Metamaterial or ordinary magneto-electric matter as an energy source for emulation of the Alcubierre Warp Drive for superluminal motion

Gianluca Perniciano*

Department of Physics of the University of Cagliari, Italy.

Abstract:

In this article, considering the work referenced in [16] that allows for emulation motion up to ¼ of the speed of light, appropriate modifications have been considered where by classes of metamaterials or ordinary magneto-electric materials can be used for an emulation Alcubierre drive that permits superluminal motion.

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.Given the paper [16], we consider a better choice of coordinates to calculate g_x [16] (the magneto-electric susceptibility [20]) of the metamaterial or magneto-electric material in such a way as to satisfy the principles of thermodynamics.

Note: In the following we adopt the notation used by Landau and Lifshitz in the second volume ("The Classical Theory of Fields") of their well known Course of Theoretical Physics [15].

*g.perniciano@gmail.com

The starting metric is that of Alcubierre, to which a coordinate transformation has been applied that, in a medium, is:

$$ds^2=(c/n)^2 dt^2-(dx-v\,f(x')\,dt)^2-dy^2-dz^2 \qquad (1)$$

performing the coordinate transformation $dx'=dx-vdt$ we have

$$ds^2=(c/n)^2 dt^2-(dx'+v\,g(x')\,dt)^2-dy^2-dz^2 \qquad (2)$$

$$g(x')=1-f(x')$$

$$ds^2=(\frac{1}{n^2}-\frac{v^2}{c^2}g(x')^2)c^2dt^2-dx'^2-2v\,g(x')\,dx'\,dt-dy^2-dz^2 \qquad (3)$$

Maxwell's equations in this gravitational field can be written in three dimensions, where D, E, H, and g are vectors [15] and [16]:

$$D=\frac{E}{\sqrt{g_{00}}}+H\,x\,g \qquad B=\frac{H}{\sqrt{g_{00}}}+g\,x\,E \qquad [15] \qquad (4)$$

where $g_{0i}=-g_{0i}/g_{00}$ (vector product x)

$$\varepsilon=\mu=(g_{00})^{(-1/2)}=\frac{1}{\sqrt{1/n^2-(v^2/c^2)g(x')^2}} \qquad (5)$$

$$g_x=\frac{(v/c)\,g(x')}{1/n^2-(v^2/c^2)\,g(x')^2} \qquad (6)$$

$$g_x^2\leq(\varepsilon-1)(\mu-1) \qquad (7)$$

$f(r)$ is one inside warp region, is zero outside warped region is $0<f(r)<1$ in warped region

Now taking the modified metric:

$$ds^2=(c/n)^2 dt^2-\left(dx-v\frac{f(x')}{a(r)}dt\right)^2-dy^2-dz^2 \tag{8}$$

and changing the coordinates, which are the most appropriate in this case:

$$dx'=dx-\frac{v}{a(r)}dt \quad \text{found} \quad ds^2=(c/n)^2 dt^2-\left(dx'+v\frac{g(x')}{a(r)}dt\right)^2-dy^2-dz^2 \tag{9}$$

where $g(x')=1-f(x')$ and have $\varepsilon=\mu=(g_{00})^{(-1/2)}=\dfrac{1}{\sqrt{1/n^2-(v^2/c^2)\dfrac{g(x')^2}{a(r)^2}}}$ (10)

$$g_x=\frac{(v/c)\dfrac{g(x')}{a(r)}}{1/n^2-(v^2/c^2)\dfrac{g(x')^2}{a(r)^2}} \qquad g_x^2\le(\varepsilon-1)(\mu-1) \tag{11}$$

$a(r)=1$ inside and outside warped region, $a(r)=A=constant\gg 1$ in warped region (discrete case) in the warped region (energy source, metamaterial, or ordinary matter)

analitycal case:

$$a(r)=\frac{2^p}{(1+(\tanh(\sigma(r-R)))^2)^p} \qquad p\gg 1 \quad \sigma\gg 1 \qquad [17]$$

Under these conditions g_x it can be reduced as desired and thus satisfy the condition (11) of not violating thermodynamics. For the equations, see [15] and [16].

Conclusion:

In this article, it is shown how to emulate a warp drive for superluminal motion using not only metamaterials but also ordinary magneto-electric materials such as Cr_2O_3 , $g_x = 1.5 10^{-3}$.

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