NEUTRAL ELECTRON INSTEAD OF NEUTRINO:
A NEW BETA-DECAY MODEL

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ABSTRACT

With the disintegration of the neutron, or β-decay (*βd*), a proton, a β ray and a third particle, the neutrino (ν), are emitted. Their mass and high kinetic energy compensate for the amount of energy and mass which the β ray is not able to fully take away, "when at least" according to Fermi, "we do not want to admit with Pauli the existence of a hypothetical particle, electrically neutral and having mass of the order of magnitude of the electronic mass." The requirements asked by Pauli and Fermi for the ν, or third particle of the *βd*, are: it must be electrically neutral and have the same mass and spin of the electron. Why not to think of a neutral electron (e°)? All requests would be satisfied, the energy balance would be restored and all Conservation Laws would be safeguarded, without having to invent a new family of particles.

Every time it was considered that the ν had been detected, they were always *indirect detection* thanks to traces left by a *ghost particle* never detected *de visu*, never directly identified.

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 the *Cherenkov Light*. No wonder it is still an electron, now without electric charge, to induce the various *CEs* highlighted during all the surveys carried out.

If we considered that the ν may coincide with an e°, the gap left by the enigma of *Dark Matter* and *Missing Mass* would be filled, so modifying the fate of the Universe: making it conform to Friedmann's first model. The e° is not antithesis with the Grand Unification Theory, since it envisages a ν of some mass.

In the Supersymmetric Model, the e° could be identified with the *lightest supersymmetric particle*, which may correspond to a *self-conjugated Majorana stable fermion*, since the latter, as well as the e° fully identify with their antiparticle (except spin: antiparallel): $e°\downarrow \equiv \bar{e}°\uparrow$.

INTRODUCTION

As it is known the idea of a new particle, electrically neutral, came to Pauli to compensate the *energy gap* that emerged from the decay of the neutron (*β decay*$^-$):

$$N \rightarrow P + e^- \qquad (1),$$

where N is the neutron, P is the proton and e^- is the electron with a negative electrical charge. It 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. In the *β-decay*(*βd*) many Conservation Laws were not respected, among which immediately stood out the violation of the Law of Conservation of Mass and Energy. In fact, when Marie Curie observed for the first time this type of decay, she only associated it to the emission of an electron. For some years it was not possible to find a solution. Even Bohr thought that it was necessary to accept this deficiency: it seemed to him it was inevitable to resign to the violation of those conservation laws. Pauli instead did not give up. Therefore, after much hesitation, on 04/12/1930 Pauli sent that famous letter to the participants of the Congress of Physics in Tubingen. Pauli wrote:

“Dear Radioactive Ladies and Gentlemen,

as the bearer of these lines, to whom I graciously ask you to listen, I will explain to you in more detail, because of the "wrong" statistics of the N- and Li-6 nuclei and the continuous beta spectrum, 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 I will call neutrons, that have spin 1/2 and obey to the exclusion principle and that further differ from light quanta in that they do not travel with the velocity of light. The mass of the neutrons should be of the same order of magnitude as the electron mass and in any event not larger than 0.01 proton mass. - The continuous beta spectrum would then make sense with the assumption that in beta decay, in addition to the electron, a neutron is emitted thus the sum of the energies of neutron and electron is constant.

But so far I do not dare to publish anything about this idea, and trustfully turn first to you, dear radioactive people, with the question of how likely it is to find experimental evidence for such a neutron if it would have the same or perhaps a 10 times larger ability to get through [material] than a gamma-ray. I admit that my remedy may seem almost improbable because one probably would have seen those neutrons, if they exist, for a long time. But nothing ventured, nothing gained. Thus, dear radioactive people, scrutinize and judge. Your humble servant W. Pauli "[1].

As Klein says - in order to save the Law of Conservation of Energy - "Pauli, obsessed with the number three, makes a hypothesis very bold: contrary to appearances, the core does not disintegrate into two bodies (another nucleus and an electron), but in three. At the same time a 3rd particle is issued carrying with it the missing energy"[2]. Pauli called this new particle *neutron*. The neutron as such was discovered by Chadwick only two years later, thus *Pauli neutron* was called *neutrino* (ν) as suggested by Fermi. In that regard Fermi elaborated one of his masterpieces, the Theory of β Disintegration, 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[3] [4]. Namely: 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 [2] (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: the Weak Nuclear Interaction (WI or *Fermi's interaction*). In fact, the explanation of the nuclear β decay(βd) Fermi gave in 1933 [3] 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 field 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"[5][6]. 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. The WI is the only force capable of changing the *flavour* of a particle, that is, to transform it into another. 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, 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 β disintegrations" [7].

DISCUSSION

I) ν **Requirements**.

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* (*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[1][2][3][4]. 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 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. Moreover, we want to emphasize that referring to this 3rd neutral particle emitted with the*βd*, Pauli wrote: "it has spin ½ and its mass should be of the same order of magnitude of the electrons" [1]. 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 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 (according to the *reductionist* approach preferably adopted in Physics).

II) ν **Detection**

It should be noted that it took 25 years to come to a detection, always *indirect*, of the anti-ν ($\bar{\upsilon}$), and then the ν. As it is known, it would have been difficult for most physicists, if not impossible, to be able to trace a ν, as Fermi asserted [4]. 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 [8]. Leafing through the vast literature about it, it is immediately obvious that all the different techniques of detection of the 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, as a hypothetical e°, for example. The apparatus designed by Reines and Cowan[9] was made of a target of about 1000 litres of aqueous solution of cadmium chloride contained in two containers alternating with three other containers filled with a liquid scintillator acting as a detector. Thus, installing this system near nuclear reactors (as Wheeler had suggested them), in which constantly occur countless βd_s, it could happen that the alleged ῡ issued, bombing water protons, created a reverse process, i.e. a βd^+, transforming the proton in neutron, moreover the emission of an e^+ and a ν. 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: neutron and positron. The race of the neutron emitted is slowed, "moderated", by the collisions with water (as it had first been shown by Fermi and his *boys of Via Panisperna*) thus, in about 10^{-5} seconds, the neutron is captured by cadmium, with immediate emission of γ rays of a particular frequency and energy (~6MeV). The positron, in its turn, annihilating with an electron of the water, generates a pair of γ photons of a defined frequency, able to produce light in the scintillators placed along the walls surrounding water. Such light is detected by photomultipliers. The characteristic time is $\sim 10^{-9}$ seconds, and the coincidence between two scintillators represents the time (t_o) of the measure. Therefore, in the same pair of scintillators it occurs a delayed coincidence, compared to t_o [9]. Yet, in order to better analyse with accuracy and without bias the findings from this experiment, we can divide it 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 ῡ. 2) The 2nd stage considers the effects produced by the clash between this ῡ with a proton of the water contained in the tanks: what occurs is a βd^+ with emission of a ν (which, just as the ῡ will never be disclosed) and with the emission of a positron which, annihilating with an electron of that same water, produces the pair of γ photons detected by the photomultiplier. 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. 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"[10]. "If instruments had revealed γ rays exactly of two energies provided, separated by suitable intervals, the investigators would have caught the ῡ " [11]. Thus, this was enough to believe to have found, specifically and unequivocally the effects of the elusive ῡ. 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 an ῡ, no other type of particle.

Other techniques to detect the ν consist in the so-called *radiochemical experiments*, in which a chemical element is dissolved in copious quantities of water. In the "*chlorine detectors*" a ν (produced in large quantities in the processes of nuclear fusion taking place continuously within stellar cores), hitting a neutron disintegrates it, producing a typical βd^-. It follows that the chlorine atom is transformed into argon, easily identifiable. The same happens with "gallium detectors", where with a similar procedure, this element is converted into germanium, easily identifiable too. Also in these experiments, however, we can know with certainty only the chemical transformation induced, but we will never know the exact identikit of the causing particle, which is presumed to be a ν: according to the facts we believe that this is the 3rd particle emitted with βd^-.

We can still quote two more neutrino detectors: the Subdury Neutrino Observatory (SNO) and the famous Superkamiokande. 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 $\bar{\upsilon}$ (or 3rd particle of βd^-) strikes a proton of a water molecule, triggering a βd^+: the electrons freed at relativistic speeds, traveling faster than light (in the same medium), emit the typical *Cherenkov light* (*CL*) which is captured by photomultipliers. 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, when the atmospheric molecules are affected by γ photons coming with cosmic rays. 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 Superkamiokande) 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* is considered as the evidence of the existence of ν and $\bar{\upsilon}$. This interpretation of the experimental data seems to us *forcing*: 1) because, 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°) because 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.

It should be remembered, in this respect, 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, emit light under a characteristic angle: the above mentioned *CL* [12] [13][14][15]. 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. 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*:

$$cos\theta = 1/n \cdot \beta \qquad (2),$$

where β = v/c is the ratio between the speed of the particle and the speed of light 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 224000 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 βd, 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. 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).

The 3rd particle emitted with βd has been likened to a thief who has left clear and unequivocal evidence of his wrongdoing, but has never been seen in the face. In this regard Franco Rasetti (the founder, together with Fermi of the School of Physics of *via Panisperna*) wrote: "*Indirect evidence of an event*, is similar, to make a simile, to the discovery of a thief that nobody saw. If a person, returned home after a short absence, discovered that some furnishings are misplaced and some valuable object are missing, he would believe that at home entered a thief, even if the thief wasn't seen by anyone" [16]. I.e., it is only possible to see the effects of the actions of the thief but it is not possible to know his identity. This can be any person, since we do not know his face, the figure. So it is for the ν: we only know it is a particle that should meet certain requirements, such as those required by Pauli and Fermi and exposed in paragraph I of our *Discussion*. But that does not mean, in our view, that we have to accept - as a *dogma* – that the 3rd particle emitted with βd_s should be identified, unquestionably, with ν. In this respect the Randall states: "though ν_s are very light and, consequently, largely to the energetic reach of colliders, it is not possible to detect them directly in the LHC (Large Hadron Collider), since they don't have an electric charge: their interaction in detectors is extremely weak. The interaction of ν is so weak that even if every second $50\cdot10^{12}$ ν_s come down from the sun, we had no idea before physical books told us. Although ν_s are so difficult to be observe, Pauli managed to hypothesize their existence: it was a 'desperate way out'. It remains to be resolved the issue of how ν can be experimentally identify. Since they don't have any electric charge and interact so weakly, the ν 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. Thus, if the *momentum* of the particles produced at the end of a certain event, measured in the detector of particles, is less than the *momentum* at the beginning of the event, this means that there has been another particle, or particles, that have escaped detection and have taken away the *momentum* missing in the assessment of the event. This kind of reasoning led Pauli to infer the existence of ν. 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. Based on the knowledge of processes authorized by the Standard Model (SM), we know that ν_s are good candidates to represent non-detected items "[17]. Thus ν_s are only "good candidates to represent" the 3rd particle emitted with βd, but without any certainty! Randall adds: "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 why the *airtightness* of the detectors, with the consequent recognition, though the most accurate, of all the collision *momenta* is so important "[17]. 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. Even Fermi in 1950 asserted that the probabilities that the ν existed were around 50% [18]. In short, 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).

III. Low interope of ν, or *Ghost Particle*, with matter.

It is just the impossibility to directly detect the ν, or 3rd particle of the *βd*, is an obvious consequence of the very rare possibility that such a particle can interact with the matter. The first to say that were Pauli and Fermi, and later many others, even on the basis of careful calculations (literature on the subject is wide). We believe there are at least 6 precise reasons for which this particle does not interact:

1) As Rasetti reminds us "the ν is the smallest object human beings have ever met. It can cross the matter very easily, that’s why it has very little propensity to interact with matter, not only because it is very small, but also because it travels at very high speeds for which it remains near to atomic nuclei – with which it could possibly interact - for a time which is too short to allow a reaction. In order to have any effect, the ν_s in their movement should fully center the nucleus of an atom, however it is such a rare event that it is estimated that these strange creatures would be able to cross a wall of a few light years thickness without finding any obstacle "[16]. Thus, either it is the *ghost particle*(*GP*), or the 3rd particle emitted with *βd* to match the ν, or it is the possible e°, one of the two should represent the lightest elementary particle in nature. Consequently its very small mass makes it very weakly subject to Gravity Interaction (GI), although it is sensitive to such interaction. In this regard Feynman states: "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})" [19]. Furthermore, considering that the GI action in itself is extremely weak, and considering that the particle in question travels at very high speed, hence it proves insensitive to the GI.

2) Being lepton particle, whether it matches the ν, or it is represented by e°, it follows that it is insensitive to the Strong Interaction (SI) too.

3) Since it doesn’t carry any electric charge, unlike the charged leptons, it is not affected by the Electro-Magnetic Interaction and goes on undisturbed on his path.

4) The very high acceleration with which it is issued (both in βd_s and in the process of nuclear fusion) makes this particle travel undoubtedly with relativistic speed, reducing in this way the time the Weak Interaction (WI) - and the GI - can exercise their action. Moreover the WI action is notoriously weak, and quite *slow* compared to the GI and SI, thus it is even more difficult that it may prevail on the kinetic energy (E_{kin}) the *GP* travels.

5) The WI acts only on a short distance [20], 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 [21].

6) 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, or *GP*, "was found to have a value as small as 10^{-44} [cm^2] and brought Bethe and Peierls to conclude that one *obviously* would never be able to see a ν" [22]. This same value was confirmed in 1959 by Reines and Cowan [23], who revealed that the cross section of the electronic ν was equal to:

$$\sigma_\nu = (11 \pm 2.6)10^{-44}[cm^2] \qquad (3).$$

In comparison, as Fermi tells us, the σ of slow neutrons, is between 10^{-24}[cm^2] and 10^{-21} [cm^2] [18].

There could also be a 7th motivation behind the difficult interope of the 3rd particle emitted with βd: the *slowness* with which the WI operates. In fact, while the SI performs its action very quickly (usually between 10^{-22} and 10^{-24} sec.), and less swiftly the Electromagnetic Interaction ($\approx 10^{-16}$sec), it takes the WI much longer to exercise its action, on average 10^{-8}seconds. It is considered, therefore, that both the *alleged* ν, and the possible e°, are subjects only to WI (bearing in mind the very weak force exerted by the GI on a single particle [19]). It should be noted, besides, that the action range of the WI corresponds roughly to 10^{-15}[cm][21], and that this space is traversed by a particle traveling at about the speed of light (likely in a time of $\sim 10^{-25}$sec). All this leads us to think that the *GP* in question flows through each individual *weak fie*ld in such a short time, to prevent the WI to take its action.

IV) Neutral particles and their antiparticle.

As we know, with regard to the electric charge, several other fermions occur in the 3 different forms: that is, with electric charge +, - or neutral: there are many, especially among massive particles, though they are mainly unstable particles. While with electrically charged particles the antiparticle has a charge which is opposite to the corresponding particle, in the case of neutral particles the corresponding antiparticle is identified with the particle itself: the only difference is that they have opposite helicity [24][25]. Even in bosons we have a similar situation. The photon for example which, as known has no electric charge, its antiparticle is identified with the photon itself [25][26]. Also in this case, the difference lies in the fact that they have antiparallel spins. In short, it is not *against nat*ure, it should not appear physically unfounded that another fermion as the electron can also present itself in three different forms: positively charged, negatively charged, or with no electric charge.

V) The WI considers the electron and neutrino as the same particle. As known, after the discovery of the neutron in the atomic nucleus, Heisenberg suggested that neutron and proton were two different states of the same particle. Therefore Heisenberg introduced the concept of *Isospin* and considered the space inside the atomic nucleus as *Isospin space*, assigning conventionally to the proton an up orientation and to the neutron a down orientation [27].Turning a neutron into a proton is equivalent to *rotate the Isospin* of the neutron in this space, taking it from down to up [28]. In the following years the concept of Heisemberg Isospin developed and it was started to investigate whether, similarly to the electromagnetic field, also this *Isospin space* (coinciding with a *strong field*) presented some form of symmetry. It was known, in fact, that the Quantum Electro-Dynamics (QED) is a *gauge theory* in which the phase symmetry U (1) of the wave function (Ψ) of the electron is linked to the Conservation of Electric Charge. Thus, it was tried to apply the Quantum Field Theory to the *strong field* too, so as to highlight a field theory of SI. "To discover a quantum field theory of SI it was necessary to understand what exactly was preserved in the SIs and to which continuous symmetry it was referred" [28]. Following Heisenberg, Yang became convinced that, as in the Electro-Magnetic Interactions the electric charge is preserved, the amount which in turn should be saved in SIs was just the *Isospin*. Thus Yang and Mills identified the *Isospin* with a local gauge symmetry, similar to the one linked to the electron Ψ phase in QED [29]. "In QED the phase variations of the electron wave function are compensated by corresponding variations in the electromagnetic field, which *reacts* in order to keep the symmetry. But a new SI field theory had to consider that the particles involved were two. If the *Isospin* is preserved, it means that the SI does not see any difference between proton and neutron. To *Turn the Isospin* transforming for instance a neutron into a proton, requires a field that *reacts* restoring the symmetry "[28].

What seems particularly interesting is that even in the *weak field* it has been found, without a doubt, a *gauge symmetry*, also meant as a *local symmetry*. That is, as there is a gauge symmetry for the electromagnetic field (conservation of electric charge) and for to the *strong field* (conservation of *Isospin*), there is a symmetry for the *weak field* too. In fact, a gauge symmetry concerns also the electron and the *ν*: in this respect it seems important to stress that it is proved that, according to the WI, the electron and the *ν* are the same thing, they can be exchanged. About a close affinity between the electron and the *ν*, we read: "A neutrino is a subatomic particle that is very similar to an electron, but has no electric charge. Nuclear forces treat electrons and neutrinos identically; neither participate in the strong nuclear force, but both participated equally in the WI"[30]. In short, according to the WI electron and *ν* behave as they were the same particle; the only difference lies only in owning or not the electric charge. That is, for all purposes, for WI electron and *ν* are the same particle!

It seems even more acceptable and likely the hypothesis that the *ν* is an electron with no electric charge, that is a neutral electron (e°).

VI) **β Decay**

Now we know that in the spontaneous decay of a nuclear neutron, or βd^-, it is a down quark (dQ) of the neutron (*N*) to be transformed, by the WI, in an up quark (uQ) through the emission of a W^- boson. Such a *flavour* exchange between Qs involves the transformation of *N* into a proton (*P*).

The W^- particle immediately decays into an e^- and an anti-*ghost particle* (anti-*GP*), which is believed to have an electronic antineutrino ($\bar{\upsilon}_e$):

$$\mathrm{udd}N \rightarrow \mathrm{udu}P + W^- \rightarrow \mathrm{udu}P + e^- + \bar{\upsilon}_e \qquad (4).$$

On the other hand, if the *GP* was an e°, we may enter into Eq.(4) an anti-e°(ē°) instead of the $\bar{\upsilon}_e$:

$$\mathrm{udd}N \rightarrow \mathrm{udu}P + W^- \rightarrow \mathrm{udu}P + e^- + \bar{e}^\circ \qquad (5).$$

As you can see, even in this new model of βd^- all Laws are safeguarded: Conservation Laws of Electric Charge, Energy, Mass, Intrinsic Angular Momentum (*S*), Lepton Number (*L*) as well as the Baryon Number (*B*). Similarly to the $\bar{\upsilon}_e$, considered with dextrorotatory helicity[25][31][32][33][34], the ē° too has dextrorotatory helicity, that is with antiparallel spin respect to the e^- released with βd^-, so as to comply, as previously mentioned, also the Law of Conservation of Lepton Number and the Law of Conservation of Intrinsic Angular Momentum(*S*).

Let’s analyze why, with this new *βd* model, the Laws of Conservation of Energy and Mass are respected too. In our view, if in βd^- we insert the ē° instead of the $\bar{\upsilon}_e$, the preservation of these last 2 Conservation Laws seems, intuitively, more natural, immediate and appropriate. In this regard, just to safeguard the Laws of Conservation of Energy and Mass in the *βd* , Fermi wrote that the 3rd particle, or missing particle in*βd*, which he called *neutrino*, should have a mass about equal to that of an electron, in addition to being devoid of electric charge[3][4]. Fermi’s calculations reveal that the total energy emitted with the *βd* does not divide constantly, that is always in the same proportions, between *β radiation* and $\bar{\upsilon}$ (or anti-*GP*). It may vary randomly within a very wide range, which manifests in a continuous energy spectrum ($\delta\eta$) in the Coulomb field, between zero (i.e. $\eta = 0$) - when all the kinetic energy (E_{kin}) is taken away exclusively by the $\bar{\upsilon}$ - and 100% of the energy emitted with βd^- (i.e. $\eta = E_{max}$), when all the E_{kin} is taken away only by the β ray [4]. However, these are the extreme cases, because (excluding the proton) more often the total energy emitted with the βd^- is almost balanced between the e^- and the $\bar{\upsilon}$, though slightly in favor of the latter, i.e. the 3rd particle of βd^-.

Let's evaluate the masses of the particles represented in Eq. (1). The neutron weighs $1.67492728\cdot10^{-24}$[g], while the proton weighs $1.67262171\cdot10^{-24}$[g]; on its turn the electron weighs $9.1093826\ \cdot10^{-28}$[g]. The mass difference between neutron and proton corresponds to Δ_M ($0.00230557\cdot10^{-24}$[g]), that is $\Delta_M = 2.30557\cdot10^{-27}$[g]. According to the mass-energy conversion factors, if we consider that “1 MeV is about $1.782\ \cdot10^{-27}$[g]" [19], and follow the *cgs* metric system, we have:

$$(2.30557/1.782)\cdot10^{-27}[\mathrm{g}] = 1.29381\ \mathrm{MeV}/c^2 \qquad (6).$$

This is the energy value that in the βd^- must be carried away by the electron and a 3rd particle, in order to safeguard the energy balance in this process. The energy value expressed in Eq.(6) represents the maximum value of the energy spectrum ($\eta = E_{max}$) of the β radiation emitted with *βd*. The minimum energy carried away by an electron corresponds to 0.511MeV, thus the value of Eq.(6) is more than double than the energy of an electron not particularly accelerated. With the decay of the neutron, instead, the β 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 β radiation is able to compensate for the difference in mass-energy between neutron and proton. If we subtract the *minimum energy* of an electron from the energy value expressed by Eq.(6), we obtain the value of the energy that could be covered by the 3rd particle of the *βd*, denoted by Δ_E:

$$\Delta_E = 0.78281 \text{ MeV} \qquad (7).$$

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.(6) we must also consider the E_{kin} of the β-ray, whose energy spectrum, as Fermi had reported [3][4], may also coincide with the entire energy value described by Eq.(6). 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 βd^- should show an E_{kin} *at least* equivalent to the e^-'s. Someone may ask why *at least*? Since they are the same particle, with equal restmass, they should be accelerated to the same speed! Well, we believe it must be remembered that e° (as well as the ē°)do not carry electric charge. Einstein's Principle of Equivalence Mass-Energy, supported by the well-known equation $E = mc^2$, implies that any energy value must match an *equivalent-mass*[35][36][37][38]. Thus, even the electron electric charge, equal to $1.602 \cdot 10^{-19}$ *Coulomb*, involves an *equivalent-mass*. It seems an insignificant value, yet it counts. This is why the speed (v) an e° is emitted is different (that is slightly greater, in our opinion) compared to that of a charged electron. This can be inferred by:

$$p = \mathrm{m}\mathrm{v} \;\rightarrow\; \mathrm{v} = p/\mathrm{m} \qquad (8),$$

where p is the *momentum*, m is the mass of the electron considered and v its velocity. Thus, even the infinitesimal amount of less mass (respect to an e^-) should enable the (supposed) e° to be emitted - during the *βd* - with a slightly greater speed: a less quantity of mass to be accelerated, as in the case of e°, allows the particle to gain a greater speed than the electron electrically charged, just as shown in Eq.(8).

The energy gap that is created when a neutron is transformed into a proton, corresponds to the value expressed by Eq.(6) 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 *βd* 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 *ν*, and unseen, that is so far not yet concretely identified.
In our view, what is more, the introduction of e° involves many other consequences.

VII) Physical consequences introduction of e° instead of *ν*.

1) First, as previously stated, the e° fully satisfies all requests of Pauli and Fermi about the essential elements of the 3rd particle emitted with the *βd* : a) it has the same mass of an electron [1] [3] [4]; b) it is electrically neutral [1] [3] [4]; c) it has the same spin of the electron [1,2,3,4].

2) Disavowing the existence of the alleged *v*, the Standard Model (SM) of elementary particles results greatly simplified and prettified. As known *elegance* is an appreciated requirement in Mathematics and Physics; the same applies to *simplicity* [17]. In addition, with our hypothesis, the SM is made significantly leaner and more symmetrical. Intuitively we believe that Nature behaves in a manner as simple and symmetrical. In fact at the basis of the SM there is a great consideration of the Principles of Symmetry. Baldo Coelin writes: "In elementary particle Physics the use of properties as *symmetry* and *invariance* are a necessity. The symmetry properties are, in general, the only thing that allows us to operate. From a symmetry descends an invariance property, and from this a Conservation Law. The symmetry properties give structure and consistency to the laws of Nature "[26]. Yang adds: "In Quantum Mechanics (QM) the concept of *symmetry* acquires even greater interest. In QM it will never be given enough value to the importance of the *principles of symmetry*. Nature seems to take advantage of the simple mathematical representation of the *Symmetry Laws*"[26]. Thus in our model SM would be represented by a single type of elementary particles on each side: Qs for hadrons and electrons to the leptons. The alleged muonic and tauonic neutrinos would identify in more energetic neutral electrons (i.e. muonic e° and tauonic e°), that is more accelerated, both with respect to the common electrons, and to e°(electronic), probably issued with the *βd*(so far considered a ν_e). In this way, moreover, they are only 2 particles that do not decay (at most they change *flavour*), since they are the lightest, and still one for a part: the upQ and the electron.

3) The e° in place of *v* allows a more uniform interpretation of the *Cherenkov Effect*. That is, it would be the same type of particles (electrons) to generate such a phenomenon, namely the production of *Cherenkov Light*: both as it can be detected naturally in the upper atmosphere, and as it can be detected in the photomultipliers.

4) Another consequence of the disavowal of *v* would be the simplification of the "Modern Mendeleyev Table"[39], since without the *v* the 4th column of table (representing the three *v* flavours) disappears.

5) As it is known only 4% of the mass distributed in the universe is known, while the rest is divided between of 23% *dark matter* and 73% of *dark energy*, representing the so-called riddle of the *Missing Mass* (MM). The problem of MM began in the 30s of last century, as a result of Zwicky surveys and studies, confirmed by several other research centers. Astronomical observations, in fact, showed a clear discrepancy between the mass of the various star systems and their orbital speed around its galactic center. It all added up only if their mass was at least 10 times higher [40][41][42][43]. When scientists realized the *v* could not be massless, it was suggested that the *v* could contribute, at least in part, to the solution of *dark matter*. It is known that, similarly to the relationship between the number of nucleons and photons distributed in the Universe, for each nucleon there are 10^9-10^{10} neutrinos (v_s) [44]. That is, the number of v_s is roughly equal to the number of photons scattered around the entire Cosmos. Rasetti states: "Yet the space is filled with v_s which, if they had a minimal mass (there are a billion of v_s for each nucleon making the ordinary matter), they would represent the major constituent of the universe”[16]. In this regard Asimov adds: "If the *ν* had even a tiny mass, just 1/13000 of the electron, they are so numerous in the space, it is possible to calculate that all together they exceed the mass of all the protons and neutrons. In this case more than 99% of the mass of the universe would be made of ν_s ; they might well represent the MM "[11].

Just because the *dark matter* may be made of ν_s, the U.S.A. Department of Energy aims to detect them in the mines of South Dakota, at a depth of 1500 meters, a depth cosmic rays cannot reach, but only ν_s. In the heart of the mountain has been built a stainless steel tank containing 300 tons of ultra-purified water, that is free of any radioactive traces. At the center of the tank it has been placed a tank with 370 kg of xenon, which has the property of emitting a light beam each time it is traversed by a particle. The detection mechanism is similar to the SuperKamiokande, where the emission of *Cherenkov Light* (*CL*) testifies there has been a contact with a *ν*. Yet we know that the *CL* is also issued (if not exclusively!) by electrons highly accelerated, thus even a charge less electron might accidentally hit the nuclei of xenon atoms, resulting in light emission. Well, if we consider that a *ν* can coincide with an e°, so that its mass corresponds more or less to that of an electrically charged electron, and bearing in mind the large number of ν_s spread-out in the Cosmos, the empty space left in the Universe by the enigma of dark matter and of MM can be filled. Indeed, there is a resounding novelty: a *ν* represented by the mass of a e° would significantly decrease the relationship between *dark energy* and *dark matter* in favor of the latter.

6) Among the various hypotheses proposed in the literature in order to solve the riddle of MM, the dominant one argues that the *dark matter* could be represented by *weakly interactive massive particles* (WIMP), that is provided with a significant hypothetical mass. These WIMP, moreover, are stable particles. The alleged *ν* is a *weakly interactive particle,* initially considered massless, and now with a mass, however infinitely small so that it meets in full only 3 of the 4 parameters of the WIMP. On the contrary, the probable e°, definitely much more massive than a *ν*, may be identified with the alleged WIMP, as it satisfies, better than the *ν*, all the 4 parameters attributed to WIMP. It is useful to point out that the main peculiarity attributed by physicists to the hypothetical WIMP, consists in their *very weak interope* with matter, which is precisely the common denominator with a *GP* or 3rd particle emitted with *βd*: either *ν* or e°. The stability of the WIMP would be retained too by identifying e° with WIMP: electrons, protons and photons are stable particles definitely known in Nature, in addition to the alleged *ν* [26], but according to calculations the mass of the latter would be too small to be identified with a WIMP.

From an interview with Rubbia we read: "From a cosmological point of view we know that the hadronic matter is only a small fraction of the total, since the *dark matter* is measured by gravitational methods and we can be sure of its existence. However this does not clearly explain what this matter is, a matter which is not produced by nucleosynthesis. Is it an elementary particle? A WIMP or a *supersymmetric particle*? Or something else? The main question is if this matter is detectable only gravitationally or it has electroweak couplings with the matter we know. Only in this case we might be able to study it experimentally, causing collisions between the *dark matter* and ordinary matter. Conversely all our experiments would give negative results. It will be necessary to build many other detectors, because the inability to register collisions may also depend on the size of the experiment. One thing is certain: the hunt is open"[45]. We can infer that the e° is not in contrast with what Rubbia assumed.

7) According to the current forecasts, the Universe will continue to expand forever, thinning more and more, until its disintegration and disappearance of all celestial objects, molecular and atomic aggregates. Leaving behind probably only elementary particles that cannot decay into lighter particles, i.e. uQs, electrons and v_s. Whereas, with the emission of the e° in place of the v, both in βd_s and in the process of nuclear fusion, the e° with its mass (multiplied by a very large number of particles: 10^9-10^{10} for each nucleon widespread in the Universe) would alter the value of the *critical density* of the Universe. In this way our universe could match the 1st model of Friedmann universes[46][25][43]. This would be, in our opinion, an event of great scope, since it would drastically alter the destiny of the universe, which would sooner or later slow its expansion till a standstill and then probably start a process of contraction.

8) Considering the e° instead of v, as the 3rd particle of βd, would probably allow Majorana calculations to be satisfied, whose particle – *Majorana particle* - must have a neutral electric charge, a mass(similarly to *Dirac particle or fermion*, but contrary to *Weyl particle*) and coincide with its antiparticle (whereas *Dirac fermion* is different from its antiparticle). As reported by Polkinghorne "On the headstone in memory of Paul Dirac, in Westminster Abbey, it is engraved the equation: $i\mathrm{Y}\partial\Psi = \mathrm{m}\Psi$, written in the space-time notation in 4 sizes(using the natural physical unity of quantum theory, for which $\hbar = 1$). Y are 4x4 matrices and Ψ is a 4-component spinor (two spin states for two states, electron/positron)" [47]. We report in full the equation:

$$[\, Y^{\mu}\,(i\ \delta/\delta x^{\mu} - eA_{\mu}\,(x)) + m]\ \Psi(x) = 0 \qquad (9).$$

“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 (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. $\boldsymbol{\mu}$ *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 $\delta/\delta x^{\circ}$ 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. They allowed Dirac to formulate an equation in which space and time appeared on an equality basis, however, forcing him to introduce a wave function with 4 components"[48]. Wilczek adds: "Dirac’s equation correctly predicts that the electrons have a spin and behave like small bar magnets. The equation contains solutions describing a way in which ordinary atoms can spontaneously annihilate in a flash of light in a split second. 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) "[48]. With brilliant intuition Dirac attributed them, in 1931, to a new type of elementary particle, until then undiscovered, having the same mass as the electron, but opposite charge. With reference to Dirac's equation Penrose states: "Pauli's description of the electron is an entity with two components $\Psi_A = (\Psi_0 ,\Psi_1)$, considering that Pauli's matrices are 2x2. However, Dirac's Clifford elements $(\mathbf{Y}_0,\mathbf{Y}_1,\mathbf{Y}_2,\mathbf{Y}_3)$ require 4x4 matrices to represent the Clifford multiplication laws. In this way, the Dirac's electron is a 4 component entity, instead of having only the two components of a *Pauli spinor*, which describe the two independent spin states that a nonrelativistic particle with spin ½ has. Actually there are only two spin components for a particles described by Dirac's equation, although the wave function has four components. The reason, from a *mathematical point of view*, is closely connected to the fact that the Dirac equation $\delta\psi = -i\mathrm{M}\psi$ is an equation of the first order, and its solution space is embraced only by half the number of solutions of the wave equation: $(\square + \mathrm{M}^2)\ \psi = 0$, which is of the second order. (This equation is also fulfilled by the solutions of anti-Dirac equation, $\delta\psi = +i\mathrm{M}\psi$, which is the Dirac equation for the negative restmass -M). From a *physical point of view,* the *counting* of Dirac Equation solutions must take into account that the degrees of freedom of the electron's antiparticle, namely the *positron*, nestle in the Dirac Equation solutions. But it would be misleading to think that two of the Dirac Equation components relate to the electron and the other two to the positron. Things are much thinner "[25].

In this regard 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]. 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 "[24]. The author 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 "[24]. Majorana adds: "It is well known that one can eliminate the imaginary unit(*i*) from the Dirac equations with no external field:

$$[W/c + (\alpha,p) + \beta mc]\Psi = 0 \qquad (10),$$

with an appropriate choice of the operators α and β (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. (10) 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 ρ_1, ρ_2, ρ_3 two independent sets of Pauli matrices, we set:

$$\alpha_x = \rho_1\ \sigma_x; \quad \alpha_y = \rho_3; \quad \alpha_z = \rho_1\ \sigma_z; \quad \beta = -\rho_1\ \sigma_y; \qquad (11);$$

dividing eqs. (11) by $-h/2\pi i$ and defining $\beta' = -i\ \beta$, $\mu = 2\pi\,\mathrm{mc/h}$, we obtain the real equations:

$$[1/c\ \delta/\delta t\ -(\alpha,grad) + \beta'\ \mu]\ \Psi = 0 \qquad (12).$$

As a consequence, eq.(10) separates into two independent set of equations, one for the real and one for the imaginary part of Ψ. We set $\Psi = U + iV$ and consider the real equations (12) as acting on U "[24]:

$$[1/c\ \delta/\delta t\ -(\alpha, grad) + \beta'\ \mu\ ]\ U = 0 \qquad (13).$$

It is of considerable importance to highlight this Majorana record with reference to Eq. (13):

"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:

$$U'(q)=RU(-q) \qquad (14),$$

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

$$U'(q,t)=i\rho_2\ U(q,-t) \qquad (15).$$

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"[24] meant as distinct particles from the respective particles. Compared to the *Weyl Spinor* [49], also with 2 components, i.e. with 2 degrees of freedom (that is, with 2 spin orientations), as Majorana states in his model "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)."[24]. Edoardo Amaldi, he too, like Majorana, one of *the boys of 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 $Y\mu$ ($\mu = 1,2,3,4$), which has the following properties:
A)Unlike what happens in the original Dirac's representation, in Majorana's representation the 4 Y_μ 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 "[50]. Also, as Recami notes: "the algebra $R(4) \cong R_{3,1}$ introduced by Majorana is quite different from the algebra $C(4) \cong R_{4,1}$ introduced by Dirac. We observe, *en passant*, that the algebra of Majorana is one of two algebras naturally associated to Minkowski space (the second being $R_{1,3} \cong H(2)$, where *H(2)* is the algebra of quaternionic matrices 2x2)"[51] Still referring to the mathematical representation of Dirac's equation, reworked according to Majorana formalism, Amaldi continues:
"B) 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 Ψ 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.
C) 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 Ψ 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 Ψ to Hermitian conjugation operator.-There has not yet been a definite answer to the question whether Majorana neutrino(ν_M),i.e. corpuscles characterized by the equality $\nu_M = \bar{\upsilon}_M$, exist in nature, or do not exist at all"[50]. However, Amaldi adds: "The interest in Majorana theory was greatly revived after the discovery of the *non-conservation of parity*" [50][31][32][52] and the success of the *2 component* theory for the interpretation of large classes of phenomena [50][53][54][55]. "Once proven that the ν observed in the βd_s has always helicity -1 (i.e. left-handed) and the $\bar{\upsilon}$ always helicity +1 (i.e. right-handed), it becomes possible to identify these two objects with a ν_M respectively with helicity -1 and +1. This property, combined with the interaction (V-A) which – since it contains only left-handed lepton currents - retains the lepton number, is equivalent to the Conservation of Lepton Number. A small mass of the ν is compatible with Majorana theory, but not with the two-component theory (Weyl Spinor). A ν with mass $(m) \neq 0$ can only be either a ν_M or a Dirac ν (ν_D) with 4 components"[50].
Thus, our ν model, identifiable with an e°, coincides perfectly with ν_M, but not with ν_D, since the latter is electrically charged (as well as Weyl Spinor). In this regard, let's group the most salient features of the 3 different spinor models that could be identified with ν, or with the 3rd particle of βd (a particle which *has never been directly detected* so far):

a) **Dirac's spinor** is a 4 component spinor, 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 spinor, an electric charge and a magnetic moment (because its spinors are electrons). It presents a mass different from zero: $m \neq 0$. There is *symmetry, charge conjugation (**C**):* $(e^+) = \boldsymbol{C}(e^-)$.

b) **Weyl's spinor** is a 2 component spinor, 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**):* $(e^+) = \boldsymbol{C}(e^-)$.

c) **Majorana's spinor** is a 2 component spinor, 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: $\Psi(\nu)\downarrow$; $\Psi(\bar{\upsilon})\uparrow$. It is incompatible with a conserved charge, since the Majorana equation requires that its spinor has neither electric charge nor magnetic moment, but it must have a mass different from zero: $m \neq 0$. According to Majorana such a spinor should coincide with "particles with no electrical charge (neutrons or hypothetical neutrinos)"[24]. 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 spinor*" [39]:

$$\bar{\upsilon} = \boldsymbol{C}(\nu) = \nu \qquad (16).$$

What does it mean? It means that the hypothetical ν identifies with its antiparticle ($\bar{\upsilon}$); they are the same particle: one is the mirror image of the other, just as described by Majorana through Eq.(14). 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 spinor* model was prophetic. In fact, just 30 years later, as we all know, it was shown that in weak interactions(WI_s) there is *violation of Parity*, just as Lee and Yang had predicted [31]. In that regard Penrose reminds us 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, γ_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 βd^-, 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 ν too is particularly interesting in this respect. Only if the ν has a levorotatory helicity it is subject to WI or it could be created in a weak interaction process. Therefore ν_s are particles with levorotatory helicity"[25]. Penrose adds: "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 $\bar{\nu}$. 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 π^+), for example, which is a boson, has an antiparticle which is the pion with negative charge (the meson π^-). Actually, several bosons are their own antiparticles: it is the case of the photon and even the neutral pion (the meson $\pi°$) "[25]. Yang had reached, experimentally, to the same conclusions [26]. It seems very important to note that what Penrose wrote confirms 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! Obviously, according to Majorana, this is particularly true for the "hypothetical ν "[24]. Consequently the ν identifies with the $\bar{\nu}$, just as shown in Eq. (16). The only difference, in fact, is in the helicity: ν_S are always left-handed and $\bar{\nu}_S$ are always right-handed. Eq.(16) could represent the *fermion* or *Majorana spinor*, as it corresponds to the "*self-conjugated spinor* in which Majorana had fallen"[39]. This is true both whether the 3rd particle emitted in *βd* corresponds to the ν, and in case it is another particle, i.e. e°. According to the latter possibility, the Eq. (16) should be well represented:

$$\bar{e}° = \boldsymbol{C}(e°) = e° \qquad (17).$$

The ***C*** (or charge conjugation) given in Eqs.(16) and (17) represents precisely the symmetry properties as expressed by these equations. In this regard, Penrose writes: "The operation that replaces each particle with its antiparticle is denoted by ***C***. A physical interaction that is invariant with respect to the replacement of the particles with their antiparticles (and vice versa) is called ***C***-invariant. The spatial reflection (specular reflection) is denoted by **P** (which stands for *parity*). WIs are not invariant neither with respect to **P**, nor with respect to ***C***, but they are invariant with respect to the combined operation ***C*P** (= **P*C***). We can assume that ***C*P** is performed by an unusual mirror, in which each particle is reflected in its antiparticle. We note that ***C*P** operation causes a left-handed particle is reflected in its right-handed antiparticle"[25]. It seems interesting to point out that this dovetails with the model of *Majorana spinor* inherent neutral particles and the "hypothetical ν"[24], and is fully compatible with our e° model, as shown in Eq.(17). What stated by Penrose had already been discussed 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 WIs. C.S. Wu et al. confirmed this hypothesis"[26]. As Dorigo reminds us, there was evidence of considerable wit in the experiment set up in 1958 by Goldhaber-Grodzins-Sunyar to determine the status of helicity of ν. "An Experiment which for depth of design and simplicity of the arrangement is to be considered a cornerstone of elementary particle physics. A.A. found a greater amount of resonant scattering with the field in the photon motion direction, confirming that the ν has a levorotatory helicity and WIs have an Hamiltonian with Vector and Axial currents" [56][57], i.e. the V-A currents we have already mentioned. Now we know that ν_s are all levorotatory, while $\bar{\upsilon}_s$ are all dextrorotatory. Yang adds: "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 ν, 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 ν 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 ν_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:

$$S= D^{-} \neq S^{-}=D \qquad (18).$$

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. 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^{-}"[26]. 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 ν 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 "[26]. 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 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, which however may not be so disastrous if a neutral particle collide with the corresponding antiparticle. It may not be excluded the possibility that, with regard to neutral particles, matter and antimatter can live together quietly, 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[24]. As regards the interpretation of Dirac equation, Weinberg writes: "The more important is an equation, the more we must be vigilant to changes in its meaning. In 1928 Paul Dirac set about finding a quantum version of Schrodinger equation that was in accord with the principles of the Special Relativity. The Dirac equation describes a particle with spin equal to ½ (in units of Planck's constant). This was considered a great triumph, because we already knew that the electron had spin ½.

The trouble is that there is no relativistic quantum theory of the kind sought by Dirac. The combination of Relativity and Quantum Mechanics inevitably leads to theories having an unlimited number of particles. 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 "[58]. Among these theories cited by Weinberg there could be *Majorana's fermion or spinor*, particularly applicable to neutral particles, where the particle identifies with its respective antiparticle. In this regard, Wilczek says: "In his short career, Ettore Majorana made several profound contributions. One of them, his concept of 'Majorana fermions' - particles that are their own antiparticle -is finding ever wider relevance in modern physics"[59]. Weinberg adds: "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"[58]. 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 spinor*, that is, a massive fermion, free of charge, which identifies with its antiparticle, that is its antiparticle corresponds to the speculative image of the particle itself. This spinor, or *Majorana's fermion*, may coincide with the hypothetical ν -see Eq. (16) - or with the possible e° we proposed: see Eq.(17). Indeed e° is equally comparable with *Majorana spinor*: in accordance with Majorana’s equations, e° is a particle without electric charge, without magnetic moment, and has mass. 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 ν), 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. However, there is today a particle that had not yet been finalized, the ν, that is the only particle of matter at the same time elementary and electrically neutral. In 2001 it has been proven that ν 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 ν can be dextrorotatory or levorotatory, the same thing happens for a $\bar{\upsilon}$. Whereas according to Majorana's theory, ν and $\bar{\upsilon}$ form a single particle. The antiparticle of left-handed ν is nothing other than the right-handed ν, and mutually. In other words, there are only two components, mirror images of each other"[2, Klein, 120]. We reiterate: the model of e° would fully satisfy the characteristics traced for *Majorana's fermion,* as showed in Eq. (17). One may ask: why the ν model as represented in Eq. (16) doesn't work to represent *Majorana's spinor*? Because, in addition to all the various reasons given above, in our opinion, the mass of the ν is too small compared to e° to be able to fully compensate the mass-energy gap that emerges in βd: there would be necessary several hundred ν_S to equate the missing energy value in βd^-.

9) Analyzing *Feynman's Diagrams*, the W particle carries away the electrical charge from an electron, which becomes electronic ν(ν_e). Well, we find it much simpler, more natural, and more congenial that in the physical process considered by Feynman it remain an electron without its electric charge, that is, a neutral electron (e°), without creating a new particle, completely different from the initial one. In this regard, it seems necessary to add that e° coincides perfectly with Feynman's ν (unlike Dirac's ν): as similarly to Feynman's ν the e° moves in both directions of time, as particle and antiparticle coincide. In this regard, see equation (15), prepared by Majorana for a time reflection.

10) Taking into consideration the Supersymmetric Model, e° could identify, for instance, with *the lightest supersymmetric particle* for two simple reasons: 1) the e° coincides with its antiparticle; 2) it is not known a lighter particle in nature where e° may decay. That is, the lightest supersymmetric particle could likely correspond to a "*Majorana stable fermion*" [39], which we think is represented by e° with its antiparticle, as can be seen in equation (17). These concepts, moreover, do not contradict Rubbia's hypothesis about the possible nature of *Missing Mass*, including "WIMP or *supersymmetric particle*" [45]: e° could identify with both (considering the WIMP less massive).

11) The introduction of the e° is by no means antithetical to the Grand Unification Theory (GUT), indeed it is perfectly congruent with such a hypothesis that considers a ν of a certain mass. Therefore, also another massive particle (such as e°) that could be emitted with βd, instead of ν (with too little mass), could be more compatible with GUT formalism.

12) The possibility of the existence of the e°, which is fully identified with its antiparticle (except the spin: antiparallel), is in agreement with the ideas proposed by Majorana against the clear distinction between matter and antimatter, which he supported by an innovative and elegant mathematical formalism. Thus, as it can be seen in Eq. (17), if the e° identifies with the *self-*

conjugated Majorana fermion, we can make a partial re-review of the clear distinction that is currently made between matter and antimatter. In this regard in our work we have reported the more or less obvious perplexities expressed by various A.A.: e.g. Penrose [25], Weinberg [58], Klein [2], Yang. The latter, we reiterate, hoped to come to "a deeper understanding of the relationship between matter and antimatter" [26].

CONCLUSIONS

Sure! It may be surprising to assume the mass of the ν equal to the electron's: at first it may seem an excessive value, especially if we think that the Standard Model considered the ν massless.

"The study of the electron's spectrum has been the main classic method to weigh the ν. Nevertheless, after over 70 years of effort, this method has not produced a measurement of the ν mass. Its *oscillations* offer a simple explanation of that failure"[60]. Later, after the Superkamiokande experiment, also the ν was considered a massive particle, though having a mass much lower than the electron. This limitation was inferred from the observations of Supernova 1987A, for which it had been assumed that the mass of the electronic ν (ν_e) was <5.8 eV[61]. Why this limit? Because the neutrinos (ν_s) of this supernova arrived on Earth a few hours before the visible light; so they "must have traveled at a speed very close to that of light. Since lighter particles travel faster than heavier ones, scientists have concluded that the mass of ν is very small"[62]. In truth, this may appear as a hasty conclusion since, for instance, it does not consider the extreme acceleration all the particles emitted with the explosion of a supernova undergo, which is notoriously lower only to the Big Bang's[63] nor does it consider the *Inflationary Phase* [64][65]. It is assigned to the ν a speed equal to or close to that of light in the vacuum, i.e. ~ c. Yet cosmic rays too travel in space at a speed ~ c, thanks to the acceleration impressed them by the supernova explosions. Then it seems necessary to make a small reflection: both the ν and the cosmic rays travel roughly at the same speed. Yet, they have enormously different masses: the smallest (and largest) component of cosmic rays are hydrogen nuclei, that is protons, which weigh nearly 4 orders of magnitude more than an electron. So if even the mass of the ν corresponded to that of an electron, it is no wonder if the ν exploded with Supernova 1987A arrived before the visible light, since it is unequivocally determined that particles with a mass nearly 10000 times heavier than the electron travel at a speed ~ c. Moreover, it is evident that in the high atmosphere cosmic rays, when affecting electrons, give them most of their kinetic energy, accelerating them at a speed faster than light, in the same propagation medium [12][13]. Therefore, even a ν identifiable with an e° is not at all incompatible with the findings from the Supernova 1987A, so there is no need to attribute to ν an extremely small mass.

As known "the state of ν is described by a combination of *mass eigenstates* ν_k ($k = 1,2,3$) according to:

$$|\nu_\alpha\rangle = \sum_k U^{*}_{\alpha,k}\,|\nu_k\rangle \qquad (19),$$

where U is the unitary matrix that determines the mixing. At the time the ν is revealed it is in a *flavour eigenstate*, which we call β. However since during the propagation from the source to the detector the phases of the wave function corresponding to the different *mass eigenstates* evolve over time in a different way, there is a finite probability that the ν revealed is in a *flavour state* different from that of the ν emitted, i.e. $|\nu_\alpha\rangle$, so that we have $\beta \neq \alpha$. For example, a ν_e , after having traveled a long distance, can be seen as a muonic ν''(ν_μ) [66]. Let's consider a ν_μ produced in a decay and "assume this ν is a composite (superimposed) state of several ν_S with masses m_i, with i = 1,2,3. Their wave functions oscillate with *fi* frequencies, proportional to their energies. Since the masses are different, energies and frequencies are different: thus, the wave functions of the 3 components do not oscillate in phase. For this reason, with the flow of time, a ν_μ does not remain equal to itself, but acquires a certain probability to become a ν_e or a tauonic ν (ν_t). We talk about ν *oscillations* or, perhaps more precisely, ν *transformations*. We do not yet know the mass of the lightest ν: we have measured the square mass differences, but not the mass of the lightest ν: given only empirical information on a speculative basis, it could be relatively large"[61]. Yet, as Bernardini reminds us, despite the undoubted successes of the current 3 flavours theory, some experimental data emerged with the Liquid Scintillation Neutrino Detector at Los Alamos, or at Fermilab(with the Booster Neutrino Beam), suggest that the theory is not complete. The anomalous measurements resulting from these experiments can be explained only by assuming the existence of other types of neutrinos(ν_S), already hypothesized by Pontecorvo. The others ν_S cannot pair with the Weak Interaction (WI) bosons, they have no charge counterpart, so they are called *sterile neutrinos* : they have a significantly larger mass than those currently attributed to the most common ν_S. They are susceptible only to the Gravity Interaction, thus they are particles even more elusive than known ν_S [67].

Thus "there is a further and peculiar possibility concerning ν_S. Right-handed states do not have electromagnetic interactions nor even weak-current or neutral interactions (coupled only to left-handed states). They are completely free of charge, to be called *sterile* ν_S. In this case, no SM symmetry prohibits them to be Majorana ν_S, with mass Λ completely independent from the electroweak scale."[68].In addition, in case it was proved that massive ν_S are Majorana particles, it would mean that the mass of ν_S is generated by a new Physics mechanism, such as, for example, the *see-saw* mechanism, where right-handed ν_S with significant Majorana masses are inserted (such as *sterile* ν_S). Thus, if right-handed ν are very heavy, they produce left-handed ν_S with very small mass, inversely proportional to the heavy mass. In short "compared to the electrically charged elementary particles, the ν is in an uncomfortable position in the present SM: in fact, in addition to having a mass, the ν could correspond to the $\bar{\upsilon}$, giving rise to Majorana hypothesis. The fact that both ν and $\bar{\upsilon}$ could be the same particle would explain its very small mass and also the enormous difficulty to observe $\bar{\upsilon}$ in nature. $\bar{\upsilon}$ have a very large but unstable mass, so far to be transformed into a tiny mass: the ν. The two particles are therefore in a sort of swing (*see-saw*) between *masses* and *forces*, which always brings the smallest mass up"[69]. Thus, if the *see-saw* mechanism was to be real, it could largely justify the mass we attributed to the supposed $\bar{\upsilon}_e$, that is, that of an electron. 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_S do not interfere . In addition, the 3rd particle emitted with βd^- is right-handed, just as the *sterile* ν, or the $\bar{\upsilon}$ (or the possible $\bar{e}^\circ$), so it is even more elusive, since it is also insensitive to WI. But then, one could still argue: given that the *sterile* ν is right-handed and provided with a certain mass, sufficient to compensate for the *energy gap* emerging from the βd^- (as the *sterile* ν is also considered as a *heavy neutral lepton*), why not to consider in the βd^- the *sterile* ν instead of $\bar{e}^\circ$? In our opinion for two simple reasons: 1) Because the *sterile* ν could have a much larger mass than the electron’s (it could oscillate in a vast range: between 1 eV and 10^{15} GeV), the mass of decay products could well exceed the value of the neutron mass itself. 2) Because the third particle emitted with the βd^- must be an antiparticle in order to counterbalance the e^- emitted. It is the only way to protect the Law of Preservation of Leptonic Number. *Sterile* ν, on the other hand, does not appear among the antiparticles, it is not an antilepton (according to present knowing).

If it is assumed that ν can interact with the Higgs field with an intensity of force similar to electrons’ (more so if ν corresponds to e°), the heavy mass could approach considerably to the scale of the Grand Unified Theory (GUT). "This possibility emerges naturally in many SM extensions. For example, the extension to the symmetry group SO(10) remains a promising candidate for the unification of electro-weak and strong interactions at high energy scale."[68]. As Maiani reminds us, with very high energies, equal to 10^{15}GeV, the three fundamental interactions could merge into one: a Great Combination of Forces, as suggested by Pati-Salam and Georgi-Glashow models. For example, in Pati and Salam GUT, based on the group O(10), there is a heavy ν, N, which may be a Majorana particle [70][71][72]. In this regard, let us not forget that Salam and Glashow are among the creators of SM: therefore, it should not cause excessive scandal that the mass of the ν corresponds to the electron’s mass.

It is now well-known that ν_s , in the end, are only sensitive to WI, as the Gravity Interaction's action on such particles is too weak: this is possible because WI acts only on left-handed particles, and ν are left -handed [31][32]. In contrast, ῡ is right-handed, so it is insensitive even to WI's action. For the same reasons, since it is not sensitive to the *weak charge*, ῡ cannot acquire mass through Higgs Mechanism (HM) [73][17]. Yet it is now asserted that the ν is a massive particle, so this is the real enigma: how does ῡ (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 ῡ 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 "[17].

It seems certain that the 3rd particle emitted by βd^- cannot acquire the mass through the modes described by SM. The ῡ, in fact, does not behave like a *Dirac fermion*, nor can it be considered as a *Weil fermion* (which is massless). This shows the possibility that the ν and ῡ (or e° and ē°) can be considered similar to a *Majorana self-conjugated spinor*. Penrose writes: "The term spinor always means one particle with spin ½, i.e. a fermion and never a boson. The spinor is represented by a 2-component wave function Ψ_A, thus the index $_A$ takes values 0 and 1, i.e.: $\{\Psi_0(x), \Psi_1(x)\}$.

Also Dirac's electron, which the author described at 4 components, can be represented as a 2-component *Dirac Spinor* :

$$\Psi=(\alpha_A , \beta_{A'}) \qquad (20).$$

This equation couples the two 2-spinors, each acting as a sort of *source* for the other, with a $2^{-1/2} M$ coupling constant that describes the strength of the *interaction* between the two. That is, Dirac's electron can be thought as made of two ingredients, α_A and β_A', each of which converts continuously into the other. Let’s call *zig* the particle α_A and *zag* the particle described by β_A'. Each of the two particles has a spin ½ ħ around its motion direction, *zig* is left-handed, and *zag* is right-handed. Typically a *zig particle* becomes a *zag*, the *zag* becomes a *zig*, this *zig* becomes a *zag* and so on, but the direction of the spin remains constant. This *zig zag* representation of both the electron and any other massive particle having a spin ½ can be seen in space-time as a continuous oscillation between a left-handed *zig particle* and a right-handed *zag particle*. Therefore, the actual motion of an electron is made up of a large number of such single processes, to constitute a *quantum overlapping* of these. This *zig-zag* representation is also valid for *v*. In this case a *v* massless could be completely *zig*; But with a very small mass we have to imagine a momentary occasional *leap* in a *zag*, and return. Thus, in a *βd* expressed in terms of *zig-zag* only the *zig* part of the neutron and the proton participates in the process, whereas for the ῡ is the *zag* part to participate"[25]. This may also be valid if we consider the e° instead of the *v*: the *zig* will identify with e°, left-handed, and the *zag* with the ē°, right handed. This *zig-zag* model of Penrose, also applicable to *v*, seems to us quite similar to the already quoted *see-saw* model.

Unfortunately, the demonstration of the real existence of the *Majorana solfconiugated spinor*, as through the verification of *double β-decay*, has been tried throughout the world but no positive results, as this type of decay is hardly evident, although in recent years more sophisticated experiments are being set up. The fact is that neutral leptons are massive, so there must be a way they acquire mass. In this respect, Terranova states: "the experimental techniques used to determine the masses of v_s never involve *single eigenstate mass*. In *βd* the distortion of the electrons’ spectrum is due to the presence of v_e therefore it involves all the eigenstates that mingle with v_e. The relationship between the *effective neutrino mass* (m_β) that determines the electron spectrum and the masses of the individual eigenstates is the following:

$$m_\beta = \cos^2 \theta_{13} \cos^2 \theta_{12}\, m^2{}_1 + \cos^2 \theta_{13} \sin^2 \theta_{12}\, m^2{}_2 + \sin^2 \theta_{13}\, m^2{}_3 \qquad (21).$$

In the past these angles were unknown but since 2012 they have all been well measured, as well as the quantities $m^2{}_2 - m^2{}_1$ and $m^2{}_3 - m^2{}_2$. This allows to determine which is the minimum m_β in when m_3 ("normal hierarchy") or m_1 ("inverse hierarchy") is the heaviest eigenstate. In particular we have: $m_\beta > 10$MeV for normal hierarchy, and $m_\beta > 50$ MeV for inverse hierarchy. In general, for the experimental observation of these processes, the inverse hierarchy is an extremely favorable condition "[60].

In short, there is a number of A.A. which assign the 3rd particle emitted through the *βd* a rather significant mass, even higher than we hypothesized. It seems that recently Yazdani's team has traced, at the ends of a superconducting wire, particles with a behavior overlapping with those hypothesized by Majorana. According to these researchers *Majorana's fermion* is not a real particle to be added to what we already know, but it is a *quantum composite state*, which arises from the interaction between Dirac's fermions [74]. It is just what we support: the third particle emitted with the *βd* is not a new particle, as *v* or $\bar{\upsilon}$, but it is a common *Dirac fermion*, as the electrons, but with the difference that they are neutral electrons.

Indeed, Enrico Fermi, the one who first and alone built the entire mathematical formalism of the βd, connected to the superb intuition of the existence of WI [3,4] (indeed his masterpiece), observed with the utmost certainty and without doubt that in the decay of the neutron, in order to preserve the laws of conservation of energy and mass, we must "admit the existence of a hypothetical particle, electrically neutral, and having mass of the order of Magnitude of the electronic mass "[7]. Well, maybe it is not correct to continue to attribute the ν a very small mass, infinitely smaller than an electron, so to compensate for the energy gap (between 0.511 and 0.7828MeV) that is created by the decay of a single neutron, we need at least a hundred of these ν_s roughly massive.

Finally, a basic point might be that every time it was considered that ν had been detected, they were always *indirect detection* by traces left by a particle: the third particle that is released during βd. It has always been this way: it is the detection the effects of impacts, such as the *Cherenkov effect* (*CE*), to represent a proof of the existence of ν, although it could be another particle to induce the *CE*. Indeed, what we can be sure of is that in nature the *CE* arouses from well-known particles: electrons. It is the electrons of the atmospheric molecules that, when 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*. One thing we can be certain about the results of all *indirect detection* of the ν: they only show the *traces* left by a *ghost particle*, that is, the 3rd particle released with the βd_s , a particle never detected *de visu*, never directly identified. In favor of our hypothesis, that in βd what is released is a e° instead of a ν (more precisely a ē° in βd^- and a 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 *CEs* highlighted during the *surveys* carried out by Reines and Cowan, or at the Superkamiokande, or the SNO, or elsewhere.

As exposed in the work, there would be many consequences induced by the introduction of the e°, both in the physical and the astrophysical field, among which what we find most intriguing is the possible identification of this particle with the *Majorana's spinor*, so we could also represent equations (16) and (17) with the following:

$$e^{\circ}\downarrow \;\equiv\; \bar{e}^{\circ}\uparrow \qquad (22).$$

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