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Abstract: A closer look at tachyon decay engineered vacuum state changes via reheat and inflation and if they could lead to a micro warp bubble as proposed by Fernando Loup and based upon the work of Glashow-Cohen and Gonzalez-Mestres.

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Starting with the Lagrangian

$$L = -V(T)\sqrt{1+g^{\mu\nu}\partial_\mu T\partial_\nu T}\sqrt{-\det(g_{\mu\nu})}$$

$$= -V(T)\sqrt{-\det\, G_{\mu\nu}},$$

the tachyon metric is given by

$$\begin{aligned} G_{\mu\nu} &= (G)_{\mu\nu} \\ &= g_{\mu\nu} + \partial_\mu T\partial_\nu .T \end{aligned}$$

The equation of motion is

$$\Big(g^{\mu\nu} - \frac{\partial^\mu T\partial^\nu T}{1+(\partial T)^2}\Big)\partial_\mu\partial_\nu T = -\frac{V'}{V}(1+(\partial T)^2).$$

If the tachyon co-metric is defined as

$$(G^{-1})^{\mu\nu} = g^{\mu\nu} - \frac{\partial^\mu T\partial^\nu T}{1+(\partial T)^2},$$

such that

$$(G^{-1})^{\mu\nu}G_{\nu\lambda} = \delta^\mu_\lambda,$$

the characteristic cones are given by the co-metric

$(G^{-1})^{\mu\nu}$

and the rays by the metric

$G_{\mu\nu}.$

linearizing around flat-space-time, we see that the maximum signal speed is that of light since

$g_{\mu\nu}$ and $G_{\mu\nu}$ coincide in that case. But in a non-trivial tachyon background tachyon fluctuations will travel at a different speed from that of light in a flat space-time vacuum. Thus, the appearance of such states depends upon the background itself.

The energy momentum tensor of the tachyon takes the form:

$$T^{\mu\nu} = -V\sqrt{1+(\partial T)^2}(G^{-1})^{\mu\nu}$$

With the equation

$$V_2(T) = \left(\frac{\lambda}{1+(T/T_{_0})^4}\right)$$

one finds that, in these potentials, inflation typically occurs around

$T \simeq T_{_0}$

corresponding to an energy scale of about λ^¼. The quantity

$(\lambda T_{_0}^2/M_{\rm Pl}^2)$

governs the inflation time period via a scalar pertribution. We can also utilize the equation for the decay rate

$$\Gamma_2 = \Gamma(T) = \mathcal{A}\left(1-\mathcal{B}\tanh\left[\left(T-\mathcal{C}\right)/\mathcal{D}\right]\right),$$

where A, B, C and D are constants that we choose suitably to achieve the desired evolution.

We can then look at the perturbations in relation to a flat background via

$$\mathrm{d}s^2 = (1 + 2\,A)\,\mathrm{d}t^2 - 2\,a\,(\partial_i B)\,\mathrm{d}x_i\,\mathrm{d}t - a^2(t)\,\mathrm{d}\mathbf{x}^2,$$

where Einstein's equations become

$$\begin{aligned} -3\,H^2 A - \left(\frac{H}{a}\right)\nabla^2 B &= (4\,\pi\,G)\,\delta\rho, \\ H\,(\partial_i\,A) &= (4\,\pi\,G)\,(\partial_i\,\delta q)\,, \\ H\,\dot{A} + \left(2\,\dot{H} + 3\,H^2\right)\,A &= (4\,\pi\,G)\,\delta p, \end{aligned}$$

where

$$\delta\rho,\ (\partial_i\,\delta q),\ \text{and}\ \delta p$$

denote the perturbations in the total energy density, the total momentum flux, and the total pressure of the complete system. These quantities further are derived by

$$\begin{aligned} \delta\rho &= (\delta\rho_{_T} + \delta\rho_{_F}) = \left(\frac{V_{_T}\,\delta T}{\sqrt{1-\dot{T}^2}}\right) + \left(\frac{V\,\dot{T}}{\left(1-\dot{T}^2\right)^{3/2}}\right)\left(\dot{\delta T} - A\,\dot{T}\right) + \delta\rho_{_F}, \\ \delta q &= (\delta q_{_T} + \delta q_{_F}) = \left(\frac{V\,\dot{T}\,\delta T}{\sqrt{1-\dot{T}^2}}\right) - \psi_{_F}, \\ \delta p &= (\delta p_{_T} + \delta p_{_F}) = -\left(V_{_T}\,\delta T\,\sqrt{1-\dot{T}^2}\right) + \left(\frac{V\,\dot{T}}{\sqrt{1-\dot{T}^2}}\right)\left(\dot{\delta T} - A\,\dot{T}\right) + w_{_F}\,\delta\rho_{_F}, \end{aligned}$$

where

$$\delta T$$

denotes the perturbation in the tachyon and

$$\psi_{_F}$$

is proportional to the potential that determines the three velocity of the perfect fluid which in our case would be the normal vacuum being energized by reheating and inflation. Starting with this type of perfect fluid it is easy to see that the resulting vacuum state bubble in the region of inflation is not going to be the same one we started with. When you combine this with the first part equations given in the start of this article then our vacuum state is no longer a true flat space-time. In this case

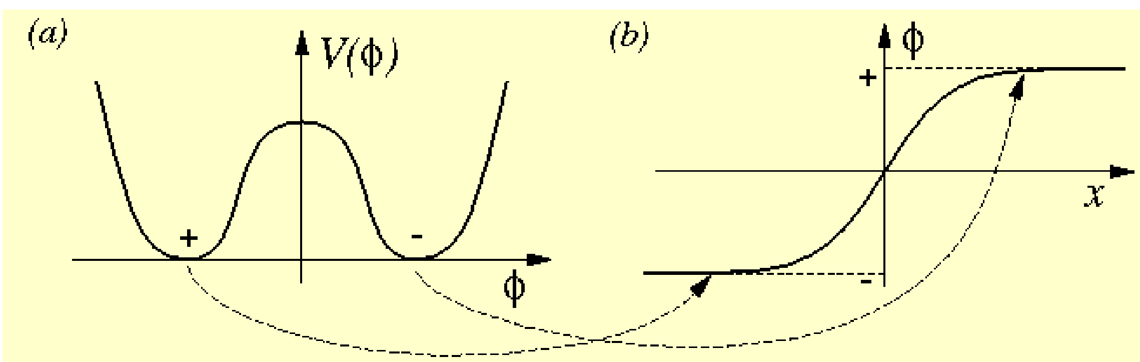
$g_{\mu\nu}$ and $G_{\mu\nu}$

do not coincide.

The question that needs to be further examined is what would be the velocity of light in such a vacuum state? If it is higher you not only have a mechanism to explain the CERN results.

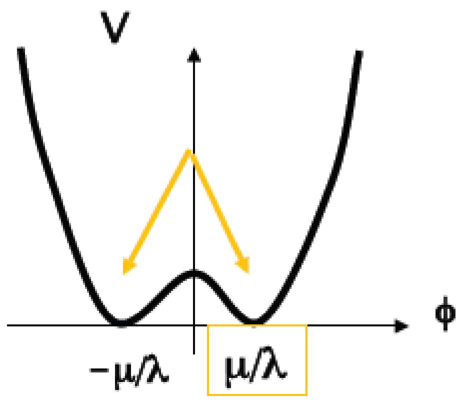
Now Fernando Loup has postulated that his Natario Warp Drive could be the solution in the form of a micro-warp bubble(1). I am going to assume for a moment the other took place an started the process whereby the neutrinos managed to achieve superluminal velocity. The two different vacuum states would then have a domain wall separating them.

There are two-dimensional objects that form when a discrete symmetry is broken at a phase transition from a vacuum with one value of C to another. A network of domain walls effectively partitions the different vacuum states into various `cells'. Domain walls have some rather peculiar properties. For example, the gravitational field of a domain wall is repulsive rather than attractive.



Domain walls are associated with models in which there is more than one separated mimimum.(fig.1)

two space-time bubbles in different vacua, separated by a domain wall at x=0
At
x=+∞ Φ=+μ/λ
X=-∞ Φ=-μ/λ



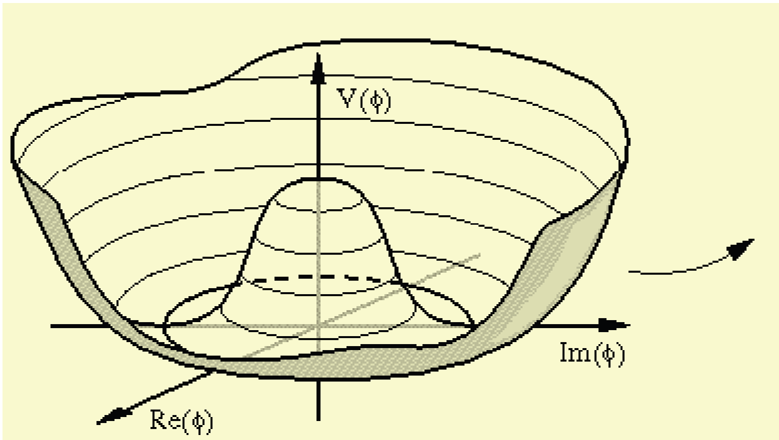
With these boundary conditions, the solution is

$$\phi(x) = \frac{\mu}{\lambda}\tanh(x/\Delta)$$

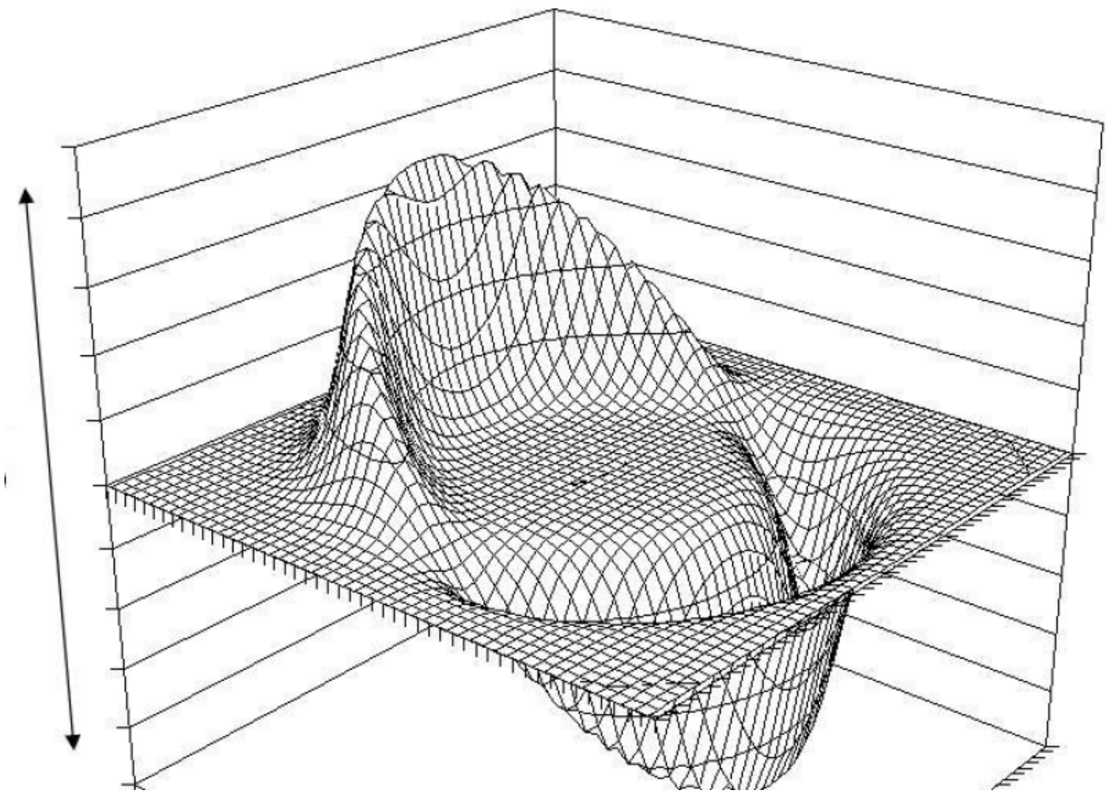
$$\text{where} \qquad \Delta = \frac{\sqrt{2}}{\lambda\phi_{\min}}$$

Domain walls separate regions of space with different vacuum topology. Configuration of the field is stable: wall can only be removed by annihilation with wall of opposite topology. Their energy density would be huge (10^{10} x current density).

In region where phase changes smoothly from 0>2π.
At centre there must be a point where the field is zero.



If this region was in motion via an inflation field transition then the mode becomes different and you end up with:



being possible. In fact, the differences in vacuum energy actual create something akin to this in the first place with the large energy of the domain wall being the gravity well and the inflated vacuum being the exotic one.   So in essence, Fernando Loup's idea of the neutrino's traveling in a microwarp bubble is possible. But, even if that is the case remember: : wall can only be removed by annihilation with wall of opposite topology. One would have to restore the inflated vacuum state back to that of the external vacuum state to shut the field off or slow down. So in essence, if this is what transpired at CERN then these neutrinos are forever trapped in those micro-warp bubbles.

What you encounter here is another example of the No-Go's that have been raised on warp drives in general before. This may or may not be a No-Go that can be solved. It may be possible to increase the internal vacuum's energy back to a normal state. If so you have a mechanism to create a usable warp field for superluminal propulsion once the whole thing can be scaled up. This mechanism of generating a warp field does solve the whole problem of how you put the field into superluminal motion to begin with. It also solves via the natural energy differences and the domain wall the exotic energy and the extreme gravity well.

To further look at this if we discard for sake of argument the exact mechanism involved at CERN that brought about inflation and revert to a more simplier look we find the following:

Consider the theory of a single scalar field defined by the action

$$S = \int d^4x \left[\tfrac{1}{2}(\partial_\mu \phi)^2 - U(\phi)\right],$$

Generally, U has two local minima,

$\phi_{\pm}$,

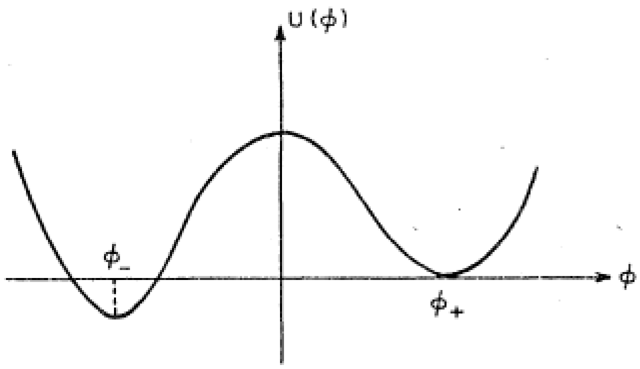
only one of which,

ϕ_{-},

is usually seen as a true minimum. Thus

$\phi = \phi_{+}$ and $\phi = \phi_{-}$

are seen as stable states.



The potential U(p) for a theory with a false
Vacuum.

Gravitation affect vacuum decay and vacuum decay affects gravitation in keeping with other laws of physics. When we plug certain values into

$$S = \int d^4x\sqrt{-g}\,[\tfrac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - U(\phi) - (16\pi G)^{-1}R],$$

where R is the curvature scalar. Here U is equivalent to adding a term proportional to

$$\sqrt{-g}$$

to the gravitational Lagrangian.

So in a false vacuum state gravity dominates while in our present state it is weaker. However, in any case where our present vacuum is forced to decay gravity would further weaken which is why the local value of C would change in such an inflated vacuum.

Now

$$S_E = \int d^4x[\tfrac{1}{2}(\partial_\mu\phi)^2 + U(\phi)]\,,$$

defines the Euclidean action where in the case above we have the values of the original false vacuum. But one can substitute the current vacuum into this to find the resultant Euclidean action. We can further simplify this to

$$S_E = 2\pi^2 \int_0^\infty \rho^3 d\rho \left[\tfrac{1}{2}(\phi')^2 + U\right],$$

And derive the equation of motion via

$$\phi'' + \frac{3}{\rho}\phi' = \frac{dU}{d\phi},$$

When we further make the substitution

$$\rho \to (|\vec{x}|^2 - t^2)^{1/2}$$

the bubble of new vacuum materializes at rest in relation to the domain wall and the external field with it's normal velocity initially with radius

$$\bar{\rho}.$$

The bubble of new vacuum accelerates to the resultant warp factor of the combined domain wall and exotic energy state.

Reference:

1.) Fernando Loup 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 **viXra:1111.0012**

All figures taken from online public sources.