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“The Road to Understanding of Neutrinos – The Hidden Truth About Neutrinos and other “quanticles““

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Abstract:

This actual submitted publication refers about recent facts and phenomenas, elusive or real particles called neutrinos.
During last few months was revealed in giant neutrino's projects in Europe–CERN–LHC (Large Hadron Collider) ATLAS DETECTOR and in MINOS EXPERIMENT / MAIN INJECTOR NEUTRINO OSCILLATION SEARCH) Fermilab NUMI / Illinois near Chicago, U.S.A. many new realities about these elementary nuclear particles, which consists of whole cosmic matter.
Were studied and observed properties of neutrinos, like emission, oscillation (Nobel Prize for Physics 2015), detection and the most interesting (qm) superposition in Project MINOS (735 km of distance between place with Detector 1 in Fermilab and place with Detector 2 in Soudan), under leading of David Kaiser from M.I.T. / Massachussett's Institute of Technology) in Cambridge, U.S.A.
D. Kaiser easily said: “The particles neutrinos can existed in many quantum states at the same time.“
According this theory, particles neutrinos can rotate according direction of clocks hands and against their direction at the same time, or could be together nonexcited and excitated.
About (QM) SUPERPOSITION before 100 years was reflected already Erwin Schrödinger in mind–experiment the Schrödinger's cat.
In July's number of Journal Physical Review Letters, Physicist David Kaiser and his team studied distribution of all types of neutrinos produced in Chicago's Fermilab and compared it with distribution of all types on neutrinos detected in Soudan.
Finally they had come to believe that, observed particles distributions are the best explanated, that neutrinos are during the flight between Chicago's Fermilab and Mine Soudan, in MINNESOTA, in state known like quantum-mechanic superposition, and not take resemblence of one's concretely type of neutrino.
From upper sets realities are offered questions like “are neutrinos immortal or like hologram“.
Further parts of this article is dedicated to summarizing of data from Superkamiokande and Sudbury Neutrino Observatory (Nobel Prize for Physics 2015), and emission and detection of neutrinos and other “quanticles“ defined by principles of Prof. Joseph Weber and other scientists.
In the ending part of this article is dedicated a chapter to theory of Fermi's Golden Rule (respectively neutrino–antineutrino cross section).

Keywords: **neutrinos, MINOS EXPERIMENT, quantum states, (qm) superposition, Schrödinger's cat, Superkamiokande, Sudbury Neutrino Observatory (SNO), Nobel Prize for Physics 2015, quanticles, Fermi's Golden Rule, neutrino–antineutrino cross section.**

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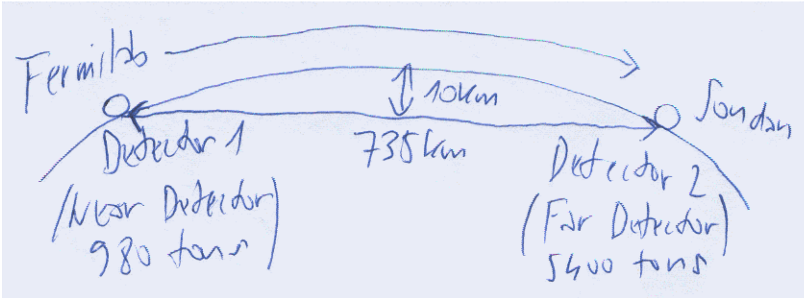

Figure: The MINOS Experiment (Sketch of Author).

Contents:

1. A Briefly Introduction to elementary particles and their history

The leptons are the electrons and its particles, the muon, and the tauon, together with their corresponding neutrinos, the anti–particles of these are reffered to as antileptons.

Both leptons and baryons are spin ½ fermions, but leptons are distinguished from baryons by the fact that they do not directly indulge in strong interactions – which is perhaps the main 'reason' that leptons tend to be much less massive than baryons (though the tauon is an exception, being almost twice as massive as the proton or the neutron).

Since the late 1940s, vast numbers of hadrons have been discovered in cosmic rays and in accelerators: even some of them was called hyperons, like:

$$\Lambda^0, \Sigma^\pm, \Sigma^0, \Xi^-, \Xi^0, \Delta^{++}, \Delta^\pm, \Delta^0, \Omega^-, \rho^0, \rho^\pm, \omega^0, \eta^0, \Psi(PS\acute{I}),$$

PSIONIC POWER DISCOVERED BY BURTON RICHTER (* 22.3.1931) in 11. November 1974 particle ψ with mass 3,1 GeV.

Mezon π is identical with Yukawa's particle decays on:

$$\pi^\pm \to \mu^\pm + \nu_\mu \qquad \pi^0 \to \gamma + \gamma,$$

and mezons μ (muons), π (pions) discovered by the Japanese physicist Hideki Yukawa in 1934 and finally mezon type κ (Kaon),

$$\kappa_1^0 \to \pi^+ + \pi^- \qquad \kappa_1^0 \to \pi^0 + \pi^0.$$

(Pais–Piccion's effect – Reborn of MEZON κ)

LIFETIME OF MEZON κ is:

$$\tau_{\kappa_1^0} \approx 10^{-10} s.$$

From hyperons to mezons and then to leptons like neutrinos or other quanticles (photon, graviton) has proved direct coherence with evolution of particles touch their birth, resonances, oscillations transformation, transposition and superposition and reborn of 'quanticles', not only theoreticaly by families, called multiplets (theoretical models by Feynman and by Murray Gell–Mann and Yuval Ne'eman in 1961), but too experimentally in accelerators (linear, cyclotrons, kosmotrons LHC, CERN, Switzerland) for example pentaquark (2015), tetraquark (2016 Tevatron – synchrotron, U.S.A., D ZERO DETECTOR in Fermilab in Batavia, State Illinois, The Second Largest Accelerator in the World).

In Fermilab were discovered:

- “b“ (beauty, bottom) quarks in 1977,
- “t” (top, truth) quarks in 1995 and
- “τ” (tau) neutrinos in 2000, and
- exotic baryons Ξb and particles Ω_b, Ω-.

Quarks belong to fermions, for them is typical, so called Pauli's exclusion, it says, that the two quarks (hadrons, baryons) or fermions can't find in the same quantum state (two formions with the identical spin can't appear in the same orbital).

These quarks or fermions are different from each other by, so called, colour charge or flavour charge it's their quantum property.

Colour charges are R(red), G(green), B(blue). Twin's of quark and atiquark are called mezons (for example PIONS and KAONS). At the experiments in many laboratories all over the World, was discovered this reality – proton isn't really elementary particle. Quarks, from which is protons and neutrons consist of connected to large associations strong interaction, the particles, which are mediators of this interaction in gluon's field's are called gluons (from english glue, what significate adhesive glue properties, bound together), changing of gluons between quarks to each other and strong interaction study the exact science discipline called Quantum Chromodynamics (QCD).

In 1985 “Princeton String Quartet“ David Gross, Jeoffrey Harvey, Emil Martinec and Ryan Rohm introduced HETEROTIC STRING THEORY, with fermionic-basonic strings and neutrino oscillations and distorsions.

1.1 Recent and future strategic focus on Neutrino's Projects

The Ice Cube experiment reports in 2016 ruling cut to a high degree of certainty the existence of a theoretical low–mass sterile neutrino.

Scientists on the world's largest neutrino experiment, Ice Cube, dealt a heavy blow to the theories predicting a new type of particle – and left a mystery behind.

With results from LSND (more than two decades ago). (LOS ALAMOS NATIONAL LABORATORY NEUTRINO EXPERIMENT).

The most popular theory is that the LSND anomaly was caused by the hidden influence of a new type of particle, a sterile neutrino.

With their new result, Ice Cube scientists are fairly certain the most popular explanation for the anomaly is incorrect.

In a paper published in Physical Review Letters, they report that after searching for the predicted form of the stealthy particle, they excluded its existence at approximately the 99 percent confidence level.

There are three known types of neutrino is: electron neutrino, muon neutrino and tau neutrinos. Scientists have caught all three types, but they have never built a detector that could catch the fourth a sterile neutrino.

Fermilab, Batavia, Illinois, U.S.A. – DUNE (The Deep Underground Neutrino Experiment) Sending neutrinos on a 800 mile (1.300 km) journey, 1,5 km under the surface (4.900 ft) formerly the Long Baseline Neutrino Experiment (LBNE) is a proposed neutrino experiment with a near detector at Fermilab and far detector at the Sanford Underground Research Facility, which will observe neutrinos produced at Fermilab.

Scientists hope to begin installation of the DUNE far detector by 2021.

The world's largest cryogenic particle detector deep underground, DUNE will be able to observe proton decay, if it should occur, and seek a relation between the stability of matter and the GRAND UNIFICATION OF NATURAL FORCES.

The strategic focus on research of DUNE are:

- neutrino oscillations,
- determine the ordering of the neutrino masses,
- search for neutrinos beyond the currently known three.

1.2 Introduction to evidence of solar neutrino's oscillation (Nobel Prize for Physics, 2015)

The Sun is a main–sequence star a stage of stable hydrogen–helium burning. It produces an intense flux of electron neutrinos as a consequence of nuclear fusion reactions whose combined effect is:

$$4p \rightarrow {}^{4}He + 2e^{+} + 2\nu_{e}, \qquad \text{(Eq. 1)}$$

where $4p$ are 4 protons of ${}_{1}^{1}H$, $4He$ is α–particle = ${}_{2}^{4}He$, $2e^{+}$ are positrons, and $2\nu_{e}$ are electron neutrinos.

Positrons annihilate with electrons. Therefore, when considering the solar thermal energy generation, a relevant expression is:

$$4p + 2e^{-} \rightarrow {}^{4}He + 2\nu_{e} + 26{,}73\ MeV - E_{\nu}, \qquad \text{(Eq. 2)}$$

where $4p$ are protons of hydrogen ${}_{1}^{1}p = {}_{1}^{1}H$, $2e^{-}$ are two electrons, ${}^{4}He$ is α–particle = ${}_{2}^{4}He$, $2\nu_{e}$ are two neutrinos, where E_{ν} represents the energy taken away by neutrinos, with an average value being $\langle E_{\nu} \rangle \approx 0{,}6\ MeV$.

Observation of solar neutrinos directly addresses the theory of stellar structure and evolution, which is the basis of The Standard Solar Model (SSM).

The Sun as a well–defined neutrino source also provides extremely important opportunities to investigate nontrivial neutrino properties, such as nonzero mass and mixing angles, because of the wide range of matter density and the great distance from the Sun to the Earth.

In December 2002, KamLAND observed clear evidence of neutrino oscillation with the allowed parameter region overlapping with the parameter region of the LMA solution.

Assuming CPT invariance, this result directly implies that the true solution of the solar ν_e oscillation has been determined to be LMA, LMA (LARGE MIXING ANGLE):

$\Delta m^2 = 5{,}0 \times 10^{-5}\ eV, \quad \tan^2\theta = 0{,}42.$

A combined analysis of all the solar–neutrino data and KamLAND data significantly constrained the allowed parameter region.

In September, 2003, SNO (Sudbury Neutrino Observatory (CANADA)) reported salt–phase results on solar–neutrino fluxes observed with NaCl added in heavy water: this improved the sensitivity for the detection of the NC reaction (neutral–current rate).

A global analysis of all the solar neutrino data combined with the KamLAND data restricted the allowed parameter region to the LMA I (Region at greater than 99% CL (confidence level)), LMA region, the allowed region splits into two bands with lower Δm^2 (~$7x10^{-5}$ eV^2, called LMA I) and higher Δm^2 (~$2x10^{-4}$ eV^2, called LMA II).

Later, further results from KamLAND significantly more constrained the allowed Δm^2 region. SNO also reported results from the complete salt phase. A combined two–neutrino oscillation analysis using the data from all solar–neutrino experiments and from KamLAND yields $\Delta m^2 = \left(8{,}0^{+0{,}6}_{-0{,}4}\right) \times 10^{-5}\ eV^2$ and $\tan^2\theta = 0{,}45^{+0{,}09}_{-0{,}07}$ $\left(\theta = 33{,}9^{+2{,}4}_{-2{,}2}\ \deg rees\right)$.

Recently, a new solar neutrino experiment Borexino reported the first realtime measurement of sub–MeV solar neutrinos with a low–background liquid scintillator detector. It is expected that Borexino as well as other low–energy solar neutrino experiments will further study properties of neutrinos and their interactions with matter on the one hand and the SSM on the other hand.

Table 1: Neutrino–producing reactions in the Sun (first column) and their abbreviations (second column). The neutrino fluxes predicted by the BS05 (OP) – The currently preferred SSM is BS05 (OP) developped by Bahcall and Serenelli, OP (Opacity Project) are listed in the third column.

Reaction	**Abbr.**	**Flux ($cm^{-2}.s^{-1}$)**
$pp \rightarrow de^{+}\nu$	pp	$5{,}99(1{,}00 \pm 0{,}01) \times 10^{10}$
$pe^{-}\,p \rightarrow d\nu$	pep	$1{,}42\left(1{,}00 \pm^{0,02}_{0,2}\right) \times 10^{8}$
$^{3}He\,p \rightarrow {}^{4}He\,e^{+}\nu$	hep	$7{,}93(1{,}00 \pm 0{,}16) \times 10^{3}$
$^{7}Be\,e^{-} \rightarrow {}^{7}Li\,\nu + (\gamma)$	^{7}Be	$4{,}84(1{,}00 \pm 0{,}11) \times 10^{9}$
$8B \rightarrow 8Be^{*}\,e^{+}\nu$	^{8}B	$5{,}69(1{,}00 \pm 0{,}16) \times 10^{6}$
$^{13}N \rightarrow {}^{13}C\,e^{+}\nu$	^{13}N	$3{,}07\left(1{,}00^{+0,31}_{-0,28}\right) \times 10^{8}$
$^{15}O \rightarrow {}^{15}N\,e^{+}\nu$	^{15}O	$2{,}33\left(1{,}00^{+0,33}_{-0,29}\right) \times 10^{8}$
$^{17}F \rightarrow {}^{17}O\,e^{+}\nu$	^{17}F	$5{,}84(1{,}00 \pm 0{,}52) \times 10^{6}$

2. Evidence for Solar Oscillations

Denoting the ^{8}B solar–neutrino flux obtained by the SNO's CC (via charged–current reaction) measurement as $\Phi^{CC}_{SNO}(\nu_e)$ and that obtained by the Super–Kamiokande, ν_e scattering as $\Phi^{ES}_{SK}(\nu_x)$, $\Phi^{CC}_{SNO}(\nu_e) = \Phi^{ES}_{SK}(\nu_x)$ is expected for the standard neutrino physics. However, SNO's initial data indicated ES (ν_e elastic scattering)

$$\Phi^{ES}_{SK}(\nu_x) - \Phi^{CC}_{SNO}(\nu_e) = (0{,}57 \pm 0{,}17) \times 10^{6}\ cm^{-2}.s^{-1}. \qquad \text{(Eq. 3)}$$

The significance of the difference was > 3σ, implying direct evidence for the existence of a non–ν_e active neutrio flavor component in the solar–neutrino flux. A natural and must probable explanation of neutrino flavor conversion is neutrino oscillation. Note that both the SNO and Super–Kamiokande flux results were obtained by assuming the standard ^{8}B neutrino spectrum shape. This assumption was justified by the measured energy spectra in both experiments.

The SNO's results for the pure D_2O phase, reported in 2002, provided stronger evidence for neutrino oscillation than (Eq. 3).

The fluxes measured with CC, ES and NC [(neutral current) results for the salt phase measurement] events were costrained to an undistorted ^{8}B shape. The results are

$$\Phi^{CC}_{SNO}(\nu_e) = \left(1{,}76^{+0,06}_{-0,05} \pm 0{,}09\right) \times 10^{6}\ cm^{-2}.s^{-1}, \qquad \text{(Eq. 4)}$$

$$\Phi^{ES}_{SNO}(\nu_x) = \left(2{,}39^{+0,24}_{-0,23} \pm 0{,}12\right) \times 10^{6}\ cm^{-2}.s^{-1}, \qquad \text{(Eq. 5)}$$

$$\Phi^{NC}_{SNO}(\nu_x) = \left(5{,}09^{+0,44}_{-0,43}{}^{+0,46}_{-0,43}\right) \times 10^{6}\ cm^{-2}.s^{-1}. \qquad \text{(Eq. 6)}$$

Eq. (6) is a mixing–independent result and therefore tests solar models. It shows good agreement with the ^{8}B solar neutrino flux predicted by the solar models. The flux of non–ν_e active neutrinos, $\Phi(\nu_{\mu\ or\ \tau})$, can be deduced from these results.

It is

$$\Phi(\nu_{\mu\ or\ \tau}) = \left(3{,}41^{+0{,}66}_{-0{,}64}\right)\times 10^6\ cm^{-2}.s^{-1}, \qquad \text{(Eq. 7)}$$

where the statistical and systematic errors are added in quadrature.

This $\Phi(\nu_{\mu\ or\ \tau})$ is 5,3σ above 0. The non–zero $\Phi(\nu_{\mu\ or\ \tau})$ is strong evidence for Neutrino flavor transformation.

From the salt phase measurement [6], the fluxes measured with CC or ES events were deduced with no constraint of the ^{8}B energy spectrum. The results are

$$\Phi^{CC}_{SNO}(\nu_e) = \left(1{,}68 \pm 0{,}06^{+0{,}08}_{-0{,}09}\right)\times 10^6\ cm^{-2}.s^{-1}, \qquad \text{(Eq. 8)}$$

$$\Phi^{ES}_{SNO}(\nu_x) = \left(2{,}35 \pm 0{,}22 \pm 0{,}15\right)\times 10^6\ cm^{-2}.s^{-1}, \qquad \text{(Eq. 9)}$$

$$\Phi^{NC}_{SNO}(\nu_x) = (4{,}94 \pm 0{,}21^{+0{,}38}_{-0{,}34})\times 10^6\ cm^{-2}.s^{-1}. \qquad \text{(Eq. 10)}$$

These results are consistent with the results from the pure D_2O phase. Fig. 1 shows the salt phase result of $\Phi(\nu_{\mu\ or\ \tau})$ versus the flux of electron neutrinos $\Phi(\nu_e)$ with the 68%, 95% and 99% joint probability contours.

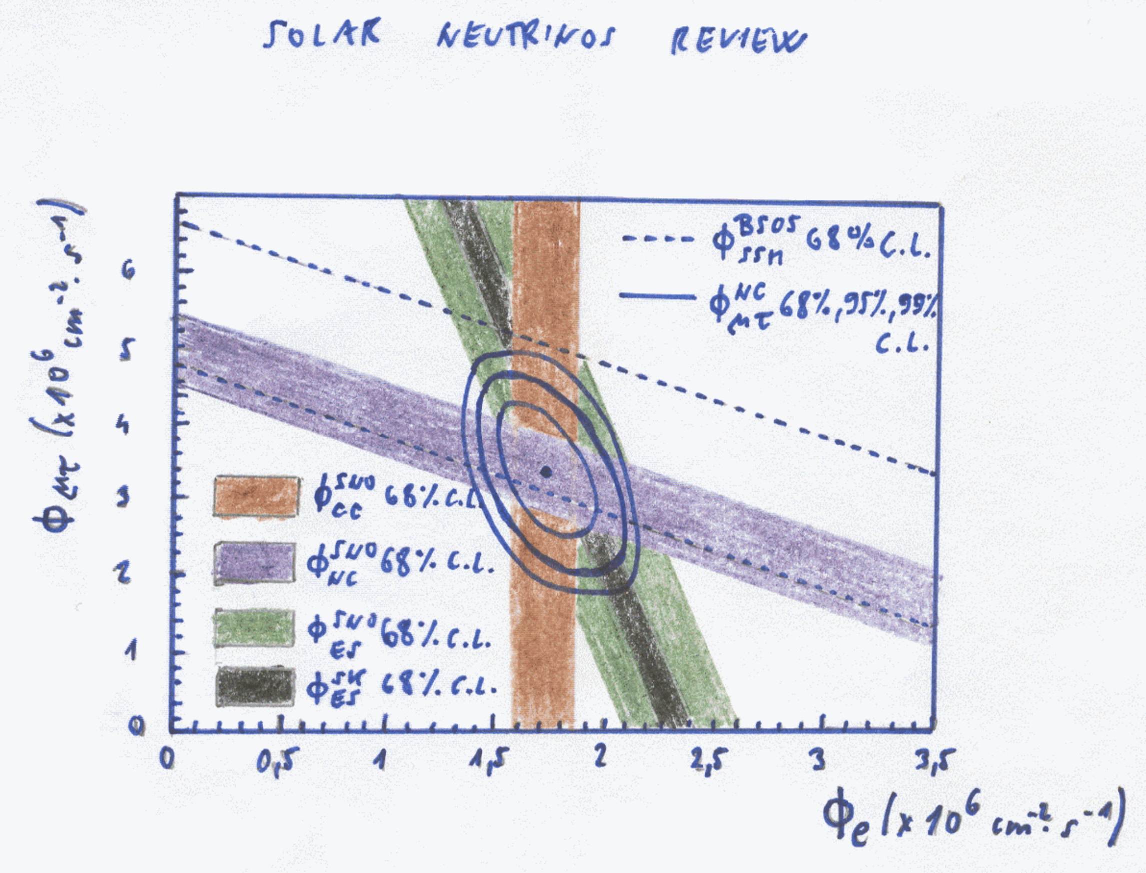

Figure 1: Fluxes of ^8B solar neutrinos, $\phi(\nu_e)$, and $\phi(\nu_{\mu\, or\, \tau})$, deduced from the SNO's charged–current (CC), ν_e elastic scattering (ES), and neutral–current (NC) results for the salt phase measurement [6]. The Super–Kamiokande ES flux is from Ref. [36]. The BS05 (OP) standard solar model prediction [8] is also shown. The bands represent the 1σ error. The contours show the 68%, 95% and 99% joint probability for $\phi(\nu_e)$ and $\phi(\nu_{\mu\, or\, \tau})$. This figure is taken from Ref. [11]. Author: I. Krištof, M.Sc. according The Physics Letters B, REVIEW OF PARTICLE PHYSICS, JULY 2008.

3. Fundamental Particles or "Quanticles" for Communication and The Earth or Moon Tomography

The neutrino is one of the four known stable elementary "quanticles" of physics, the other three being the proton, electron and photon. Like the photon, the neutrino reacts only very weakly with matter and for this reason it can traverse matter over very large distances. Half life of "quanticles" is about 2,22 microseconds. High energy neutrinos (E > 10 keV), whereas in the present invention most interest is in low–energy (E < 10 keV) neutrinos and antineutrinos.

Transmitting information by means of composities of the elementary particles, namely atoms and molecules is possible, it is equivalent to transmitting sound.

In the present invention, detection of neutrinos occurs by the process of stimulated deexcitation instead of absorption and use is made of low–energy neutrinos in the $_{pe}\nu$,

$_{ne}\nu$, $_{\mu e}\nu$, $_{me}\nu$ and $_{e}\nu$ energy regions.

These neutrinos can stimulate the deexcitation of an atomic or molecular state and the photon emitted in such a resonant frequencies of deexcitation can be detected by the signaling the ”fly-by” of neurino or antineutrino.

According to the neutrino–composed photon (NCP) theory, photons are made up of neutrino and antineutrino with the same frequency which travel in exactly the same directions and whose spins counter–rotate.

Extending the NCP concept further, there is a finite probability that, instead of emitting a photon or equivalent neutrino–antineutrino pair traveling coherently in the same direction, a neutrino and antineutrino pair is emitted in which each is traveling in exactly opposite direction when an excited atom or molecule deexcites.

For example, for a 1,8 eV transition (λ = 6940 A°) one out of every 10^{16} spontaneous emission events yields a neutrino–antineutrino pair traveling in the same direction. With the discovery in the 1960's that there are two neutrinos, one with left–handed spin and one with right–handed spin, a four component or dual two–component neutrino theory has emerged (for each neutrino there is a corresponding antineutrino).

In the present invention a new technique is described for the generation, modulation, and detection of neutrino and antineutrino beams. An entirely new wireless communication system is thereby provided which will alleviate some of the present crowding of the electro–magnetic spectrum. The new system also is ideal for secure comunications since, in general, it utilizes directed beams whose exact location must be known for interception. In contrast to electromagnetic comunications, neutrino and antineutrino beam communications can be done though the Earth from one side to the other, through bodies of water such as oceans and lakes, or the like (NEUTRINO TOMOGRAPHY OF THE EARTH OR OTHER BODIES OF SOLAR SYSTEM).

There are many indications in physics that all fundamental paricles or”quanticles” or nature have a spin of ½ units of ħ and since the photon has a spin of 0 or 1, it has long been suspected of actually being a composite quanticle. The fact that at high energies the photon decomposes in a Coulomb field into an electron and positron (pair production) with spins $s = \pm 1/2$, also points to the basic composite nature of photon.

The present invention extends the NCP phenomenon to the process of stimulated deexcitation of electronic, vibration and/or rotational excited levels of molecules and/or atoms by which it becomes possible to observe low–energy neutrinos and antineutrinos and to use them in practical communications systems (NEUTRINO COMMUNICATIONS AND NEUTRINO SPINTRONICS).

4. Is Photon According (NCP – Neutrino Composed Photon) Theory Made Up of Neutrino–antineutrino Pair?

In addition to the rare spontaneous emission event of oppositely traveling neutrino–anineutrino pairs discussed abobe, two other interactions of neutrinos or antineutrinos with electrons are possible which have much higher cross–sections, namely: (1) the stimulated deexcitation of an atomic or molecular excited state by a photon resulting in the generation of a neutrino–antineutrino pair traveling in opposite directions coherent with the incoming stimulating photon, and (2) the stimulated deexcitation of an excited atomic or molecular state.

These interactions may be written in shorthand by the formulas:

$$\xrightarrow{\gamma} + X^{*} \to X + \xleftarrow{\nu} + \xrightarrow{\bar{\nu}},$$

$$\xrightarrow{\gamma} + X^{*} \to \gamma + X + \xleftarrow{\nu} + \xrightarrow{\bar{\nu}},$$

$$\xrightarrow{\bar{\nu}} + X^{*} \to \xrightarrow{\bar{\nu}} + X + \xleftrightarrow{\gamma},$$

$$\xrightarrow{\nu} + X^{*} \to \xrightarrow{\nu} + X + \xleftrightarrow{\gamma}.$$

Here γ represents a photon ($\xrightarrow{\gamma} \equiv \xrightarrow{\nu} \xrightarrow{\bar{\nu}}$), ν is a neutrino, $\bar{\nu}$ is an antineutrino, X is an excited atom or molecule, and X* is an excited atom or molecule. The arrows under γ, ν and $\bar{\nu}$ indicate directions of travel.

An arrow pointing in the same direction on the left–hand–side and the right–hand–side of the right–hand–side of the interaction relations indicates that the quanticles (photon, neutrino or antineutrino) so labeled travel in the same direction.

The generation of monochromatic, spatially coherent neutrinos and antineutrinos in the emitter is achieved by process using a raser, maser, laser, or graser medium (gaseous, solid, or liquid) containing rasable, masable, lasable or grasable molecular species X*. For convenience, as utilized herein, the word “maser” is utilized generally to denote any of a raser, maser, laser or graser, which are acronyms that stand, respectively, for Radiowave (1 Hz – 100 MHz), Microwave (100 Mhz – 1 THz), Light (1 THz – 10^{6} THz) and Gamma–Ray (10^{6} – 10^{9} THz) Amplication by Stimulated Emission of Radiation.

Mirrors with a reflectivity approaching 100 percent (at the maser photon frequency) are placed at the ends of an emitter maser cavity containing excited molecules X* in order to build up a high internal standing wave flux of maser photons inside the cavity.

Table 2. Typical three–level converter media

Compound	**Fundamental Vibrational Energy (cm^{-1})**
A. LIQUIDS	
Water	3651
B. SOLIDS	
Quartz	128; 466
Lithium Niobade	152; 298; 628
α–sulfur	216; 470
Calcium Tungstate	911
Stilbene	997; 1591
Polystyrene	1001; 3054
Calcite	1084
Diamond	1332
Napthalene	1380
Triglycine Sulphate	2422; 2702; 3022
C. GASES	
Oxygen (O_2)	1552
Hydrogen (H_2)	4155

5. Method for Observation of Neutrinos and Antineutrinos According Professor Joseph Weber (Wave Functions, Fermi's Golden Rule, Cross Section and Spinor's)

5.1 Scattering By A Planar Array

Let us imagine that there are N scatterers equally spaced along the x and y directiuons (Fig. 2). The x and y scatterer spacing is length b. A beam of particles has incident momentum $\overline{p}_{IF}$ after elastic scattering. The interactions occur in a volume V. Incident and scattered particles are represented by the wave funtions:

$$\Psi_0 = \frac{1}{\sqrt{\nu}} e^{i\overline{p}_{I0}\cdot\overline{r}/\hbar - iEt/\hbar},$$

$$\psi_F = \frac{1}{\sqrt{\nu}} e^{i\overline{p}_{IF}\cdot\overline{r}/\hbar - iEt/\hbar}. \qquad (1)$$

Fermi's golden rule gives a transition probability w with:

$$w = \frac{2\pi}{\hbar}\left|H'\right|^2 p(E). \tag{2}$$

The density of states p(E) is computed by noting that in a range dE the total number of states for the outgoing particles is, for solid angle dΩ.

$$H' = \frac{1}{V}\int e^{-i\bar{p}_{IF}\cdot\bar{r}/\hbar} U(\bar{r}) e^{i\bar{p}_{I0}\cdot\bar{r}/\hbar} d^3x\,. \tag{3}$$

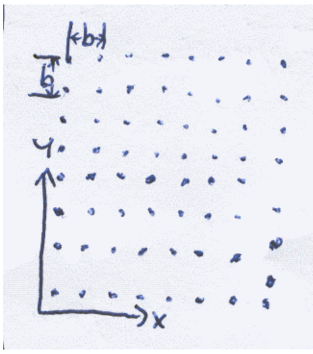

Fig. 2: A two–dimensional array of delta function potential scatrerers.

$$p(E)dE = \frac{V}{(2\pi\hbar)^3}\left|p_{IF}\right|^2 dp_{IF}\, d\Omega\,. \tag{4}$$

For zero rest mass particles, $dE = cdp$. Expression then gives (5)

$$p(E) = \frac{V}{c(2\pi\hbar)^3}\left|p_{IF}\right|^2 d\Omega\,. \tag{6}$$

The differential cross section in (7) has a maximum value proportional to N^2, given by

$$\left[\frac{d\sigma}{d\Omega}\right]_{\max} = \frac{\left|p_{I0}\right|^2 B^2 N^2}{4\pi^2\hbar^4 c^2}\,. \qquad . \tag{7}$$

For zero rest mass particles, $dE = cdp$.

$$\sigma = \frac{\left|p_{I0}\right|^2 B^2}{4\pi^2\hbar^4 c^2}\int \frac{\sin^2\left[\frac{1}{2}N^{1/2}b(\bar{p}_{I0}-\bar{p}_{IF})x/\hbar\right]\sin^2\left[\frac{1}{2}N^{1/2}b(\bar{p}_{I0}-\bar{p}_{IF})y/\hbar\right]}{\sin^2\left[\frac{1}{2}b(\bar{p}_{I0}-\bar{p}_{IF})x/\hbar\right]\sin^2\left[\frac{1}{2}b(\bar{p}_{i0}-\bar{p}_{IF})y/\hbar\right]} d\Omega\,. \tag{8}$$

Solid angle:

$$d\Omega \approx \pi\left|\frac{2\pi\hbar}{N^{1/2}bp_{I0}}\right|^2 . \tag{9}$$

The total cross section associated with this forward scatttering peak is the product of (7) and (9), $\Delta\sigma_F$, given by:

$$\Delta\sigma_F = \frac{\pi B^2 N}{\hbar^2 b^2 c^2}\,. \qquad (10)$$

The incident particle velocity c and normalization imply an incident particle flux

$$\frac{c}{v} \qquad (11)$$

Elastic scattering momentum radius p_{IF},

$$n_p = \frac{b^2 p_{IF}^2}{4\pi\hbar^2} \qquad (12)$$

The total cross section σ_{total}, is then given approximately by the product of (12) and (10) as

$$\sigma_{total} \approx \frac{|p_{I0}|^2 B^2 N}{4\hbar^4 c^2} \qquad (13)$$

Equation (13) is proportional to N in consequence of the fact that the peak values (7) in the differntial cross section are multiplied by a solid angle for each peak, inversely proportional to N. A similar result is obtained for one– and three–dimensional scatterer arrays. Expressions (8) and (10) are given in the literature and describe the scattering of x rays very well.

5.2 Coherent Inelastic Scattering

The Copenhagen interpretation of quantum mechanics permits a coherent scattering process in which all of the momentum is exchanged by certain unidentified scatterers while other unidentified scatterers may exchange energy.

5.3 Coherent Scattering of Neutrinos and Antineutrinos

In ”spinor” representation, all elements here are 2x2 matrices

$$\gamma_5 = \begin{vmatrix} -1 & 0 \\ 0 & 1 \end{vmatrix}, \qquad \bar{\gamma} = \begin{vmatrix} 0 & -\bar{\sigma} \\ \bar{\sigma} & 0 \end{vmatrix}, \qquad (1)$$

$$\bar{\gamma}(1+\gamma^5) = \begin{vmatrix} 0 & -2\bar{\sigma} \\ 0 & 0 \end{vmatrix}. \qquad (2)$$

Let

$$U_S = \begin{vmatrix} n_s \\ x_s \end{vmatrix}, \qquad U_\nu = \begin{vmatrix} n_\nu \\ x_\nu \end{vmatrix}, \qquad (3)$$

n and x are two–component spinors,

$$\bar{U}_S \bar{\gamma}(1+\gamma_5)U_S = -2x_s^+ \bar{\sigma} x_s\,, \qquad (4)$$

$$\bar{U}_S \gamma^0 (1+\gamma_5)U_S = 2x_s^+ x_s\,, \qquad (5)$$

therefore,

$$\frac{G_w}{\sqrt{2}} U_S \gamma^\alpha (1+\gamma_5) U_\nu \overline{U}_\nu \gamma_\alpha (1+\gamma_5) U_S =$$

$$= \frac{4G_w}{\sqrt{2}} \left(x_{SF}^+ x_{S0} x_{\nu F}^+ x_{\nu 0} - x_{SF}^+ \overline{\sigma} x_{S0} x_{\nu F}^+ \overline{\sigma} x_{\nu 0} \right). \quad (6)$$

For unpolarized scatterers, the last (spin terms) in (6) average to zero.

5.4 Experiments

A number of experiments have confirmed theoretical predictions of relatively large cross sections. One series observed heating of a nuclear spin system in a target crystal, associated with inelastic coherent scattering of anti–neutrinos the ten megawatt reactor at the National Bureau of Standards in Gaithersburg, Maryland.

A second experiment observed a repulsive force of 4×10^{-7} dyn (**Comment:** Force $F \approx 1\, dyn = 10^{-5}\, N.$) on a 12 g crystal elastic scattering antineutrinos from a 600 Ci tritium source. This corresponds to a total cross section approximately 1,5 cm^2.

A third experiment also employed antineutrinos from the ten megawatt reactor at National Bureau of Standards. Elastic scattering was observed, with a cross section approximately 2 cm^2, for as 100 g crystal. A larger crystal was empolyed as a shield. Repulsive force changes, approximately 3×10^{-5} dyn, were observed as the shield was placed between the reactor and the target crystal.

5.5 Conclusion

Theory predicts large cross sections for tightly coupled nuclei interacting with low energy neutrinos and antineutrinos.

6. A Principle of Emission and Detection of Neutrinos by Principles of Prof. Joseph Weber and Jozef Eerkens and Other American Physics Scientists

A communication system comprising an emitter and a receiver (detector) utilizing modulated beams of neutrino and antineutrino waves as information carriers between the emitter and the receiver.

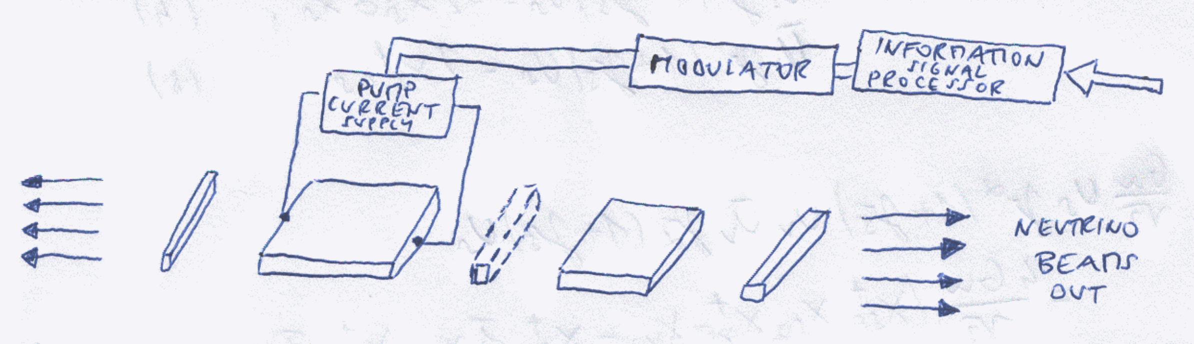

Fig. 3: Emitter (Sketch of Author).

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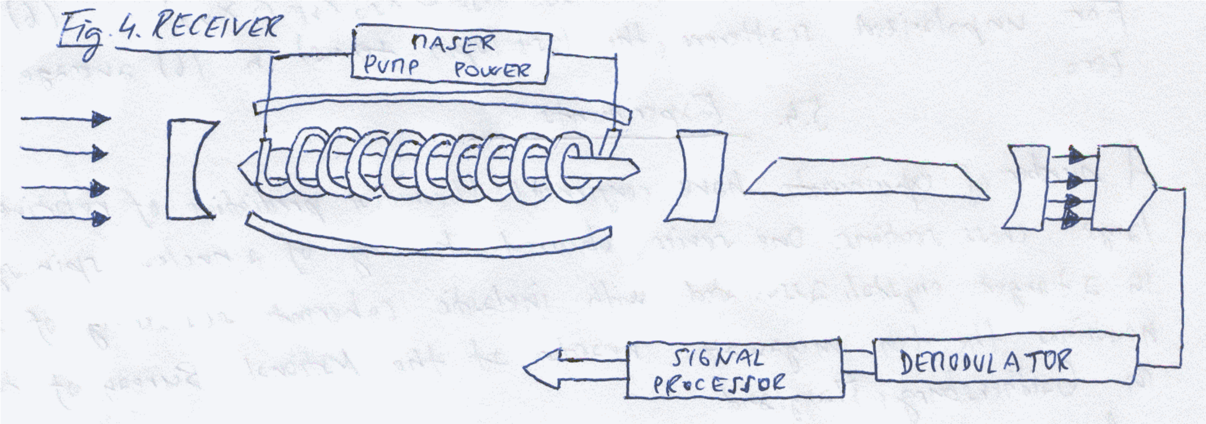

Fig. 4:Receiver (Sketch of Author).

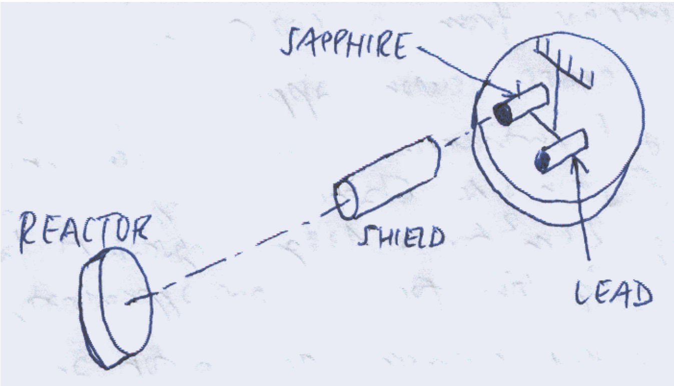

Fig. 5: Sketch of reactor antineutrino experiment. From Weber (1988).

7. Fermi's Golden Rule (Theoretical Model About Cross Section of Antineutrinos)

7.1 According to the Fermi's Golden Rule estimate, how depends on cross section of interaction $\bar{\nu}_e + p \to e^+ + n$, on total energy $\sqrt{s}$ of an electron antineutrino and proton in barycentrum's system, if $\sqrt{s} >> m_p c^2, m_\nu c^2$. How depends on cross section of interaction on energy of flown of an electron antineutrino, if is his energy $E_\nu >> m_p c^2$ and, an electron antineutrino interacts with proton in calm state? Use the rule of theoretical model.

7.1.a. According to the Fermi's Golden Rule is Decay constant (frequency of interactions on one's target centrum) given by relation $\lambda = \frac{2\pi}{\hbar} \left| \langle H \rangle \right|^2 \frac{dN}{dE_0}$, where N is number of accesible ending states and E_0 is total accessible Energy during the interaction.

Estimate, how depends on, cross section of interaction $\bar{\nu}_e + p \to e^+ + n$ on Energy and dynamics (motivity) of produced positrons during the low–energy of flown an electron antineutrino, $E_\nu << m_p c^2$, which interacts with proton in a calm state. Interaction's matrix's element is $\langle H \rangle = \frac{2G_F}{V}$, where $G_F \approx 10^{-7}\, GeV.fm^3$ is Fermi's constant and V (Volume) of interaction region (field).

Factor the Second (2) in interaction's matrix's elements of explore's process is reasoned with, that during the relativistic description is weakly interaction comprehend like interaction of vector's and axial's streams, so called VECTOR–AXIAL THEORY (V-A theory).

What is the cross section of this interaction for $E_\nu = 2{,}3 MeV$?

Calm's Energies are $m_p c^2 = 938{,}27 MeV$, $m_n c^2 = 939{,}57 MeV$, $m_e c^2 = 0{,}511 MeV$ and antineutrino is probably massless (intangible).

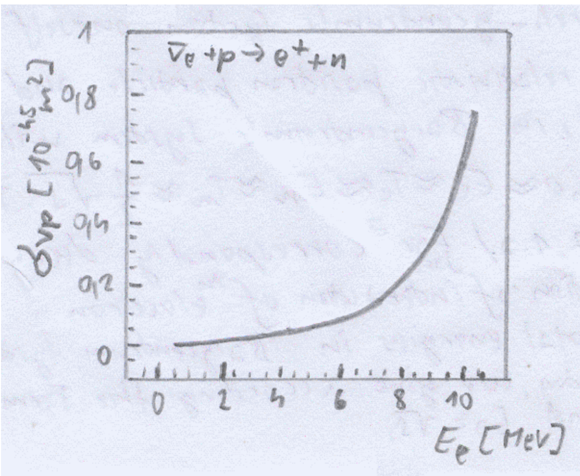

Fig. 6: Cross section $\sigma_{\nu p} = \sigma_{\nu p}(E_e) \bar{\nu}_e + p \rightarrow e^+ + n$ interaction for energies of flown antineutrino $E_\nu << m_p c^2$.

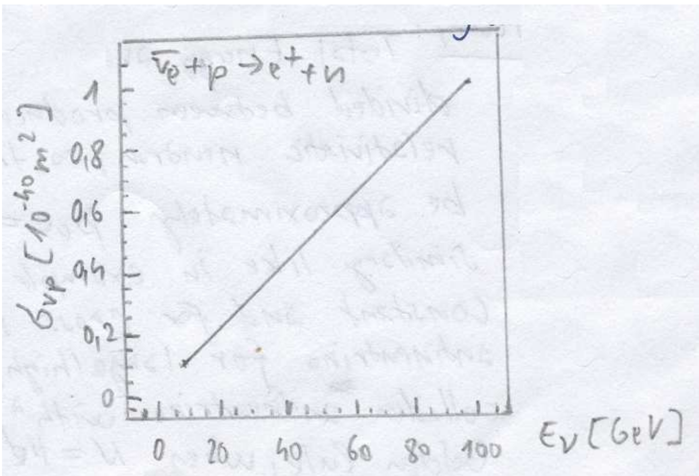

Fig. 7: Cross Section $\sigma_{\nu p} = \sigma_{\nu p}(E_\nu) \bar{\nu}_e + p \rightarrow e^+ + n$ interaction for energies of flown antineutrino $E_\nu >> m_p c^2$.

Solution (Answer) (7.1.a.a.)

For absorption of low–energy electron antineutrino on proton, when proton is in calm state and when we neglect the kinetic Energy of reflected neutron, will be total accessible Energy:

$E_0 \approx E_e \approx E_\nu + m_p c^2 - m_n c^2 = E_\nu + Q + m_e c^2$ where E_e is total energy of originated positron and $Q = m_p c^2 - m_n c^2 - m_e c^2 \approx -1{,}80\,MeV$ is an energy of a research interaction.

For number of ending states of positrons N_e with dynamics (motivity) in interval $\langle 0, p_e \rangle$, which are situated in volume (V), and for corresponding density of ending states of positrons we give:

$$N_e = \frac{4\pi p_e^3 V}{3\cdot(2\pi\hbar)^3},$$

$$\frac{dN_e}{dE_e} = \frac{dN_e}{dE_\nu} = \frac{4\pi p_e^2 V}{(2\pi\hbar)^3}\cdot\frac{dp_e}{dE_\nu} = \frac{4\pi p_e^2 V}{(2\pi\hbar)^3}\cdot\frac{E_e}{p_e c^2}, \qquad (7.1.a.1.)$$

where $p_e^2 c^2 = \left(E_\nu + m_p c^2 - m_n c^2\right)^2 - m_e^2 c^4$ and $p_e = \dfrac{dp_e c}{dE_\nu} =$

$= E_\nu + m_p c^2 - m_n c^2 = E_e$, because $N = N_e$ and $E_0 = E_e$, according comment(7.1.a.c.) we gives (Fig. 6),

$$\lambda(E_e) = \frac{2\pi}{\hbar}\left|\langle H\rangle\right|^2 \frac{dN}{dE_0} = \frac{2\pi}{\hbar}\left|\langle H\rangle\right|^2 \frac{dN_e}{dE_e} =$$

$$= \frac{2\pi}{\hbar}\frac{4G_F^2}{V}\frac{4\pi p_e c E_e}{(2\pi\hbar c)^3}, \qquad (7.1.a.2.)$$

$$\sigma_{\nu p}(E_e) = \frac{\lambda(E_e)V}{c} = \frac{4G_F^2\, p_e c E_e}{\pi(\hbar c)^4}. \qquad (7.1.a.3.)$$

For $\bar{\nu}_e$ about Energy $E_\nu = 2{,}3\,MeV$ is $E_e \approx 1{,}0\,MeV$, $p_e c \approx 0{,}80\,MeV$ and

$\sigma_{\nu p} \approx 5{,}8\cdot 10^{-48}\, m^2$.

Comment (7.1.a.b.):

During calculation of cross section we are well–advised, that for a particle collides with a target particle is possible a formal introduction of a decay constant $\lambda = j\sigma = vn\sigma = \dfrac{v}{V}\sigma$, where $j = vn$ is density of flux of flown particles, n is a density of target center's, V is interaction's Volume and v is a dimension of relative velocity of flown's and target particle.

Solution (Answer) (7.1.b.)

Total Energy available in Barycentrum's System oneself is divided between produced relativistic positron particle and a relativistic neutron, so that, in Barycentrum System will be approximately

$$p_e c = p_n c \approx E_e \approx T_e \approx E_n \approx T_n \approx \frac{1}{2}\sqrt{s}\ .$$

Then similary like in example (7.1.a.) for a correspondly decay constant and for cross section of an interaction of an electron antineutrino for large (high) total energies in Barycentrum System of collider antineutrino with a proton, we give according to the Fermi's Golden Rule, when $N = N_e$ and $E_0 = \sqrt{s}$.

$$\lambda\left(\sqrt{s}\right) = \frac{2\pi}{\hbar}\left|\langle H\rangle\right|^2 \frac{dN}{dE_0} \approx \frac{2\pi}{\hbar}\left|\langle H\rangle\right|^2 \frac{dN_e}{d\left(\sqrt{s}\right)} \approx \frac{G_F^2 sc}{2\pi V\left(hc\right)^4} \qquad (7.1.b.1)$$

$$\sigma_{Vp}\left(\sqrt{s}\right) = \frac{\lambda\left(E_\nu\right)V}{2c} \approx \frac{G_F^2 s}{4\pi\left(\hbar c\right)^4},$$

$$\sigma_{Vp}\left(E_V\right) \approx \frac{G_F^2 E_V m_p c^2}{2\pi\left(\hbar c\right)^4}, \qquad (7.1.b.2)$$

where we substitute $s \approx 2E_V m_p c^2$ and where number of ending states of positrons and their density are $\left(\frac{d_p ec}{d\left(\sqrt{s}\right)} \approx \frac{1}{2c}\right)$

$$N_e = \frac{4\pi p^3 eV}{3\cdot\left(2\pi\hbar\right)^3},$$

$$\frac{dN_e}{d\left(\sqrt{s}\right)} = \frac{4\pi p_e^2 c^2 V}{\left(2\pi\hbar c\right)^3}\cdot\frac{dpec}{d\left(\sqrt{s}\right)} \approx \frac{4\pi s V}{8\cdot\left(2\pi\hbar c\right)^3}. \qquad (7.1.b.3.)$$

Depending quantity $\sigma_{\nu N} \alpha G_F^2 E_\nu$, picture (Fig. 7), which is gratefully experimental proved, express, that weak interaction is forcefully on short distances, so that during the high energies.

Comment (Fig. 7 and 7.1.b.)

The first theory about weak interaction worked with constant interaction and changing particles not needed. Historically was in connection with weak interaction, which runs through, during low energies $E < m_W c^2 = 80{,}2\, GeV$. where $m_w c^2$ is calm Energy of intermediar boson, introduced by Fermi's constant:

$$G_F = \frac{4\pi\sqrt{2}\left(\hbar c\right)^3}{m_w^2 c^4}\alpha, \qquad G_F \approx 10^{-7}\, GeV\cdot fm^3, \qquad (7.1.b.4)$$

where α is lattice constant of hyper–soft structure. Exact value of Fermi's constant was definited (defined) from measuring of median of lifetime of muon, when $\tau_{\mu,\exp} \approx 2{,}187\cdot 10^{-6} s^{-1}$ and

$$\tau_\mu = \frac{192\pi^3\left(\hbar c\right)^7}{G_F^2 m_\mu^5 c^{10}}\frac{1}{c},$$

$$G_F = \sqrt{\frac{192\pi^3\left(\hbar c\right)^7}{\tau_\mu c m_\mu^5 c^{10}}} \approx 8{,}96\cdot 10^{-8}\, GeV.fm^3$$

Comment (7.1.c.)

Result from relation (7.1.b.2), $\sigma\left(\sqrt{s}\right) \approx \frac{c_F^2 s}{4\pi(\hbar c)^4}$, (7.1.b.5)

will be valid for other weak processes too, when Energies of interacting particles are sufficiently large/big, $\sqrt{s} >> mc^2$, where mc^2 is typical calm Energy of interacting particles.

Comment (7.1.d)

Cross section of antineutrino with proton is possible in the first approximation estimate according reduced de Broglie's wavelength of antineutrino in Barycentrum's System of antineutrino an proton.

For energy of interacting antineutrino $E_\nu >> m_p c^2$ we have

$s \approx 2E_\nu m_p c^2 >> m_p^2 c^4$ and cross section is $\sigma_{Vp} \approx \alpha_w^2 \pi r_\nu^2 \approx \alpha_w^2 4\pi \frac{(\hbar c)^2}{s}$, where

$r_\nu \approx \frac{\lambda' \nu}{2\pi} = \frac{\hbar c}{p'_\nu\, c}$ is radius of antineutrino defined by his reduced de Broglie's

wavelength and $p'_\nu c = \frac{\sqrt{s}}{2}$ is size of dynamics (motivity) of antineutrino in Barycentrum's System of antineutrino–proton. Comparation with relation (7.1.a.3), $\sigma_{Vp} \approx \frac{G_F^2 s}{4\pi(\hbar c)^4}$¨, we have for constant of weak interaction depending

$\alpha_w \approx \frac{G_F s}{2\pi\sqrt{2}(\hbar c)^3} \alpha E_\nu^2$.

Comment (7.1.e.)

Result (7.1.b.2.) is not quite correct, because during high–energies of interacting electron antineutrino it is impossible a target proton understand like a point (dot) object, but like object composed (compound) from QUARKS. Because though calm Energy of quarks not known, is not possible by this method, described in calculation, estimate cross section of interaction high–energy antineutrino with quarks. However is possible derived non–elastic cross section of antineutrino on nucleon is an event, that we known distribution of motivity (dynamics) of quarks in nucleons.

On the top of it, cross section (7.1.b.2.) like a consequency of onefold Fermi's theory increased, with increasing high–energy of antineutrino E_ν grow up over the all limits, though not exceed value:

$$\sigma_{\nu p,\lim} = 4\pi\left(\frac{\lambda'}{2\pi}\right)^2 \approx \frac{8\pi(\hbar c)^2}{E_\nu m_p c^2},$$

$$\frac{\lambda'}{2\pi} = \frac{\hbar c}{p'_\nu c} = \frac{\hbar c}{E'_\nu} = \frac{2\hbar c}{\sqrt{s}}, \qquad (7.1.b.6.)$$

where λ' is de Broglie's wavelength of flown antineutrino in Barycentrum's System, and where we find $s \approx 2E_\nu m_p c^2$, for interaction of antineutrino with proton in calm state. Limit's value of cross section is reached for $E_\nu \approx 10^6\, GeV$. Though that energy is extremely high, described lack of Fermi's theory lead to prerequisite, that weak interaction is mediated by intermediar boson with non–zero calm state Energy and have consequently ending reach.

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Photo 1: Author of this Publication in Secondary School – Eko–gymnasium, Labská 27 Street, Brno, Czech Republic, in 1993. Dr. Helena Doložílková and Professor František Továrek in the right Background of photography.

9. Author Thanks to

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