

On the Arbitrary Reduction of Energy in Alcubierre Warp Drive Solutions with Positive Energy in the Warped Region for Superluminal Motion

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Abstract:

Building on the article [16] where a superluminal Alcubierre propulsion system with positive energy density and positive energy is possible as an improvement over [16], we make a small modification to have a positive energy and positive energy density for a curvature bubble of generic radius R and introduce a way to arbitrarily reduce such energy sources in the warped region.

Introduction:

In 1994, Alcubierre [1] proposed a solution to the equations of general relativity that provides the only viable means to accelerate a spaceship to superluminal velocities without using wormholes. However, a problem was soon identified: Pfenning [4] showed that the required energy is comparable to the total energy of the universe and that it is negative. In the article [16], the problem of the negative energy source in the warped region of the original Alcubierre solution [1] was brilliantly solved by the author of [16]. This paper continues the work by making small modifications to reduce the energy density and energy for the Alcubierre drive with a positive energy source.

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Brief Summary of the Article [16]:

It starts from the most general formulation of Alcubierre [1] in the form of the 3+1 ADM splitting for motion in a generic direction with a given bubble velocity v_x , v_y , and v_z in all spacial directions. under these conditions, the metric is:

$$ds^2 = (dx - X dt)^2 + (dy - Y dt)^2 + (dz - Z dt)^2 - dt^2 \quad (1)$$

where for the [16] the values X, Y, and Z are given by:

$$X = \partial_x \psi_1 \quad Y = \partial_y \psi_2 \quad Z = \partial_z \psi_3 \quad (2)$$

the functions ψ_1 , ψ_2 e ψ_3 e depend implicitly on the velocity $v(t)$

$$v(t) = \sqrt{(v_x(t))^2 + (v_y(t))^2 + (v_z(t))^2} \quad \text{where} \quad v_x(t) = \frac{dx_s}{dt} \quad v_y(t) = \frac{dy_s}{dt} \quad v_z(t) = \frac{dz_s}{dt} \quad (3)$$

are respectively the velocities along the x, y, z axes and from the radius vector that starts from the center of the warp bubble in motion, the modulus of this vector is:

$$r(t) = \sqrt{(x - x_s)^2 + (y - y_s)^2 + (z - z_s)^2} \quad (4)$$

by setting [16]:

$$\psi_x = \psi_y = \psi_z = \psi(r) \quad (5)$$

we have:

$$K^2 - K_j^i K_i^j = 2 \partial_x^2 \psi \partial_y^2 \psi + 2 \partial_x^2 \psi \partial_z^2 \psi + 2 \partial_z^2 \psi \partial_y^2 \psi - 2 (\partial_x \partial_y \psi)^2 - 2 (\partial_x \partial_z \psi)^2 - 2 (\partial_y \partial_z \psi)^2$$

which can be simplified [16] for a soliton ψ described by the equation

$$\partial_x^2 \psi + \partial_y^2 \psi - (2/v_{h2}) \partial_z^2 \psi = \rho$$

the energy density in the warped region is equal to:

$$\text{energy density} = \frac{1}{16\pi} (K^2 - K_j^i K_i^j) = (1/16) (2 \partial_z^2 \psi (\rho + \partial_z^2 \psi) - 4 \partial_x^2 \psi) \quad [16] \quad (6)$$

with the condition $(\partial_z^2 \psi)^2 \geq v_h^2 (\partial_z \partial_x \psi)^2$ (6) [16] this energy density becomes positive:

$$Energy\ warped\ region = k R^2 \frac{v^2}{w} > 0 \quad (7)$$

R is the radius of the warp bubble, and $w < R$

w is the size of the warped region, k is a constant of the order of c^4/G see Pfenning [4]

$$Energy\ density\ warp\ region \cong k R^2 \frac{\frac{v^2}{w}}{R^2 w} \quad (8)$$

ψ it is chosen such that inside the warp bubble X, Y, Z are equal to v (warp bubble velocity) and zero outside the warp bubble.

Proposed Solution Modification:

Setting $\frac{\psi}{b(x, y, z)}$ in place of ψ , with example $b(r) = \frac{2^p}{(1 + (\tanh(\sigma(r-R)))^2)^p}$ $p \gg 1$

and if $b(r)$ equals $b(r) = B \gg 1$ in warped region and 1 inside and outside warped region.

And knowing that:

$$\partial_i \left(\frac{\psi}{b} \right) = \frac{\partial_i \psi}{b} - \frac{\psi}{b^2} \partial_i b > 0 \quad \partial_i b < 0, \quad \partial_i \psi > 0 \quad (\text{small for soliton})$$

and

$$\partial_i^2 b < 0 \quad \partial_i^2 \left(\frac{\psi}{b} \right) \ll 1 \quad \partial_i^2 \left(\frac{\psi}{b} \right) > 0 \quad \partial_i b \cong 10^5 b$$

the (6) after setting $\frac{\psi}{b(x, y, z)}$ in place of ψ and $(\partial_z^2 \frac{\psi}{b})^2 \geq v_h^2 (\partial_z \partial_x \frac{\psi}{b})^2$ is positive

for a value of $B = 10^{50}$ or greater becomes:

$$0 < \text{energy warped region} \leq k R^2 \frac{v^2}{B w} \ll 1 \quad \text{for} \quad [4] \quad (9)$$

w size warped region $w < R$

the energy is small, for example, for an $R = 100$ m, $w=1$, and energy density is:

$$0 < \text{Energy density warp region} \cong k R^2 \frac{\frac{v^2}{B w}}{R^2 w} \ll 1 \quad (10)$$

Conclusion:

The modifications made to [16] maintain a positive energy density and positive energy that can be reduced at will, making the Alcubierre drive a realistic possibility with the existence of superluminal motion.

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