New Approach of explaining the missing sources of UHE Neutrinos as an Effect of Approaching Planck Length

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Abstract. In this paper a new effect have been taken into account which has ever been used before in physics, this effect related to two different fields, Quantum physics and General Relativity. This effect takes name: Time Dilatation as an Effect of Approaching Planck Length, this effect is completely different from the gravitational time dilatation in general relativity and time dilatation due to closing to the speed of light in special relativity. The new effect becomes obvious and strong for the particles that have high energies and very small diameters. Experiments in particle physics and astrophysics had got conclusion that the particles may travel faster than the speed of light in vacuum, such as MINOS experiment and Fermilab1979 in particle experiments and supernova SN1987A and Gamma Ray Bursts (GRBs) in astronomy field. And that seems violating the theory of relativity, but this theory can explain all these unusual observations easily and doesn't violating the theory of relativity.

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1. Introduction

Elementary particles which traveling millions of light years through space, are continuously collide with earth's atmospheric atoms. A showrs of different short-lived particles are creating by these collisions. A few numbers of muons as remnants of these showers reaching the surface of the earth and we can observe them. Many huge world wide detectors were deployed to measure the intensity and the energy spectrum of these particles. Despite the discovery of the cosmic rays as early as 1912 by Victor Hess, 1936 Nobel Laureate in Physics, we still do not know the original sources of them. Scientists expect that most of the particles are originated from supernova explosions in our host galaxy but the very high energy cosmic ray particles are assumed to come from unknown sources outside our galaxy. The highest observed cosmic rays have energies of 50 joules. The acceleration process giving the particles these extreme high energies is not known. Neither are the sources of these particles. The energy of the highest cosmic ray particles is ten million times higher than the energy for particles availabe by the worlds most powerful particle accelerator LHC (Large Hadron Collider) at CERN, Geneva. Because of the electric charge of cosmic rays, the directions of them always deflecting by the distributed magnatic fields in space . That means that the initial direction of the cosmic rays and it's original source will not be known. To detect the source one needs non-charged particle like the neutrino which is not affected by the magnetic field. there are many cosmic candidate sources for high energy neutrons as Gamma-Ray bursts(GRB), Active galactic Nucleus (AGN) and others. Also, GZK-neutrinos (after Greisen, Zatseptin and Kuzmin) are a guaranteed source of extraterrestrial high energy neutrinos. but still there are no significant source for these ultra high energy neutrinos.

2. Theory

According to the length contraction effect due to closing to the speed of light as special relativity says, the diameter of the particles (interaction radius such as electroweak radius for neutrinos) and wavelength will contract in the direction of movement and the time will expand and the mass increases as the following equations:

$$L{=}L_0\sqrt{1-\frac{v^2}{c^2}} \quad , \quad m{=}\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \quad , \quad t{=}\frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}} \tag{1}$$

and because of the high energy and the small original radius of particles, the radius will be closing to the Planck length ($L_p = 1.61624{\times}10^{-35}$m) and that leading to time dilation in the particle frame according to the outer observer, so the outer observer will see the particle moving faster than light. In fact, the particle will not exceed the speed of light, this effect caused by time dilation in the particle frame as the outer observer predicts. At Planck length the gravitational effects will be strong enough beside the Quantum effects in a unified Quantum Gravity World. Because of the big value of Planck mass ($m_p = 2.17645{\times}10^{-8}$kg) and the very tiny diameter scale (Planck length), strong effects can occur, one of them is the time dilation at these small scales given by:

$$t{=}\frac{t_0}{\sqrt{1-\frac{2Gm_p}{c^2R}}} \tag{2}$$

Where R is the real radius of the particle:

$$R{=}\mathrm{r}{+}2l_p \tag{3}$$

$$l_p{=}\frac{Gm_p}{c^2}{=}\sqrt{\frac{hG}{c^3}}$$

The Planck length has been added to R because of:

$$\frac{2l_p}{R} < 1 \Rightarrow R > 2l_p \Leftrightarrow \; R{=}\mathrm{r}{+}2l_p$$

And it gives:

$$t{=}\frac{t_0}{\sqrt{1-\frac{2Gm_p}{c^2R}}} = \frac{t_0}{\sqrt{1-\frac{2l_p}{R}}} = \frac{t_0}{\sqrt{1-\frac{2l_p}{\mathrm{r}+2l_p}}} \tag{4}$$

Where r is the particle radius which can shrink and expand according to special relativity lows. From the equations of length contracting and time dilation and mass increasing above, and using the radius of particle r instead of the length L the following ratios can be extracted:

$$\frac{m_0}{m} = \frac{L}{L_0} = \frac{r}{r_0} \tag{5}$$

$$r = r_0 \frac{m_0}{m} \tag{6}$$

The total energy of particle can be written as:

$$E = \sqrt{{m_0}^2 c^4 + P^2 c^2} = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{7}$$

Where the momentum P=mυ. By using E_0=m_0c^2, the following equation can be written:

$$r = r_0 \frac{E_0}{E} \tag{8}$$

The time dilation is given by:

$$\Delta t = t - t_0 = t_0 \left(\frac{1}{\sqrt{1 - \frac{2l_p}{\mathrm{r} + 2l_p}}} - 1 \right) = t_0 \alpha \tag{9}$$

Where:

$$\alpha = \frac{1}{\sqrt{1 - \frac{2l_p}{\mathrm{r} + 2l_p}}} - 1$$

As the time dilates due to closing to Planck length, the observer frame will see faster than light particles. If the new limit of speed is c > c_0, so the particles according to the observer frame will not moving faster than this new limit of speed (υ < c). The value of the new limit of speed is depending on the type of particles and the diameter and energy, so this limit is not constant.
In fact, the value α in equation 9 can be written as:

$$\alpha = \frac{\triangle t}{t_0} = \frac{\triangle c}{c_0} = \frac{c - c_0}{c_0} \Rightarrow c = (\alpha + 1) c_0 \tag{10}$$

From equation 10 the new limit of speed c > c_0 as a result of $\alpha > 0$ because the radius of particle r cannot go to the infinity. So, from the equation 7 the velocity of particles can not exceed the new limit of velocity (υ < c). By using the equations 7 and 10 the following equation can be written:

$$\upsilon = \left[1 - \left(\frac{(\alpha + 1)^2 m_0 {c_0}^2}{E} \right)^2 \right]^{\frac{1}{2}} (\alpha + 1) c_0 \tag{11}$$

So, the difference between the velocity of particle υ and the speed of light c_0 is:

$$\frac{\upsilon - c_0}{c_0} = \left[1 - \left(\frac{(\alpha + 1)^2 m_0 {c_0}^2}{E} \right)^2 \right]^{\frac{1}{2}} (\alpha + 1) - 1 \tag{12}$$

At high energy particles having small diameter, the value of α is nearly the same as the ratio (υ-c_0)/c_0, because of the velocity υ is very close to the new limit of speed c.

3. Explaining MINOS, Fermilab1979, Supernova SN1987A, ICE Cube and AMANDA II experimental results:
At the beginning, we will suppose the value of electron neutrino mass $m_{\upsilon e}$= 0.02 eV and it will be used in the next calculations, this value is estimated according to the most recent experiments and observations[**?**],[2],[3], also the neutrino oscillation should be taken into account. The electroweak radius of electron neutrino is about ($r_{\upsilon e}= 6.7\times10^{-19}$ m),[4].

3.1. MINOS results [5]:
The neutrinos have energy with a peak of about 3 GeV and the spectrum extended to 100 GeV, they measured the value: $(\upsilon\text{-}c_0)/c_0= 5.1\pm2.9\times10^{-5}$. This result is in a good agreement with the equations above. For the latest value the corresponding energy according to this theory is about 42 GeV, and this value of energy is contained within the energy spectrum of MINOS neutrinos. So, the time dilation equations above can easily explain the results of MINOS.

3.2. Fermilab1979 results:
Neutrinos have energy spectrum range between 30 GeV to 200 GeV and they measured the value: $(\upsilon\text{-}c_0)/c_0\leq 4\times10^{-5}$. This result totally agrees with the equations above of time dilation and neutrino velocity at the lower limits of energy range of neutrinos in this experiment.

3.3. Supernova SN 1987A results [6],[7]:
This supernova is far from earth 168000 light years away and scientists found that the electron neutrinos emitted by this supernova reach the detector on earth about 3 hours earlier than the light emitted from it. These electron neutrinos have an energy spectrum range between 5 MeV to 40 MeV according to the SN1987A data. The scientists measured the value: $(\upsilon\text{-}c_0)/c_0\leq 2\times10^{-9}$ for SN1987A electron neutrinos.

When the lowest limit of energy range is (5 MeV), and by putting it in the equations above, the value $(\upsilon\text{-}c_0)/c_0= 6\times10^{-9}$, but this value is about 3 times the upper limit of measured values. So, that means either the neutrinos emitted from this supernova should have energies below 2 MeV to fit the equations above or there is something in the supernova or in the way between the supernova and earth have delayed the neutrinos only instead of the photons for many hours in the case of that both neutrinos and photons emitted at the same time from the supernova. Or if not, then that means the photons have released after neutrinos for many hours. The most realistic explanation of this result is that the neutrinos are in an oscillated composed case mostly between electron neutrinos and muon neutrinos (and maybe rarely tau neutrinos). So, by dividing the obtained result from the calculation by two or three due to the flavors of neutrinos, then the new result will be in a good agreement with the SN1987A faster than light neutrino observations.

These suggestions can be confirmed by astrophysicist's experiments on Supernova and Gamma Ray Bursts (GRBs) and others.

3.4. ICE Cube and AMANDA II results:
Ice Cube and AMANDA II experiments are the most advanced and largest detectors for high energy atmospheric and cosmic neutrinos [8]. Until now they found nothing from the cosmic sources of neutrinos when they observing the most available sources of high energy neutrinos: Gamma Ray Bursts (GRBs).

Each year these detectors detect about 1000 new GRBs by observing the gamma rays or the light emitted from these objects with huge amounts. The distance of GRBs to earth can be calculated by using the red shift of light emitted from them when traveling long distances to earth. The nearest GRB to earth is GRB 980425 at 40 Mpc or 130 Mly. The detectable range of neutrino energies for these detectors is between 10^{11} eV to 10^{18} eV.

All events collected by AMANDA II during 3.8 years of operation time between the years 2000 to 2006 reached to 6595 events, and scientists of AMANDA II had proved that all of these events are atmospheric neutrinos and non of them where cosmic neutrinos produced by GRBs as they predicted before [9].

Also, after finishing ICE CUBE building in 2010, 300 Known GRBs have been observed and there are no neutrinos have been detected from these sources until now [10].

All of these results are totally agree with the current theory of time dilation due to closing to Planck length as following: the high energies of neutrinos emitted from the GRB as the same time as the photons, causing the radius of the neutrinos closing to Planck length, then the time dilation will be obvious. As a result the outer observer will see the neutrinos moving faster than light, and that doesn't happening to the photons, so the neutrinos will arrive detectors on earth earlier than photons. The differences in time depending on the energy of neutrinos and neutrino oscillation during the path to the earth.

One of the properties of neutrino oscillation is that this probability goes to a minimum value when the energy increases and vice versa, which means for ultra high energy neutrinos coming from cosmic objects will stay in the same flavor as it was most of time. So the electron neutrino will stay electron neutrino mostly, also the same for the two other flavors. Hence, if we suppose electron neutrino emitted from the nearest GRB to the earth (GRB 980425 at 40 Mpc) with energy of 1×10^{15} eV then by doing the calculations we find the neutrino has velocity of $\upsilon = 1.85\times c_0$, which means the neutrinos will reaches earth about 110 millions of years earlier than the light emitted from the same GRB. On the other hand, if the emitted neutrinos where muonic neutrinos (the limited upper mass is taken which is $m_{\upsilon\mu}<170$ keV and the electroweak radius is about $r_{\upsilon\mu}= 6.4\times10^{-19}$ m) with the same previous energy then the velocity will be about: $\upsilon = 1.00000015\times c_0$, this means the muon neutrinos will reaches earth before light about 19 years earlier.

That explains why we have never detected any neutrinos from all known observed GRB or other sources observed by light emitted from them until now by all available detectors since it built.

As addition: The value of energy of electron to begin having faster than light speed is from the above equations: $E_{critical} = 2.2$ TeV and this value is much bigger than the available energies by recent accelerators for electrons.

At CERN experiments on protons which will have a maximum energy of 7000 GeV, according to this theory the value of $(\upsilon\text{-}c_0)/c_0$should be: $(\upsilon\text{-}c_0)/c_0= -1.0\times10^{-8}$ if the radius of proton is ($r_p = 1\times10^{-15}$m). It is small value but measurable one by using latest devices at CERN. The value of energy of proton to begin having faster than light speed is from the above equations is about: $E_{critical} = 3100$ TeV, and this value is much bigger than the available energies by recent accelerators for protons, it can be found only in the cosmic rays.

3.5. Applicable experiment to detect neutrinos from cosmic sources such as GRBs:

If we suppose that the ICECUBE detected a muon neutrino with energy of many hundreds of GeV (the lower limit of ICECUBE detection) then we should turn the gamma rays satellites to the same point of incoming neutrino in the sky and according to this theory the gamma rays satellites will detect a burst of gamma and light photons after hours or days or more depending on the neutrino energy and neutrino oscillation and the distance. The better scenario is the applicable lowest muon neutrino energy emitted from the probable nearest sources, because the difference in time between detecting the neutrino and detecting the gamma bursts is in minimum, so it's more realistic experiment.

3.6. Applicable experiment to detect atmospheric neutrinos within air showers produced by ultra high energy cosmic rays (UHECRs):

Most experiments on atmospheric neutrinos refer to that the collisions between UHECRs with energies reach more than 10^{20} eV and the atoms of atmosphere occur at altitude approximately 20 km to the earth surface. A flash of light are produced at the point of collision and a shower of many kinds of particles emitted as neutrinos with spectrum of energy between 10^{9} eV and 10^{15} eV [11].

The upper point of the shower can be estimated by tracking the paths of the particles produced by the collision to intersect in a point.

If we suppose atmospheric electron neutrino with energy 10^{15} eV then the velocity will be $\upsilon = 1.85\times c_0$, also if we suppose the altitude of production of this neutrino about 20 km, so the neutrino will arrives the detector of ICECUBE or AMANDA II about 30 microsecond earlier than the flash photons. This experiment is realistic to be done and to check the new theory.

4. Conclusion:

The new theory in this paper provides explanations for many unsolved mysteries from particle physics and cosmology related to neutrino physics. Also it provides a good estimation to the mass of electron neutrino and can predicts the exact values of the other flavors of neutrinos when we do suitable experiments. It not contradicts the special theory of relativity but it expands it to fit new physics of particles especially neutrinos, and maybe it can solve other unsolved mysteries haven't mentioned here as the particles having energies above GZK cutoff limit and black holes and the big bang it self. In addition, many realistic experiments have suggested here to check this theory.

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