A Realistic Solution To Warp Drive Without Exotic Energy

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Abstract: I will show there exists a positive only energy solution to the original Warp Metric that utilizes an Inflation Field based False Vacuum state.

Introduction.—The concept of a warp drive or warp field, while originally more a Science Fiction concept has since the advent of Dr. Alcubierre's original article(1) become an issue of the real Scientific Community. Many authors, including myself have done articles on warp drive metrics. Some of these have been published in peer reviewed Journals like those of the IOP. Others have been done of the LANL system like one I helped Co-Author a bit back(2). The original metric and most of those that followed have all been based upon the usage of negative energy to produce the inflation like field in the rear of warp field. This was assumed partly because the original Alcubierre metric(1) required it, and partly because the assumption has always been that to produce a bi-polar gravitational field negative energy was required. However, a closer examination of this whole Bi-polar issue sheds some new light on this whole subject. What I am about to show is that exotic energy of the type forbidden by quantum energy conditions is not actually required to produce a bi-polar field at all.

To begin with let's consider the case of what is required to move space-time like an inflation field does.

INFLATION FIELD DYNAMIC.—To introduce any de Sitter expansion or inflation into most modern quantum based theories like String Theory has created many problems to date. The principal obstacle has been the fact that the low-energy dynamics of the theory contains massless scalar fields with non-minimal couplings to gravity whose coupling constants are precisely given by the conformal symmetry and/or the dualities of string theory. In an expanding universe, these fields roll during the course of the expansion as dictated by their equations of motion, consuming the available energy and hence decreasing the rate of expansion. That is, besides the Minkowski space solution, there are no other solutions to Einstein's equations, where the Gauss-Bonnet curvature squared terms are kept, of the dilaton-gravity system with constant curvature and a stationary dilaton. de Sitter solutions are possible if the dilaton sits in a potential minimum (with $V\neq 0$) due to supersymmetry breaking effects, but in this case, the theory suffers a graceful exit problem.. We simply cannot get the inflation field to drop out as quickly as most regular inflation fields and observation generally requires.

Instead, one typically finds solutions where the scale factor of the universe grows as a power of time, with the power determined by the scalar coupling constants. Once the numerical values of these constants, fixed by string theory, are taken into account, it has been found that the resulting power laws are too slow to give an inflationary universe required by everything else we know in physics. However, the whole drop off issue has a hint coming at us from nature in the form of the accelerated expansion(3).

For example, if we ignore the compact 6-space and include a cosmological term λwe have a 4D action

$$S = \frac{1}{2\kappa_4^2}\int d^4x\sqrt{g_s}\Big\{e^{-2\phi}\Big(R_s + 4(\nabla\phi)^2 + \cdots + \Lambda\Big) + \cdots \qquad (1)$$

where now $\kappa_4^{-2} = M_4^2 / 8\pi$. In the Einstein frame this becomes

$$S = \frac{1}{2\kappa_4^2}\int d^4x\sqrt{g_s}\Big\{\Big(R - 2(\nabla\phi)^2 + \cdots + e^{2\phi}\Lambda\Big) + \cdots \qquad (2)$$

In the Einstein frame, the solution to the equations of motion yield a scale factor which grows linearly in time. What is moving here is space-time itself. Larger bodies such as planets and galaxies move with space-time. Now if we included a massive scalar field in the action we would find that the scale factor relative to the Compton wavelength $\lambda \sim m^{-1}$ is constant, as is the String or Plank scale under this general model. In its simplest form, the model is equivalent to a theory of gravity with an R^2 correction which can be written as

$$S = \frac{1}{2\kappa^2}\int d^4x\sqrt{g}(R + R^2/6M^2) \qquad (3)$$

It is well known that this theory based model is conformally equivalent to a theory of Einstein gravity plus a scalar field. The potential for the resulting scalar is extremely flat for field values $\phi >> M_4$ and has a minimum at $\phi = 0$ with $V(\phi = 0) = 0$. For large initial values of ϕ, one can recognize this as an excellent model for chaotic inflation. In general, quantum corrections to the right-hand side of Einstein's equation in the absence of matter can be written as

$$\begin{aligned}\langle T_{\mu\nu}\rangle = &\ (\frac{k_2}{2880\pi^2})(R_\mu^\rho R_{\nu\rho} - \frac{2}{3}RR_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R^{\rho\sigma}R_{\rho\sigma} + \frac{1}{4}g_{\mu\nu}R^2) \\ &+ \frac{1}{6}(\frac{k_3}{2880\pi^2})(2R_{;\mu;\nu} - 2g_{\mu\nu}R^{;\rho}_{;\rho} - 2RR_{\mu\nu} + \frac{1}{2}g_{\mu\nu}R^2)\end{aligned} \qquad (4)$$

where k_2 and k_3 are constants that appear in the process of regularization. k_2 is related to the number of light spin states, which can be very large in variants of string theories based on M theory. On the other hand, the coefficient k_3 is independent of the number of light states. This term is equivalent to the variation of the R^2 term in the effective action. The theory admits a de Sitter solution which can be found from the 00 component of gravitational equation of motion. Defining $H' = 2880\pi^2 / k_2$ and $M^2 = 2880\pi^2 / k_3$, and setting the spatial curvature $k = 0$, one finds

$$H^2(H^2 - H'^2) = (H'^2/M^2)(2\ddot{H}H + 2H^2\dot{H} - \dot{H}^2) \qquad (5)$$

where H is the Hubble parameter. The de Sitter solution corresponds to $H = H'$ and of course $\dot{H} = \ddot{H} = 0$.

In order to avoid the overproduction of gravitons there is a *lower* limit on the parameters $k_{2,3}$ $k_2 >> \sim 10^{10}$ implying the need for billions of spin degrees of freedom to be present. While this seems like an inordinately large number, it is possible to generate very large numbers of degrees of freedom in theories with either extra dimensions like M-Theory or compacted varying lightcone regions like certain Double Special Relativity models.(4)

Alan Guth and Andre Linde(5) independently proposed in 1981-2 that the Big Bang begins in a hot dense state, but as it cools through the so- called Grand Unification Theory (GUT) transition energy at 10^15 GeV and 10^-35 seconds, it gets caught in a false vacuum state. This causes the universe to exponentially grow in size in what is called a quasi-de Sitter state. The expansion ceases once the universe enters its true vacuum phase, with a release of energy that appears as a fireball phase of particle and radiation creation by 10^-33 seconds after the Big Bang. The expansion then resumes with the Friedmann expansion phase which it is now continuing to undergo, but at a greatly reduced speed. The transition occurs by the nucleation of true vacuum bubbles within the expanding matrix of the de Sitter false vacuum phase. These bubbles either merge together to form the present day uniformity of the universe (Old Inflation), or remain as separate domains that grow to sizes billions of times larger than our observable universe (New Inflation). The supermassive, scalar Higgs field is identified as the culprit whose phase transition initiates Inflation.

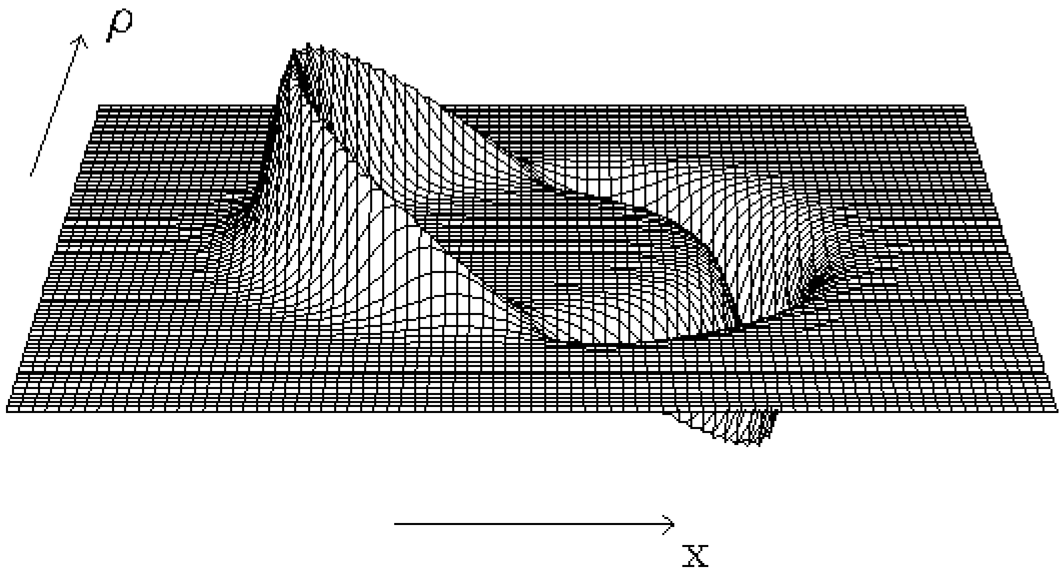
The important thing to look at here is the actual energy condition of the vacuum during this false vacuum state. According to every model run on this and the original theory the vacuum under went inflation while in a higher positive energy state. This implies that inflation type fields, as I originally mentioned were required for producing a Bi-Polar gravity field do not require negative energy at all. They require positive energy, or rather, a compressed vacuum state.

The question then becomes how do we increase the energy of the vacuum? The answer is simple. We increase the energy of the vacuum itself and let gravity do the work of compression in a field shape we determine. What is that field shape? The one required for a warp field itself by it's metric. An example of such is

$$ds^2 = (A^2 - B^2\beta^2 f^2)dct^2 + 2B^2\beta f r dct d\theta - B^2 r^2 d\theta^2 \quad (6)$$

Here's a figure from Alcubierre's paper showing the curvature of space in the region of the travelling warp.

$$\vartheta = - \alpha \ \mathrm{Tr}(K)$$



which even the above metric follows. This has sometimes been referred to as a Top Hat. However, if we renormalized the center baseline to a zero mark, representing the real normal vacuum state at the top of this graph we'd actually have the same general field being generate with nothing more than positive energy. The format would now be a dual graph one where the region around the craft stays at the new baseline and the field itself would now be of a wedge shape showing a region with a vacuum state that increases in energy to a point slightly behind the craft and then is allowed to inflate back to it's normal vacuum state. We get the same moving frames effect without ever having to violate one known energy condition in the process. There is a subtraction of energy involved here. But in this example the energy involved never goes below the normal baseline for the vacuum. So there can be shown examples of a valid warp field with bi-polar gravity fields that do not require us to generate exotic energy of any type.

For those familiar with usual rules of special relativity, with its Lorentz contraction, mass increase, and time dilation, the Alcubierre warp metric has some rather peculiar aspects. Since a ship at the center of the moving volume of the metric is at rest with respect to locally flat space, there are **no** relativistic mass increase or time dilation effects for the craft at all in either proposed field model. In fact, an examination of any inflation field effects will show that while particles entering such a field do display untra-violet blue shifts, those shifts are do to our time slice of sampling being shortened. In simple terms even within the regular warp field region those particles do not undergo any real change in energy from their normal C or sub-light state. An observer in the field, but not the craft's region or external to the field would see photon's shifted to UV cutoff and exiting the field as Hawking like radiation. But, if we actually measured the energy of those photon's they would have no more energy than they would in normal space-time. The Blue shift is caused by our measurement point(limited to C) being shorted in relation to the whole wave itself. The Key to this is the fact that every ability to measure them in limited by our normal lightcone, while the field itself has an expanded lightcone involved where C is shifted to some multiple of it's normal value.

The starting point of a theoretical exploration of cosmology is the Einstein equation

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G_N T_{\mu\nu}$$

with a metric of the form

$$ds^2 = -dt^2 + a(t)^2 \left(\frac{dr^2}{1-kr^2} + r^2 (d\theta^2 + \sin^2\theta \, d\phi^2) \right)$$

The spacetime being modeled by this equation can be neatly separated into time and space, so we can talk of this spacetime as representing the evolution of space in time.

To solve the Einstein equation, we need to postulate some "stuff" in the spacetime, such as matter, radiation or vacuum energy, with energy momentum tensor $T_{\mu\nu}$ whose components are the energy density ρ and pressure p of the "stuff" in question. The equations for the scale factor a(t) are

$$\left(\frac{\dot{a}(t)}{a(t)} \right)^2 = H^2 = \frac{8\pi G}{3} \rho - \frac{k}{a^2}$$

$$\frac{\ddot{a}(t)}{a(t)} = -\frac{4\pi G}{3} (\rho + 3p)$$

Here we have truncated Newton's constant G_N to plain G. The top equation contains the condition for the closure density of the Universe.

What is part of the energy density ρ, can be many things.   For bookkeeping purposes, let's label each different ρ by an index i, so that ρ_i refers to the energy density from the ith type of "stuff" in this spacetime. Let's also set something called the critical density ρ_{crit} and then make the above equation dimensionless by dividing everything by the critical density:

$$\rho_{crit} = \frac{3H^2}{8\pi G}, \quad \Omega_i = \frac{\rho_i}{\rho_{crit}}, \quad \Omega = \sum_i \Omega_i$$

Let's call Ω the density parameter. The equation that will tell us the curvature of space from the stuff content of the space-time becomes

$$\Omega - 1 = \frac{k}{H^2 a^2}$$

The three possibilities for the value of the parameter k correspond the three different possibilities for the curvature of space in this space-time. A value of k=1 corresponds to constant positive curvature, k=0 to zero curvature and k=-1 to constant negative curvature.

The time evolution of space is more complicated because it depends on the equation of state of the stuff in space-time. The equation of state is the relationship between pressure and density in the stuff. Energy conservation plus the equation of state determine how the energy density changes as space evolves in time.

This is where vacuum energy becomes important. The energy densities for matter, radiation and vacuum energy change with the size of space (the scale factor a(t)) like

$$\rho_{matter} \sim a(t)^{-3}$$
$$\rho_{radiation} \sim a(t)^{-4}$$
$$\rho_{vacuum} \sim 1$$

So as the Universe is getting bigger, the energy density from matter and radiation would be getting smaller, but vacuum energy density would remain the same. The only point where energy density for the vacuum changes normally is when energy is introduced into the vacuum like with a coupled scalar field or even an EM field itself. There is also the case, growing in supporting evidence for a time variable vacuum energy density which could be related to a varying Cosmological constant.

The upper bound in terms of energy density for what we assume to be our now present stable vacuum is 10^-9 joules per cubic meter. So any increase in the local energy density of a confined region of space-time would translate to the vacuum shifting from that of a stable case to a false vacuum state. In the presence of mass this is not true. But in the presence of a confined energy field this would hold true since this state will shift back to it's normal energy level as that confined field effecting it, drop's off at a rate, in the case of EM, following the 1/r^2 rule.

Energy systems in general can be treated as the sum of electromagnetic and gravitational energy. But one key is that confined EM energy also produces a local change in the whole energy present which does equal a change in the overall gravitational energy since it's the energy present in a given volume of space-time that produces the curvature effect of gravity in the first place. So an EM field can in theory produce a curvature of space-time. The real problem is that the strength difference between the two field's is some 1000 fold. For an example, an EM field of 10^-9 Joules per cubic meter would translate to approximately a gravity field of 10^-12 joules per cubic meter. So with regular EM we do not get much for our buck, so to speak. To produce 1 joule per cubic meter we'd need a field strength of 1000 joules per cubic meter. The conversion into voltage is even more interesting:

J/s/A(W/A)

$$V = \frac{W}{q_{moved}}$$

$$1\frac{J}{C} = 1\text{volt}$$

since

1eV=1.6*10^-19C

then

1eV=1.6*10^-19J

One can from this get a hard perspective on the energy involved in even some simple vacuum energy state changes.

Now, If a volume of gas expands or contracts, the mass density changes, producing a positive pressure that, in the simplest case, follows the Ideal Gas Law (**p = nRT/v**). However if a volume of mass-containing vacuum expands or contracts, the mass-energy density remains constant, and the pressure in this case is *negative*. The gravitational effect of this negative pressure overwhelms gravitational attraction of the mass and results in a net repulsive force. That force grows linearly with distance, becoming very strong at large distances and balancing the tendency of model to collapse in the cosmological case. In our case, since the model is based upon a controllable EM field producing the contraction we keep the model from collapse into a stable singularity and we alter the original constant of the mass-energy density of the local vacuum in the process.

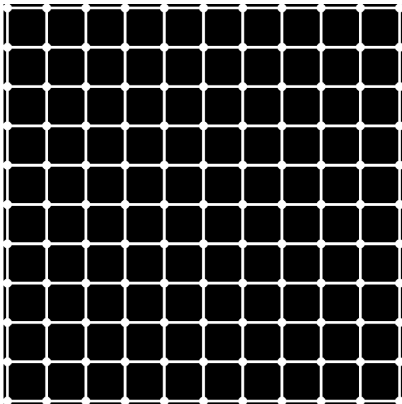
Now simple EM fields, even of a controlled shape, while possible are not the only way to possible alter the energy density. Following Puthoff with his PV model and others including those of coupling scalars to gravity there may be other means available that offer more effect for a given energy input. Each of these could be looked at an experiments projected to test the idea out. But at the present, at least for Sub-light small models of a working Positive energy Warp field the EM approach seems to be the easier one to tackle.

The model this whole positive energy warp drive is based upon is an assumption, in keeping with general relativity and QM that

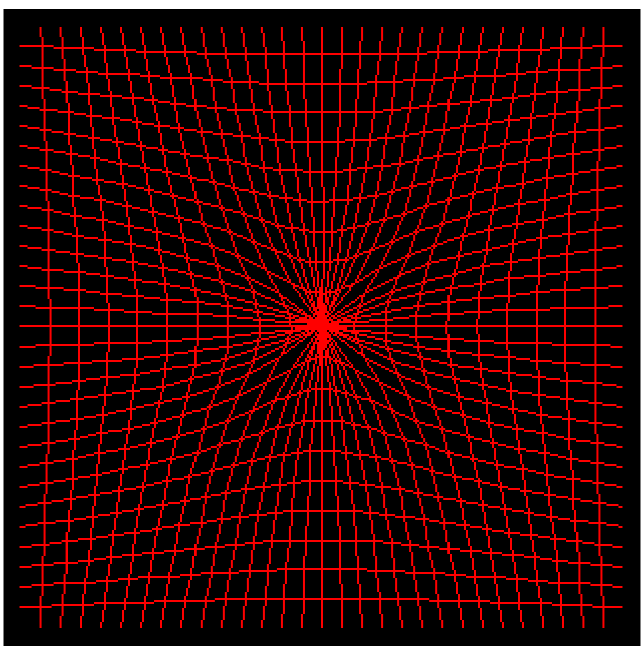
Space-time is a continuous, 3-dimensional elastic field structure which can be "modeled" as a lattice or matrix of interconnected "space-time moments". Tension in this structure increases in the vicinity of matter as does energy density. The effect we see on the vacuum as we look backwards in time is that at some point it's energy density increases to that of a false vacuum state who's initial condition we can at best guess on at present based on certain known facts. We can also assume that any increase in the vacuum's energy density will, once the cause of this increase

is eliminated cause the vacuum to inflate back to normal since such a state is not stable on it's own.

An interesting 2-dimensional model of space-time would consist of interconnected nodes with four filaments, forming a "plane-time continuum".



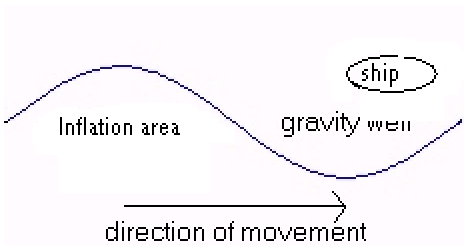
Each of these intersection points is equal to those zero points from my own article and is the origin point of virtual particles in theory. A simple focused energy density change can be illustrated in this format by



This is for a point concentration only. If you picture the above field bouncing back to normal after the compaction field is removed you get an image that returns to that given above at the first which some flux around the normal point as the impulse settles back to it's assumed zero point. Our actual warp field would give a different effect with the frontal region being conical in shape towards a focus point like above and the rear being simple that bounce back effect. What is interesting to note is

that the signature of such a field in supersonic mode approaches that of the original 1D string model I referenced before. One could get the actual warp field shape in the above diagram if we removed the two center fields above and below and just left the left and right side areas effected.

The *assymetric warp field can be shown by*

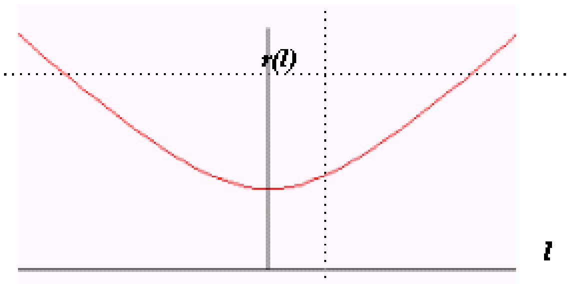


The difficult part is producing a gravity field of large enough strength and shaping it into this format. Mass the size of the earth generates enough gravity to leave us anchored to earth. The moon is 1/6 the size of earth but only generates 1/10 of the gravity. Even if we could duplicate an energy field with the earth's field in a shape like above and given the pull/push effect would be the same once that was done we'd still have to pulse the field fast enough and cover a large enough area of compaction to get a usable multiple of C out of the drive. The problem isn't so much the energy involved. It's the force applied from compaction/inflation and the amount of space-time being moved that would control velocity. An example can be seen by taking 1 light second of space-time(186300 miles) and dividing it out into a certain duration of pulse time, say $1/100000^{th}$ of a second. If our craft could move 186300 miles per .00001 seconds we'd get an average velocity of 100000C out of the drive. But if we can only move say 1 mile per .00001 seconds then we'd get .53C out of the drive. Given the earth's field with an approximate acceleration of 32 feet per second at a pulse rate of .00001 seconds we'd get 3,200,000 feet per second. This is still vastly shy of warp velocity since it's only about 606.06 miles per second. But this is still greater than our current rockets can push a craft. In fact, it's equal to .00035C since our fastest to date does about 6.25 miles per second. So usable ideas based on this propulsion method are within the reach at present if we can find ways to shape the field correctly.

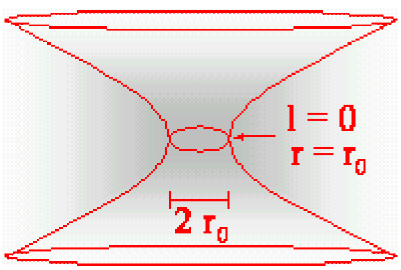
A metric that aptly discribes the shape of the field we need can be taken from the Morris-Thorne-wormhole solution(6)

$$ds^2 = -e^{2\Phi(l)}dt^2 + dl^2 + r(l)^2(d\theta^2 + \sin^2\theta d\phi^2)$$

This describes a wormhole which can be visualized as in the figure below, where r(l) denotes the distance from the center, but the proper radial distance for a traveller moving through the wormhole is measured by the coordinate l.

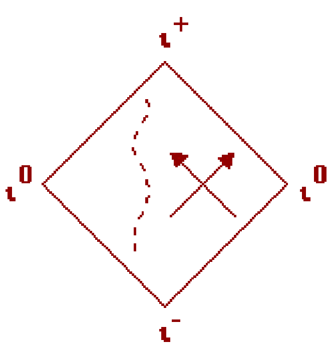


As the wormhole shaped field connects two asymptotically flat space-times, the coordinate l covers the entire range from $-\infty$ to $+\infty$. What we are after here is in our example an EM field shaped like this. Since we control the actual energy involved there is no singularity encountered with the EM approach and the whole structure isn't a real wormhole at all. The absence of event horizons, except those encountered in the forward and rear once in warp makes this field a moving frame's system as discussed before along similar lines to the original Alcubierre warp drive metric(7). Note that r(l) has a minimum value r_0. This would be a region we control to focus the field behind the craft's region. The space-like 2-sphere with the radius r_0 is called 'throat' or 'horizon'.



This leads to the so-called 'flare-out' condition, front and back of the craft that together yields our desired bi-polar field for propulsion.

In order to visualize the causal properties of a space-time, Penrose diagrams can be employed (8). Fig.3 shows the diagram for flat Minkowski-space, where two dimensions are suppressed.

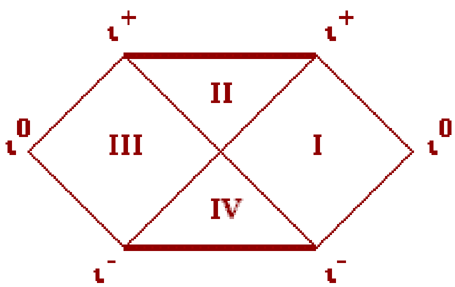


The symbol **i** stands for infinity. $\mathbf{i}^-$ denotes the past, $\mathbf{i}^+$ the future infinity and $\mathbf{i}^0$ the spatial infinity. Thus we have got a compactified space-time: Every time-like, space-like or null curve must lie completely within.

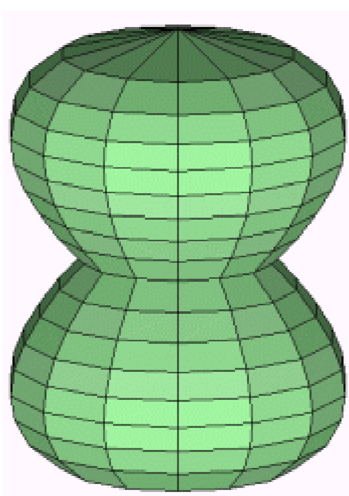
The two arrows shown are two null vectors. In Penrose diagrams null vectors are always orthogonal and parallel to the directions $\mathbf{i^-i^0}$. This makes the discussion of the causal properties of a space-time easy.

The dotted line is a time-like curve, i.e. every tangent vector is time-like, so it could be the path of a test particle.

Fig.4 symbolizes a black/white hole. The regions I and III have the same causal properties as in fig.3. But a test-particle in the region II will always meet the upper bold line $\mathbf{i^+i^+}$, which denotes the future singularity. In analogy, a particle in region IV must always come out of the past singularity $\mathbf{i^-i^-}$ ('white hole'). The lines $\mathbf{i^-i^+}$ are the event horizons.

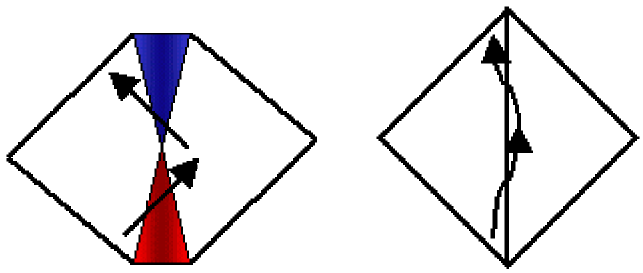


The great advantages of the definition of a wormhole shape by the flare-out condition can be seen when examining some more general space-times.

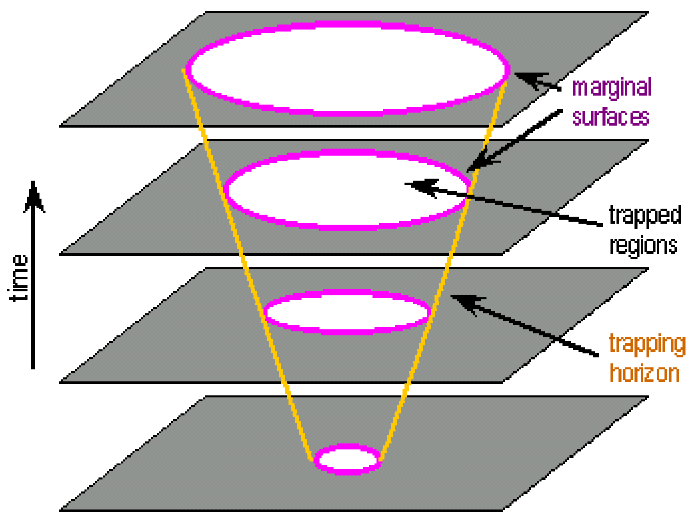


You have a region of flat space-time being compressed by the field which increases by artificial means the local stress-energy tensor at the focus point of the field. After this region the second flare out region at the bottom of the above diagram is formed by the natural drop off of our field that allows the vacuum to inflate back to the normal flat space-time condition specified in QM as the Zero Point Field condition. This inflation generates a temporary energy condition violation that provides our engineered negative energy like field to produce the bi-polar effect. The important thing to remember is the energy condition violation is provided by natural inflation of a false vacuum state back to it's baseline level, not by shifting the normal vacuum below that baseline.

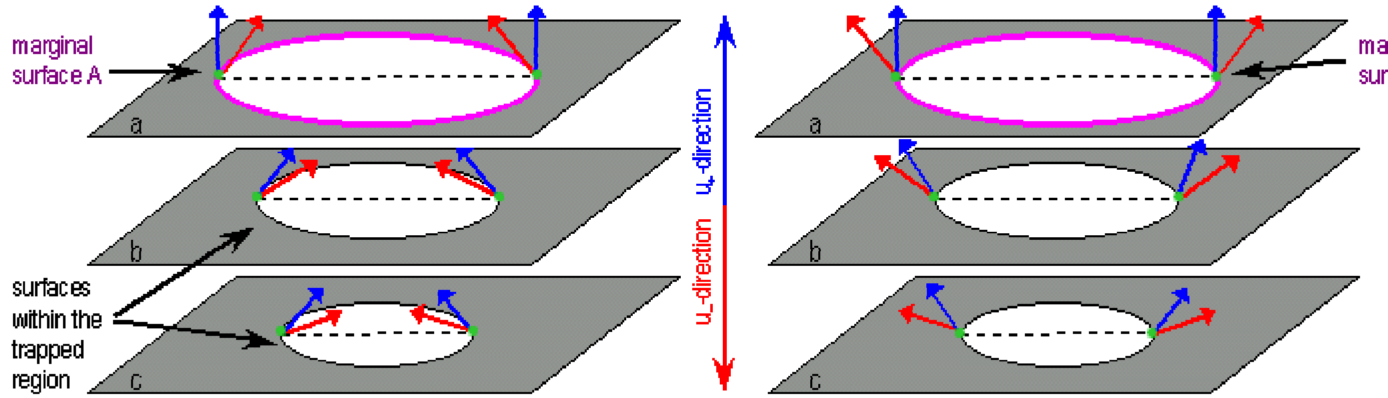
In order to cover the dynamic case, too, we define a wormhole through the trapping horizon generated by the marginal surfaces: a wormhole throat is given by a time-like (and therefore traversible) outer trapping horizon.



The case we are generating is a field in the traversable case show by the diagram to the right instead of the diagram to the left. There is a traped surface encountered in two direction with this field. One is forward of the craft as far as control goes beyond the Plank scale. The other is aft of the craft for signals originating there. This same issue has been encountered before with the Alcubierre type drive. But at the plank scale, once in warp there would remain a finite region ahead of the craft that we have control over based upon the wave function of the field for that area.



The *foliation of marginal surfaces generates a trapping horizon for any craft moving past C for the local vacuum.*



The first example is how future lightcones become trapped while the second deals with the past ones. In our field example the forward regions become compressed around the Plank scale ahead of the craft. The rear region is fully controlled by the craft since our control is moving backwards in time, not forward. But we cannot view anything from that region while in warp. There is still the question of being able to scan ahead for objects in our path and to navigate. However, in pulsed mode only this issue can be addressed with the scans being run in between pulses(see afterword for a solution to this). We'd only be flying blind during the duration of each pulse itself since during the off points of the pulse no trapping surface exists ahead or behind the craft.

The reason I addressed this negative energy issue with the side step of avoiding exotic energy is based upon the following. Every normal wormhole like warp field must contain exotic matter. This expression is often used to stress the fact that several energy conditions are violated. It follows from the claim $\partial\theta_+/\partial u_- < 0$ and the traversability of the trapping horizon (throat) that the null energy condition (NEC) is violated.

$$\text{NEC} \Leftrightarrow T^{\mu\nu}k_\mu k_\nu \geq 0$$

where T is the energy density and k any null vector. Thus a violation of the NEC requires the existence of negative energy matter. As we do not know matter with such properties, the expression exotic matter is sometimes used. The problem is that outside of certain Casimir like effects no such exotic matter is known to exist. Secondly, there are some strick energy condition violation rules(9) that must be obeyed that put strong constraints on regular warp field's being possible. However, none of these apply to a false vacuum state which by nature must violate its own energy conditions to seek a stable condition.

(For A strong treatment on both the expanded compact lightcone states and a possible solution to our forward control issue see afterword following the general article's reference section.)

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AFTERWORD

INTRODUCTION

String theory is naturally formulated in more than four space-time dimensions. Studies of duality symmetries have revealed that what used to be thought of as five distinct ten-dimensional superstring theories - Type I, Types IIA and IIB, and heterotic theories based on gauge groups E(8) $\times$ E(8) and SO(32) - are, along with eleven-dimensional supergravity, different low-energy weak-coupling limits of a single underlying theory, sometimes known as M-theory. In each of these six cases, the solution with the maximum number of uncompactified, flat spacetime dimensions is a stable vacuum preserving all of the supersymmetry. To bring the theory closer to the world we observe, the extra dimensions can be compactified on a manifold whose Ricci tensor vanishes. There are a large number of possible compactifications, many of which preserve some but not all of the original supersymmetry. If enough SUSY is preserved, the vacuum energy will remain zero; generically there will be a manifold of such states, known as the moduli space.

To describe our world we want to break all of the supersymmetry. We also want one solution that generates, for all intents a vacuum energy of zero, and only 4 large dimensions. Most of this same problem is encountered with more classical approaches like the Standard model. There have been proposals over the years on how to deal with this. In three space-time dimensions supersymmetry can remain unbroken, maintaining a zero cosmological constant, in such a way as to break the mass degeneracy between bosons and fermions. This mechanism relies crucially on special properties of spacetime in (2+1) dimensions, but in string theory the strong-coupling limit of one theory is another theory in one higher dimension. Really String Theory, in many ways, is a combination of many theories in one set.

String theory obeys the ``holographic principle'', the idea that a theory with gravity in *D* dimensions is equivalent to a theory without gravity in *D*-1 dimensions. The Problem is no one to date has one unified set of equations derived from a unified number of dimensions that generates all the above, except certain forced models(1). In fact, we have a multitude of models being generated, each with their own mass, their own set of compact, or non-compact dimensions, and even their own brand of off the brane state.

Now some narrowing of the field has been accomplished over the years. This narrowing has come from several fronts with the two main ones being experiment and observation. The experiments have centered on predicted mass for the Higg's Boson and the observation has put contraints on the size of these other dimensions.

THE COMPACT OR NON-COMPACT ISSUE

The novel approach to compactification starts by imagining that the fields of the Standard Model are confined to a (3+1)-dimensional manifold (or ``brane'', in string theory parlance) embedded in a larger space. This was the one I took in my own dual time model. This other larger or smaller dimensional universe under this theory normally does not have a size limit imposed except that it not be visable. Being not visable can be accomplished by something as simple as a time difference(phase, direction, or duration) with the last leading to expanded lightcone states. While gravity is harder to confine to a brane, phenomenologically acceptable scenarios can be constructed if either the extra dimensions are any size less than a millimeter, or if there is significant space-time curvature in a non-compact extra dimension. To date, the strongest observational evidence places the scale of these extra dimensions closer to that of the Plank scale(2). This same restraint, I might add, is encountered in more classical Relativity based theory like Double Special Relativity and certain models that employ compacted regions in a 4D universe with expanded lightcone states that fall under the scale varying C approaches.

Now almost all of the non-compact versions are 5 dimensional and relate backwards to the Kaluza- Klein, which it is true, Einstein endorsed the view of Kaluza that gravity could be combined with electromagnetism if the dimensionality of the world is extended from 4 to 5. Their original theory was not compact, but just assumed this fifth dimension could not be view. In the more modern String theory view this fifth dimension is assumed to be part of the higher 11 dimensional universe. But to date, no one has been able to come up with a sound theory that answers the original problems I stated in the introduction. So it can be assumed that these proposed theories are not only incomplete if the assumption on M-Theory being correct is taken at face value. The fact, that observational evidence places strong constraints on their size even further limits the accuracy of these theories at the present. For the moment there is no ten-dimensional version of this scenario.

One thing that is often forgotten in all this large extra dimensions idea is that the whole idea behind String Theory in the first place is to model the particle world and come up with a real Unified Field Theory. The quantized normal modes of a closed string appear as an infinite tower of particles. Unlike theories of point particles, consistent quantization imposes severe restriction on what string theories we can have. At the perturbative level, this requires that the theory must live in ten space-time dimensions and has to be supersymmetric. There are five such known perturbative theories which are consistent – and all of them have the feature that their spectrum contains a massless spin-2 field which has properties identical to that of a graviton. In fact while we don't know a complete formulation of the theory we know its low energy behavior: this is given by a usual field theory –supergravity. And we also know that the spin-2 field which appears in the perturbative spectrum is indeed the graviton in this supergravity theory. In other words, the low energy limit of string theory contains standard general relativity. This implies it must obey at the low level the same general set of rules from GR. At High energy scales(equal to very compact regions) it does not follow that it obey such and there can be expanded lightcone states.

There is also the issue that certain brane states wrapped around other states must generate a model in the end run that obeys what we already know experimentally true from both QM and the Standard model. Another words, somewhere along the way these different states have to combine to give at least the illusion of point particles. This in itself limits the scale of these extra dimensions. If they were generally large we'd notice a deformation in their shape. The fact we do not as far down as we can observe them we see no such deformation. At current date the smallest state ever partially observed is that of a single atom suspended in a container and forced to glow as at one time demonstrated on the TV show Discovery.

The Strongest observational evidence for small extra dimensions comes from the study of gravity. If they we very large we'd notice a direct drop off effect on gravity. To date, everything points towards it following the 1/R^2 rule(3).

The important thing to remember is there is strong theoretical evidence for it being possible to send Boson's like the Graviton or the Photon off the brane or into these hidden dimensions to take advantage of these expanded lightcone states.

THE CENTRAL IDEA

The string is closed by considering the multidimensional frame either 11 or 26 to be a compactified 25+1 dimensional Minkowski spacetime due to considering the Universe to "... be a perfect absorber in the future ...[as in]... the Wheeler-Feynman ... absorber theory of radiation (4). For most of the matter in our universe this requires a Black Hole Era. This era is fully satisfied by the general concepts of the Inflationary Big Bang Model since you have the start of creation from a finite point in time and space I have refered to in publication(5) as a zero point. Such a compactification is also similar to the conformally compactified 3+1 dimensional Minkowski spacetime(6). Roger Penrose says(7),

"... We can now consider the gravitational self-energy of that mass distribution which is the difference between the mass distributions of the two states that are to be considered in quantum linear superposition. The reciprocal of this self-energy gives ... the reduction timescale ...".

This is the decoherence time $T = h / E$.

For a given Particle, Stuart Hameroff describes this as a particle being separated from itself, saying that

The Superposition Separation a is "... the separation/displacement of a mass separated from its superposed self. ... The picture is space-time geometry separating from itself, and reanealing after time T. ...". The fundamental question is where is that geometry separated to during those off times? It must be going somewhere. It's this somewhere that some call off the brane and this Author terms into the zero point or absolute reference frame.

Let's assume the Superposition consists of States involving one Particle of Mass m, but with Superposition Separation a, then the Superposition Separation Energy Difference is the gravitational energy

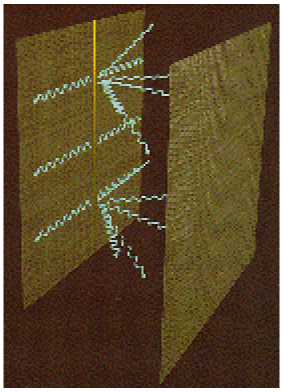
$$E = G m^2 / a$$

Now Hameroff says in the Osaka paper(8)
…that Penrose describes Superposition Separation as "... shearing off into separate, multiple space-time universes as described in the Everett "multi&endash;worlds" view of quantum theory. ...".

If 26-dimensional closed unoriented bosonic string theory is interpreted as a Many-Worlds Quantum Theory in which strings correspond to World Lines then massless spin-2 Gravitons or other Bosons like the Photon correspond to interaction among States with Penrose-Hameroff Superposition Separation. This clearly implies that these particles can exist off the brane, so to speak, and as such if they can exist into these expanded lightcone states then we should be able to send a control signal or receive information via those states also. It not so much a question of Can We, but more a question of How Do We Do It.

A simple description of how they can propagate is given by Stephen Hawking(9). Hawking speaks of branes, which from the viewpoint of this paper, such branes should be regarded as 4-dimensional physical space-time neighborhoods of individual particles. Timelike parts of such branes should be described in terms of 27 -dimensional M-theory, and spacelike parts of such branes should be described in terms of 28-dimensional F-theory(10), with only the character of such states being sought since my own assumption is that these are simply higher energy compacted regions of our regular 4D manifold which by scale are nearer the zero point or absolute reference frame(11) to begin with.

These added frames of reference would imply that we live in a low energy 4D manifold built up of higher energy 4D frames each with there own local and global value for C. Matter and particles possessing rest mass would be confined to the low energy states, except under certain altered reference frame cases. On the other hand, Non-Rest mass particles would permeate the whole bulk of the higher-energy space-time because they would spread out in the extra dimensions. However, they would fall off faster with distance than it would in our low energy four dimensional manifold. This would be controlled by the actual separation scale as the illustration below shows.



In theory the deeper into these warped states a particle goes the further the scale based separation becomes. There is an increase in velocity with an increase in how fast they fall off. An example would be that if a photon falls off at the 1/R^2 rule here in say a 2C state it might fall off at $1/R^{\wedge}4^{th}$. An interesting thing to note is that certain Casimir effect experiments with negative energy have found them to fall off from the focus point of the effect at a 1/R^8 rule. Given that most of these experiments are dealing with a micron or less scale it's possible they are seeing such effects themselves. However, it must be remembered the focus point is itself less than the experiment scale and vastly closer to the Plank level. This could be say, with the first example, a 3C expanded lightcone state or something even higher since we have no real experimental model to base any scale upon at present. It must also be remember that each brane state near our brane would prevent gravity from spreading far into the extra dimensions unless the power level was very high and would mean that at distances greater than the brane separation, gravity would fall off at the rate one would expect for four dimensions.

However for argument sake let's assume the 1/R^8 rule shown by Casimir effects was an upper limit on these states we can actual penetrate. We know it must be a state with a C value greater than our own. If that is the case then we should be able to send signals over this channel for at least a distance equal to that wave's drop off back to the low energy scale. We also should be able to receive such signals since two way communication is not forbidden. In the limit as we approach the horizon, the background space is approximately anti-de Sitter space (a cosmology of constant negative curvature forced to compact). Macroscopically, we have a surface with a U(N) super-Yang-Mills theory living on it, considered in the limit of large N. This limit of Yang-Mills theory has its own special simplifications, pointed out long ago by 't Hooft and resurfaced by myself(12). Anti-de Sitter space has the peculiar property that light can propagate to spatial infinity in finite time. Thus, the boundary at spatial infinity plays an essential role in the dynamics. It's this boundary region between what I have termed sub-space domains that would be the area we need to explore further before one can say for sure we have a full means of extending a warp field control beyond the Plank scale into macro-scale ranges. The background issues needed to make stronger theory in this area may be found in Witten's own article and several others(13).

AFTER THOUGHTS IN MATH

Einstein's 1915 symmetric connection gravity field equation is

$R_{uv} - (R/2)g_{uv} + Cg_{uv} = -(8pi\ G/c^4)\ T_{uv}$

C is the cosmological constant. Replace G by G' below to get a much stronger local anholonomic hyperspace bending of space-time geometry ~ G(R/r)^7 or ^8 by the stress-energy tensor of matter. That is, under certain controllable conditions, we may find that the effectiveness of energy in bending space-time can be greatly amplified in small regions of 4-dim space-time without huge energy densities from the T_{uv} tensor field itself. This would imply that there exists an energy threshold of sorts beyond which we can push signals over into these compacted regions and take advantage of their expanded lightcone states. A negative-pressure equation in T_{uv} makes negative curvature the norm of Anti-de Sitter space-time. It's this effect that actually widens the lightcone of each compacted sub-space domain since the effect is to reduce T_{uv} for each of these regions in a specific way. This same effect is what gives any valid warp metric it's ability to increase velocity far in excess of the normal space-time barrier limits on C.

Suppose we want to inflate the Planck scale from 10^-35 meters to 10 meters in a limited space-time region, i.e., "Mr. Tompkins in Wonderland" (George Gamow) for real. This means that G1/2 gets 36 powers of 10 stronger.

R/r ~ 10^72/7 ~ 10^10.3

If R ~ 10 meters, r ~ 1 nanometer. The Planck scale is

L* = (h'G'/c^3)^1/2

Suppose, in general

R ~ L*

R ~ (h'G(R/r)^7)/c^3)^1/2

1 ~ (h'G R^5(1/r)^7)/c^3)^1/2

The electro-gravitic/magneto-gyro Blackett effect in rotating neutral masses is

Q = G'^1/2M

> >

> > If $m = 10^{-27}$ gm (electron)

$$G^{1/2} \sim 2.6 \times 10^{-4} \text{ cgs Newton}$$

$$Q(\text{Newton}) \sim 10^{-32} \text{ cgs/esu}$$

Compare to the electron's $e \sim 4.8 \times 10^{-10}$ in the same cgs units. For the 10 meter inflated Planck scale the Blackett $Q \sim 10^4$ esu $\sim 10^{14}e$ for a single electron mass. Similarly, for the Wesson Regge effect

$$J = pM^2$$

$$p \sim G'/c$$

Note the relation between the Blackett and Wesson effects in terms of the extreme nonradiating blackhole with zero surface gravity is

$$(G'M/c^2)^2 - G'(Q/c^2)^2 = (J/mc)^2$$

If we apply Blackett effect equation to the bare mass M and bare charge Q,

$$(G'M/c^2)^2 - G'G(M/c^2)^2 = (J/mc)^2$$

$$(G'/c^2)^2 - G'G(1/c^2)^2M^2 = (J/mc)^2$$

$$(G'^2 - G'G)M^2 = (Jc/m)^2$$

$$(G'M/c^2)^2(1 - G/G') = (J/mc)^2$$

$$m = M(1 - G/G')^{1/2} = M [1 - 1/(1 + (R/r)^7)]^{1/2} = M [(R/r)^7/(1 + (R/r)^7)]^{1/2}$$

Which in the Newtonian limit $m \to 0$ because $R/r \to 0$. The bare mass M is regained in the strong hyperspace limit $R/r \gg 1$. In general, we have the Wesson law from the Blackett law provided that elementary particles are tiny black holes. This connection between strings and blackholes is known. The maximal J is then

$$J = (G'/c)m^2$$

for a rotating 1-dim string like state. Thus,

$$J \sim m^{(1 + 1/n)}$$

for n-dim object because the maximal

$$J \sim mvr, \quad \max v \sim c$$

so omega $\sim 1/r$, n-dim object of uniform density has m

$\sim r^n$, $r \sim m^{1/n}$, & $J \sim mcr \sim m(1 + 1/n)$.

If we look at

$$m = M [(R/r)^7/(1 + (R/r)^7)]^{1/2}$$

and let $r = h/mc$ then

$$m^2 = M^2 [(Rmc/h)^7/(1 + (Rmc/h)^7)]$$

$$m^2(1 + (Rmc/h)^7) = M^2 (Rmc/h)^7$$

$$(Rmc/h)^2(1 + (Rmc/h)^7) = (RMc/h)^2 (Rmc/h)^7$$

$$x = Rmc/h$$

$$x^2 (1 + x^7) = X^2 x^7$$

$$x^9 - X^2 x^7 + x^2 = 0$$

which has 2 zero roots.

$$(x^7 - X^2 x^5 + 1)(x - 0)^2 = 0$$

We then seem to get a self-consistent mass spectrum with 7 possibly non-zero roots that is consistent with the Wesson Regge plot. This implies we can at least keep certain physical states stable in any compacted region state.

Now you must notice I did imply real mass values here for a purpose. This is where that often quoted assumption we can transfer large bulk items from our normal 4D low energy manifold off the brane, so to speak, comes from. Nothing forbids mass, by the math from such a transfer except the size of these compacted regions. My assumption above was totally based upon a larger low energy scale in contrast to something I stated at the start that this effect is scale limited in the first place. If it is found that these extra regions or domains are indeed smaller than low energy scales then this whole argument falls apart. However, the argument does not fall apart for Boson like states which EM relies upon since the carrier of any electromagnetic effect is a spin one Boson.

I believe the strongest evidence outside of observation concerns the small value of the Cosmological Constant. Again Einstein's 1915 symmetric connection gravity field equation is

$$R_{uv} - (R/2)g_{uv} + Cg_{uv} = -(8\pi G/c^4) T_{uv}$$

Where C is the cosmological constant. If we do the same replacement from before, but assume the scale to be much smaller then we end up with a set of near infinite domains that cancels out to a low energy limit with a Cosmological Constant near what observational evidence requires. There would also seem to be a left over extra amount of energy that would be the driving mechanism behind the observed accelerated expansion and variance of C with time. The key is the fact that the effectiveness of matter in bending space-time can be greatly amplified in small regions, not large one's, as I stated at the first in this afterword example. That being the case there exists some strong math reasoning and observational evidence against the case of large extra dimensions and in favor of very large energy small scale compacted regions instead. These two constitute a solid No-Go against any bulk matter transfer off the brane and a solid Go for creating artifical inlarged quantum states in any case where the local value of T_{uv} can be altered and in being able to signal through these compact regions to achieve FTL control of a warp field.

In a weak field approximation and a vacuum region gravitational waves travel at the speed c by deriving the gravitational wave equation:

$$\eta^{\lambda\sigma}h'_{\mu\nu,\lambda\sigma} = 0$$

In the weak or low energy condition the equation for the affine connection becomes

$$\Gamma^{\lambda}{}_{\mu\nu} = (1/2)\eta^{\lambda\sigma}(h_{\mu\sigma,\nu} + h_{\nu\sigma,\mu} - h_{\mu\nu,\sigma})$$

If we then refer to the equation for the Riemann tensor

$$R^{\lambda}{}_{\mu\rho\nu} = \Gamma^{\lambda}{}_{\mu\nu,\rho} - \Gamma^{\lambda}{}_{\mu\rho,\nu} + \Gamma^{\lambda}{}_{\sigma\rho}\Gamma^{\sigma}{}_{\mu\nu} - \Gamma^{\lambda}{}_{\sigma\nu}\Gamma^{\sigma}{}_{\mu\rho}$$

Replacing in the expression for the affine connections and keeping only first order terms in $h_{\mu\nu}$ we arrive at

$$R^{\lambda}{}_{\mu\rho\nu} = (1/2)[h^{\lambda}{}_{\nu,\rho\mu} - \eta^{\lambda\sigma}h_{\mu\nu,\rho\sigma} - h^{\lambda}{}_{\rho,\nu\mu} + \eta^{\lambda\sigma}h_{\mu\rho,\nu\sigma}]$$

We next contract this to get the Ricci tensor

$R_{\mu\nu} = R^{\lambda}{}_{\mu\lambda\nu}$

resulting in

$$R_{\mu\nu} = (1/2)[h^{\lambda}{}_{\nu,\lambda\mu} - \eta^{\lambda\sigma}h_{\mu\nu,\lambda\sigma} - h^{\lambda}{}_{\lambda,\nu\mu} + \eta^{\lambda\sigma}h_{\mu\lambda,\nu\sigma}]$$

Using the raising index property of the contravarient metric tensor we simplify this to

$$R_{\mu\nu} = (1/2)[h^{\lambda}{}_{\nu,\lambda\mu} - \eta^{\lambda\sigma}h_{\mu\nu,\lambda\sigma} - h^{\lambda}{}_{\lambda,\nu\mu} + h_{\mu}{}^{\sigma}{}_{,\nu\sigma}]$$

Rearranging the terms we have

$$R_{\mu\nu} = -(1/2)[\eta^{\lambda\sigma}h_{\mu\nu,\lambda\sigma} + h^{\lambda}{}_{\lambda,\nu\mu} - h^{\lambda}{}_{\nu,\lambda\mu} - h_{\mu}{}^{\sigma}{}_{,\nu\sigma}]$$

With a little algebraic manipulation, insertion of delta kronecker, and redefinition of indices, this can be rewritten

$$R_{\mu\nu} = -(1/2)\{\eta^{\lambda\sigma}h_{\mu\nu,\lambda\sigma} - [h_\mu{}^\sigma - (1/2)\delta_\mu{}^\sigma h^\lambda{}_\lambda]_{,\sigma\nu} - [h^\sigma{}_\nu - (1/2)\delta^\sigma{}_\nu h^\lambda{}_\lambda]_{,\sigma\mu}\}$$

Einstein's field equations can then be expressed as

$$R_{\mu\nu} = (8\pi G/c^4)[T_{\mu\nu} - (1/2)g_{\mu\nu}T]$$

resulting in

$$-(1/2)\{\eta^{\lambda\sigma}h_{\mu\nu,\lambda\sigma} - [h_\mu{}^\sigma - (1/2)\delta_\mu{}^\sigma h^\lambda{}_\lambda]_{,\sigma\nu} - [h^\sigma{}_\nu - (1/2)\delta^\sigma{}_\nu h^\lambda{}_\lambda]_{,\sigma\mu}\} = (8\pi G/c^4)[T_{\mu\nu} - (1/2)\eta_{\mu\nu}T]$$

Now turning to which coordinate system to use at this point. We may have a coordinate system in which the

$[h_\mu{}^\sigma - (1/2)\delta_\mu{}^\sigma h^\lambda{}_\lambda]_{,\sigma\nu}$ and $[h^\sigma{}_\nu - (1/2)\delta^\sigma{}_\nu h^\lambda{}_\lambda]_{,\sigma\mu}$ terms are not zero. In this case, consider the following infinitesimal coordinate transformation

$$x'^\mu = x^\mu + \varepsilon^\mu$$

Doing this we find that $h_{\mu\nu}$ transforms according to

$$h'_{\mu\nu} = h_{\mu\nu} - \varepsilon_{\mu,\nu} - \varepsilon_{\nu,\mu}$$

We can then choose to do the infinitesimal coordinate transformation so that

$$\eta^{\lambda\sigma}\varepsilon_{\mu,\lambda\sigma} = [h_\mu{}^\sigma - (1/2)\delta_\mu{}^\sigma h^\lambda{}_\lambda]_{,\sigma}$$

which is the same as requiring

$$\eta^{\lambda\sigma}\varepsilon_{\nu,\lambda\sigma} = [h^\sigma{}_\nu - (1/2)\delta^\sigma{}_\nu h^\lambda{}_\lambda]_{,\sigma}$$

Inserting these in the formula and computing the transformation for $h_{\mu\nu}$ to $h'_{\mu\nu}$ into the first term and simplification results in

$$\eta^{\lambda\sigma}h'_{\mu\nu,\lambda\sigma} = -(16\pi G/c^4)[T'_{\mu\nu} - (1/2)\eta_{\mu\nu}T']$$

In vacuum $T_{\mu\nu} = T = 0$ resulting in

$$\eta^{\lambda\sigma}h'_{\mu\nu,\lambda\sigma} = 0$$

From this we derive the ordinary wave equation for waves traveling at the speed c. Therefore in a weak field or low energy limit and vacuum region gravitational waves travel at the speed c.

This makes for a second math based strong argument in favor of small compacted regions because the whole situation alters if we employ strong field or high energy limits to this argument. We do know from planetary orbits involving large masses that there is some indication for faster waves being involved as I once discussed on the issue of the speed of gravity before. The argument is simple stated as: if the field source begins to move, does the field gradient point toward the instantaneous or retarded position of the source? This is the crux of the Gravity speed issue. If it points towards the instantaneous position then C is not a limit on velocity or information transfer since gravity waves would transfer information at least on mass. So the answer depends on whether the field updates or regenerates instantly or with delay. This raises a corollary of the causality principle which prohibits the prohibition of true "action at a distance", because every effect must have a *proximate* cause. That means that something (call it an "agent"), whether particle or wave or wavicle, must pass (or fail to pass) between a source of gravity and an accelerated target to produce the acceleration. Moreover, this agent is the carrier of the momentum transferred between source and target.

If gravity is C limited. This would imply, since most gravitating bodies are in motion that for all objects the field gradient point toward the retarded. For fast objects this seems to be counter to current experiments:

1) a modern updating of the classical Laplace experiment based on the absence of any change in the angular momentum of the Earth's orbit (a necessary accompaniment of any propagation delay for gravity even in a static field);
2) an extension of this angular momentum argument to binary pulsars, showing that the position, velocity, *and acceleration* of each mass is anticipated in much less than the light-time between the masses;
3) a non-null three-body experiment involving solar eclipses in the Sun-Earth-Moon system, showing that optical and "gravitational" eclipses do not coincide;
4) planetary radar ranging data showing that the direction of Earth's gravitational acceleration toward the Sun does not coincide with the direction of arriving solar photons;
5) neutron interferometer experiments, showing a dependence of acceleration on mass, and therefore a violation of the weak equivalence principle (the geometric interpretation of gravitation);
6) the Walker-Dual experiment, showing in theory that changes in both gravitational and electrostatic fields propagate faster than the speed of light, *c*, a result reportedly given preliminary confirmation in a laboratory experiment. With results of:
7) An earlier laboratory experiment with summary description in L.J. Wang, A. Kuzmich, A. Dogariu, Nature 406 (2000).277-279.) showed that charges respond to each other's instantaneous positions, and not to the "left-behind potential hill", when they are accelerated. This demonstrates that electrodynamic forces must

likewise propagate at faster than lightspeed more convincingly than earlier experiments showing angular momentum conservation.

8) A new laboratory experiment at the NEC Research Institute in Princeton claims to have achieved propagation speeds of 310 *c*. This supplements earlier quantum tunneling experiments. It is still debated whether these experiment types using electromagnetic radiation can truly send information faster than light. [P. Weiss, Sci. News 157 (2000) p. 375.] Whatever the resolution of that matter, the leading edge of the transmission is an electromagnetic wave, and therefore always travels at lightspeed. However, such experiments have served to raise public consciousness about the faster-than-light-propagation concept.

Of all these experiments, #2 above -- the binary pulsars -- places the strongest lower limit to the speed of gravity: 2×10^{10} *c*. So some experimental evidence does exist that gravity has to have a short cut so that the field gradient point toward the instantaneous to account for all this. But the two together constitute proof that within the low energy limit it's value must equal C and that only small scale compacted regions could have a higher value. It is these compacted regions that not only makes it possible for us to retain forward control at least at the Plank scale, but which also implies it may be possible eventually to increase this distance of control forward to produce a much longer warp field.

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