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Neutral Electron (e°) or Neutrino (ν): $e^{\circ} \equiv \nu$

Antonio Puccini[1]

[1] Neurophysiologist of Health Ministry, Naples, Italy

Correspondence: Antonio Puccini, Neurophysiologist of Health Ministry, Naples, Italy. E-mail: antonio.puccini.4rr1@na.omceo.it, ant1puccini@gmail.com

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Abstract

In order to solve the *Neutron decay mass gap problem*, Pauli proposed a precise solution. The brilliant idea of a 3rd particle came to Pauli (fully shared by Fermi) to compensate the *energy-mass gap* that emerged from the disintegration of the neutron, or *negative β decay* (βd^-): $N \rightarrow P + e^-$.

The basic requirements originally requested by Pauli and Fermi for the new particle, later called *neutrino*, are essentially three: it is electrically neutral and it must have the same mass and spin of an electron. Hence, if the mass of the *neutrino* (ν) corresponded to that assumed by Pauli and Fermi, the *βd^- mass gap problem* would be brilliantly solved.

However, the current upper limits of the mass of the ν are < 2eV.

Here we show that a clear incongruity comes out: the mass attributed to the ν will never be able to solve the *energy gap problem* of the βd^-: it takes $\simeq$ 250,000 ν to compensate the energy-mass gap.

Unless we consider, instead of ν, another particle, probably still unknown, as the 3rd particle of βd^-. To find a solution, we hypothesized the existence of an electron with no electric charge: a neutral electron (e°).

Keywords: neutrino (ν), negative Neutron β decay (βd^-), electron (e^-), neutral electron (e°)

1. Introduction

1.1 Neutron Decay (βd^-) Mass Gap Problem

With the *neutron* (*N*) *decay* a proton (*P*) and an electron (e^-) are emitted:

$$N \rightarrow P + e^- \tag{1}$$

It clearly appears that the sum of the masses of the proton and the electron (and thus the sum of the corresponding energy values) is less than the mass of the neutron. As it is known, indeed, when Marie Curie observed for the first time this type of decay, she only associated it to the emission of an electron (Curie).

The *mass-energy gap* (Δ_E) emerging from the Eq.(1) corresponds to:

$$\Delta_E = 0.78281 \text{ MeV} \tag{2}$$

To this purpose, in order to solve the *Neutron decay mass gap problem*, the brilliant idea of a 3rd particle came to Pauli (fully shared by Fermi).

In the *Neutron decay*, in fact, many Conservation Laws were not respected, among which immediately stood out the violation of the Law of Conservation of Mass and Energy.

In this respect, let's evaluate the masses of the particles represented in Eq.(1). The neutron (*N*) weighs $1.67492728 \cdot 10^{-24}$[g], while the proton (*P*) weighs $1.67262171 \cdot 10^{-24}$[g]; on its turn the electron (e^-) weighs $9.1093826 \cdot 10^{-28}$[g]. The mass difference (Δ_M) between neutron and proton corresponds to $0.00230557 \cdot 10^{-24}$[g], that is $\Delta_M = 2.30557 \cdot 10^{-27}$[g].

In agreement with the mass-energy conversion factors, if we consider that 1 MeV is about $1.782 \cdot 10^{-27}$[g], and follow the *cgs* metric system, we have:

$$\frac{2.30557}{1.782} \cdot 10^{-27}[\text{g}] = 1.29381 \text{ MeV/c}^2 \tag{3}$$

This is the mass-energy value that in the *neutron decay*, or *negative β decay* (*βd*⁻), must be carried away by the electron and a 3rd particle, in order to safeguard the mass-energy balance in this process.

2. Materials and Methods

2.1 Pauli's Solution to βd⁻ Mass Gap Problem

As known, for some years it was not possible to find a solution to compensate the *energy-mass gap* that emerged from the disintegration of the neutron. Even Bohr thought that it was necessary to accept this deficiency. Pauli instead did not give up, until there was a *master strike*. In effect, after much hesitation, on 04/12/1930 Pauli sent that famous letter to the participants of the Congress of Physics in Tubingen. Pauli wrote: "I have hit upon a desperate remedy to save the 'exchange theorem' of statistics and the law of conservation of energy. Namely, the possibility that in the nuclei there **could exist electrically neutral particles, which have spin 1/2 and the mass must be of the same order of magnitude as the electron mass**"(Pauli).

Pauli called this new particle *neutron*. The neutron as such was discovered by Chadwick only two years later (Chadwick), thus *Pauli neutron* was called *neutrino* as suggested by Amaldi to Fermi.

2.2 Pauli-Fermi βd⁻ Model

At this regard, Fermi asserted: "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 β rays, some clues that, according to Bohr, 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**"(Fermi 1934,a).

In this respect Fermi elaborated one of his masterpieces, the Theory of Neutron Disintegration, or *negative Neutron β decay* (*βd*⁻), according to which whenever in a radioactive nucleus there is the spontaneous disintegration of a neutron, it follows the emission of a proton, a β ray and a 3rd particle, the ν, which with its mass, together with its high kinetic energy (E_{kin}), compensates for the amount of energy and mass that cannot be entirely taken by the β ray. Namely, according to Fermi: 1) Proton and Neutron are two different states of the same fundamental object or Nucleon. 2) The electron ejected, or β ray, does not exist within the nucleus, but it is created, together with this 3rd particle during the process of the neutron transformation into proton (in what Fermi deviates from Pauli). 3) The process of radioactive decay of the nucleon is governed by a new Fundamental Force introduced by Fermi, now known as Weak Nuclear Interaction(WI) or *Fermi's interaction*. In fact, the explanation of the nuclear β decay(*βd*) Fermi gave in 1933 (Fermi 1934,a) was the prototype of the WI. He, taking as a model the description of the electron-proton diffusion (provided by Quantum Electro-Dynamics), proposes also for the *βd* a type of interaction based on the fields theory. Fermi uses the mathematical formalism of the operators of creation and destruction of particles introduced to the Electro-Dynamics by Dirac, Jordan and Klein, called *second quantization* (Jordan & Klein), (Dirac). In this case, however, the interaction is punctiform and called '4 fermions interaction'. It constitutes a *contact interaction* between the 4 particles involved: the neutron(which constitutes the initial state) plus the proton, the electron and this 3rd particle, or ν.

These concepts were represented by Fermi through the mathematical formalism of the *βd*⁻.

This new model of *βd*⁻ was represented by Fermi as follows:

$$N \rightarrow P + e^- + \bar{\nu}_e \tag{4}$$

where $\bar{\nu}_e$ is the *electronic anti-neutrino*, or 3rd particle of the *βd*⁻.

Now we know that in the *βd*⁻, it is a down quark (Q_d) of the N to be transformed, by the Weak Interaction(WI), in an up quark (Q_u) through the emission of a W^- boson (Gell-Mann), (Zweig). Such a *flavour* exchange between quarks involves the transformation of N into a P (Puccini 2020,b). The W^- particle immediately decays into an electron (e^-) and an electronic antineutrino ($\bar{\nu}_e$):

$$\mathrm{udd}(N) \rightarrow \mathrm{udu}(P) + W^- \rightarrow \mathrm{udu}(P) + e^- + \bar{\nu}_e \tag{5}$$

2.3 βd⁻ Energy-Mass Gap: Unsolved Problem

Therefore, if the mass of the *neutrino* (ν) corresponded to that assumed by Pauli and Fermi, that is equal to an electron's, the *energy-mass gap problem* of the *βd*⁻ would be brilliantly solved.

Nevertheless, as we all know, over the years, the idea that ν had a small mass was diffused, a mass increasingly limited, even equal to zero, along with the *gauge theories* (Weyl). However, after the evidence for oscillation of atmospheric ν, carried out at the Super-Kamiokande (Fukuda et al.), it had to recognize a mass at ν, though infinitesimal, and more than 5 orders of magnitude less than electron masses (Puccini 2020,c). In fact, according to Maiani, the current upper limits of the mass of the ν (m_v) emitted with the βd^- are $m_v < 2$eV (Maiani 2015,b), a value corresponding to <1/250˙000 of the electron rest-mass and of the βd^- *energy gap* (Δ_E), as shown by Eq.(2).

2.4 Pauli-Fermi's Neutrino Requirements

Yet it may seem like a conspicuous contradiction to accept the inclusion of a particle in an equation, with the precise aim of filling the *mass gap*, without solving the problem.

It is clear, indeed, that with these values attributed to ν, and thus to anti-neutrino ($\bar{\nu}$), the *energy-mas gap* of the βd^- remains irremediably unsolved and conspicuously *unbalanced*.

On the contrary, the basic requirements originally requested by Pauli and Fermi for the ν, i.e. for the 3rd particle or missing particle in the βd^-, defined by several authors as a *ghost particle*, are essentially three: 1) it is electrically neutral; 2) it has the same mass of an electron; 3) it has the same spin of the electron (Pauli), (Fermi 1934,a).

Yet, there could be a solution: one could think that the third particle hypothesized by Pauli for the *Neutron Decay* is not a ν, but another particle, probably still unknown, and obviously provided with a sufficient mass. Therefore, it cannot be any particle, but it must satisfy certain requests: 1) In order to preserve the Law of Electric Charge, within the Eq.(4), it must be a neutral particle. 2) In order to comply with the Law of Conservation of the Lepton Number, it must certainly be an anti-lepton. 3) In order to safeguard the Laws of Mass and Energy Conservation, its values must absolutely be between 0.78281MeV and 0.511MeV (this latter value, as known, represents the *rest mass*, or *minimal energy* carries out by an electron).

Thus, this 3rd particle will first have to correspond to a neutral anti-lepton, but having a mass ≤ 0.78281MeV, according to Eq.(2). At this point, the circle has really tightened: the only known anti-leptons are $\bar{\nu}_e$ and positron (e^+). But since it must be a neutral particle, we must also renounce the e^+. And what's left? Only the $\bar{\nu}_e$ But we exclude it, because of its very limited mass.

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. It could be said that the same results reached by a e° are obtained similarly even with a ν. 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 ν, when suggested by Pauli, was an invention. Moreover the ν 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 (in keeping with the *reductionist* approach preferably adopted in Physics (Randall), (Puccini 2019).

3. Results

3.1 Very Low Interactivity of the 3rd Particle of the βd^-

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 ν does not interfere. Moreover, the 3rd particle emitted with βd^- is right-handed, just as the $\bar{\upsilon}$ (or the possible $\bar{e}^{\circ}$), so it is even more elusive, since it is also insensitive to the Weak Nuclear Interaction (WI). Therefore, the e° has not been detected yet for the same reasons the ν has not yet been *directly* identified. In this regard, according to Lisa Randall, it is not possible to detect neutrinos(ν_s) directly in the Large Hadron Collider (LHC), since they don't have an electric charge: their interaction in detectors is extremely weak. Although ν_s are so difficult to be observe, it remains to be resolved the issue of how ν_s can be experimentally identify. Since they don't have any electric charge and interact so weakly, the ν_s escape the detectors without leaving any trace. Then how is it possible to affirm their presence in an experiment conducted at the LHC? The principle of conservation of *momentum*, such as energy, has never been experimentally refuted. In the same way today we are aware of the existence of particles that interact weakly, apparently invisibles. We still have the question of how to know exactly which particle it is, among the number of potential particles that could leave no trace in the detector. What has been said about ν is also applicable to other possible new uncharged particles or having such a weak charge to be not directly detectable (Randall).

Now, let's try to understand why the 3rd particle emitted by the βd does not interact at all with the matter, so it has never been seen directly: 1) Being a lepton particle, whether it matches the ν, or it is represented by e °or another unknown particle, it follows that it is insensitive to the Strong Interaction (SI). 2) Being neutral particles (one of the primary requirements dictated by Pauli and Fermi), they are insensitive to Electro-Magnetic Interaction too. 3) Its very small mass makes it very weakly subject to Gravity Interaction (GI), although it is sensitive to such interaction. To this purpose, as Feynman reminds us, the gravitational activation between two objects is extremely weak: the GI between two electrons is less than the electrical strength of a 10^{-40} factor (or maybe 10^{-41}) (Feynman 1985). Considering that the GI action in itself is extremely weak and, in addition, considering that the particle in question travels at very high speed, hence it proves insensitive to the GI. 4) Further, the 3rd particle emitted with βd^- is right-handed, just as the hypothetical $\bar{\nu}$ (or the possible $\bar{e}°$), so it is even more elusive, since it is also insensitive to WI.

But even considering the respective particles, which are left-handed, and therefore potentially sensitive to WI, they are essentially unaffected. First of all because very high acceleration with which the 3rd particle is issued (both in βd and in the process of nuclear fusion) makes this particle travel undoubtedly with relativistic speed, reducing in this way the time the WI -and the GI- can exercise their action. Moreover the WI action is notoriously weak, and quite *slow* compared to the SI, thus it is even more difficult that it may prevail on the *kinetic energy* the 3rd particle travels. The WI acts only on a short distance, which restricts even more the possibilities of such a particle to interact since, as it can be seen from our calculations, the maximum distance WI bosons can travel corresponds to $1.543 \cdot 10^{-15}$[cm] for W^+ and W^- particles, and $1.36 \cdot 10^{-15}$[cm] for Z °particles (Puccini 2018). So, even e °, despite being sensitive to the WI (since it is left-handed), should be able to cross every *weak field* undisturbed.

Yet, it is important to add that probably the most significant reason for the very low interactivity of ν (or the 3rd particle of the βd^-) with the matter is provided by Maiani, who points out that neutrinos (ν_s) produced in the Big Bang do not interact with matter when the temperature(T) of the Universe falls below 1 MeV (Maiani 2015,a): it is a very high T, just below $3 \cdot 10^9$ °K (Weinberg). This limit of T is far above most of the common physical reactions. Moreover, if we consider that the T permeating the entire Universe is <3 °Kelvin, i.e. close to absolute Zero, it is better understood ν_s why they never interact, or almost never, neither with matter, nor with other ν_s.

3.2 The Neutrino Hunting

As known, in announcing the possible existence of a 3rd particle in the βd^-, both Pauli and Fermi scrupulously specified that it would be very difficult to detect such a particle. At this regard, Pauli writes: "This particle would have the same or perhaps a 10 times larger ability to get through [material] than a γ ray"(Pauli). Fermi adds: "This particle, for its enormous penetrating power, escapes any current detection method, and its *kinetic energy* helps to restore the energy balance in the β disintegrations"(Fermi 1934,a).

Bethe and Peierls, i.e., after several calculations, wrote that it would be impossible to detect a ν, since this would pass, without interacting, through a lead wall of over 3500 light years! (Bethe & Peierls). It must be added that the very small *cross section* (σ) of such a particle causes it can more easily pass through the matter without interacting with it. In fact, the σ of ν was found to have a value as small as 10^{-44}[cm^2] (Bethe & Peierls). It is really a very small cross section. This same value was confirmed in 1959 by Reines and Cowan (Reines & Cowan 1959), who revealed that the σ of the ν_e was equal to:

$$\sigma = (11 \pm 2.6)10^{-44}[\mathrm{cm}^2] \tag{6}$$

3.3 Neutrino Detection: Never Directly Identified

One could say: while the e °has never been seen, the ν is continuously produced in nuclear reactors and detected with particular equipment.

To this purpose, however, a fundamental clarification must be made: every time it was considered that the ν_s had been detected, they were always *indirect detections* thanks to traces left by a *ghost particle* never detected *de visu,* never directly identified. It is the detection of the impact's effects, such as the Cherenkov Effect (*CE*), to prove the existence of ν, although it might be another particle to induce the *CE*. In effect, in nature the *CE* is only elicited by electrons (Cherenkov), (Puccini 2012). 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*.

3.4 Radiochemical Methods

Leafing through the vast literature about it, it is immediately obvious that all the different techniques of detection of the 3rd particle of βd, or ν, have always only showed the effects (on the particles involved in the reaction) determined by a particle freed in radioactive decays: to be exact an invisible particle, believed to be the ν (but those detected may well be indirect effects induced by another particle). In fact, It took 25 years to come to a detection, always *indirect*, of the $\bar{\nu}_e$, and then the ν.

In this respect, the apparatus designed by Reines and Cowan for the ν detection was made of a target of about 1000 liters of aqueous solution of cadmium chloride contained in two containers alternating with three other containers filled with a liquid scintillator acting as a detector (Reines & Cowan 1956). Hence, installing this system near nuclear reactors, in which constantly occur countless βd^-, it could happen that the alleged ῡ issued, bombing water protons (P_s), created a reverse process, i.e. a βd^+, transforming the P in neutron (N), moreover the emission of an e^+ and a ν (Puccini 2018,a). Since it was known that the 3rd particle emitted in this process could never be detected, identified directly, Reines and Cowan pointed the research on two the other particles: N and positron(e^+). The race of the N emitted is slowed, "moderated", by the collisions with water thus, in about 10^{-5} seconds, the N is captured by cadmium, with immediate emission of γ rays of a particular frequency and energy (~6MeV). The e^+, in its turn, annihilating with an e^- of the water, generates a pair of γ photons of a defined frequency, able to produce light (*Cherenkov Light*) in the scintillators placed along the walls surrounding water. Such light is detected by photomultipliers. The characteristic time is ~10^{-9} seconds, and the coincidence between two scintillators represents the time (t_o) of the measure. Thus, in the same pair of scintillators it occurs a delayed coincidence, compared to t_o (Reines & Cowan 1956).

In short, we can divide this experiment into two phases:

1) The 1st stage takes into account any βd^- which occurred in the nuclear reactor, resulting in the emission of a 3rd particle, believed to be a $\bar{\nu}$.

2) The 2nd stage considers the effects produced by the clash between the 3rd particle (or this $\bar{\nu}$) with a proton (P) of the water contained in the tanks: what occurs is a βd^+ with emission of a ν (which, just as the $\bar{\nu}$ will never be disclosed) and with the emission of an e^+ which, annihilating with an e^- of that same water, produces the pair of γ photons detected by the photomultiplier. In this regard, we read: "The mark that distinguishes events sought is therefore a double coincidence in a pair of scintillators, separated by a time of a few microseconds" (Dionisi). As Asimov reminds us, if instruments had revealed γ rays exactly of two energies provided, separated by suitable intervals, the investigators would have caught the $\bar{\nu}$ (Asimov).

That's all. That is, the strategy of *data taking* by the experimenters essentially consists in recording time, which separate the events sought, and the energy value registered by the photomultipliers.

It is the detection of the impact's effects, such as the Cherenkov Effect (Cherenkov), to prove the existence of ν, although it might be another particle to induce the Cherenkov Effect (*CE*).

It does not seem to be a chance that in Nature the *CE* is only elicited by electrons. That is the mark that distinguishes events sought is therefore a double coincidence in a pair of scintillators, separated by a time of a few microseconds. If instruments had revealed γ rays exactly of two energies provided, separated by suitable intervals, the investigators would have caught the $\bar{\nu}$. Thus, this was enough to believe to have found, specifically and unequivocally the effects of the elusive $\bar{\nu}$.

With good conscience, this statement seems to us a *stretch* in the interpretation of the findings. That statement, in our view, requires a preconceived, a *dogma*: that the 3rd particle emitted with βd^- must be only and unquestionably a $\bar{\nu}$, no other type of particle.

3.5 SNO and Super-Kamiokande

At this regard, among the several techniques to detect the ν we can mention two ν detectors: the Subdury Neutrino Observatory (SNO) and the Super-Kamiokande. They are both made of huge pools of water, whose walls are covered with an infinity of 'light detectors', or photomultipliers. Both experiments use the procedure characterizing the 2nd phase of the detection of Reines and Cowan, for which the alleged $\bar{\nu}$ (or 3rd particle of βd^-) strikes a proton (P) of a water molecule, triggering a βd^+: the electron(e^-) freed at relativistic speeds, traveling faster than light (in the same medium), emit the typical *Cherenkov light* (*CL*) which is captured by photomultipliers (*CE*) (Cherenkov), (Puccini 2011,a).

It is believed that it is the ν to trigger the series of reactions leading to the production of the *CL*: event for us perfectly reasonable even more if it were an e°; since it is just electrons to emit the *CL* in our atmosphere. In fact, the electrons of the atmospheric molecules, hit by cosmic rays at high altitude, are accelerated at very high speed so emitting the *CL*. There is no other particle in nature, apart from electrons and the alleged ν, to be able to produce the *CL*. Yet, even in these experiments (SNO and Super-Kamiokande) the ν remains elusive: it is only possible to detect the effects of the invisible particle, the *ghost particle* issued in βd. Nevertheless, in such surveys the production of *CL* and CE_s are considered as the evidence of the existence of ν and $\bar{\nu}$.

This interpretation of the experimental data seems to us *forcing* for three reasons: 1) since the precise identikit of the 3rd particle emitted with βd is not known, we cannot say with scientific certainty that the effects it produces are attributable specifically and exclusively to a ν; 2) we know, with certainty, that the *CL* is a typical natural phenomenon generated by electrons highly accelerated (which, as we know, are released also in βd_s); 3) the fact that it is known and proven that the *CL* is produced specifically by extremely accelerated electrons, makes clear, fair, compatible, and even more likely the hypothesis that in βd_s are emitted e° too (or its antiparticle) instead of ν. No wonder it is still an electron, now without electric charge, to induce the various CE_s highlighted during all the surveys carried out.

And yet we are talking about the ν, a particle with a precise and determined characteristic: its mass must be equal to the mass of the electron! This is really the minimum value that can be attributed to the 3rd particle, to balance numbers into the Neutron disintegration, or βd^-.

Therefore, let's consider the value of the *minimum energy* of an electron, i.e. the so-called Z*ero Point Energ*y (ZPE) (Chandrasekhar), (Puccini 2011,b): it is equal to 0.511 MeV.

Now, if we subtract this value from the energy value expressed by Eq.(3), we obtain the value of the energy that could be covered by the 3rd particle of the βd, denoted by Δ_E = 0.78281 MeV, as shown by Eq.(2). This value exceeds the 53.192 % 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 electron 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.(3) we must also consider the *kinetic energy* (E_{Kin}) of the β-ray (i.e. the electron), whose energy spectrum, as Fermi had reported (Fermi 1933; 1934,a; 1934,b), may also coincide with the entire energy value described by Eq.(3).

4. Discussion

4.1 Cherenkov Phenomena

To this purpose, it should be remembered that when charged particles such as electrons, present in a medium such as air pollution, are accelerated at speeds exceeding the light in the same medium (Puccini 2020,a) emit light under a characteristic angle: the above mentioned *C*herenkov Light (*CL*). The reason of such issue can be traced to the effects of polarization and depolarization of the medium, associated to the passage of the charge (Feynman et al. 1965), (Puccini 2005). These motions charge around each point touched by the moving charge generate a series of spherical waves (which in a non-dispersive medium travel with the group velocity $v_g = c/n$, where $n > 1$ is the refractive index) whose envelope constitutes a coherent conical wave front, propagating at a greater speed than the solar light in that medium, and in order to create a coherent wave front, characterized by an angle (θ), known as *Cherenkov angle*:

$$\cos\ \theta = \frac{1}{n} \cdot \beta \tag{7}$$

where $\beta = v/c$ is the ratio between the speed (v) of the particle and the speed of light (c) in the vacuum, whereby β corresponds to 1, for particles traveling at relativistic speed, while $n = c/c_{medium}$ is the refractive index of the considered medium (as known the speed of light in the air corresponds to 224,000 km/sec).

The *Cherenkov Effect* (*CE*) is comparable to the formation of a wake generated from a boat traveling with a speed greater than that of the waves on the water surface. It can be considered also as the *optical equivalent* of the sonic boom generated by the breaking of the wall sound barrier.

It must be considered that, apart from the alleged ν, what is known for certain is that the *CL* is produced firstly (and probably only) by extremely accelerated electrons.

Therefore, our model to consider e° instead of ν is in the fullest and perfect accord with the mechanism underlying the *CE*, i.e. with Nature, without the necessity to *invent* entirely new particles. We wish to repeat: the only known particles able to emit *CL* (as occurs constantly in our atmosphere) are electrons accelerated at high speed, after the impact with cosmic rays in the upper atmosphere.

Then, it was considered that the alleged ν were able to issue *CL* (however with no direct evidence that this radiation was produced precisely by neutrinos (ν_s). In contrast, without similar forcing, it may appear far more natural that, instead of the supposed ν it is the e° which, accelerated at high speed in the *β-decays*, is able to emit the *CL*, like the (electrically charged) electrons of atmospheric molecules, in turn accelerated by the violent shock suffered by cosmic rays (Puccini 2020,d).

It really seems more appropriate, compatible and consistent with the findings of course *naturally* supplied by the *CE* in the upper atmosphere, and therefore *without having to force Nature herself*.

In short, the findings reported in these various detection techniques of the ν are nothing but the effects attributable to an invisible particle, *transparent* to matter: really a *ghost particle* (*GP*). Instead of ν we prefer to call it *GP*, or 3rd particle of the βd, since we only know its indirect effects: it has never been seen or detected directly, to date (even the experiment of Reines and Cowan gives an *indirect* evidence).

In brief, a basic point might be that every time it was considered that ν 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 ν, although it might be another particle to induce the *CE*.

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* (Cherenkov). 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 βd_s, a particle never directly identified.

In favor of our hypothesis, that in βd what is released is a e° instead of a ν (more precisely an $\bar{\mathrm{e}}^{\circ}$ in βd^- and an e° in the βd^+), is the fact that the main detection techniques of ν 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 CE_{s} highlighted during the *surveys* carried out by Reines and Cowan (Reines & Cowan 1956), or at the Super-kamiokande, or the Subdury Neutrino Observatory (SNO), or elsewhere.

Reflecting on the possibility that new discoveries come out at the LHC, it is important to keep in mind this way of relating to the problem. What has been said about ν is also applicable to other possible new uncharged particles or having such a weak charge to be not directly detectable. In these cases to understand what the underlying reality is we can only combine theoretical considerations with experimental evaluations on the missing energy. This is the reason, according with Randall, why the *airtightness* of the detectors, with the consequent recognition, though the most accurate, of all the collision *momenta* is so important (Randall).

In short, even the LHC detectors, considered among the most reliable and sophisticated in the world, are not able to discern the dilemma of secure identity of the 3rd particle emitted in the process of βd. We repeat: since we have never identified the hypothetical ν, but only through the *effects* it produced, we cannot say with certainty that it exists. This seems the crucial point: since this 3rd particle issued with βd has never been identified, directly, concretely, but always and only indirectly, the same effect as that ν could also, with equal possibilities, be attributed to e° or another particle compatible with the βd (unless it is proved that the existence of a 3rd type of electron, e°, is incongruous with the reality of our Universe and incompatible with the known physical laws).

5. Conclusions

In closing, the minimal mass attributed to the $\bar{\nu}_e$ will never be able to solve the *mass gap problem* of the *N decay*: it takes ≥ 250,000 neutrinos to balance the mass gap!

An anti-neutral electron ($\bar{\mathrm{e}}^{\circ}$), instead, would have all requirements to represent the 3rd particle of the βd^-. Only in this way, in our opinion, and in agreement with Pauli (Pauli), the energy balance in the β 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.

That is, Pauli's opinion, this 3rd particle should be a fermion and "must be of the same order of magnitude as the electron mass" (Pauli), but without carrying electric charge; you could really think of an electron without electric charge: a neutral electron (e°).

Well, all Pauli-Fermi requests would be satisfied (Pauli), (Fermi 1934,a).

So, if the existence of the e° should be real, the Eq.(4) describing the βd^-, should be rewritten as follows:

$$N \rightarrow P + \mathrm{e}^{-} + \bar{\mathrm{e}}^{\circ} \tag{8}$$

where $\bar{\mathrm{e}}^{\circ}$ indicates the anti-neutral electron.

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