How The 17 GeV OPERA Superluminal Neutrino From CERN Arrived At Gran Sasso Without Desintegration??:It Was Carried Out By A Natario Warp Drive.Explanation for the results obtained by Glashow-Cohen and Gonzalez-Mestres

Fernando Loup *

Residencia de Estudantes Universitas Lisboa Portugal

November 2, 2011

Abstract

Recently Superluminal Neutrinos have been observed in the OPERA experiment at CERN.Since the neutrino possesses a non-zero rest mass then according to the Standard Model,Relativity and Lorentz Invariance this Superluminal speed result would be impossible to be achieved.This Superluminal OPERA result seems to be confirmed and cannot be explained by errors in the measurements or break-ups in the Standard Model,Relativity or Lorentz Invariance. In order to conciliate the Standard Model,Relativity and Lorentz Invariance with the OPERA Superluminal Neutrino we propose a different approach: Some years ago Gauthier,Gravel and Melanson introduced the idea of the micro Warp Drive:Microscopical particle-sized Warp Bubbles carrying inside sub-atomic particles at Superluminal speeds. These micro Warp Bubbles according to them may have formed spontaneously in the Early Universe after the Big Bang and they used the Alcubierre Warp Drive geometry in their mathematical model.We propose exactly the same idea of Gauthier,Gravel and Melanson to explain the Superluminal Neutrino at OPERA however using the Natario Warp Drive geometry.Our point of view can be resumed in the following statement:In a process that modern science still needs to understand,the OPERA Experiment generated a micro Natario Warp Bubble around the neutrino that pushed it beyond the Light Speed barrier.Inside the Warp Bubble the neutrino is below the Light Speed and no break-ups of the Standard Model,Relativity or Lorentz Invariance occurs but outside the Warp Bubble the neutrino would be seen at Superluminal speeds.Remember that the CERN particle accelerators were constructed to reproduce in laboratory scale the physical conditions we believe that may have existed in the Early Universe so these micro Warp Bubbles generated after the Big Bang may perhaps be re-created or reproduced inside particle accelerators. We believe that our idea borrowed from Gauthier,Gravel and Melanson can explain what really happened with the neutrinos in the OPERA experiment.We also explain here the results obtained by Glashow-Cohen and Gonzalez-Mestres

---

*spacetimeshortcut@yahoo.com

1 Introduction:The OPERA Superluminal Neutrino At CERN

In September 2011 The OPERA Team at CERN published their results about experiments to measure the velocity of neutrinos ([7]).The experiment was conceived to send neutrinos by a tunnel of about 730 km between CERN(Switzerland) and Gran Sasso(Italy).The final result was quite unexpected:The neutrino arrived earlier than the time a photon would need to cross the same distance!!!!(see abs of [7]).This means to say that the neutrino travelled Faster Than Light(FTL)!!!A Superluminal Speed!!! The result seems to be confirmed.[1] If this is true then what happened with the OPERA neutrino??? According to Standard Model and Relativity a non-zero rest mass particle cannot exceed the speed of light and neutrinos have non-zero rest masses[2].The reason why a non-zero rest mass particle cannot surpass the light speed and go to FTL started in 1905 when Einstein published his Special Theory of Relativity(SR).Einstein established a Universe speed limit:Light Speed c.Nothing can travel faster than the speed of the light(at least locally in SR Frames of Reference) or as is also known:"Thou Shall Not Travel Faster Than The Speed Of Light". This can be better pictured by the equations given below:

$$m = \frac{m_0}{\sqrt{1 - (\frac{v^2}{c^2})}} \tag{1}$$

$$E_0 = m_0 c^2 \tag{2}$$

$$E = mc^2 \tag{3}$$

$$K = E - E_0 \tag{4}$$

From the set of equations above if we accelerate a body we give it Kinetic energy K but since due to the equivalence between mass and energy this Kinetic energy also have mass..so a body in motion have Kinetic energy but have a mass m that is much heavier than the same body at the rest with mass m_0 because the Kinetic energy accounts for a mass increase.As faster the body moves the body possesses more Kinetic energy and more mass....it becomes more heavier...as it becomes more heavier it will require a stronger force to accelerate the body giving even more Kinetic energy which means to say even more mass and the body becomes even more heavier.....Ad Infinitum..... In order to reach the speed of light an infinite amount of energy and an infinite force is needed.So its impossible to reach the speed of light and if we cannot reach it we cannot surpass it.This is the reason why we cannot travel Faster Than Light.This is the reason why we cannot go FTL.A tachyonic behavior could be assumed for neutrinos in certain conditions(eg OPERA) but how a neutrino would pass from a real non-zero rest-mass to an imaginary non-zero rest mass assuming a continuous variation in the rest-mass?? From September 2011 to the current date a lot of papers appeared in the current e-print literature(arXiv,HAL) explaining the behavior of the OPERA neutrino ranging from errors in the measures[3] to modifications in the Standard Model,Relativity and Lorentz Invariance.

---

[1]http://hal.archives-ouvertes.fr/ the Homepage of HAL mentions the Superluminal OPERA neutrino and the main document of the experiment HAL-00625946 twice

[2]see the neutrino masses in the Appendix

[3]We dont believe in errors measurements.See [7].It is signed by 173 experts.Such a number of scientists can easily verify the measures checking for errors before publish documents

Of course we cannot exclude the possibility of the fact that Standard Model,Relativity and Lorentz Invariance needs review but these worked very well and accurately until the OPERA experiment.
But although Special Relativity cannot explain the OPERA neutrino then perhaps General Relativity can explain it.
General Relativity can provide a way to make the OPERA neutrino Superluminal while conciliating these results without conflicts with previous established theories(eg Standard Model,Lorentz Invariance):This way is simply called:The Warp Drive.
The Warp Drive as a solution of the Einstein Field Equations of General Relativity that allows Superluminal travel appeared first in 1994 due to the work of Alcubierre.([1]) The Warp Drive as conceived by Alcubierre worked with an expansion of the spacetime behind an object and contraction of the spacetime in front.The departure point is being moved away from the object and the destination point is being moved closer to the object.The object do not moves at all[4].It remains at the rest inside the so called Warp Bubble but an external observer would see the object passing by him at Superluminal speeds(pg 8 in [1])(pg 1 in [2]).
Later on in 2001 another Warp Drive appeared due to the work of Natario.([2]).This do not expands or contracts spacetime but deals with the spacetime as a "strain" tensor of Fluid Mechanics(pg 5 in [2]). Imagine the object being a fish inside an aquarium and the aquarium is floating in the surface of a river but carried out by the river stream.The Warp Bubble in this case is the aquarium whose walls do not expand or contract. An observer in the margin of the river would see the aquarium passing by him at a large speed but inside the aquarium the fish is at the rest with respect to his local neighborhoods.
Many other works appeared on the scientific literature about the Warp Drive outlining Negative Energy requirements,Doppler Blueshifts and Horizons(Causally Disconnected portions of spacetime).
However in 2002 Gauthier,Gravel and Melanson appeared with a different idea:([8],[9])
According to them,microscopical particle-sized Warp Bubbles may have formed spontaneously immediately after the Big Bang and these Warp Bubbles could be used to transmit information at Superluminal speeds.These micro Warp Bubbles may exist today.(see abs of [9])
A micro Warp Bubble with a radius of 10^{-10} meters could be used to transport an elementary particle like the electron whose Compton wavelength is 2.43×10^{-12} meters at a Superluminal speed.These micro Warp Bubbles may have formed when the Universe had an age between the Planck time and the time we assume that Inflation started.(see pg 306 of [8])
The main idea behind this work is now becoming clear:In our opinion the OPERA Experiment generated in a process that still needs to be explained,one of these micro Warp Bubbles around the neutrino able to carry it at a Superluminal speed $vs > c$ however this Superluminal speed is very close to $c, vs \cong c$. This micro Warp Bubble can move the neutrino Superluminally while maintaining compatibility with the well established theories of Standard Model,Relativity and Lorentz Invariance.We also explain the results of Glashow-Cohen [10]and Gonzalez-Mestres [6].This work is a companion and a complement work to our previous work in the OPERA Experiment [3] and we recommend the reading of [3] first.

---

[4]do not violates Relativity

This work is divided in the following sections:

- 2)-Natario Warp Drive and the micro Warp Bubbles of Gauthier,Gravel and Melanson

- 3)-How The 17 GeV OPERA Superluminal Neutrino From CERN Arrived At Gran Sasso Without Desintegration??:It Was Carried Out By A Natario Warp Drive

In Section 2 we discuss briefly the mathematical definition of the Natario Warp Drive and the micro Warp Bubbles of Gauthier,Gravel and Melanson[5].

In Section 3 we discuss the results obtained by Glashow-Cohen [10]and Gonzalez-Mestres [6]

---

[5]see our companion work [3] for a detailed discussion

2   Natario Warp Drive and the micro Warp Bubbles of Gauthier,Gravel and Melanson

In 2001 Natario introduced a new Warp Drive spacetime defined as follows(pg 4 in [2])

- 1)-Any Natario Vector nX generates a Warp Drive Spacetime if $nX = 0$ for a small value of $|x|$ defined by Natario as the interior of the Warp Bubble and $nX = -vs(t)dx$ or $nX = vs(t)dx$ for a large value of $|x|$ defined by Natario as the exterior of the Warp Bubble with $vs(t)$ being the speed of the Warp Bubble(pg 5 in [2]).

Explaining the definition better:A given Natario Vector nX generates a Natario Warp Drive Spacetime if and only if satisfies these conditions stated below:

- 1)-A Natario Vector nX being $nX = 0$ for a small value of $|x|$(interior of the Warp Bubble)

- 2)-A Natario Vector $nX = -Xdx$ or $nX = Xdx$ for a large value of $|x|$(exterior of the Warp Bubble)

- 3)-A Shift Vector X depicting the speed of the Warp Bubble being $X = 0$(interior of the Warp Bubble) while $X = vs$ seen by distant observers(exterior of the Warp Bubble).

The Natario Warp Drive can be defined by the following expression(pg 5 in [2])

$$nX = -v_s(t)d\left[f(r)r^2\sin^2\theta d\varphi\right] \sim -2v_sf(r)\cos\theta\mathbf{e}_r + v_s(2f(r) + rf'(r))\sin\theta\mathbf{e}_\theta \tag{5}$$

From now on we will use this pedagogical approach that gives results practically similar the ones depicted in the original Natario Vector shown above

$$nX = -v_s(t)d\left[f(r)r^2\sin^2\theta d\varphi\right] \sim -2v_sf(r)\cos\theta dr + v_s(2f(r) + rf'(r))r\sin\theta d\theta \tag{6}$$

In order to make the definition of the Natario Warp Drive holds true we need for the Natario Vector nX a Natario Shape Function being $f(r) = \frac{1}{2}$ for large r(outside the Warp Bubble) and $f(r) = 0$ for small r(inside the Warp Bubble) while being $0 < f(r) < \frac{1}{2}$ in the walls of the Warp Bubble(pg 5 in [2])

To avoid contusion with the Alcubierre Shape Function $f(rs)$ (pg 4 in [1])we will redefine the Natario Shape Function as $n(r)$ and the Natario Vector as shown below

$$nX = -v_s(t)d\left[n(r)r^2\sin^2\theta d\varphi\right] \sim -2v_sn(r)\cos\theta dr + v_s(2n(r) + rn'(r))r\sin\theta d\theta \tag{7}$$

$$nX = -v_s(t)d\left[n(r)r^2\sin^2\theta d\varphi\right] \sim -2v_sn(r)\cos\theta dr + v_s(2n(r) + r[\frac{dn(r)}{dr}])r\sin\theta d\theta \tag{8}$$

The Natario Vector $nX = -vs(t)dx = 0$ vanishes inside the Warp Bubble because inside the Warp Bubble there are no motion at all because $dx = 0$ or $n(r) = 0$ or $X = 0$ while being $nX = -vs(t)dx \neq 0$ not vanishing outside the Warp Bubble because $n(r)$ do not vanish.Then an external observer would see the Warp Bubble passing by him with a speed defined by the Shift Vector $X = -vs(t)$ or $X = vs(t)$.

Redefining the Natario Vector nX as being the Rate-Of-Strain Tensor of Fluid Mechanics as shown below(pg 5 in [2]):

$$nX = X^r \mathbf{e}_r + X^\theta \mathbf{e}_\theta + X^\varphi \mathbf{e}_\varphi \tag{9}$$

Applying the Extrinsic Curvature for the Shift Vectors contained in the Natario Vector nX above we would get the following results(pg 5 in [2]):

$$K_{rr} = \frac{\partial X^r}{\partial r} = -2v_s n'(r) \cos\theta \tag{10}$$

$$K_{\theta\theta} = \frac{1}{r}\frac{\partial X^\theta}{\partial \theta} + \frac{X^r}{r} = v_s n'(r) \cos\theta; \tag{11}$$

$$K_{\varphi\varphi} = \frac{1}{r\sin\theta}\frac{\partial X^\varphi}{\partial \varphi} + \frac{X^r}{r} + \frac{X^\theta \cot\theta}{r} = v_s n'(r) \cos\theta \tag{12}$$

$$K_{r\theta} = \frac{1}{2}\left[r\frac{\partial}{\partial r}\left(\frac{X^\theta}{r}\right) + \frac{1}{r}\frac{\partial X^r}{\partial \theta}\right] = v_s \sin\theta\left(n'(r) + \frac{r}{2}n''(r)\right) \tag{13}$$

$$K_{r\varphi} = \frac{1}{2}\left[r\frac{\partial}{\partial r}\left(\frac{X^\varphi}{r}\right) + \frac{1}{r\sin\theta}\frac{\partial X^r}{\partial \varphi}\right] = 0 \tag{14}$$

$$K_{\theta\varphi} = \frac{1}{2}\left[\frac{\sin\theta}{r}\frac{\partial}{\partial \theta}\left(\frac{X^\varphi}{\sin\theta}\right) + \frac{1}{r\sin\theta}\frac{\partial X^\theta}{\partial \varphi}\right] = 0 \tag{15}$$

Examining the first three results we can clearly see that(pg 5 in [2]):

$$\theta = K_{rr} + K_{\theta\theta} + K_{\varphi\varphi} = 0 \tag{16}$$

The Expansion of the Normal Volume Elements in the Natario Warp Drive is Zero.

A Warp Drive With Zero Expansion.

Spacetime Contraction in one direction(radial) is balanced by the Spacetime Expansion in the remaining direction(perpendicular)(pg 5 in [2]).

Imagine an object being a fish inside an aquarium and the aquarium is floating in the surface of a river but carried out by the river stream.The Warp Bubble in this case is the aquarium whose walls do not expand or contract. An observer in the margin of the river would see the aquarium passing by him at a large speed but inside the aquarium the fish is at the rest with respect to his local neighborhoods.

The Energy Density in the Natario Warp Drive is given by the following expression(pg 5 in [2]):

$$\rho = -\frac{1}{16\pi}K_{ij}K^{ij} = -\frac{v_s^2}{8\pi}\left[3(n'(r))^2\cos^2\theta + \left(n'(r) + \frac{r}{2}n''(r)\right)^2\sin^2\theta\right]. \tag{17}$$

$$\rho = -\frac{1}{16\pi}K_{ij}K^{ij} = -\frac{v_s^2}{8\pi}\left[3(\frac{dn(r)}{dr})^2\cos^2\theta + \left(\frac{dn(r)}{dr} + \frac{r}{2}\frac{d^2n(r)}{dr^2}\right)^2\sin^2\theta\right]. \tag{18}$$

This Energy Density is negative and depends on the configuration of the the Natario Shape Function $n(r)$ or its derivatives..In order to generate the Warp Drive as a Dynamical Spacetime large outputs of

energy are needed due to the factor vs^2 and this is a critical issue unless we use very low derivatives of the Natario Warp Drive Shape Function $n(r)$.

Replacing r by the term rs we have:

$$nX = -v_s(t)d\left[n(rs)rs^2\sin^2\theta d\varphi\right] \sim -2v_s n(rs)\cos\theta drs + v_s(2n(rs) + rs[\frac{dn(rs)}{drs}])rs\sin\theta d\theta \qquad (19)$$

The Natario Piecewise Shape Function $n(rs)$ for the Natario Warp Drive being $n(rs) = \frac{1}{2}$ for large rs(outside the Warp Bubble) and $n(rs) = 0$ for small rs(inside the Warp Bubble) while being $0 < n(rs) < \frac{1}{2}$ in the walls of the Warp Bubble(pg 5 in [2]) is defined by:(pg 16 in [3])[6]

- 1) $n_{rs} = 0 \dashrightarrow rs < R - \frac{\Delta}{2}$

- 2) $n_{rs} = [\frac{1}{2}][-\Delta(rs - R - \frac{\Delta}{2})]^{WF} \dashrightarrow R - \frac{\Delta}{2} < rs < R + \frac{\Delta}{2}$

- 3) $n_{rs} = \frac{1}{2} \dashrightarrow rs > R + \frac{\Delta}{2}$

Note that this Shape Functions satisfies the Natario condition $0 < n_{rs} < \frac{1}{2}$.Remember that $R >> \Delta$ and inside the Warp Bubble $rs < R$.The minus sign is due to the condition $R - \frac{\Delta}{2} < rs$
We are interested in the derivatives of the Natario Piecewise Shape Function in the Warped Region where $0 < n_{rs} < \frac{1}{2}$

$$n_{rs} = [\frac{1}{2}][-\Delta(rs - R - \frac{\Delta}{2})]^{WF} \qquad (20)$$

$$n'_{rs} = \{[\frac{1}{2}](WF)[-\Delta(rs - R - \frac{\Delta}{2})]^{WF-1}\}(-\Delta) \qquad (21)$$

$$n'(rs)^2 = \{[\frac{1}{4}](WF^2)[-\Delta(rs - R - \frac{\Delta}{2})]^{2[[WF-1]}\}\Delta^2 \qquad (22)$$

$$n''_{rs} = \{[\frac{1}{2}](WF)(WF - 1)[-\Delta(rs - R - \frac{\Delta}{2})]^{WF-2}\}(\Delta^2) \qquad (23)$$

$$n''(rs)^2 = \{[\frac{1}{4}][(WF)^2][(WF - 1)^2][-\Delta(rs - R - \frac{\Delta}{2})]^{2[WF-2]}\}(\Delta^4) \qquad (24)$$

The Negative Energy Density is given by:

$$\rho = -\frac{1}{16\pi}K_{ij}K^{ij} = -\frac{v_s^2}{8\pi}\left[3(n'(rs))^2\cos^2\theta + \left(n'(rs) + \frac{rs}{2}n''(rs)\right)^2\sin^2\theta\right]. \qquad (25)$$

Note that in order to compute the Negative Energy density requirements for our Natario Warp Bubble we must leave the units system in which $c = G = 1$ and work with the real units.(pg 11 eqs 45,46 in [5]):

$$\rho = -\frac{c^2}{G}\frac{1}{16\pi}K_{ij}K^{ij} = -\frac{c^2}{G}\frac{v_s^2}{8\pi}\left[3(n'(rs))^2\cos^2\theta + \left(n'(rs) + \frac{rs}{2}n''(rs)\right)^2\sin^2\theta\right]. \qquad (26)$$

---

[6]suitable for very small Bubble thickness Δ as expected for micro Warp Bubbles

Gauthier,Gravel and Melanson proposed some years ago the idea of the micro Warp Bubble:([8],[9]) According to them,microscopical particle-sized Warp Bubbles may have formed spontaneously immediately after the Big Bang and these Warp Bubbles could be used to transmit information at Superluminal speeds.These micro Warp Bubbles may exist today.(see abs of [9])
A micro Warp Bubble with a radius of 10^{-10} meters could be used to transport an elementary particle like the electron whose Compton wavelength is 2.43×10^{-12} meters at a Superluminal speed.These micro Warp Bubbles may have formed when the Universe had an age between the Planck time and the time we assume that Inflation started.(see pg 306 of [8])

Following the ideas of Gauthier,Gravel and Melanson ([8],[9]) a micro Warp Bubble can send information or particles at Superluminal speeds.(abs of [9],pg 306 in [8]).Such a Bubble would be able to shelter the OPERA Superluminal Neutrino so we must concentrates ourselves on the Natario micro Warp Bubbles in our attempt to explain the Superluminal OPERA Neutrino at CERN.

Examining again the definition of the Natario Warp Drive: statement(pg 4 in [2]):

- 1)-Any Natario Vector nX generates a Warp Drive Spacetime if $nX = 0$ for a small value of rs defined by Natario as the interior of the Warp Bubble and $nX = -vs(t)dx$ or $nX = vs(t)dx$ for a large value of rs defined by Natario as the exterior of the Warp Bubble with $vs(t)$ being the speed of the Warp Bubble(pg 5 in [2]).

The OPERA neutrino lies in the interior of the micro Warp Bubble at the rest or with a speed below light speed,but an external observer outside the micro Warp Bubble(eg the measurement equipment of OPERA Experiment) sees the neutrino passing by with a large Superluminal speed[7].

Gauthier,Gravel and Melanson (pg 306 in [8]) defined a micro Warp Bubble with a radius of 10^{-10} meters that could be used to transport an elementary particle like the electron whose Compton wavelength is 2.43×10^{-12} meters at a Superluminal speed.So our Warp Bubble Radius is $R = 10^{-10}$ meters and the thickness is $\Delta = 10^{-13}$ meters.A very small thickness.This micro Warp Bubble can shelter an electron...and the OPERA Superluminal neutrino.

The Superluminal OPERA neutrino was slightly above the light speed but we will compute the Negative Energy for a micro Natario Warp Bubble with a speed $vs = 2c, vs = 6 \times 10^8, vs^2 = 3,6 \times 10^{17}, c = 3 \times 10^8$, $c^2 = 9 \times 10^{16}$ and $G = 6,67 \times 10^{-11}$ all in its respective International System of units (MKS)

The terms $\frac{c^2}{G} = 1,35 \times 10^{27}, \frac{vs^2}{8\pi} = 1,4 \times 10^{16}$.The product is $1,89 \times 10^{43}$

A number with 43 zeros!!

The Radius of our micro Natario Warp Bubble is $R = 10^{-10}$ and the thickness is $\Delta = 10^{-13}$.Our Warp Factor[8] is $WF = 5$

Then we have:

---

[7]see the Artistic Presentation of the Natario Warp Bubble in the Appendix
[8]Remember that the Warp Factor is a dimensionless arbitrary parameter.See pg 9 eq 38 in [5]

$$n'(rs)^2 = \{[\frac{1}{4}](WF^2)[-\Delta(rs - R - \frac{\Delta}{2})]^{2[[WF-1]]}\}\Delta^2 \tag{27}$$

$$n'(rs)^2 = \{[\frac{1}{4}](25)[-10^{-13}(rs - 10^{-10} - \frac{10^{-13}}{2})]^8\}10^{-26} \tag{28}$$

From the power expressions above we can see that the term 10^{43} can be greatly reduced independently of the value of $rs < R$. Making $rs \cong R$ we have:

$$n'(rs)^2 \cong \{[\frac{1}{4}](WF^2)[-\Delta(-\frac{\Delta}{2})]^{2[[WF-1]]}\}\Delta^2 \tag{29}$$

$$n'(rs)^2 \cong \{[\frac{1}{4}](WF^2)[(\frac{\Delta^2}{2})]^{2[[WF-1]]}\}\Delta^2 \tag{30}$$

$$n'(rs)^2 \cong \{[-10^{-13}(-\frac{10^{-13}}{2})]^8\}10^{-26} \tag{31}$$

$$n'(rs)^2 \cong \{[(\frac{10^{-26}}{2})]^8\}10^{-26} \tag{32}$$

$$n'(rs)^2 \cong \{[(10^{-26})]^8\}10^{-26} \tag{33}$$

$$n'(rs)^2 \cong \{[(10^{-208})]\}10^{-26} \tag{34}$$

$$n'(rs)^2 \cong 10^{-234} \tag{35}$$

We do not need to go further in order to see that the number 10^{43} is completely obliterated by the expression above producing a micro Natario Warp Bubble with a very small Negative Energy density requirements. The Natario micro Warp Bubble agrees with the conclusions of Gauthier,Gravel and Melanson.A micro Warp Bubble requires very small amounts of Negative Energy.(see abs of [8])

Then a micro Natario Warp Bubble is more than capable to shelter the Superluminal OPERA neutrino and carry it beyond the light speed without conflicts with the established theories of Standard Model,Relativity and Lorentz Invariance. How this micro Natario Warp Bubble was created in the OPERA Experiment is a reason to justify further studies.

In the next section we will see how the OPERA Superluminal neutrino from CERN arrived at Gran Sasso with $17\ GeV$ without desintegrations

3   How The $17\ GeV$ OPERA Superluminal Neutrino From CERN Arrived At Gran Sasso Without Desintegration??:It Was Carried Out By A Natario Warp Drive

We will now examine the dynamics of the OPERA Subluminal Neutrino inside a Superluminal micro Warp Bubble.This will remember closely the dynamics of the photon and the problem of the Horizon that occurs naturally in the Natario Warp Drive Spacetime due to the Geometry of the Spacetime itself(pg 6 in [2])(pg 20 in [4])(pg 10 in [3]).

Starting with the Natario Warp Drive with motion only in the $x - axis$ as defined by pg 6 in [2].

Lets assume that this micro Warp Bubble was generated by the OPERA Experiment in a process that science still needs to figure out and this micro Warp Bubble was created in a given region of the Opera tunnel when the Subluminal Neutrino was passing by it with a speed $v_\epsilon < c$ but also with $v_\epsilon \cong c$ in order to produce the mass of $17\ GeV/c^2$ since the Neutrino rest-mass[9]is nearly $10^{-9}\ GeV/c^2$.

The geometry of this problem is exactly the same of the geometry of a stationary observer at the rest in the center of the micro Warp Bubble sending a Subluminal Neutrino with a speed $v_\epsilon < c$ $v_\epsilon \cong c$ to the front of the Warp Bubble which moves itself at a Superluminal speed.

Remember that $X = 0$ inside the Warp Bubble where the observer is at the rest but the Subluminal Neutrino moves in this region with $v_\epsilon < c$ $v_\epsilon \cong c$,remember also that $X = vs$ outside the Warp Bubble being $vs > c$ and of course $vs > v_\epsilon$and remember also that $0 < X < vs$ is the Warped region(Walls of the Bubble)

If we send a Neutrino to the front of the Warp Bubble we have the following result:

- 1)- Neutrino sent towards the front of the Warp Bubble $\frac{dx}{dt} = X - v_\epsilon$

But if $X = 0$ inside the Warp Bubble and $X = vs$ outside the Warp Bubble with $vs > c > v_\epsilon$ then in order for X to pass from 0(inside) to vs(outside) with a continuous growth then X must enter in the region where $0 < X < vs$ which means to say that X enters in the Natario Warped Region $0 < X < vs$ and in a given region of the Natario Warped Region $X = v_\epsilon$ and for the Neutrino sent towards the front of the Warp Bubble we have:

$$\frac{dx}{dt} = X - v_\epsilon = v_\epsilon - v_\epsilon = 0 \tag{36}$$

The Neutrino speed becomes zero!.

The Neutrino stops inside the Natario Warped Region where $X = v_\epsilon$ never reaching the region outside the Warp Bubble where $X = vs$

The Neutrino enters the Natario Warped Region and cross the portion of the Natario Warped Region

---

[9]see Appendix on the Neutrino rest-masses

where $0 < X < v_\epsilon$ stopping effectively where $X = v_\epsilon$.The remaining part of the Natario Warped Region $v_\epsilon < X < vs$ will remain outside the range of the Neutrino that will never leave the Warp Bubble,

Remarkably similar to what happens with a photon that stops when reaching the Horizon of the Warp Bubble(pg 20 in [4])(pg 10 in [3])

Remember that our micro Warp Bubble have according to Gauthier,Gravel and Melanson (pg 306 in [8])a radius of 10^{-10} meters that could be used to transport an elementary particle like the electron whose Compton wavelength is 2.43×10^{-12} meters at a Superluminal speed.So our Warp Bubble Radius is $R = 10^{-10}$ meters and the thickness is $\Delta = 10^{-13}$ meters.A very small thickness.This micro Warp Bubble can shelter an electron...and the OPERA Superluminal neutrino.Then the OPERA Superluminal Neutrino will remain itself trapped and at the rest in the part of the Natario Warped Region where $X = v_\epsilon$.

Remember also that in the previous Section we made the Warp Bubble speed $X = vs = 2c$ in order to demonstrate that this micro Warp Bubble requires an infinitesimal small amount of Negative Energy.(see abs of [8])

But when the OPERA Subluminal Neutrino was inside the Warp Bubble in the region where $X = 0$ moving with a speed $X = v_\epsilon$ its mass was $17\ GeV/c^2$ and its energy was $17\ GeV$. Now the Opera Neutrino is stopped in the Natario Warped Region with a rest-mass of $10^{-9}\ GeV/c^2$ and rest-energy of $10^{-9}\ GeV$

These remaining $17\ GeV$ are released when the Neutrino stops in the Natario Warped Region but this released energy remains also inside the micro Warp Bubble because the size of the Warp Bubble if it can shelter an electron then it does have room enough to store the Opera Superluminal Neutrino and the released energy.

At this point we must clarify the following situations:

- 1)-The OPERA Neutrino was NEVER Superluminal:It was ALWAYS Subluminal with a speed $X = v_\epsilon$ and terminated its journey at the rest inside the Natario Warped Region

- 2)-The $17\ GeV$ released when the Neutrino stopped remained also inside the Warp Bubble[10]

- 3)-What was ALWAYS Superluminal was the micro Warp Bubble carrying the Subluminal Neutrino inside[11].

- 4)-According to Gauthier,Gravel and Melanson in [9] the Subluminal Particle inside a Superluminal Warp Bubble and the Warp Bubble itself must both be regarded as a single physical entity of its own.

---

[10]Some authors says that this would raise the temperature inside the Warp Bubble but we are not covering these topics here

[11]See Appendix on the Artistic Presentation of the Natario Warp Bubble

- A)-According to the OPERA Team the Neutrino arrived at Gran Sasso Superluminally with 17 GeV.(see pg 5 in [7]).[12][13]

- B)-According to Gonzalez-Mestres the Neutrino would decay in pions Subluminally and with an energy of 14 GeV.(see pg 1 in [6])

- C)-According to Glashow-Cohen the Neutrino would decay in pions Subluminally and with an energy of 12 GeV.(see pg 4 in [10])

- D)-Since the Neutrino was NEVER Superluminal and remained ALWAYS Subluminal inside a Superluminal micro Warp Bubble then the decay in pions could never happen

If the OPERA measures are correct(and we believe in the OPERA results) then these results cannot be explained by the Standard Model,Special Relativity and Lorentz Invariance(otherwise Glashow-Cohen and Gonzalez-Mestres would be right) but can be perfectly explained by General Relativity and the micro Warp Bubbles of Gauthier,Gravel and Melanson.

---

[12]http://hal.archives-ouvertes.fr/ the Homepage of HAL mentions the Superluminal OPERA neutrino and the main document of the experiment HAL-00625946 twice

[13]We dont believe in errors measurements for OPERA.See [7].It is signed by 173 experts.Such a number of scientists can easily verify the measures checking for errors before publish documents

4 Conclusion:The OPERA Superluminal neutrino At CERN

In this work we tried to give an explanation for the OPERA Superluminal Neutrino discovered at CERN without modifications of the current well established theories of Standard Model,Relativity and Lorentz Invariance while explaining the results obtained by Glashow-Cohen and Gonzalez-Mestres.We borrowed the idea of Gauthier,Gravel and Melanson of micro Warp Bubbles carrying particles or information at Superluminal speeds.These micro Warp Bubbles requires very small amounts of Negative Energy and may have been created in the Early Universe and perhaps may be reproduced in particle accelerators.([8],[9]).Perhaps the Superluminal OPERA neutrino was generated by any other physical effect but the explanation using the ideas of Gauthier,Gravel and Melanson fits very well in the attempt to explain it.

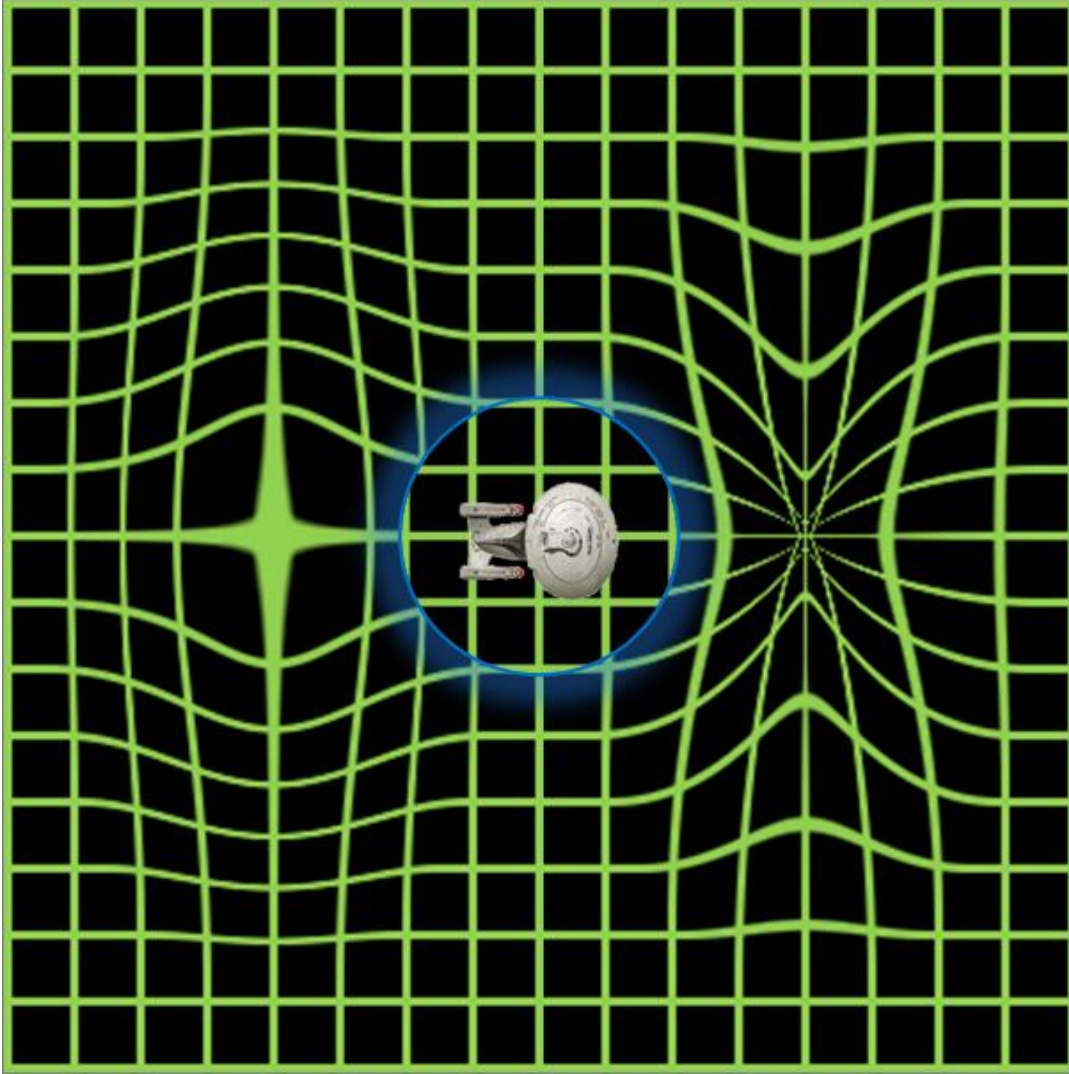Figure 1: Artistic representation of the Natario Warp Bubble .(Source:Internet)

5 Artistic Graphical Presentation of the Natario Warp Bubble

According to the Natario definition for the Warp Drive using the following statement(pg 4 in [2]):

- 1)-Any Natario Vector nX generates a Warp Drive Spacetime if $nX = 0$ and $X = vs = 0$ for a small value of rs defined by Natario as the interior of the Warp Bubble and $nX = -vs(t)dx$ or $nX = vs(t)dx$ with $X = vs$ for a large value of rs defined by Natario as the exterior of the Warp Bubble with $vs(t)$ being the speed of the Warp Bubble(pg 5 in [2]).The blue region is the Warped Region(Warp Bubble walls)

A given Natario Vector nX generates a Natario Warp Drive Spacetime if and only if satisfies these conditions stated below:

- 1)-A Natario Vector nX being $nX = 0$ for a small value of rs(interior of the Warp Bubble)

- 2)-A Natario Vector $nX = -Xdx$ or $nX = Xdx$ for a large value of rs(exterior of the Warp Bubble)

- 3)-A Shift Vector X depicting the speed of the Warp Bubble being $X = 0$(interior of the Warp Bubble) while $X = vs$ seen by distant observers(exterior of the Warp Bubble).

The Natario Vector nX is given by:

$$nX = -v_s(t)d\left[n(rs)rs^2\sin^2\theta d\varphi\right] \sim -2v_s n(rs)\cos\theta drs + v_s(2n(rs)+rsn'(rs))rs\sin\theta d\theta \qquad (37)$$

This holds true if we set for the Natario Vector nX a continuous Natario Shape Function being $n(rs) = \frac{1}{2}$ for large rs(outside the Warp Bubble) and $n(rs) = 0$ for small rs(inside the Warp Bubble) while being $0 < n(rs) < \frac{1}{2}$ in the walls of the Warp Bubble(pg 5 in [2])

The Natario Vector $nX = -vs(t)dx = 0$ vanishes inside the Warp Bubble because inside the Warp Bubble there are no motion at all because $dx = 0$ or $n(rs) = 0$ or $X = 0$ while being $nX = -vs(t)dx \neq 0$ not vanishing outside the Warp Bubble because $n(rs)$ do not vanish.Then an external observer would see the Warp Bubble passing by him with a speed defined by the Shift Vector $X = -vs(t)$ or $X = vs(t)$.

The "spaceship" above lies in the interior of the Warp Bubble at the rest $X = vs = 0$ but the observer outside the Warp Bubble sees the "spaceship" passing by him with a speed $X = vs$.

Replacing the "spaceship" by a neutrino and reducing the size of the Warp Bubble to microscopical sizes we can explain the OPERA Superluminal neutrino at CERN without conflicts with the Standard Model,Relativity and Lorentz Invariance.

FERMIONS	matter constituents spin = 1/2, 3/2, 5/2, …					
Leptons spin =1/2			**Quarks** spin =1/2			
Flavor	Mass GeV/c^2	Electric charge		Flavor	Approx. Mass GeV/c^2	Electric charge
ν_L lightest neutrino*	$(0-0.13)\times10^{-9}$	0	u	up	0.002	2/3
e electron	0.000511	−1	d	down	0.005	−1/3
ν_M middle neutrino*	$(0.009-0.13)\times10^{-9}$	0	c	charm	1.3	2/3
μ muon	0.106	−1	s	strange	0.1	−1/3
ν_H heaviest neutrino*	$(0.04-0.14)\times10^{-9}$	0	t	top	173	2/3
τ tau	1.777	−1	b	bottom	4.2	−1/3

Figure 2: Neutrino Rest Masses .(Source:Internet)

6   Neutrino Rest Masses

$$m = \frac{m_0}{\sqrt{1-(\frac{v^2}{c^2})}} \tag{38}$$

$$E_0 = m_0 c^2 \tag{39}$$

$$E = mc^2 \tag{40}$$

$$K = E - E_0 \tag{41}$$

From the set of equations above and from the figure we can see that the neutrino possesses non-zero rest-mass.If we accelerate a neutrino we give it Kinetic energy K but since due to the equivalence between mass and energy this Kinetic energy also have mass..so a neutrino in motion have Kinetic energy but have a mass m that is much heavier than the same neutrino at the rest with mass m_0 because the Kinetic energy accounts for a mass increase.As faster the neutrino moves the neutrino possesses more Kinetic energy and more mass....it becomes more heavier...as it becomes more heavier it will require a stronger force to accelerate the neutrino giving even more Kinetic energy which means to say even more mass and the neutrino becomes even more heavier.....Ad Infinitum..... In order to reach the speed of light an infinite amount of energy and an infinite force is needed. So its impossible to reach the speed of light and if the neutrino cannot reach it then the neutrino cannot surpass it.This is the reason why the neutrino cannot travel Faster Than Light.This is the reason why the neutrino cannot go FTL. If the FTL OPERA result for the neutrino is confirmed.[14]then what happened with the OPERA neutrino???

---

[14]http://hal.archives-ouvertes.fr/ the Homepage of HAL mentions the Superluminal OPERA neutrino twice

Figure 3: Photon Rest Mass .(Source:Internet)

7 Photon Rest Mass

In Newtonian Mechanics the formula for relative speeds is given by:

$$v' = v_2 + v_1$$

Imagine that the observer A is at the rest and the observer B is in a train wagon moving with a speed v_1. B throws a stone to the front of the wagon with a speed v_2. Observer A sees the stone with a relative velocity of v'

But in Relativity the addition of speeds do not work due to the Lorentz Invariance. If the observer B send a light pulse to the front of the wagon then $v2 = c$

$$v' = \frac{v_2 + v_1}{1 + \frac{v_1 v_2}{c^2}}$$

$$v' = \frac{c + v_1}{1 + \frac{v_1 c}{c^2}} = \frac{c + v_1}{1 + \frac{v_1}{c}} = \frac{c + v_1}{\frac{c}{c} + \frac{v_1}{c}} = c$$

Imagine now that the wagon moves at light speed $v1 = c$ and the observer B send the light pulse to the front of the wagon $v2 = c$

$$v' = \frac{2c}{1 + \frac{c^2}{c^2}} = \frac{2c}{1 + 1} = \frac{2c}{2} = c$$

Light Speed always have the value of c regardless of relative motion.There exists no frame in which $c = 0$.Since the photon moves at light speed the frame where the photon is at the rest do not exist.This is the reason why the photon mass is zero.

8 Epilogue

- "The only way of discovering the limits of the possible is to venture a little way past them into the impossible."-Arthur C.Clarke[15]

- "The supreme task of the physicist is to arrive at those universal elementary laws from which the cosmos can be built up by pure deduction. There is no logical path to these laws; only intuition, resting on sympathetic understanding of experience, can reach them"-Albert Einstein[16][17]

9 Remarks

Reference 8 was taken from Internet although not from a regular available site like the one of references 1,2,5,6 and 7(arXiv,HAL).We can provide the Adobe PDF Acrobat Reader of this reference for those interested.

10 Legacy

This work is dedicated to all the 173 scientists of the OPERA Team.Before OPERA the Superluminal Velocities existed only in the theoretical mathematical physics and were regarded as academic curiousities without a single proof ox existence in Nature.After the OPERA Experiment everything changed.A special mention to Dario Authiero(France) and Antonio Ereditato(Italy) the Head Scientists of OPERA.

---

[15]special thanks to Maria Matreno from Residencia de Estudantes Universitas Lisboa Portugal for providing the Second Law Of Arthur C.Clarke

[16]"Ideas And Opinions" Einstein compilation, ISBN $0-517-88440-2$, on page 226."Principles of Research" ([Ideas and Opinions],pp.224-227), described as "Address delivered in celebration of Max Planck's sixtieth birthday (1918) before the Physical Society in Berlin"

[17]appears also in the Eric Baird book Relativity in Curved Spacetime ISBN $978-0-9557068-0-6$

References

[1] *Alcubierre M., (1994). Class.Quant.Grav. 11 L73-L77,arXiv gr-qc/0009013*

[2] *Natario J.,(2002). Class.Quant.Grav. 19 1157-1166,arXiv gr-qc/0110086*

[3] *Loup F.,(2011).,HAL-00630737*

[4] *Loup F.,(2011).,HAL-00599640*

[5] *Loup F.,(2011).,HAL-00599657*

[6] *Gonzalez-Mestres L.,(2011).,HAL-00627917*

[7] *Authiero D,Ereditato A.(Et. Al.)(OPERA Team),(2011).,HAL-00625946*

[8] *Gauthier C.,Gravel P.,Melanson J.,(2003). Gravitation and Cosmology. Vol 9 No.4(36) 301-306*

[9] *Gauthier C.,Gravel P.,Melanson J.,(2002). Int.J.Mod.Phys.A(IntJMPA). Vol 17 No.20 2761*

[10] *Glashow S.L.,Cohen. A.G.,(2011).,arXiv:1109.6562*

.