation, it comes that to represent a load corpuscle it is just sufficient to take a $\Psi$ combination of two real solutions. The fermionic field generates a quadruple vector with electric charge not exactly null due to the interference terms between the two real fields: it also enjoys the known properties for a scalar field that the conjugate field operator with respect to the charge (i.e. the operator which describes a particle of opposite charge to that of corpuscle considered) is obtained by applying the operator $\Psi$ to Hermitian conjugation operator. There has not yet been a definite answer to the question whether Majorana corpuscles, i.e. particles characterized by the equality with own anti-particle, exist in nature, or do not exist at all"[7]. Weinberg adds: "Dirac's theory claimed as his greatest triumph the prediction of the existence of the positron, the electron's antiparticle, which was discovered a few years later in cosmic rays. From the point of view of Quantum Field Theory there is, however, no reason why a spin ½ particle should have a distinct antiparticle. In some theories half-integer spin particles are antiparticle of themselves, even though so far none of them has been found. At that time it was still unclear that Dirac's equation had nothing to do with the need for antiparticles. When an equation is so successful as Dirac's, it can never be just wrong. It may not be valid for the reason supposed by its author, may fail in new contexts, and may also not have the meaning that the author attributed to it. We must always be open to reinterpretations of these equations, but the great equations of modern physics are a permanent part of scientific knowledge"[8].

Thus, one can consider reasonable the attempt, such as that proposed by Majorana, to reinterpret with another mathematics Dirac's equation, thus postulating the existence of a *self-conjugated spynor*, that is, a massive fermion, free of charge, which identifies with its antiparticle. As Penrose reminds us "the Spynor, or spynorial object, is an essential mathematical concept, a marvellous idea of remarkable importance: an essential mathematical significance for quantum physics of fundamental particles such as electrons, protons, and neutrons. Common solid matter would not exist without the consequences of this idea. What is a spynor? Basically it is an object that, after a rotation of $2\pi$, turns into its opposite. Spynorial objects represent the wave functions of fermions, never those of the bosons. Indeed the term spynor always means one particle with spin ½, i.e. a fermion and never a boson. The spynor is represented by a 2-component wave function $\Psi_A$, thus the index $_A$ takes values 0 and 1, i.e.: $\{\Psi_0(x), \Psi_1(x)\}$ [9]. In this regard, let's group the most salient features of the 3 different spynor models:

1) **Dirac's spynor** is a 4 component spynor, i.e. it has 4 degrees of freedom, consisting in 2 spin orientations (antiparallel) for $e^-$ and 2 spin orientations for $e^+$, i.e.: $\Psi(e^-)\uparrow\downarrow$; $\Psi(e^+)\uparrow\downarrow$. It is compatible with a conserved charge, since Dirac's equation requires, for its spynor, an electric charge and a magnetic moment (because its spynors are electrons). It presents a mass different from zero: $m\neq0$. There is *symmetry*, *charge conjugation (**C**):* $(e^+) = \boldsymbol{C}(e^-)$.
2)**Weyl's spynor** is a 2 component spynor, it has two degrees of freedom, namely: $\Psi(e^-)\downarrow$; $\Psi(e^+)\uparrow$. It is compatible with a conserved charge. It is massless: $m=0$. There is *symmetry, charge conjugation (**C**):* $(e^+) = \boldsymbol{C}(e^-)$.
3)**Majorana's spynor** is a 2 component spynor, i.e. it has two degrees of freedom, consisting always in the same spin orientation for the particle (levorotatory: ↓), and antiparallel for the respective antiparticle (dextrorotatory: ↑), namely: $\Psi(S)\downarrow$; $\Psi(\bar{S})\uparrow$ ,where S is the spynor and $\bar{S}$ the anti-spynor. It is incompatible with a conserved charge, since the Majorana equation requires that its spynor has neither electric charge nor magnetic moment, but it must have a mass different from zero: $m\neq0$. According to Majorana such a spynor should coincide with "particles with no electrical charge (neutrons or hypothetical neutrinos)"[1,Majorana]. It could also likely coincide with another neutral particle, not yet identified (most likely because of its very low interope with ordinary matter), with mass and electric charge compatible with *Majorana particle*. As Barbieri says: "Majorana starts from the symmetry between electrons and positrons, ***C***. As he tries to overcome it he stumbles in the idea of a *self-conjugated spynor*" [10]:

$$\bar{S}_M = \boldsymbol{C}(S) = S_M \quad (8),$$

where $S_M$ and $\bar{S}_M$ indicate *Majorana's spynor* and its antiparticle, which has not yet been identified: it must be massive and free of electric charge. In turn, ***C*** indicates the *charge conjugation*. What does it mean? It means that the *Majorana spynor* (which can be represented by a hypothetical neutrino ($\nu$), or other neutral particle) identifies with its antiparticle; they are the same particle: one is the mirror image of the other, just as described by Eq.(8) or by Majorana through Eq.(6). The mirror image shows the same particle, but with a spin rotating in the opposite direction. That is, the particle has always a rotating spin in one direction, and the so-called antiparticle, on the contrary, revolves in the opposite direction (just as when we see a rotating ball in front of the mirror: it is the same particle). We can really say that the *Majorana self-conjugated spynor model* was prophetic. In fact, just 30 years later, as we all know, it was shown that in Weak Interactions(WI) there is *violation of Parity*, just as Lee and Yang had predicted[11][12]. We read by Yang: "The laws of Physics have always shown a complete symmetry between left and right. In Quantum Mechanics this symmetry can also be formulated as a conservation law, called *Conservation of Parity*, which is identical to the principle of symmetry between left and right. In the summer of 1956 Tsung Dao Lee and I came to the conclusion that, contrary to general belief, there was actually no experimental proof of the symmetry between left and right for WI. C.S. Wu et al. confirmed this hypothesis. With the discovery of the lack of symmetry between right and left two new circumstances regarding the symmetry and asymmetry between right and left in elementary particles physics and their interactions, came to light. The first has to do with the structure of neutrino($\nu$) and, interestingly, is the rebirth of a concept originally formulated by Weyl in 1929. It had been discarded in the past because it did not preserve the symmetry between right and left. Since the $\nu$ enters only in phenomena governed by WI, the defeat of the symmetry between right and left in WIs canceled the ground for refusal and revived Weyl's idea. In 1957 a lot of experiments on $\nu_s$ were carried out, which confirmed the predictions of Weyl's theory. The second aspect concerns the matter whether the symmetry between right and left is really lost in the light of new developments. Here the important point is that, if you change the definition of specular reflection, the symmetry for specular reflection can be restored. To explain this point, we shall call S and D, respectively, the results of the readings of two instruments placed one to the left and another to the right. We shall call then the readings on the same devices, but built with antimatter, respectively with $S^-$and $D^-$. Before the experiment of Wu et al. it was believed that S=D and $S^-=D^-$ , according to the symmetry between left and right. It was also believed that $S=S^-$ and $D=D^-$ , according to the symmetry between matter-antimatter. Therefore it was believed that $S=D=S^-=D^-$. The aforementioned experiment proved the fallacy of this belief, explicitly showing that $S\neq D$. From the quantitative results of the mentioned AA. and subsequent experiments carried out in many laboratories, it was possible to prove that indeed:

$$S= D^- \neq S^-=D \qquad (9).$$

Evidently in this way there is less symmetry than what was previously thought, but there is always *some* symmetry, as revealed by the relationship: $S=D^-$ and $S^-=D$. They can be both summarized in the principle that if you run a specular reflection and *contemporarily* you convert all matter in antimatter, then the laws of physics remain unchanged. This *combined transformation*, which leaves unchanged the physical laws, could thus be defined as the true mirror reflection process. According to this definition, symmetry for speculative reflection is restored. That is, a particle reflects in the mirror its antiparticle, since the reading of the device that examines the particle, S, is equal to the reading of the instrument that examines the corresponding antiparticle, $D^-$"[13]. This, in our view, seems to coincide perfectly with the insights of Majorana and what emerges from his equations so the mirror image of the $\nu$ coincides entirely with that of the $\bar{\upsilon}$ (what changes is only the spin rotation direction). Yang concludes: "There is of course the question of why it is necessary, in order to have symmetry, *combine* the operation of exchanging matter and antimatter with a mirrored reflection. The answer to this question can be achieved only through a deeper understanding of the relationship between matter and antimatter. Currently such an understanding is not glimpsed "[13]. We could say, comforted by mathematicians results achieved by Majorana, that the matter coincides with the antimatter, with the difference that in the neutral particles the rotation of the spin changes, and the charged particles changes too, or at least the electric charge. That is, the matter could not be so much different from antimatter, although it makes a lot of their clash effect, with instant annihilation of the particles. But this annihilation process could simply be a result of the clash between two opposite charges. It may not be excluded the possibility that, with regard to neutral particles, matter and antimatter can live together without damage (so antimatter could be much wider than we think). On the other hand the concept of antimatter is a consequence of the interpretations of Dirac's equation on the electron which was proposed by Dirac himself in 1931. What had emerged consisted in the representation of an electron with a positive electric charge, that is opposite to that of the common electron: for this reason was considered as antimatter, although it was just the same particle, but with opposite electric charge. Moreover, as previously reported, Majorana composed his last work (as he set forth in the Abstract) in order to propose a different mathematical interpretation of Dirac's equation and the resulting concept of *antimatter*, at least with regard to the neutral particles[1,Majorana]. Klein adds: "Majorana in his last work, the most profound and even the most prophetic, proposes an unprecedented way of conceiving the bond between matter and antimatter. For Dirac the particles were subject to be some states, called of negative energy. These states are in infinite numbers and form *Dirac's sea*. However, such particles are not directly observable. For Majorana things are different. He processes a theory of neutral particles in which no more negative states are used. In his model neutral particles, free of charge (neutron and $\nu$), are necessarily identical to their same antiparticles. More specifically, neutral particles must have their mirrored image as antiparticles. These particles are called 'Majorana', although today no one has yet determined their existence. In the context of the 1930s, a theory such as that proposed by Majorana was out of the way, and it was hard to imagine, also because of an absolutely original mathematical formalism that rests on unusual abstract symmetries for physicists of the time. The few who were aware of it remained troubled. Dirac's theory, better known and certainly more affordable, became in a short time the reference theory: to every particle of matter, even without electricity charge, corresponds an anti-particle which is not identical"[2].

It seems very important to note what emerges from Majorana equations where, especially in the case of an electrically neutral particle, this, placed in front of a mirror, you identifies with its antiparticle: i.e. particle and neutral antiparticle differ only in the spin, which are antiparallel!

Eq.(8) could represent the *fermion* or *Majorana spynor*, as it corresponds to the "*self -conjugated spynor* in which Majorana had fallen"[10]. This is true both whether the 3rd particle emitted in $\beta d$ corresponds to the $\nu$, and in case it is another particle, without electric charge too (according to Majorana calculations). Why should it be another particle? There is the $\nu$ ! Yes, there might be the $\nu$, but it is not sure. In addition, the $\nu$ was considered by the Standard Model (SM) as a mass-free particle, so it could never be identified with the Majorana particle, which, as emerges from Majorana's equations, must be absolutely a massive particle (as well as neutral). Later, after the Superkamiokande experiment and the neutrino oscillations ($\nu_s$) verifications, it was admitted that the $\nu$ could have a mass, though very small, i.e. ≤ 0.01 electronic masses.

It is well known that it was Pauli to think that in the disintegration of the neutron (*N*), or beta decay ($\beta d$), in addition to the proton (*P*) and the electron with negative electric charge ($e^-$), in order to compensate for the energy gap , a 3rd particle was also emitted, without electric charge, and having the same mass and spin of the electron [14]. This concept was subsequently shared by Fermi, who said: "We still have the problem of knowing the laws of forces acting between the particles making up the nucleus. It has indeed, in this regard, in the continuous spectrum of $\beta$ rays, some clues that, according to Bohr, this would suggest that perhaps in these new unknown laws even the Principle of Conservation of Energy is not valid any more; unless we admit – together with Pauli - the existence of the so-called *neutrino*, that is a hypothetical electrically neutral particle having a mass of the order of magnitude of the electron mass. This, for its enormous penetrating power, escapes any current detection method, and its kinetic energy helps to restore the energy balance in the $\beta$ disintegrations" [15]. These concepts were represented by Fermi through the mathematical formalism of so-called negative $\beta$ decay ($\beta d^-$):

$$N \rightarrow P + e^- + \bar{\upsilon} \qquad (10),$$

where $\bar{\upsilon}$ is the anti-neutrino. Therefore, The basic requirements originally requested by Pauli and Fermi for the $\nu$, i.e. for the 3rd particle or missing particle in the $\beta d$, defined by several authors as a *ghost particle* (*GP*), are essentially three: 1) it is electrically neutral; 2) it has the mass of an electron; 3) it has the same spin of the electron[14][15][16][17]. Well, why not to think immediately to a neutral electron (e°)? All requests would be satisfied. It seems the most logical answer, and physically more than adequate to meet the demands of Pauli and Fermi. Even in this way the energy balance in the $\beta$ disintegration is restored, thus safeguarding the Laws of Conservation of Mass and Energy and at the same time safeguarding the Law of Conservation of Electric Charge and Angular Momentum [6]. Moreover, we want to emphasize that referring to this 3rd neutral particle emitted with the$\beta d$, Pauli wrote: "it has spin ½ and its mass should be of the same order of magnitude of the electrons" [14]. That is, Pauli's opinion, this 3rd particle should be a fermion, with the mass of the electron, but without carrying electric charge: you could really think of an electron without electric charge, a neutral electron (e°). It could be said that the same results reached by a e° are obtained similarly even with a $\nu$. And then: e° does not exist, this is an invention! The only known electrons are those carrying an electric charge: $e^-$ and $e^+$. Yet even the $\nu$, when suggested by Pauli, was an invention. Moreover the $\nu$ was a particle totally unknown, invented from scratch. Indeed, it was forced to introduce in Physics, *compulsorily*, a new family of particles, with their own characteristics, and with presumed properties quite different from the other elementary particles known at the time. The e°, instead, refers to one of the fundamental particles more widespread in nature, even if only those electrically charged are known. In addition, a not negligible result, with the e° it is not necessary to invent a new category of particles to be added to the Standard Model (SM), maintaining the symmetry of the SM and further simplifying it (according to the *reductionist* approach preferably adopted in Physics)[6].

A basic point might be that every time it was considered that $\nu$ had been detected, they were always *indirect detection* thanks to traces left by a *ghost particle* never detected *de visu*. It is the detection of the impacts' effects, such as the Cherenkov Effect (*CE*), to prove the existence of $\nu$, although it might be another particle to induce the *CE*[18][19]. In Nature the *CE* is only elicited by electrons. The electrons of the atmospheric molecules, hit by cosmic rays at high altitude, are accelerated at very high speed, so emitting those photons that give consistency to the so-called *Cherenkov Light*[20][21]. One thing we can be certain about the results of all *indirect detection* of the *v*: they only show the *traces* left by a *ghost particle*, that is, the 3rd particle released with the $\beta d_s$ , a particle never directly identified. In favor of our hypothesis, that in $\beta d$ what is released is a e° instead of a $\nu$ (more precisely an ē° in $\beta d^-$ and an e° in the $\beta d^+$), is the fact that the main detection techniques of $\nu$ all use the *CE*: a phenomenon *naturally* induced by electrons. So it's no wonder if it is still an electron, this time without electric charge, to induce the various *CEs* highlighted during the *surveys* carried out by Reines and Cowan[22], or at the Superkamiokande, or the Subdury Neutrino Observatory (SNO), or elsewhere.

Yet, one might object: why the *e°* has never been detected, even accidentally? Electron decay products emerge continuously in the *colliders*! But it is clear: the crucial difference lies in the fact that we are talking about electrons without electricity charge, they do not interact with matter for all the same reasons $\nu_s$ do not interfere . In addition, the 3rd particle emitted with $\beta d^-$ is right-handed, just as the hypothetical $\bar{\upsilon}$ (or the possible $\bar{e}°$), so it is even more elusive, since it is also insensitive to WI.

Let's try to analyze the mass-energy gap emerging from the $\beta d$. Let's evaluate the masses of the particles represented in Eq. (10), without the $\bar{\upsilon}$. The neutron weighs $1.67492728 \cdot 10^{-24}$[g], while the proton weighs $1.67262171 \cdot 10^{-24}$[g]; on its turn the electron weighs $9.1093826 \cdot 10^{-28}$[g]. The mass difference between neutron and proton corresponds to $\Delta_M$ ($0.00230557 \cdot 10^{-24}$[g]), that is $\Delta_M = 2.30557 \cdot 10^{-27}$[g]. According to the mass-energy conversion factors, if we consider that "1 MeV is about $1.782 \cdot 10^{-27}$[g]" [23], and follow the *cgs* metric system, we have:

$$(2.30557/1.782)\cdot 10^{-27}[g] = 1.29381\ MeV/c^2 \quad (11).$$

This is the energy value that in the $\beta d^-$ must be carried away by the electron($e^-$)and a 3rd particle, in order to safeguard the energy balance in this process. The energy value expressed in Eq.(11) represents the maximum value of the energy spectrum ($\eta = E_{max}$) of the $\beta$ radiation emitted with *βd*. The minimum energy carried away by an electron corresponds to 0.511MeV, thus the value of Eq.(11) is more than double than the energy of an electron not particularly accelerated. With the decay of the neutron, instead, the $\beta$ ray is accelerated to a very high speed, showing a marked $E_{kin}$. Nevertheless, only in very limited circumstances, and coincidentally, the total energy carried away by the $\beta$ radiation is able to compensate for the difference in mass-energy between neutron and proton[6]. If we subtract the *minimum energy* of an electron from the energy value expressed by Eq.(11), we obtain the value of the energy that could be covered by the 3rd particle of the *βd*, denoted by $\Delta_E$:

$$\Delta_E = 0.78281\ MeV \quad (12).$$

This value exceeds the 53.1413% the energy of an electron *at rest*. But it is worth pointing out that this is the maximum value the 3rd particle can reach (considering that at the same time the $e^-$ is emitted too). This does not mean that it always has so much energy, rather the contrary. In fact in the value expressed by Eq.(11) we must also consider the $E_{kin}$ of the $\beta$-ray, whose energy spectrum, as Fermi had reported [16][17], may also coincide with the entire energy value described by Eq.(11). Thus, from the analysis of the *βd*, we seem to catch two important results: 1) the total energy of the emitted charged electron can fluctuate *randomly* (depending on the intensity of acceleration) in a precise range between 1.29381MeV and 0.511MeV; 2) the energy the 3rd particle can acquire, should fluctuate, still *randomly* distributed between 0.78281MeV and 0.511MeV. These values are perfectly adequate if we consider that the *GP* of the *βd* is represented by an e°. The ē° too issued with the $\beta d^-$ should show an $E_{kin}$ at least equivalent to the $e^-$'s[6]. This new $\beta d^-$ model should be represented as follows:

$$N \rightarrow P + e^- + \bar{e}^\circ \quad (13).$$

In short, Majorana, in an attempt to not drown in Dirac's *negative energy seas*, nevertheless remains trapped in the description of a massive neutral particle that identifies itself with its own antiparticle. More precisely: the neutral particle highlighted by Majorana (which we can call: *Majorana Particle*, or *Majorana Fermion*, or *Majorana Spynor*) is completely different from Dirac's particle or fermion, since the latter is provided with electric charge. In addition, the mathematical formalism related to the description of Dirac's Fermion requires that the particle and its antiparticle are two distinct, independent entities. On the contrary, from the deeply innovative mathematical formalism used by Majorana emerge massive neutral particles *selfconjugated*, that is they are fully identified with their antiparticle, but with a single difference: they have opposite spin rotation, that is antiparallel, just as if they both looked In the mirror: see Eq.(6),(8). Considering the e°, it seems to emerge that this potential particle may have the characteristics to identify with the *Majorana Spynor*: it is a spynor (as well as a fermion), it is massive and has no electrical charge. They are the major Majorana's requirements for its particle. In addition, similar to other neutral particles, e° could identify with its antiparticle, just as if each of them looked in the mirror: even in that case they should only differ in the direction of spin rotation, that is, antiparallel. This last feature would satisfy the last demand that emerges from the calculations of Majorana: *Majorana Spynor* must be *self-conjugated*! In this regard we report with Penrose that "Madame Wu examined the distribution of the electrons emitted by the radioactive core of cobalt 60, finding a clearly asymmetrical relation to reflection between this and the directions of the spins of the nuclei of cobalt. This finding was puzzling, because it had never been observed an asymmetric mirror image phenomenon into a fundamental physical process! The *chiral asymmetry*, arises from the fact that in a mirror for a left-handed helicity particle it appears similar to the same particle with right-handed helicity, and *vice versa*. Each of these is converted in the other in a *specular reflection*. (In more conventional terminology, $\gamma_5$ changes sign for reflection, so that the roles of the parties of left-handed and right-handed helicity of the electron wave function, $(1-\gamma_5)\Psi$ and $(1+\gamma_5)\Psi$ are exchanged). In this way, the *non-invariance* of WIs, with respect to the *reflection*, has resulted in the fact that only the levorotatory electron is subject to WI. The same thing can be said for the neutron when undergoing a spontaneous $\beta d^-$, so as for the resulting proton. It is only the levorotatory neutron and the levorotatory proton to take part in the weak decay process. The $\nu$ too is particularly interesting in this respect. Only if the $\nu$ has a levorotatory helicity it is subject to WI or it could be created in a weak interaction process. Therefore $\nu_s$ are particles with levorotatory helicity. In the case of the electron's antiparticle, i.e. the positron, it will be the right-handed positron to be subject to WI. A similar observation also applies to the antiproton, the antineutron and anti-Q. It could also apply to ῡ. One should not really think that an antiparticle is something totally distinct from a particle. In the context of modern Quantum Field Theory, you do not need to present things in Dirac's original way (apparently asymmetric). Antiparticles are as particles as the particles of which are the antiparticles. Moreover, the notion of antiparticle is valid both for bosons and for fermions, whereas Pauli Principle only applies to fermions, thus the point of view of *Dirac's sea* cannot apply to bosons. The pion with positive charge (the meson $\pi^+$), for example, which is a boson, has an antiparticle which is the pion with negative charge (the meson $\pi^-$). Actually, several bosons are their own antiparticles: it is the case of the photon and even the neutral pion (the meson $\pi°$) "[9]. This is also true for the e°, so in the $\beta d$ processes can also participate e° (which should only be levorotatory) and ē° (which should only be dextrorotatory). This is a very important detail, since dextrorotatory particles are insensitive to the action of the WI, so the ē° will cross undisturbed any *weak field*. Actually, e°, despite being sensitive to the WI (since it is levorotatory), should be able to cross every *weak field* undisturbed, both because it travels at relativistic speeds (whereas WI acts slowly: $\approx 10^{-8}$ seconds), and because the WI bosons have a very limited radius, according to our calculations $1.543 \cdot 10^{-15}$ [cm] for $W^+$ and $W^-$ particles, and $1.36 \cdot 10^{-15}$ [cm] for Z° particles [24]. In addition, being leptons, the e° (and so the ē°) are not affected by the action of Strong Interaction, as well as being non-electric carriers are insensitive to the Electro-Magnetic Force. They are only sensitive to the Gravity Force (GI). In this respect, Feynman reminds us that "gravitational activation between two objects is extremely weak: the GI between two electrons is less than the electric force for a factor of $10^{-40}$ (or perhaps $10^{-41}$) [23]. Furthermore, considering that the GI action in itself is extremely weak, and considering that the particle in question (e°) travels at very high speed, even the GI will not manage to interfere with an e°. Ultimately, as it was considered for *ν*, also the e° does not interact with the matter at all: this is even more important for the ē° (since it is dextrorotatory). That is why each of us is crossed by 50.000 billions of $\nu$ or $\bar{\upsilon}$ (e° or ē°) every second but without ever realizing it.

There remains an unresolved problem, which already existed assuming the $\bar{\boldsymbol{\upsilon}}$ as the 3rd particle of the $\beta d^-$, related to the ē° too. We should remember that the problem arises because they are both antiparticles. And why is this a problem? Because they are right-handed. On the contrary, the respective particles are left-handed, therefore sensitive to WI and also the *weak charge* that permeates the Higgs field (HF)[25][26][27]. According to the Standard Model(SM) all particles have a null intrinsic mass. The problem can be solved by postulating the existence of a *complex scalar field* permeating the space: the HF. According to SM only left-handed particles tend to interact, to mate with this HF, acquiring an energy at rest which is not null, which for almost all respects is analogous to a value of mass at rest, then describable as a parameter mass. As it is well known the mechanism just described is the so-called Higgs Mechanism(HM). The HM requires the intervention of a permeating particle the HF, i.e. the Higgs Boson (HB), which mass is between 125 and

126.5 GeV[28]. The maximum limit of the HB range, i.e. the maximum distance the HB can take, is slightly smaller than range of WI's bosons [24], In accordance with the inverse proportional relationship between the range of action of a Fundamental Force and the mass of its bosons [29]. Our calculations show a very small range of HB action, exactly $9.8828 \cdot 10^{-16}$ [cm] [30]. The HM is valid for left-handed particles, in contrast $\bar{\upsilon}$ and ē° are right-handed, so they are insensitive even to WI's action. For the same reasons, since they are not sensitive to the *weak charge* (whereas Dirac's particles are ), $\bar{\upsilon}$ and ē° cannot acquire mass through HM[26] [31]. Yet it is now asserted that the *v* is a massive particle, so this is the real enigma: how does ū (or for it the ē°) acquire mass, and in what quantity? At this point, it seems necessary a new Physics, still to be understood, capable of describing in what ways, and through which mechanisms, an anti-lepton without electric charge, and insensitive to the weak charge (being right-handed) can equally acquire mass, without using HM, at least as it is currently described. Unless we think that there may be another type of HM, in this case interacting with neutral right-handed antileptons, so that even these can gain mass, and *without breaking the symmetry*. Under such circumstances the ū temporary acquisition of mass, would *overshadow symmetry*. In this case, it would be necessary to understand whether those leptons can get mass through one Higgs Boson, or there are two distinct Higgs Bosons, one of which would interact selectively with right-handed leptons. Randall states: "We have no certainty about the precise set of particles involved in the HM. For example if the *breaking of the electroweak symmetry* was to be attributed to 2 Higgs fields, rather than to one. However, there are other models that hypothesize more complex *Higgs sectors*, with even more articulated consequences. For example: Supersymmetric models provide higher number of particles in the Higgs sector. In that case we would always expect to find a Higgs Boson, but its interactions should be different from those deducible by a model that includes only one Higgs particle "[31].

It seems certain that the 3rd particle emitted by $\beta d^-$ cannot acquire the mass through the modes described by SM. The ū, in fact, does not behave like a *Dirac fermion*, nor can it be considered as a *Weyl fermion* (which is massless). This shows the possibility that the *v* and ū (or e° and ē°) can be considered similar to a *Majorana self-conjugated spynor*.

**CONCLUSIONS**

In short, the energy gap that is created when a neutron is transformed into a proton, corresponds to the value expressed by Eq.(11) which coincides roughly to the energy value of 2 particles, such as 2 electrons with which a great $E_{kin}$ is summed, because of the considerable acceleration experienced by these particles. Well, in the $\beta d$ an electron is already represented, the other particle, if it was a 2nd electron, could match just with the e°. Besides our hypothesis should appear reasonable and plausible, since it does not violate any Conservation Law, and without being forced to *invent* a totally new type of particle as the $\nu$, and unseen, that is so far not yet concretely identified. Klein adds: “However, there is today a particle that had not yet been finalized, the $\nu$, that is the only particle of matter at the same time elementary and electrically neutral. In 2001 it has been proven that $\nu$ is massive. At this point, it is important to know whether they are Dirac's or Majorana's, since it is necessary to know whether they are identical to their antiparticle. This is an essential issue. According to Dirac's theory a $\nu$ can be dextrorotatory or levorotatory, the same thing happens for a $\bar{\upsilon}$. Whereas according to Majorana's theory, $\nu$ and $\bar{\upsilon}$ form a single particle. The antiparticle of left-handed $\nu$ is nothing other than the right-handed $\bar{\upsilon}$, and mutually. In other words, there are only two components, mirror images of each other"[2]. However what stated for the *v* is valid for the e° too. We reiterate: the model of e° would fully satisfy the characteristics traced for *Majorana's fermion*. One may ask: why the $\nu$ model doesn't work to represent *Majorana's spynor*? Because, in addition to all the various reasons given above, in our opinion, the mass of the $\nu$ is too small compared to e° to be able to fully compensate the mass-energy gap that emerges in $\beta d$: there would be necessary several hundred $\nu_s$ to equate the missing energy value in $\beta d$. On the contrary, just one e° - considered as 3rd particle of the $\beta d$ - sufficiently accelerated, will be enough to compensate for that gap. The *missing particle* in $\beta d$ can *randomly* transmit a mass-energy quantity between a minimum of 0.511 MeV (or a little more) and a maximum of 0.78281MeV (too high values to be compensated by a *v* with so little mass). Indeed, it does not seem too vague to suppose that the e°, with its mass, summed up with a high kinetic energy, fits perfectly in the $\beta d$, probably like a mosaic tile, filling in full the mass-energy gap emerging from the $\beta d$. Perhaps the e° was just the *missing tile* to the $\beta d$ mosaic. Moreover, disavowing the existence of the alleged *v*, the Standard Model (SM) of elementary particles results greatly simplified. As known *elegance* is an appreciated requirement in Mathematics and Physics; the same applies to *simplicity* [31]. In addition, with our hypothesis, the SM is made significantly leaner and more symmetrical, reducing to only 2 the particles which never decay, that is one for each of the two main classes of particles**:** up Quark for adrons, the electron for leptons. Intuitively we believe that Nature behaves in a manner as simple and symmetrical.

Ultimately, we find it more likely that in the $\beta d$ it is a e° to be emitted, instead of a ν (or relative antiparticles)[6]. It follows that Eq. (8) should be represented as follows:

$$\bar{e}^\circ = \boldsymbol{C}(e^\circ) = e^\circ \qquad (14),$$

where ***C*** (or *charge conjugation*) represents precisely the *symmetry properties* of e°, expressed by that equation, which we can simplify further:

$$\downarrow e^\circ \equiv \bar{e}^\circ \uparrow \qquad (15).$$

Based on all the above-mentioned reasons, Eq. (15) should indicate the *Majorana Particle or Spynor*, which we believe is represented by a *neutral self-conjugated stable electron.*

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