Physico-Mathematical Models of Elementary Particles and Physical Processes of Oscillation

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Abstract

Modelling of elementary particles is a very important question in contemporary physics, in fact in the absence of a real physical representation, due to smallest sizes of particles, the identification of suitable models becomes necessary. It is known that postmodern physics is characterized still by the indeterministic dualism wave-corpuscle that prevents to give an unequivocal identity to elementary particles as per the obsolete paradigm: is the particle wave or corpuscle? or: is the particle at the same time wave and corpuscle? Research of suitable and coherent models is therefore fundamental in contemporary physics and it can give an important contribution also to the solution of the present problem relative to the physical phenomenon of oscillation that regards neutrino but also all other elementary particles.

1. Introduction

Ordinary bodies, that we see, we finger, we observe and whose we measure important physical characteristics like mass, speed, geometric dimensions, etc...., require only a mathematical modelling for description of their physical behaviour.
Elementary particles instead elude our immediate sensory perceptions and often also the probe with technical instruments and they require therefore also a physical modelling. We need namely a physical model that allows us to imagine how an elementary particle is made even if it eludes directly our instruments of probe. Quantum Mechanics eliminated that necessity introducing the Indeterminacy Principle that postulates an ineliminable indetermination into the physical reality for which in the world of elementary particles concepts of position, dimension, distance, speed, momentum, etc... are intrinsically indeterministic; it follows that for instance the concept of geometric dimension of an elementary particle has no meaning and mostly a probabilistic description can be given. In QM therefore there is no need of a physical model of elementary particles and in fact the dualism wave-corpuscle, that is at heart of the theory, generates a complete indetermination with regard to the choice of a physical model privileging a mathematical model that is similarly dualistic and indeterministic. We observe nevertheless present techniques are able to measure lower distances than 10^{-18}m and it was inconceivable altogether up until some ten years ago. Science is an activity in progress and there is no need to place insurmountable limits to the ability of probe and of research.

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The Theory of Reference Frames (TR), Deterministic Quantum Physics (DQP) and the Non-Standard Model (NSM) recognize the present real difficulty of measuring a few important physical quantities but they prove it isn't due to an intrinsic fundamental property of the nature but it is due only to a present inadequacy of our tools of probe. It is confirmed for instance by the fact that if 100 years ago sizes on the scale of the μm were inaccessible to measurement instruments today those sizes are altogether normal. Apart from this if it is true that for elementary particles there are many difficulties to measure a few classical quantities, like position and speed, it is also true that present science is able to measure with very good precision other physical quantities regarding elementary particles like frequency spectra of emission, electric charge, average life, mass, etc.... . Postmodern physics, in continuity with main theories of modern physics (SR, GR, QM, SM), is characterized by unsurmountable theoretical limits like the constancy of light speed, the impossibility to overcome limits imposed by the Indeterminacy Principle and the Planck length that would seem an insuperable wall for scientific probe and research. Let us think instead those limits are only temporary and physical and engineering research, whether theoretical or applied, must have the object to exceed those contingent limits that theoretical research imposes each time.

2. Modelling of stable free massive elementary particles: electron and proton

Electron and proton are the most important elementary particles into the zoo of massive particles[1][2]. Charge of electron and proton is the same but the sign is opposite ($e=\pm 1.6\times10^{-19}$C). In the Non-Standard Model then, as per the Theorem of Spin and Charge[3][13], also spin of the two particles is the same but with opposite sign ($q_s=\pm\hbar/2$).
We demonstrated in the Theory of Reference Frames we cannot apply the same concept of mass that is valid for ordinary bodies also to massive elementary particles. In fact mass of ordinary bodies is the inertial mass that coincides with the gravitational mass: inertial mass m_i is the physical property of ordinary bodies by which they respond to an external force generating an acceleration ($F=m_ia$), gravitational mass m_g is the same mass that responds to the force of a gravitational field generating a gravity acceleration ($F_g=m_gg$) where $m_g=m_i$.
For massive elementary particles the situation is evidently different, but the fundamental difference is that accelerated charged massive elementary particles emit electromagnetic radiant energy that doesn't happen relative to accelerated neutral ordinary bodies. For these bodies instead we proved the existence of a gravitational perturbation when they are accelerated into a gravitational field but it doesn't have electromagnetic nature[4].
It induces to think for massive elementary particles it needs to consider a mass with different physical nature: the electrodynamic mass, that is connected with the electric nature of massive elementary particles and it is able to emit electromagnetic energy when it is accelerated into a force field.
We have demonstrated electrodynamic mass changes with the speed according to the relationship

$$m = m_o \left(1 - \frac{v^2}{2c^2}\right) \qquad (1)$$

where m_o is the resting mass of the massive elementary particle (electron or proton). We have given various demonstrations[3][5][6][of the (1), but here we will see the most simple that consists in considering the resting intrinsic energy of massive particle, given by $E_o=m_oc^2$. The accelerated particle acquires at the speed v a kinetic energy $E_c=m_ov^2/2$ and simultaneously emits electromagnetic energy at the expense of the kinetic energy for which the intrinsic energy $E_i=mc^2$ of the accelerated particle at the speed v is

$$E_i = E_o - E_c \qquad (2)$$

and replacing we have

$$mc^2 = m_oc^2 - \frac{m_ov^2}{2} \qquad (3)$$

from which the (1). In actuality we have proved the considered physical process has quantum nature[7] for which the variation of mass with the speed isn't continuous but it happens for two particular values of speed of the accelerated particle: the physical speed c of light and the critical speed $v_c=\sqrt{2}\,c$. In the event of electron, relative to these two values of speed, the accelerated electron emits two gamma quanta, each one with energy E=0.255MeV[3]. In the event of accelerated proton, it emits relative to the same speeds two delta quanta, each one with energy E=469.125MeV[2]. It is represented in the graph of fig.1 whether for electron (m_e) or for proton (m_p).

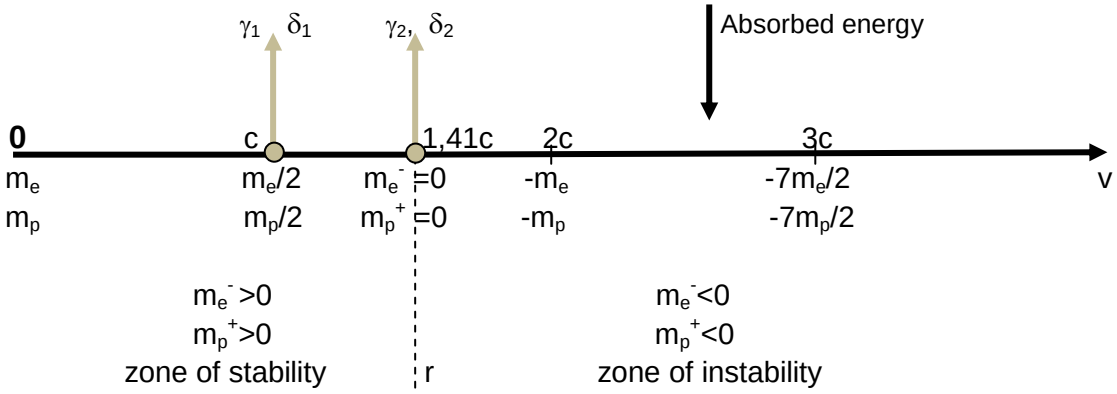

Fig.1 Feynman's dynamic diagram relative to the behaviour of both the accelerated electron and the accelerated proton.

Spin of particles has mechanical nature because it is defined by the angular momentum, and we have demonstrated in DQP[8] it is equal to

$$q_s = m_s v_s r_s \qquad (4)$$

where m_s is the mass, v_s is the tangential speed and r_s is the radius of particle in a spherical geometric model. In the event of electron and of proton, except the sign, we have $q_{se} = q_{sp}$ and consequently

$$m_e v_e r_e = m_p v_p r_p \qquad (5)$$

From the (5) we deduce

$$\frac{r_e}{r_p} = \frac{m_p v_p}{m_e v_e} = \frac{p_p}{p_e} \qquad (6)$$

in which p_p and p_e are tangential momentums of proton and of electron.
Every massive elementary particle has a resting intrinsic energy $E_o=m_o c^2$ and as per the Planck relation ($E_o=hf$) it has a Compton's equivalent wavelength $\lambda_C=h/m_o c$.
Compton's wavelength coincides with De Broglie's wavelength $\lambda_{DB}=h/m_o v$ when $v=c$, i.e. it is possible to say Compton's wavelength is De Broglie's wavelength at the speed of light. Considering the relativistic variation of electrodynamic mass of particle with the speed it is suitable to define a relativistic wavelength λ_r

$$\lambda_r = \frac{h}{2mv} \qquad (7)$$

where v is the linear speed. In the Theory of Reference Frames electrodynamic mass of massive elementary particles changes with the speed according to the relation (1). At the physical speed of light c electrodynamic mass becomes half $(m_o/2)$ and consequently with respect to the privileged reference frame, supposed at rest, at the speed of light the relativistic wavelength coincides whether with De Broglie's equivalent wavelength or with Compton's wavelength

$$\lambda_{rc} = \lambda_{DBc} = \lambda_C = \frac{h}{m_o c} \qquad (8)$$

Considering the (1) the relativistic wavelength is given by

$$\lambda_r = \frac{h}{2m_o \left(1 - \frac{v^2}{2c^2}\right) v} \qquad (9)$$

Charting the relativistic wavelength and the relativistic frequency $f_r=c/\lambda_r$, we have graphs of fig.2.

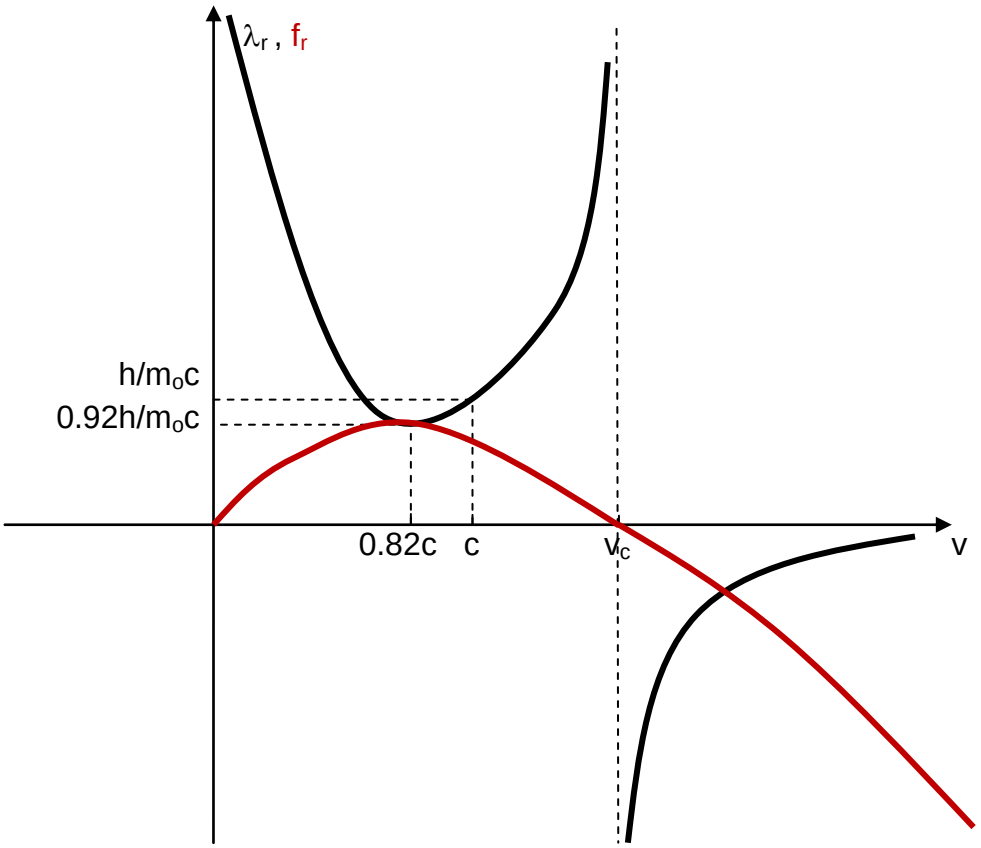

Fig.2 The black graph represents the variation of the relativistic wavelength with the speed, the red graph represents the relativistic frequency.

Because $v_s=\omega_s r_s$, angular momentum or spin of an elementary particle may be written[8][9]

$$q_s = m_s \omega_s r_s^2 \qquad (10)$$

where ω_s is the intrinsic angular speed of particle. From the (5) we obtain

$$m_e \omega_e r_e^2 = m_p \omega_p r_p^2 \qquad (11)$$

Because electron and proton have the same spin, supposing that $\omega_e=\omega_p$, from the (11) we have

$$r_e = r_p \sqrt{\frac{m_p}{m_e}} = 42.85\, r_p \qquad (12)$$

We deduce from the (12) in the model here developed the electron radius is about 43 times greater than the proton radius, because radius and mass are in inverse proportion. Because proton mass is about 2000 times greater than electron mass also it follows that proton has a mass density ρ_p greater than the mass density ρ_e of electron so as we have $\rho_p = 144.5 \times 10^6\, \rho_e$. (**)

Besides intrinsic angular spin, elementary particles have also an intrinsic magnetic spin that is due to rotating electric charge while angular spin is due to rotating mass. For the magnetic spin of free particles (k=1, s=1/2) we assume here the expression[8] that is valid in the International System MKSA

$$M_s = \frac{eh}{4\pi m_o} \qquad (13)$$

From (13) we deduce intrinsic magnetic momentums of electron M_{se} and of proton M_{sp} are in the ratio

$$\frac{M_{se}}{M_{sp}} = \frac{m_p}{m_e} = 1836.1 \qquad (14)$$

In the physico-mathematical model here described, deduced from the Non-Standard Model, electron and proton into the stable free state have the following properties:

Electron

a. resting mass $m_e=9.1x10^{-31}$kg equal to 0.51MeV/c^2
b. resting intrinsic energy equal to 0.51MeV
c. electric charge -1 equal to $-1.6x10^{-19}$C (15)
d. intrinsic angular spin $-\hbar/2$
e. intrinsic magnetic spin $M_{se}=eh/4\pi m_e = 9.28x10^{-24}$ J/Tesla

Proton

a. resting mass $m_p=1836.1m_e$ equal to 938.25MeV/c^2
b. resting intrinsic energy equal to 938.25MeV
c. electric charge +1 equal to $+1.6x10^{-19}$C (16)
d. intrinsic angular spin $+\hbar/2$
e. intrinsic magnetic spin $M_{sp}=eh/4\pi m_p = 0.5x10^{-26}$ J/Tesla

Moreover, free electron and free proton share the following properties:

** In the question "Why has the classical electron radius generally been rejected in quantum physics" proposed by Andrew Worsley in ResearchGate, Michael A.Sherbon has informed about the result of his calculation in which the following relatioship is valid

$$\frac{m_p}{m_e} = 4\frac{r_e}{r_p}\alpha \qquad (a)$$

where α=1/137 is the constancy of fine structure. From the (a) we deduce $r_e = 3.35\, r_p$ (b)
In both calculations we have $r_e>r_p$ but in the Non-Standard Model the relation (12) is valid.

a. electrodynamic mass of two particles changes with the speed according to the same relation given by the (1), in which only the resting mass is different
b. the two accelerated particles emit similarly two energy quanta at the physical speed of light and at the critical speed, electron in the gamma band of frequency and proton in the delta band
c. the ratio of radii of the two particles, into a geometric model with spherical symmetry, is $r_e/r_p = \sqrt{m_p/m_e}$
d. the ratio of the two angular spins, apart from the sign, is 1
e. the ratio of the two magnetic spins is $M_{se}/M_{sp}=m_p/m_e$, where m_p and m_e are resting masses.

For particles of antimatter[10], positron and antiproton, the same considerations are valid except for the fact that the values of electric charge and of angular spin are reversed.

3. Modelling of unstable free elementary particles

Accelerated massive elementary particles, whether leptonic or baryonic, become unstable[1][2][11] for greater speeds than the critical speed $v_c=\sqrt{2}\,c$.
At the critical speed electrodynamic mass of particles is null and for greater speeds it becomes negative with the generation of antimass. Antimass is a specific property of unstable massive particles that at the free state, when the acceleration force defaults, experience a decay process with the emission of an energy quantum or neutrino, that is characteristic for every unstable particle.
In consequence of the decay they come back to the basic particle that is head of the family (electron or proton for matter and positron or antiproton for antimatter)[10] . In fig.3 main unstable particles of electron subfamily are represented[1][11].

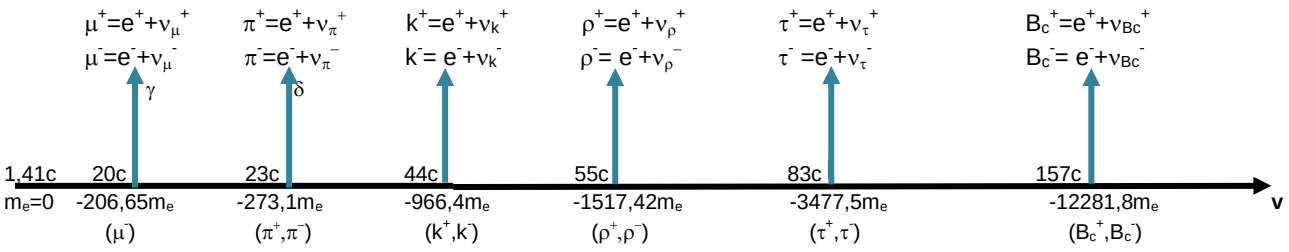

Fig.3 Graph relating to unstable electrodynamic particles of the electron subfamily with variable negative electrodynamic mass; $m_e=E_o/c^2=0.55$ MeV/c^2 is the mass of resting electron.

In the Non-Standard Model unstable massive electrodynamic particles, whether leptonic or baryonic, have the following properties:

a. negative electrodynamic mass increases in absolute value when the speed increases, with absorption of energy from the field of acceleration force (fig.1)

b. when the acceleration force defaults, in accordance with the average life of the unstable particle, this is subjected to a decay process with the emission of an energy quantum (neutrino) and generally it comes back to the basic particle of the subfamily (with v≈0, this state isn't represented in fig.3)[1][2][11]
c. the energy quantum (neutrino) belongs to the delta band for leptonic particles and to the delta-Y for baryonic particles
d. the question why renowned unstable particles of any subfamily (electron, positron, proton, antiproton) have just those values of antimass is still an open question and it needs to probe if it hides a quantization law[7].

4. Modelling of electron and of proton that are bound inside matter

Inside matter, massive elementary electrodynamic particles have a different behaviour with respect to the free state and besides the behaviour of electron is different from proton. In the Non-Standard Model, in concordance with models of the deterministic quantum physics[8] atom electron is into quantum states characterized by orbital levels and by quantum numbers. With regard to particles of antimatter (positron and antiproton) we know, as per the Principle of Asymmetry[10] , they are unable to generate stable complex antimatter.

4.1 Tied electron

The quantization law of orbital electrons is defined historically by the De Broglie relation that makes use of the concept of equivalent wavelength λ_{DB} for which

$$2\pi r=n\lambda_{DB} \qquad (17)$$

where n is an integer number. It needs to specify in the Non-Standard Model the dualism wave-corpuscle has no physical meaning and massive particles are exclusively non- point corpuscles of electrodynamic matter with definite geometric sizes. In this model the use of the concept of equivalent wave for massive particles is due only to the respect of the historical convention. In fact we start from the (17) for reaching a new law of quantization. Because $\lambda_{DB}=h/m_o v$, from the (17) we deduce

$$2\pi r = n\frac{h}{m_o v} \qquad (18)$$

and

$$m_o v_n r_n = n\hbar \qquad (19)$$

where $\hbar=h/2\pi$ and $q_{on}=m_o v_n r_n$ is the quantum orbital angular momentum of electron inside atom called "orbital spin of electron". From the (19) we can obtain energy levels of

electrons in atom and considering the variation of electrodynamic mass with the speed we obtain also energy levels of the hyperfine structure due to the Lamb shifts[8].
Electron therefore has three spins: 1. the angular spin that is connected with the electric charge through the "Theorem of Spin and Charge" [13], 2. the magnetic spin given by the (13), both are intrinsic properties of electron, and 3. the orbital spin that is connected instead with its behaviour inside atom. The quantization law (19), that has a more manifest real physical meaning, is able to replace for all practical purposes the (17) and it is possible to deduce all properties of atom electron from it.

4.2 Tied proton

The physical behaviour of proton inside matter and in particular inside nucleus is different with respect to tied electron because proton represents, despite its small sizes, the heavy matter of the universe.
The atom nucleus is composed of protons and neutrons and the proton-neutron bond gives stability to nucleus. In the Non-Standard Model the structure of neutron is composed of one proton and of one electron and consequently the proton-neutron bond is actually a bond between two protons through one nuclear electron of exchange which moves around the two protons with greater than light speed[12][13], at least equal to the critical speed (fig.4).

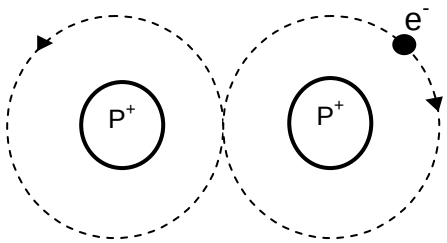

Fig.4 Proton-neutron bond with the nuclear electron of exchange.

The proton-neutron bond is a very stable nuclear bond characterized by a binding energy of 2,23 MeV that holds protons and neutrons together inside the nucleus through the nuclear electron of exchange that in the NSM generates the strong nuclear force.
Physical properties of the electron of exchange inside nucleus are:

a. greater speed than the physical speed of light, at least equal to the critical speed
b. null or negative electrodynamic mass (antimass)
c. negative electric charge equal to - e
d. intrinsic angular spin -ħ/2

5. Modelling of neutron

Neutron isn't an effective elementary particle because it has a structure consisting of plus massive particles. In the classical model neutron is made up of two massive particles: one proton and one electron, in the Standard Model a structure with three massive particles is

supposed: one quark up and two quarks down. We know neutron is an important source of neutrinos and because lately the postmodern research is inclined to assign a mass to neutrinos, it follows that in the postmodern model neutron would be composed of four massive particles: three quarks and one neutrino. The Non-Standard Model supposes instead neutron n is made up of two massive particles like in the classical model: one proton p^+ and one electron e^-, with the difference that in NSM the two particles have electrodynamic nature. In this model neutron is characterized by a weak internal bond between proton and electron when it is into the free state, while when it is tied inside nucleus, that bond becomes strong through nuclear electron of exchange[13]. In the weak bond between proton p^+ and electron e^- inside the free neutron the sum of masses of the two particles is smaller than mass of the free neutron: it determines instability of the free neutron and therefore spontaneous decay with an average life of about 887s[12].
Energy that is produced in decay represents the "electron neutrino ν_e " and it is equal to 0,78 MeV that represents also the weak binding energy in the free neutron. After the decay (fig.5) we have

$$n \longrightarrow p^+ + e^- + \nu_e \qquad (20)$$

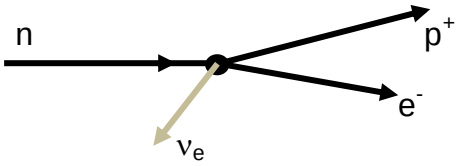

Fig.5 Feynman's diagram for the decay of free neutron

Applying the Planck relation (E=hf) to neutrino we have

$$f = \frac{E}{h} = \frac{0,78}{6,63x10^{-34}} \frac{MeV}{Js} = 1,9x10^{20}\ Hz \qquad (21)$$

$$\lambda = \frac{c}{f} = 1,58x10^{-2}\ Angstroms \qquad (22)$$

Electron neutrino belongs to the frequency spectrum of gamma rays (γ) and like all energy quanta it is an electromagnetic nanowave[14].
When a neutron is firmly tied with protons[12][13] the bond between proton and electron inside neutron is defined by

$$n \longrightarrow p^+ + e^- + E_B \qquad (23)$$

where E_B is the binding energy.
Electrodynamic mass of electron inside nucleus is zero at the critical speed and it is negative for greater speeds. Values of electrodynamic mass and of electrodynamic energy for neutron and its component particles are

neutron $\longrightarrow$ 939.36 MeV/c^2 $\longrightarrow$ 939.36 MeV
proton $\longrightarrow$ 938.07 MeV/c^2 $\longrightarrow$ 938.07 MeV
electron $\longrightarrow$ E_e/c^2 $\longrightarrow$ E_e

where E_e is the intrinsic energy of electron that inside nucleus can be null (at the critical speed v_c=1.41c) or negative (for greater speeds than the critical speed), normally in resting free electron E_e=0.51MeV.
The binding energy E_B between proton and electron inside free neutron is given by 0.78MeV, but for the tied neutron that energy is greater with a minimum of 1.29 MeV when electron is at the critical speed. So the bond between proton and electron in neutron that is firmly tied inside nucleus is stronger than the same bond in free neutron, but a weakly tied nuclear neutron, inside nucleus, can suffers a change to proton because of its oscillatory energy, due for example to the thermal agitation, that is able to weaken further the bond of neutron with proton. On this account neutron is how if it was free inside nucleus and therefore decays according to the transformation of free neutron

$$n \longrightarrow p^+ + e^- + \nu_e \qquad (24)$$

Electron that leaves nuclear neutron (radiation β^-) acquires a positive electrodynamic mass at much lower speed (smaller than the critical speed) and simultaneously an energy quantum (neutrino) is emitted with frequency and wavelength that are, for a binding minimum energy equal to 1.29 MeV,

$$f = \frac{E}{h} = \frac{1,29}{6,63 \times 10^{-34}} \frac{MeV}{Js} = 3,1 \times 10^{20} \text{ Hz} \qquad (25)$$

$$\lambda = \frac{c}{f} = 10^{-2} \text{ Angstroms} \qquad (26)$$

The energy quantum that is emitted presents still characteristics of frequency and wavelength that are peculiar to the gamma radiation.
The residual proton remains inside nucleus and it is available to create a strong bond with other protons of nucleus. The continuous spectrum of electrons β^-, coming from the neutron decay inside matter, is a peculiar characteristic[12][13] of the radiation β^-, unlike the spectrum of orbital atomic electrons that is instead discontinuous and quantum.
The theory, that here has been developed, allows to explain effectively the continuous spectrum of electrons β^- because electrons β^- derive from nuclear electrons with a variable and continuous content of energy starting from the minimum value of energy of 1.29 MeV.

6. Modelling of energy particles

In the Non-Standard Model we have distinguished massive electrodynamic particles from energy particles[13]. Massive electrodynamic particles have been considered in preceding paragraphs. Let us want to consider now energy particles: in NSM they are represented by all energy quanta or electromagnetic nanowaves[14] belonging to different bands according to their frequency of oscillation: infrared rays, photons, ultraviolet rays, X rays, γ rays, δ

rays, δ-Y rays. The mathematical model of photon in QM and in SM makes use of wave functions[8] of the classical trigonometry (sine and cosine) that are defined on the entire axis of the independent variable (x for the space and t for the time) where they recur similarly in the same shape of the first cycle or period. In Heisenberg's model it is assumed that the wave function f(x,0), that represents photon at the time t=0, has the existence domain coinciding with the entire axis x; in the interval (-L, L) it is the normal trigonometric function while it is defined and equal to zero outside that interval [-∞,L], [L,+∞] (fig.6).

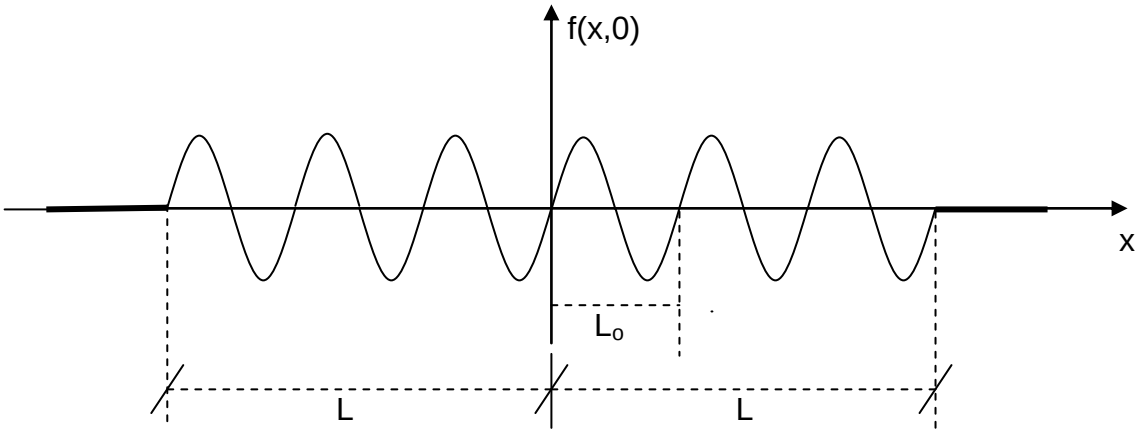

Fig.6 Heisenberg's graphic representation through wave function of photon

The spectrum of Heisenberg's wave function f(x,0), represented in fig.6, is the "bell curve" (fig.7) that is characterized by the loss of monochromaticity and by a rich spectrum in wavelengths because of the space truncation. The central extended spectrum line has a width Δk that is inversely proportional to the length 2L of the wave group.

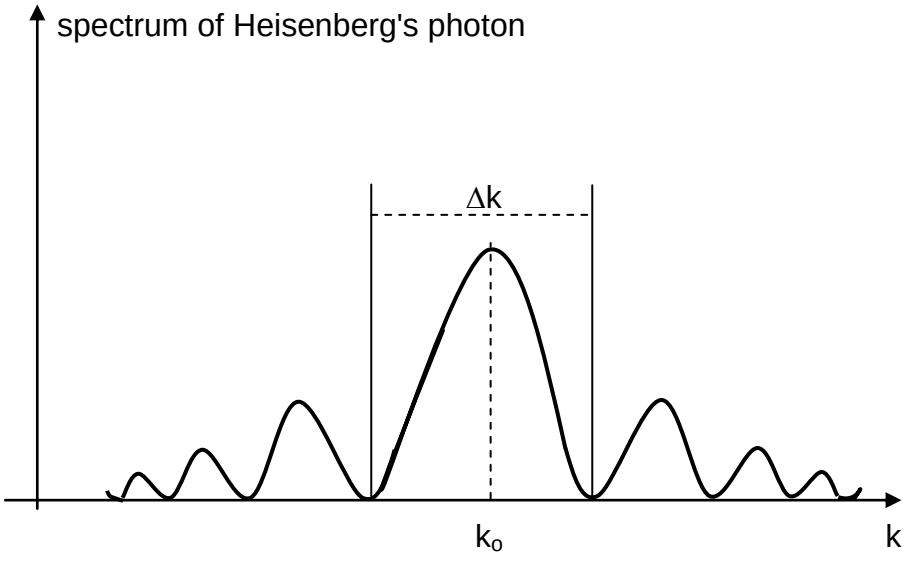

Fig.7 Graph representation of Heisenberg's spectrum for photon

The loss of monochromaticity of the wave function of photon, due to the choice of the described mathematical model, is the cause of the uncertainty and of the indetermination in QM and it is the theoretical basis of the Indetermination Principle.

In Deterministic Quantum Physics (DQP) and in the Non-Standard Model (NSM) the mathematical model of photon and of all energy quanta is based on a concept of "rational trigonometry" for which in order to have a representation of a wave function, that is physically valid, it isn't necessary to consider an existence domain that coincides with the entire axis of the independent variable but it is sufficient to consider a limited number of cycles or of periods (also only one) and the wave function isn't defined outside that domain. For instance in fig.8 an existence domain with three cycles of the wave function is assumed. In that event the mathematical representation of energy quantum is

$$f(x,0) = \text{sen}2\pi K_o\, x \qquad \text{for} \quad 0 \le x \le L$$
$$f(x,0) = \text{non-defined} \qquad \text{for} \quad x<0 \quad \text{and} \quad x>L \tag{27}$$

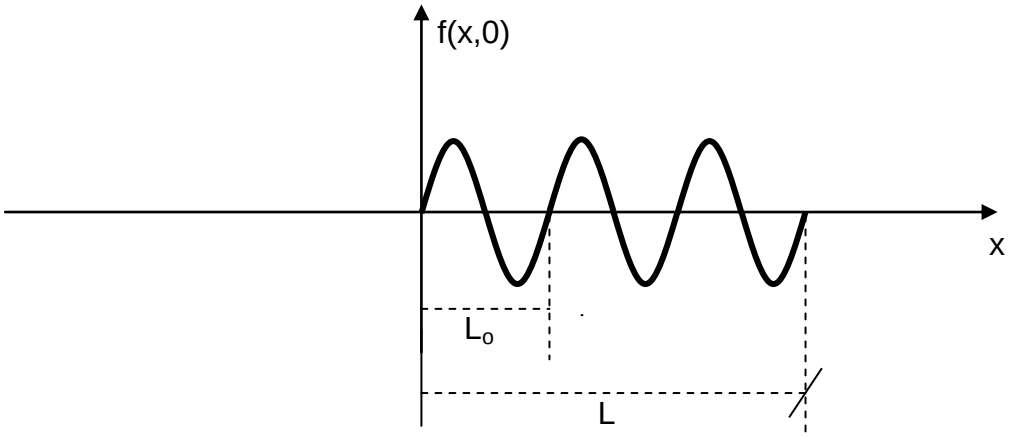

Fig.8 Graphic representation of energy quantum through concepts of "rational trigonometry" in DQP

Extending the periodicity of that function to the entire real axis x we obtain the development in Fourier series of the wave function f(x,0) of fig.8 is characterized by only one spectrum line (fig.9), where K_o is the number of wavelength in one metre: $K_o=1/L_o$.

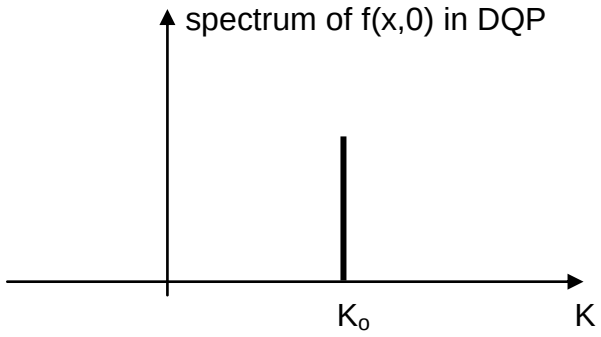

Fig.9 Graph representation of the spectrum of an energy quantum in DQP

Like this the choice of a new mathematical model, based on concepts of rational trigonometry, allows to remove causes of indetermination in Quantum Physics. Analogous representations of the spectrum in frequency are possible in the time domain.

Energy quanta belonging to gamma, delta and delta-Y bands are called also neutrinos, when they come from decay processes of unstable particles with conversion of mass or antimass to energy[1][2][11][12][13] , while other energy particles involve an energy process that doesn't derive from decay of unstable particles[3][6][7] .
In the NSM common properties to all energy particles (and therefore also to neutrinos) are:

a. They are electromagnetic nanowaves and like all energy quanta they are described by the Planck relation
b. Real mass is exactly zero
c. Particle and antiparticle are the same particle
d. Their physical speed is exactly the speed c of light
e. They are bosons
f. Their spin is zero

a. All energy particles, including neutrinos, respect the Planck relation E=hf, where f is now the unique frequency of the rational wavefunction, without indetermination, that represents any nergy quantum, including photons and neutrinos. The Planck relation allows to associate an equivalent virtual mass with energy quanta as per the concept of intrinsic energy $E=m_{eq}c^2$. Besides energy particles are described by equations of electromagnetic nanofield[14].

b. Real mass of energy particles is exactly zero but, as over, we can associate each particle with an equivalent virtual mass m_{eq} that depends on its energy given by the Planck relation (E=hf), for which

$$m_{eq} = \frac{hf}{c^2} \qquad (28)$$

Naturally that mass is virtual and it can be useful in a few physical situations in concordance with the considered model. As per the (28) for instance a few energy particles have the following values of virtual mass with respect to electron mass:

photon with frequency $f=0.5\times10^{15}$Hz : $m_{eq} = 4.04\times10^{-6}m_e=2.06\text{eV}/c^2$
electron neutrino γ with frequency $f=1.9\times10^{20}$Hz : $m_\gamma = 1.5m_e=0.77\text{MeV}/c^2$
mesonic neutrino δ with frequency $f=2.6\times10^{22}$Hz : $m_\delta = 210m_e=107.1\text{MeV}/c^2$
baryonic neutrino δ-Y with frequency $f=5.14\times10^{23}$Hz : $m_{\delta\text{-}Y}= 4200m_e=2142\text{MeV}/c^2$

c. In the NSM all energy antiparticles coincide with particles, in concordance with the E. Majorana hypothesis.

d. In the NSM the physical speed of energy particles, including neutrinos, is exactly the speed of light. Besides in the NSM the physical speed of light is a local constant with respect to the privileged reference frame while with respect to all other reference frames the relativistic speed of energy particles and of light can be smaller or greater than the physical speed in concordance with the theorem of composition of

speeds. The NSM assumes it is valid also for neutrinos as it has been confirmed by the CERN-LNGS experiment (2011).

e. In the NSM all energy particles are bosons[13], while in the SM neutrinos are fermions.

f. In the SM photons have spin 1 and neutrinos have spin 1/2. In the NSM all energy particles, because they have null electric charge, have zero spin as per the "Theorem of Spin and of Charge".

7. Physical Processes of oscillation

Oscillation consists in a physical process of transmutation from a real physical entity to another in a situation of forced regime or in a situation of unstable free regime. It regards massive elementary particles and energy particles. Let us consider separately the two types of oscillation and let us make reference to electron for massive particles and to neutrino for energy particles.

7.1 Electron oscillation

Electron oscillation happens when electron is accelerated or decelerated and in that case it needs to distinguish two cases according as electron is stable or it is unstable. In fact accelerated stable electron (so with positive electrodynamic mass) experiences a first characteristic oscillation at the speed of light with the simultaneous emission of a gamma quantum that has energy equal to the half of the resting intrinsic energy of electron ($E=m_oc^2/2=0.255MeV$). The gamma quantum has the frequency ($f=E/h=0.62x10^{20}Hz$) and the wavelength ($\lambda=2h/m_oc=4.9x10^{-2}$Angstroms) that are peculiar to gamma radiation [3][6][12].
The accelerated stable electron is subjected to a second oscillation at the critical speed $v_c=1.41c$ with the emission of a second gamma quantum of energy that has the same characteristics of the first gamma quantum (fig.6).
What remains at the critical speed about the initial electron is a particle that has lost all resting electrodynamic mass (m=0) but it has conserved the conventional negative electric charge and because the electric charge is associated always with an angular spin, null electrodynamic mass doesn't mean disappearance of the particle but just only that in those physical conditions (i.e. electron at critical speed) the electrodynamic mass has a null value and the particle experienced a double process of transmutation that is reversible. We know also this physical process of oscillation happens with quantum modalities [7].
If electron is now decelerated it acquires energy from force field and its electrodynamic mass begins to increase becoming again positive and at the physical speed of light it reacquires the first half of the resting mass that is connected with the energy quantum that has been absorbed in deceleration. At zero speed electron acquires the second half of the resting mass with the simultaneous absorption of the second gamma quantum of energy

(in figure gamma quanta are yellow). The oscillation process of stable electron is therefore perfectly reversible.

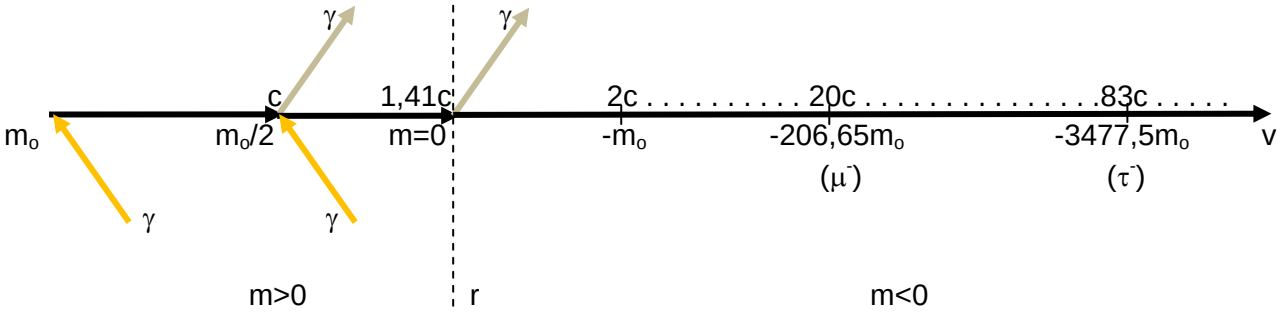

Fig.6 Diagram relating to the behavior of accelerated electron. The dotted line r separates the stable behavior from unstable behavoir. Yellow gamma quanta represent the energy absorption of decelerated electron in the stable state and grey gamma quanta.represents the emitted energy.

Electron accelerated becomes unstable at greater speeds than the critical speed and in that case electrodynamic mass assumes negative values (antimass) like kinetic energy and intrinsic energy.
Our knowledges of unstable particles prove a few characteristic values of speed and of electrodynamic mass determine the transformation of accelerated unstable electron to particular particles, themselves unstable: these oscillations regard in particular the birth of muon and of tauon. In that case if the force field stops its action, promptly because of the instability of particle, a decay process and consequently an oscillation process begins and particle returns to its state of resting stable electron with the simultaneous emission of a delta quantum of energy. Let us observe therefore oscillation happens differently according as electron is stable or unstable.

7.2 Neutrino oscillation

Neutrino oscillation consists in the physical process that generates a transmutation from a particular type of neutrino to another. In the Standard Model three types of neutrino are considered: electron neutrino ν_e, muon neutrino ν_μ, tauon neutrino ν_τ. This phenomenon was predicted by the Italian physicist B. Pontecorvo in 1969. According to this theory it is necessary that neutrinos have mass, even if smallest but anyway different from zero, so that oscillation can happen. In actuality this assumption is in conflict with the SM in which neutrinos have zero mass. The Non-Standard Model instead is able to explain the oscillation process of neutrinos, also in the absence of mass, according to a different logic. In the first place it needs to specify that in the NSM neutrinos derive from the decay processes of unstable particles and therefore for every unstable particle the relative neutrino exists: on this account in the NSM neutrinos are much more numerous than the three neutrinos that are predicted in the SM[1][2][11][12][13] .

Electron neutrinos[12] belong to the gamma band; muon neutrinos, tauon neutrinos[11] and in general mesonic neutrinos[1] belong to the delta band: these neutrinos represent leptonic neutrinos. Baryonic neutrinos[2] belong instead to delta-Y band. Theoretically the oscillation could happen between two whichever neutrinos but the experimental evidence has confirmed at the moment, in little verified cases, only oscillations from muon neutrino to electron neutrino and from muon neutrino to tauon neutrino.
It is possible to observe the neutrino oscillation happens always like an interaction of initial neutrino with matter (Earth's atmosphere for cosmic neutrinos, great containers of massive materials for neutrinos produced in laboratory). These processes of oscillation are rarest because of the smallest wavelength of neutrinos and of smallest cross-section that involve a greatest difficulty of collision of neutrinos with matter. The phenomenon of oscillation can be detectable in statistical manner when the number of neutrinos that passes through matter is greatest.
The oscillation $\nu_\mu \longrightarrow \nu_e$ had some experimental confirmation and it can be explained actually through a collision process, at small probability, of a muon neutrino at high energy (δ rays) with a nuclear neutron N_c inside matter (fig.7).

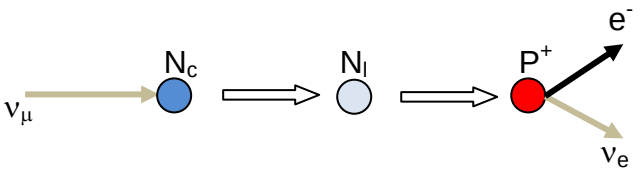

Fig.7 Collision process of a muon neutrino with a nuclear neutron that is practically fixed

The nuclear neutron because of collision absorps neutrino's energy breaking the nuclear bond and becoming a practically free neutron N_f inside nucleus

$$N_c + \nu_\mu \longrightarrow N_f \qquad (29)$$

This nuclear neutron, practically free inside nucleus, decays spontaneously to proton generating radiation β^-, that leaves nucleus, and one electron neutrino

$$N_f \longrightarrow P^+ + e^- + \nu_e \qquad (30)$$

The event of oscillation $\nu_\mu \longrightarrow \nu_e$ is rare and it is very hard to observe it even if a few experimental verifications there were.
Also for oscillations $\nu_\mu \longrightarrow \nu_\tau$ few oscillations have been observed until now (a few in USA (2008) and others in succeeding times in the project OPERA at CERN and at LNGS). That rare event can be explained through a hypothesis of collision of muon neutrino with one electron of sufficient energy (fig.8).

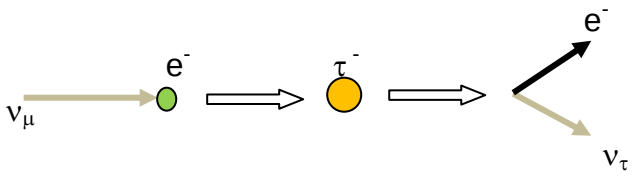

Fig.8 Collision process of a muon neutrino with one electron of sufficient energy

The electron absorbs the energy (all or in part) of the muon neutrino changing in the unstable particle τ^- that then decays spontaneously in shortest times equal to the average life of the tauon to one electron and to one neutrino ν_τ.

$$e^- + \nu_\mu \longrightarrow \tau^- \qquad (31)$$

$$\tau^- \longrightarrow e^- + \nu_\tau \qquad (32)$$

The oscillation $\nu_\mu \rightarrow \nu_\tau$ has a much smaller probabilty of happening than the oscillation $\nu_\mu \rightarrow \nu_e$ because the probability for a muon neutrino of colliding with one electron with sufficient energy is much smaller than the probability of colliding with one nuclear neutron.

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