ISSN: 2639-0108
Review Article
Advances in Theoretical & Computational Physics

Is neutrino lensing possible?

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Submitted: 02 Nov 2022; **Accepted:** 17 Nov 2022; **Published:** 24 Nov 2022

Citation: *Vasiliev, B. V. (2022). Is neutrino lensing possible? Adv Theo Comp Phy, 5(4), 629-636.*

Introduction

Neutrino is a fundamental neutral stable particle. Neutrino is unique because of its extremely high penetrating power. Finding out the mysterious nature of neutrinos seems to be one of the most interesting tasks of elementary particle physics.

Let's consider properties of neutrinos, which can be described in the framework of classical electrodynamics.

A magnetic dipole in Maxwell's theory

Fields created by a magnetic dipole

Consider the description given by Maxwell's theory for the emission of electromagnetic waves by a magnetic dipole in vacuum.

To simplify, we will assume that electric charges and currents, dipoles and quadrupoles are absent in the problem. Let the only source of electromagnetic fields in the following consideration be the time-varying magnetic dipole moment M(t). According to Maxwell's theory [2], the electromagnetic field on the distance R from the dipole in this case can be described by a vector-potential

$$\mathbf{A}(R,t) = \frac{[\dot{\mathfrak{M}}(t^*) \times n]}{cR}, \qquad (1)$$

(to account for the delay of the electromagnetic signal, a retarded time is introduced here $t^* = t - \frac{R}{c}$).

By definition, in the absence of free charges (i.e. when φ = 0) electric field Strength

$$\mathbf{E}(R,t) = -\frac{1}{c}\frac{d\mathbf{A}(R,t)}{dt^*} = -\frac{1}{c^2R}[\ddot{\mathfrak{M}}(t^*) \times \mathbf{n}]. \qquad (2)$$

Magnetic field created by a time-varying magnetic dipole (assuming φ= 0), by definition ([2], Eq.46.4)

$$\mathbf{H}(R,t) = rot\mathbf{A}(R,t) = \left[\nabla \times \frac{[\dot{\mathfrak{M}}(t^*) \times n]}{cR}\right] = \frac{1}{c}\left[\nabla \times [\dot{\mathfrak{M}}(t^*) \times \mathbf{n}] \cdot \frac{1}{R}\right] \qquad (3)$$

In general, the rotor of a function F, depending on the parameter ξ, can be written as:

$$[\nabla \times \mathbf{F}(\xi)] = \left[grad\ \xi \times \frac{d\mathbf{F}}{d\xi}\right]. \qquad (4)$$

Therefore, since grad t*= Δ (t-R/c)= -n/c, we get,

$$rot\ \dot{\mathfrak{M}}(t^*) = \left[grad\ t^* \times \frac{d\dot{\mathfrak{M}}(t^*)}{dt^*}\right] = -\frac{1}{c}[\mathbf{n} \times \ddot{\mathfrak{M}}(t^*)]. \qquad (5)$$

The second term obtained by differentiating Eq.(3) has the form

$$\frac{1}{c}\left[\nabla\frac{1}{R} \times [\dot{\mathfrak{M}}(t^*) \times \mathbf{n}]\right] = \frac{1}{cR^2}\left[\mathbf{n} \times [\dot{\mathfrak{M}}(t^*) \times \mathbf{n}]\right]. \qquad (6)$$

Finally, we get that the magnetic field created by dipole

$$\mathbf{H}(R,t) = -\frac{1}{c^2R}\left[\mathbf{n} \times [\ddot{\mathfrak{M}}(t^*) \times \mathbf{n}]\right] + \frac{1}{cR^2}\left[\mathbf{n} \times [\dot{\mathfrak{M}}(t^*) \times \mathbf{n}]\right] \qquad (7)$$

Thus, according to Maxwell's theory, electromagnetic waves excited in vacuum by a magnetic dipole must have an electric field component determined by Eq.(2) and a magnetic component with intensity Eq.(7), which have the appropriate orientation. In this case, two cases are possible, since two types of waves are exist.

Photons

This option is studied in all courses of electrodynamics. It is realized in the case when a magnetic dipole carries out a motion described by a differentiable function of time. I.e., the function that describes the motion of a magnetic dipole has two first derivatives in time. A typical example of such a motion is the harmonic oscillation of the dipole M(t) = M· *sinωt*, in which both the E and H fields exist, since M(t) ≠ 0 and M (t) ≠0.

The same solution has problems where fluctuations of the magnetic moment are described by more complex formulas, if the spectrum of these oscillations can be decomposed into harmonic components.

With harmonic oscillations at a considerable distance from the oscillating dipole, the second term in Eq.(7), which depends on M, is in ⅄/R times smaller than the first term. (Here ⅄ is the length of the generated wave, R is the distance from the dipole).

Therefore, the second term in Eq.(7) can be neglected.

As a result, we get that in this case the fields E and H (Eq.(2) and Eq.(7)) of an electromagnetic wave are equal to each other and only rotated on 90o degrees.

Magnetic excitation of ether

Fundamentally different solutions are obtained if time-dependence of M(t) is a discontinuous function of the Heaviside step type [3].

More precisely, such an excitation of the ether should be classified as a kind of particle, since it is characterized by a very short time interval.

The emission of such a particle occurs, for example, during β-decay, in which a free electron bearing a large magnetic moment arises relativistically quickly.

Thus, the time dependence of the magnetic moment in this reaction has the form of a very sharp step, which is zero for negative arguments and one for the rest.

Another example is the transformation of π-meson into muon.

π-meson does not have a magnetic moment, but the muon does.

The uncertainty ratio makes it possible to estimate the time of transformation of π-meson into muon:

$$\delta\tau_{\pi\to\mu} \approx \frac{\hbar}{(M_\pi - M_\mu)c^2} \approx 10^{-23} sec \qquad (8)$$

For beta-decay, in which a free electron is born relativistically quickly, the characteristic time interval is even shorter, i.e. the Heaviside-step is even sharper.

Such a sharp step cannot be divided into phases, because the duration of the β-decay is shorter than the propagation of the signal inside the decaying particle. If we assume that the characteristic size of the beta-decaying particle is close in order of magnitude to the Compton radius r_c, then the characteristic propagation time of the signal inside it

$$\frac{r_c}{c} \gg \delta\tau_\beta \qquad (9)$$

Therefore, such a sharp rung cannot have a structure and must be written in the form

$$He(t) = \begin{cases} 0 & if \quad t < 0 \\ 1 & if \quad t \geq 0 \end{cases}$$

Since the first derivative of the Heaviside step is the Dirac δ-function [3]:

$$\frac{dHe(t)}{dt} = \delta(t), \qquad (11)$$

the relativistically rapid occurrence of the electron's magnetic moment during beta-decay can be described by the equation:

$$\dot{\mathfrak{M}}(t) = \mathfrak{M}(\tau)\cdot\delta(t-\tau). \qquad (12)$$

At the same time, the second derivative of the magnetic moment can be calculated by taking the derivative of the delta-function [3]:

$$\ddot{\mathfrak{M}}(t) = \mathfrak{M}\cdot lim_{\tau\to 0}\left\{\frac{\delta(t+\frac{\tau}{2})}{\tau} - \frac{\delta(t-\frac{\tau}{2})}{\tau}\right\} \qquad (13)$$

Since δ(t)-function is an even function

$$\delta\left(t+\frac{\tau}{2}\right) = \delta\left(t-\frac{\tau}{2}\right) \qquad (14)$$

so that

$$\ddot{\mathfrak{M}}(t) = 0 \qquad (15)$$

at any small τ.

The magnitude of the magnetic field strength carried by a magnetic photon can be estimated if its energy ε is known. When ε ≈ 1MeV

$$H_m \approx \sqrt{\frac{8\pi\mathcal{E}}{\delta\tau^3c^3}} \approx 10^{16} Oe. \qquad (16)$$

It is advisable to consider such a short magnetic burst in time and space as a particle.

Thus, Maxwell's equations say that the departure of a free electron at β- decay should generate magnetic excitation in ether, similar to photon, but weakly interacting with matter.

The unusual property that a magnetic photon should possess arises from the absence of magnetic monopoles in nature. The fact is that ordinary photons with an electrical component, as shown by J.J. Thomson, they are scattered and absorbed in the substance due to the presence of electrons in it. In the absence of magnetic monopoles, a magnetic photon that does not possess an electrical component, at low energy, must interact extremely weakly with matter and its free path length in the medium should be about two dozen orders of magnitude greater than that of an ordinary photon [4].

In addition, being circularly polarized, a full-fledged photon with both a magnetic and an electric components has a spin equal to $\hbar$. It seems natural to assume that a circularly polarized magnetic photon, devoid of an electrical component, should have a spin equal to $\hbar/2$.

Thus, under the condition Eq.(15), the general solution Eq.(7) reduces to Equality

$$\mathbf{H}(R,t) = \frac{1}{cR^2}\left[\mathbf{n}\times[\dot{\mathfrak{M}}(t^*)\times\mathbf{n}]\right], \qquad (17)$$

It means that from the volume bounded by the surface 4πR2, which surrounds the point of birth of a particle with a magnetic moment M, a photon-like excitation of the ether, which carries an image of the magnetic moment, ies out at
the speed of light

$$\dot{\mathfrak{M}}(t^*) = \mathfrak{M}(\tau)\cdot\delta(t^*-\tau). \qquad (18)$$

At the same time, in accordance with Eq.(15)

$$\mathbf{E}(R,t) = 0, \tag{19}$$

i.e., this excitation of the ether does not carry electrical field.

Cross section of reactions with neutrinos

Reactions due to neutrino energy

In 1934, X. Bethe and R. Peierls proposed that the so-called reverse beta-decay reaction can be used for neutrino registration. This possibility is following from E. Fermi's theory:

$$\overline{\nu} + p \to e^+ + n \tag{20}$$

This is an endothermic (more precisely, end energetic) reaction, which is due to the energy of neutrino initiating it. This energy should be sufficient to cover the mass defect that exists between its products. Thus, the reaction experimentally realized by F. Reines and C. Cowan (Eq.(20)) is possible at an antineutrino energy greater than 1.8 Mev, which corresponds to the excess of the total mass of the neutron and positron over the mass of the proton.

According to measurements of Raines and Cowan, the cross-section of this Reaction

$$\sigma \approx 6 \cdot 10^{-20} barn. \tag{21}$$

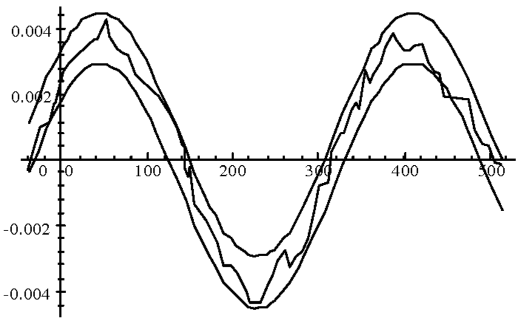

Figure 1: Modulation of the beta-decay rate by the solar neutrino flux, discovered by E. Falkenberg [5].

Beta-decay

Another reaction by which neutrinos can be registered is beta-decay. In the twentieth century, beta-decay was considered a purely accidental phenomenon.

However, at the turn of the new millennium, professor E.Falkenberg [5] in the article Radioactive Decay Caused by Neutrinos? gave experimental evidence that solar neutrinos actually affect beta-decay.

A few years later, researchers on different continents confirmed the presence of this effect for a number of other beta-active isotopes [6], [7].

According to their data, solar neutrinos change the beta-decay rate. They modulate it on about 0.4% with the period equals to a year (Fig.(refFal)). It is convenient to analyze the phenomenon of beta-decay using the example of neutron decay. Neutron decay is an exoenergetic reaction. Since the mass of neutron is greater than the sum of the rest masses of proton and electron, this reaction releases energy corresponding to the mass difference of its products.

Therefore, taking into account that it must go under the influence of the neutrino initiating it, it can be represented as:

$$\nu + n \to p^+ + e^- + \overline{\nu} + \nu. \tag{22}$$

Due to the fact that the neutrino causing this reaction is scattered on the neutron and flies away unnoticed, our instruments register this reaction in a shortened

form: $$n \to p^+ + e^- + \overline{\nu}. \tag{23}$$

Experiment with reactor neutrinos

The experiment with reactor neutrinos was performed in Dubna (Russia) at the IBR-2 reactor [8]. This reactor operates in pulsed mode, repeating its ashes every 200 ms. At the same time, it develops an average power of 1.6 MW. In its active zone approximately

$$F_{IBR} = 5 \cdot 10^{16} \tag{24}$$

acts of plutonium fission occur per second
Measurements on a pulsed reactor allow the use of an accumulation mode.

In this mode, the measurement results obtained during the time between the reactor ashes are superimposed on one another. Due to this, synchronous accumulation of a useful signal occurs. With an accumulation time equal to days, the sensitivity of such measurements increases by several orders of magnitude.

However, at the same time, from the entire spectrum of reactor neutrinos, those are cut out that are born by fragments of fission of reactor fuel, the decay time of which is less than the period between reactor ashes, i.e. less than 200 ms.

In this experiment [8], the rate of beta-decays was measured in a 63Ni source protected from the penetration of reactor radiation and located at a distance of about R = 20m from the reactor core. This source was small in size compared to a at scintillator that recorded the radiation of the source. Therefore, it can be assumed that the measuring system recorded all beta-electrons that few out of the source into a solid angle almost equal to 2π. The remaining electrons that few into the other hemisphere were not registered and, thus, dropped out of consideration during all calibrations and measurements.

Given the fact that the core ^{63} Ni has a long half-life, the decay rate (number of decays per second) can be written as

$$n_\star = \frac{dN_{Ni}}{dt} = N_{Ni} \cdot \frac{de^{-\frac{t}{\tau}}}{dt} = \frac{N_{Ni}}{\tau}. \tag{25}$$

Where NNi is number of nuclei ^{63} Ni in the source.

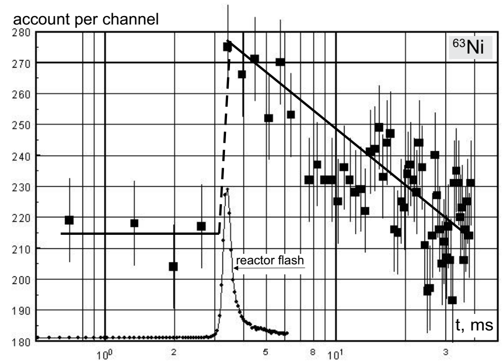

Figure 2: The result of the accumulation of registered beta-electrons emitted by the source 63Ni.

The measurement time is 1 day.

The level of amplitude discrimination close to the boundary energy was chosen experimentally.

On abscissa time (in ms) is plotted in logarithmic scale [8].

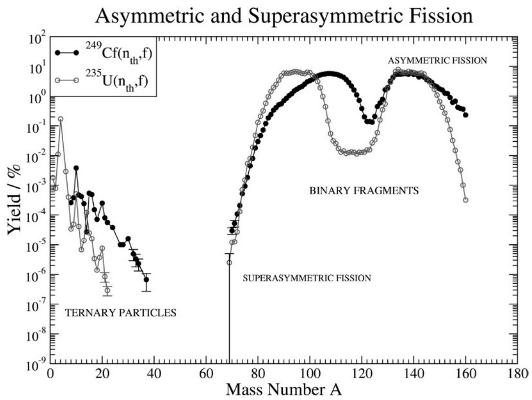

Figure 3: The probability of the formation of fission fragments of nuclear fuel, de-pending on their mass number [9].

Measurements showed that the number of registered decays per second was approximately equal to

$$n_\star \approx 10^5 \qquad (26)$$

Therefore, the total number of beta-active nuclei ^{63}Ni in the source (excluding those that decay into the upper hemisphere):

$$N_{Ni} = n_\star \cdot \tau_{1/2}(Ni) \approx 3 \cdot 10^{14} \qquad (27)$$

The result of the impact of reactor neutrinos generated by a pulsed reactor on an isolated source ^{63}Ni is shown in Figure.2. From these measurements, it can be seen that the count increase induced by the reactor pulse decreases with a time constant equal to about 20 ms.

Based on the data given in the reference book [10], it can be concluded that this is the result of the effects of those neutrinos that are born in the active zone due to the beta-decay of two fission fragments - ^{12}B and ^{13}B. Their half-lives are 20:3ms and 18:6ms respectively. Other fragments with half-lives of less than 200ms apparently do not form in noticeable quantities.

The probability of the formation of ^{12}B and ^{13}B isotopes as a result of plutonium fission is quite small. According to [9], this probability is approximately w $\approx 10^{-4}$ for each isotope.

Thus, of all the neutrinos generated by the isotopes ^{12}B and ^{13}B, the ux passing through the measuring unit is equal to

$$\Phi_r = \frac{F_{IBR} \cdot 2 \cdot w}{4\pi R^2} \approx \frac{5 \cdot 10^{16} \cdot 2 \cdot 10^{-4}}{4\pi \cdot 2000^2} \approx 2 \cdot 10^5 \frac{\nu}{cm^2 s}. \qquad (28)$$

As a result of the impact of reactor neutrinos, the number of beta-electrons per second should increase by

$$n_r = \sigma \cdot N_{Ni} \cdot \Phi_r. \qquad (29)$$

Where σ is the cross section of this reaction.

Summing up the score obtained during measurements channel by channel (see Fig.(2)) and subtracting the background level, we get, that during the entire measurement time ($\tau\Sigma$ =1 day), the impact of reactor neutrinos led to approximately 800 additional decays. That is, the counting rate per second was equal

$$n_r \approx \frac{800}{86400} \approx 9 \cdot 10^{-3} \frac{beta}{sec} \qquad (30)$$

Thus, the reaction of nuclear decay ^{63}Ni, which is caused by the action of a stream of reactor neutrinos with an average energy of about 6 MeV, has a cross section

$$\sigma = \frac{n_r}{\Phi_r N_{Ni}} \approx 10^{-22}\ cm^2 \qquad (31)$$

This unusually large cross-section value compared to the cross-section of other reactions involving neutrinos should not cause confusion.

All commonly used methods of neutrino detection are based on reverse beta decay reactions. In all such cases, the reaction products are recorded, which were formed due to the endo-energy process, which proceeds due to the absorption of neutrino energy.

For beta-decay, the neutron (or nucleus) does not need to absorb additional energy. The neutron, according to the electron-proton model [11], exists in a stable state due to electromagnetic forces that do not carry degradation processes.

However, unlike the Bohr atom, whose stable state is formed due to the Coulomb interaction, magnetic forces play a major role in the formation of the stable state of the neutron.

Neutrino carries a very short burst of a very strong magnetic field Eq.(16).

At an elastic collision of neutron and neutrino, the latter does not need to waste its energy on the collapse of the neutron. Since the mass of neutron is greater than the sum of the rest masses of proton and electron, there is no need to transfer energy to it for the collapse of such an energetically unstable particle.

It is enough to introduce a disturbance into its equilibrium state by acting on it with magnetic field of neutrino. Naturally, the cross-section of this reaction should correspond in order of magnitude to other electromagnetic processes.

The lensing of neutrinos

Diamagnetic susceptibility of a substance

Everyone knows from childhood that to collect solar light rays, you need to use a convex lens. This is due to the refractive index of the glass from which it is made.

The dielectric permittivity of glass ε is slightly greater than 1, and its magnetic permeability μ differs little from 1. Therefore, the refractive index of glass

$$n = \sqrt{\varepsilon\mu} > 1. \qquad (32)$$

Under this condition, light rays can be collected by passing them through a convex lens.

Neutrino lensing requires a different approach.

Since neutrinos do not carry electric field (Eq.19) and, they can be called clumps of purely magnetic energy(Eq.18). Therefore, the electric polarization of the medium does not occur during their propagation. With respect to neutrinos, for they any medium, just like a vacuum, has a dielectric constant of ε = 1.

Therefore, the refractive index of a substance for neutrinos is determined by its magnetic permeability:

$$n = \sqrt{\mu} \qquad (33)$$

Diamagnetic susceptibility of a substance

Within the framework of standard Maxwell electrodynamics, the magnetic permeability of a substance μ can be expressed in terms of its magnetic susceptibility χ:

$$\mu = 1 + 4\pi\chi \qquad (34)$$

All substances have diamagnetic properties to one degree or another, since diamagnetism is the reaction of a closed electron shell to an externally applied magnetic field.

With relatively small magnetic fields, the electron shells process in the applied magnetic field.

The precession frequency of an electron shell [14]:

$$\omega = \frac{e}{2m_e c}H. \qquad (35)$$

As a result of this precession, an atom having Z electron shells acquires a magnetic moment directed against the applied magnetic field [15]:

$$\mathfrak{M} = -\frac{Ze}{2c}\langle\rho^2\rangle\omega = -\frac{Ze^2}{4m_e c^2}\langle\rho^2\rangle H. \qquad (36)$$

Where ⟨ p^2 ⟩ is the average square of the distance of electrons from the axis passing through the nucleus parallel to the field.

With a spherically symmetric charge distribution of atomic shells, it is convenient to introduce into consideration the average square of the distance of electrons from the nucleus [15]

$$\langle r^2\rangle = \frac{3}{2}\langle\rho^2\rangle. \qquad (37)$$

So the magnetic susceptibility of the substance turns out to be equal [14]

$$\chi = \frac{N\mathfrak{M}}{H} = -\frac{NZe^2}{6m_e c^2}\langle r^2\rangle. \qquad (38)$$

Where N is atomic density.

Assuming that ⟨ r ⟩ is approximately equal to the atomic radius R_a, we can Write

$$\chi \approx -\frac{NZe^2}{6m_e c^2}R_a^2. \qquad (39)$$

So, for example, for lead, using experimental values
$R_{pb} \approx 1.75\cdot 10^{-8}$
$N_{pb}=3.3.10^{22}$ atom/cm^3
Z=82,
From Eq.(39) we have

$$\chi_{Pb} \approx -20\cdot 10^{-5}. \qquad (40)$$

The reaction of a diamagnetic to the short-term application of a super-strong magnetic field

A super-strong magnetic field in which the precession velocity exceeds the rotation velocity of electron in an atomic orbit ($\upsilon_{orbital} \approx \alpha c$), must have strength:

$$H \geq \frac{\alpha c}{\frac{e}{2m_e c}R_a} = \frac{2\alpha m_e c^2}{eR_a} \approx 4\cdot 10^{11} Oe. \qquad (41)$$

With a short-term exposure to such a field, the diamagnetic reaction of the electron orbit will be directed at shielding this field, and the energy of this shielding will make up the main part of the kinetic energy of the electron shells:

$$T \approx \frac{H^2}{8\pi}\frac{4\pi}{3}{R_a}^3. \qquad (42)$$

That is, we can write

$$T = \frac{m_e}{2}\Omega^2 R_a^2 \approx \frac{H^2}{8\pi}\frac{4\pi}{3}{R_a}^3 \qquad (43)$$

Therefore, the motion of an orbital electron in a super-strong field can be attributed to the frequency

$$\Omega \approx \sqrt{\frac{R_a}{3m_e}}\, H. \qquad (44)$$

Assuming that for heavy atoms

$$R_a \approx 3a_B, \qquad (45)$$

(where a_B is the Bohr radius) and comparing the value of (Eq.44) with the precession rate in relatively small fields (Eq.35), we get:

$$\frac{\Omega}{\omega} \approx \frac{1}{\alpha}. \qquad (46)$$

The magnetic susceptibility of a diamagnetic in a super-strong field should also be approximately 1/α times higher than previously calculated (Eq.38).

That is, for lead, the magnetic susceptibility in a super-strong field

$$\chi^{Pb}_{super} \approx -0.03. \qquad (47)$$

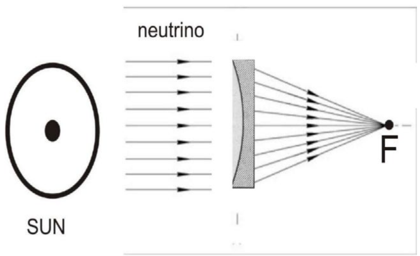

Figure 4: Solar neutrinos collected by a lens made from a diamagnetic material with a refractive index n < 1

Given that the neutrino carries a super-strong magnetic field (Eq.16), the refractive index for the neutrino flux in lead will be:

$$n = \sqrt{\mu} = \sqrt{1 - 4\pi \cdot \chi^{Pb}_{super}} \approx 0.77. \qquad (48)$$

In this regard, in order to collect the neutrino flux, it is necessary to use a at-concave lens. At the radius of curvature of the lens r = 10*cm*, the focal length of the lead lens will be equal to [16]:

$$f = \frac{r}{(1-n)} \approx 43.5cm. \qquad (49)$$

How A. Parkhomov's experiments can be explained

The A. Parkhomov's the treatise contains a description of an experiment in which the author, as he thinks, observed some new H-radiation [7].

Without going into the author's explanations about the essence of the H-radiation itself, let us consider the possibility of explaining the obtained results within the framework of standard ideas about neutrinos.

In this experiment, the author used a metal light - tight tube in which the photographic film was placed. The tube was oriented apparently more or less randomly, and in this position, the film was exposed for about a week. ((Fig.(5)).

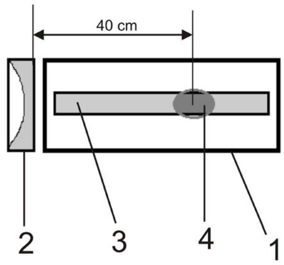

Figure 5: Scheme of A.Parkhomov's experiment

In this diagram:
1-metal light-tight pipe,
2-flat-concave lens made from the lead-tin alloy,
3-photographic film,
4-spot of illumination.

After film development, spots of illumination were detected at the distance of about 40 cm from a flat-concave lens which was made from lead-tin alloy.

In the absence of a lens or when using a convex lens, there were no illumination spots.

When using a flat-concave glass lens, the darkening on the film was observed by the author at distances of 3÷4 times larger.

If we do not attach importance to the author's explanation that he registered a new H-radiation, then we can attribute the formation of a spot to the effect of a neutrino flux.

It can be assumed that at certain time intervals, a neutrino stream from a cosmic source fell on the lens in this installation and the concave lens collected it in its focus. Since the air was not removed from the tube, a reverse beta decay reaction could occur in the focus area on the protons entering the atoms of air molecules, and this area could become a source of positrons or Cherenkov radiation, which caused the l*m* to darken in the focus area of the lens.

It should be noted that Parkhomov used a lead-tin alloy lens and the position of the spot created by it on the film is quite consistent with the focal length of the lead lens calculated above (Eq.49).

In the absence of a lens, the reverse beta-decay also had to go, but evenly. There was no reason for the appearance of a spot of film illumination in this case. A. Parkhomov observed the formation of a spot in the presence of a flat-concave lens only.

About licensing of solar neutrinos

The magnitude of the solar neutrino flux strongly depends on their energy.

Estimates show that with neutrino energy about 0.5 MeV, the solar neutrino flux flux $\Phi_{\odot} \approx 10^{11} \frac{\nu}{cm^2 sec}$, but with an increase in energy to 10 MeV, their flux decreases by about 6 orders of magnitude (Figure.6).

If it is not possible to collect all the rays exactly in the focus of the lens, then when creating an image of a distant object (the Sun) near the focus of the lens, it is possible to increase the density of rays compared to the density of the incident beam at the level of $\vartheta \gtrsim 10^3$.

Thus, the flux of solar neutrinos falling on the beta-source and making up a fraction of a percent of the total neutrino flux without a lens will increase with

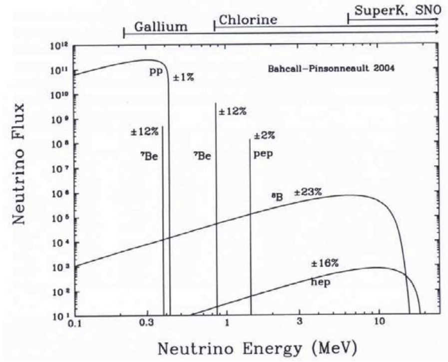

Figure 6: The spectrum of solar neutrinos [13].

the help of the lens and become dominant.

It should be noted that in addition to the Sun, there may be other sources that create a neutrino flux in terrestrial conditions. First of all, it would be interesting to measure the neutrino flux emitted by the Sagittarius A quasar located in the center of our Galaxy.

The lensing of neutrinos emitted by a beta-source

Consider an experiment in which two beta-sources are located on the axis of the lens. Let the source $^{90}Sr/^{90}Y$ be on the left at the focal length from the lens, and the source 63Ni is on the right at the same distance (Figure.(7)).

We will strive to register an increase in the beta-decay rate in the source ^{63}Ni, which occurs under the influence of neutrinos emitted by nuclei ^{90}Y.

If the source $^{90}Sr/^{90}Y$ has an activity A ≈ 1mCi, i.e. it gives about 10^7 decays per second, then the neutrino flux created by it passes through a lens with the area S ≈10^2cm^2, located at the distance of d ≈10cm from the source

$$\Phi_S = \frac{A \cdot S}{4\pi d^2} \approx 10^6 \frac{\nu}{sec}. \quad (50)$$

It can be assumed that all these neutrinos will be collected by the lens at the source 63N*i* and will cause a nuclear decay reaction in it with a probability
$W = \sigma N_{Ni}$.

If we use the same source ^{63}Ni on which the reactor measurements were carried out, then substituting the parameters (Eq.27) and (Eq.31), we get the

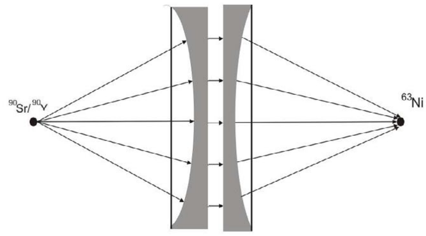

Figure 7: Scheme of lensing for neutrinos emitted by a beta-source probability W ≈10^{-8}.

Thus, it turns out that the decay rate in the source 63Ni under the action of the source 90Sr/90Y increases by V beta-electrons:

$$V = \sigma \cdot N_{Ni} \cdot \Phi_S = \sigma \cdot N_{Ni} \cdot \frac{A \cdot S}{4\pi d^2} \approx 5 \cdot 10^{-2} \frac{beta}{sec}. \quad (51)$$

When measurements are carried out for 1 day, this will give an additional approximately 5000 beta-electrons, which seems quite measurable, since the effect was registered several times smaller in the experiment with reactor neutrinos
[8].

Synchronisation at the neutrino registration

The basis for the success of these reactor measurements was the method of synchronous accumulation, in which measurement data for each cycle between reactor flares are superimposed on data for other cycles. As a result, it is possible to significantly increase the signal-to-noise ratio to highlight the effect synchronous with the reactor ash.

It is obvious that when measuring the effect of the source 90Sr/90Y on beta decay in 63Ni will require the use of a similar method of synchronous detection.

To do this, during measurements, it is necessary to alternate periods when the lens focuses the neutrino on the source 63Ni and when there is no such focusing.

Periodic repeated violations of the focusing conditions in any mechanical way can destroy the _ne adjustment in the installation.

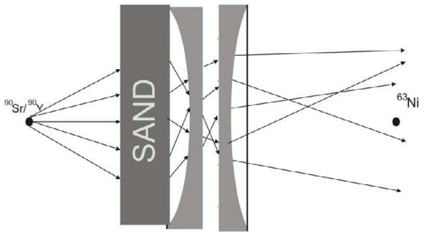

Figure 8: "Entanglement" of neutrino trajectories in sand

It is impossible to absorb or screen a neutrino ux in any way, but it is apparently possible to cause refraction on something. For example, to do this, a vessel with sand can be placed in the path of the neutrino ux (Fig.8). At refraction on grains of sand, neutrinos trajectory will "confuse". It disrupts the lensing process. By periodically shifting the vessel with sand and returning it to its place, it is possible to implement the process of synchronous detection without disturbing the lensing in the measuring unit.

Conclusion

In conclusion, it should be noted that neutrino lensing seems to be a very interesting direction of modern physical research. In general, the neutrino theme attracts a lot of attention in the physics community due to its unusual nature.

Neutrino lensing is also interesting because the opinion has taken root in the minds of many scientists that since neutrinos have a very small cross-section of interaction with matter, no lensing of the neutrino ux is possible at all, and the very formulation of this question is fundamentally erroneous.

On the other hand, the creation of neutrino lenses opens the way for many new experiments to further study this most interesting physical phenomenon.

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