

# Artificial Wormhole as a Warp Drive Replacement

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Abstract: In the short article I discuss a possible way to replace warp drive with an artificial wormhole generated around a craft in motion and thus use the ability of the wormhole to shorten distance between two points in space-time to replace a warp drive's field effect. I also suggest just how such a field could be generated in the first place.

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A single wormhole can be viewed as a couple of conjugated spheres

$$S_{\pm}^3$$

of the radius  $a$  with a distance

$$d = \left| \vec{R}_+ - \vec{R}_- \right|$$

between centers of spheres. The interior of the spheres is removed and surfaces are glued together. The Green Function of the normal Euclidean space within each sphere is

$$G_0(x, x') = \frac{1}{4\pi^2} \frac{1}{(x-x')^2} \quad (G_0(k) = 1/k^2).$$

This is derived from the Green Function of the Laplace equation:

$$-\Delta G(x, x') = \delta(x - x')$$

The actual throat has a surface density defined by

$$\delta(\vec{x} - \vec{R}_{\pm}) \rightarrow \frac{1}{2\pi^2 a^3} \delta(|\vec{x} - \vec{R}_{\pm}| - a).$$

From this we can now determine that the distance between one side of the wormhole or one sphere to the other side of the wormhole or other sphere is determined by that surface density of the throat.

Now translating this into something akin to our mathematical understanding of Warp drive we are more familiar with there are two aspects that the ship has

control of when it comes to velocity. It can alter its own speed thus changing how fast that additive distance the wormhole provides crosses any single region of space. We can also control the density of that throat region since it is the ship generating the throat in the first place. There is also a third hidden benefit to this method of travel over standard Warp field modeling along either AWD or NWD paths: We can also alter the direction this craft is traveling in which also alters the wormhole's orientation and reverse thrust with a reversal of direction of travel.

But the question remains on how one could generate a wormhole. One cannot simply capture and enlarge a quantum size or virtual wormhole since enlargement in itself will dilute both the wormholes Black hole gravity well and at the same time dilute what ever energy is keeping the throat open. It is also well known that wormholes require exotic energy in most cases to enlarge the throat enough for passage of an object through them. In our case, while the width of that throat has to be enough to generate a wormhole effect in either case certain energy conditions would have to be violated to even create such a wormhole except in the case of a zero expansion throat as mentioned in(1).

In going back to the similarity between Warp drive and Wormholes it might be mentioned that this is similar in some aspects to Fernando Loup's Natario Warp Drive with zero expansion(2) while other wormhole ideas tend more to a similarity to the Alcubierre Warp drive(3).

Now if we look at the two spheres glued together modeling for a wormhole when we consider a warp drive we have again two spheres of space-time glued together or patched with the frontal sphere being a region where the volume of space-time is contracting due to a frontal region just ahead of the craft with a very high gravitational field causing the contraction. The rear sphere is a region of expansion of space-time brought about by a usually equal amount of exotic energy. The region the craft sits in is the actual glued region of the two spheres where the craft sits in free fall towards the frontal gravity well.

Now in a wormhole one has two spheres far removed from each other by a distance controlled by the throats energy density contracted together at the glue point with the craft again in free fall towards the center or cross over point just prior to that singularity gravity field. The difference is a wormhole put into motion by a craft that generates the field is constantly moving forward at what ever distance between the two spheres that the energy density has established. The singularity point actually serves as a shield against incoming radiation and objects. But except on the edges of the throat for navigation one would have to switch the field on and off to see ahead because directly ahead of the craft is a region with black hole like properties.

In general, since expansion of the throat is only needed in the forward direction

one could best use the idea of a zero expansion wormhole and avoid the need for exotic energy altogether. However, we would still need to come up with a means to generate the initial singularity region in a fashion that it could be shut off at will by the craft and its crew. Other than that this means of travel in most articles requires creating a man made singularity opening up the throat and using it more like a Star gate.

The general static metric with cylindrical symmetry can be written

$$ds^2 = -A(r)dt^2 + B(r)dr^2 + C(r)d\varphi^2 + D(r)dz^2,$$

In the coordinates

$$X^\alpha = (t, r, \varphi, z),$$

where

$$A, B, C \text{ and } D$$

are positive functions of  $r$ . The union of the two spheres is at hypersurface

$$\Sigma \equiv \Sigma^\pm = \{x/r - a = 0\}$$

For the throat hypersurface one can use the coordinates

$$\xi^i = (\tau, \varphi, z),$$

where  $t$  is proper time on shell. The curvature of both sides of the shell is given by

$$K_{ij}^\pm = -n_\gamma^\pm \left( \frac{\partial^2 X^\gamma}{\partial \xi^i \partial \xi^j} + \Gamma_{\alpha\beta}^\gamma \frac{\partial X^\alpha}{\partial \xi^i} \frac{\partial X^\beta}{\partial \xi^j} \right) \Big|_\Sigma,$$

with the shell defined by

$$\Sigma : \mathcal{H}(r, \tau) = r - a(\tau) = 0.$$

The Einstein equation is given by

$$- [K_{\hat{i}\hat{j}}] + [K]g_{\hat{i}\hat{j}} = 8\pi S_{\hat{i}\hat{j}},$$

the trace is

$$[K_{\hat{i}\hat{j}}] \equiv K_{\hat{i}\hat{j}}^+ - K_{\hat{i}\hat{j}}^-, [K] = g^{\hat{i}\hat{j}}[K_{\hat{i}\hat{j}}],$$

and

$$S_{\hat{i}\hat{j}} = \text{diag}(\sigma, p_\varphi, p_z)$$

is the stress energy tensor of the surface. With a little substitution we get

$$\sigma = -\frac{\sqrt{1+B(a)\dot{a}^2}}{8\pi\sqrt{B(a)}} \left[ \frac{C'(a)}{C(a)} + \frac{D'(a)}{D(a)} \right],$$

$$p_\varphi = \frac{1}{8\pi\sqrt{B(a)}\sqrt{1+B(a)\dot{a}^2}} \left\{ 2B(a)\ddot{a} + B(a) \left[ \frac{D'(a)}{D(a)} + \frac{2B'(a)}{B(a)} \right] \dot{a}^2 + \frac{D'(a)}{D(a)} + \frac{B'(a)}{B(a)} \right\},$$

$$p_z = \frac{1}{8\pi\sqrt{B(a)}\sqrt{1+B(a)\dot{a}^2}} \left\{ 2B(a)\ddot{a} + B(a) \left[ \frac{C'(a)}{C(a)} + \frac{2B'(a)}{B(a)} \right] \dot{a}^2 + \frac{C'(a)}{C(a)} + \frac{B'(a)}{B(a)} \right\}.$$

where

$p_\varphi$ ,  $p_z$  and  $\sigma$

satisfy the equation

$$p_z - p_\varphi = \frac{C(a)D'(a) - C'(a)D(a)}{C(a)D'(a) + C'(a)D(a)}\sigma.$$

If we establish that the circular radius is defined as

$$\mathcal{R}(r) = \sqrt{C(r)}$$

where

$$C'(a) > 0,$$

We leave free the sign of

$$(CD)'(a)$$

allowing for positive energy to do the same as negative or exotic energy in wormholes. In a flare out state associated with

$$C'(a) > 0,$$

and

$$\sigma > 0$$

we find using an EM field coupled to gravity

$$\begin{aligned} C'(a) &= 2aG(a) [G(a) + aG'(a)] \\ &= 2a (k_1 a^m + k_2 a^{-m}) [(1+m)k_1 a^m + (1-m)k_2 a^{-m}], \end{aligned}$$

$$\begin{aligned} (CD)'(a) &= 2a^{2m^2+1} G^3(a) [(m^2+1)G(a) + 2aG'(a)] \\ &= 2a^{2m^2+1} (k_1 a^m + k_2 a^{-m})^3 [(1+m)^2 k_1 a^m + (1-m)^2 k_2 a^{-m}]. \end{aligned}$$

If we always maintain that

$$\sigma > 0,$$

then any observer or craft within the wormhole or anything passing through the wormhole will always see positive energy matter.

What has been utilized in this treatment is the Israel junction condition. This is the same basic condition under which Fernando Loup utilizing an RS Brane modeling(4) invoked his published idea on hyper drive. However, in this case the same basic junction condition is modified to construct a thin shell wormhole. It was Fernando's thoughts that high energy particles could alter the Israel Junction condition. What I am suggesting is those same high energy particles could be utilized to create the junction condition of both the wormholes singularity and the wormhole's throat. If we could then create the singularity we could also shut off that singularity via a reversal of the process. The logic on this is simple. If we create the Israel Junction condition for a singularity in essence the singularity will appear in that region of space-time. Once that boundary condition is altered the singularity should itself vanish. It is my contention that once you shut off the high energy particles creating the altered boundary space-time should revert back to a normal condition.

One will notice that the general math of the Israel Junction condition lends itself well to both multidimensional brane models and to more conventional modeling of space-time. In this above suggested method to self create a wormhole the space-time involved was our more conventional 4D Einstein type. However, if in the future space-time was proved to be multidimensional then in essence the same basic methods could be redesigned to create at least three types of FTL propulsion: Warp Drive, Wormhole Drive, and Hyperdrive. The reason I have included Warp Drive with all its variants is that the similarity between a wormhole and Warp drive metrics suggests that if you can build one you can build the other. It would only be a matter of which performs the task better. As for testing this out I might suggest some of Fernando's other articles and their suggestion on how to test the whole hyper drive idea out.

(Author's note: Math treatment in this comes from two basic articles.

1. A. A. Kirillov and E.P. Save ova , Dark energy from the gas of wormholes

2.

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Some general aspects of thin-shell wormholes with cylindrical symmetry

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