Journal of High Energy Physics, Gravitation and Cosmology, 2025, 11(3), 914-931
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

Hexagonal Structural Warp Driven Spacecraft: Metamaterials of Alconi-CrAlconi Plates Absorption Negative Matters Casimir Energy from Vacuum

Hung-Te Henry Su[1*], Po-Han Lee[2,3*]

[1]Department of Physics, CCU, Chia-Yi
[2]Department of Electro-Optical Engineering, Taipei Tech, Taipei City
[3]The Affiliated Senior High School of NTNU, Taipei City
Email: *hydrogen0221@gmail.com, *leepohan@gmail.com

How to cite this paper: Su, H.-T.H. and Lee, P.-H. (2025) Hexagonal Structural Warp Driven Spacecraft: Metamaterials of Alconi-CrAlconi Plates Absorption Negative Matters Casimir Energy from Vacuum. *Journal of High Energy Physics, Gravitation and Cosmology*, **11**, 914-931.
https://doi.org/10.4236/jhepgc.2025.113058

Received: December 23, 2024
Accepted: July 13, 2025
Published: July 16, 2025

Abstract

Widely-known that work by Dr. Harold, NASA Johnson Space Center has showed one that the warp drive is feasible. One has seen the spacecraft traveling faster than light-speed in television series Star Trek. The physicists have discussed this. However, current theories are limited to the huge amount of energy required when the spaceship uses Casimir energy. If admits the correctness of Alcubierre's theory, there is no physical reason not to believe that the warp drive can be realized. One generally believes that this is due to the lack of energy sources. We have proved it in previous papers that the Casimir energy has the properties of negative matter (exotic matter) such as 0.00206 *K*-photons and these negative-photons are enclosed by the positive photon "light sphere" of outer shell of spacecraft. We found that the ability of the order of 0.1 nm scale structures can easily solve this problem.

Keywords

Spacecraft, Warp Drive, Alcubierre Metric, Casimir Energy, Exotic Matter, 0.1 nm Scale

1. Introduction

Mexican theoretical phycsian named as Alcubierre who promotes the famous Alcubierre metric [1]. In daily life, the distance between two points on a piece of paper is recorded as the point *a*. If one bends a paper so that two points coincide,

*Corresponding author.

then the distance between the two points is $a = 0$, instead of the distance $a > 0$ on the paper at the beginning.

1.1. Alcubierre Metric

Following Einstein's equations in general relativity, a special space-time metric is established within this context. In 1994, physicist Michel Alcubierre proposed that the wave method can extend space, causing the space in front of the spacecraft (referred to as the "ship") to shrink and the space behind to expand. The direction the ship wants to sail. The ship travels forward on the waves in a range called a "warp bubble", which is a section of flat space-time. Since the ship is not actually moving inside the bubble, but is being carried by the bubble, the restriction in general relativity that the speed of an object cannot exceed the local speed of light is not applicable. Although Alcubierre's metric is mathematically feasible (it conforms to Einstein's field equations), its calculation results may not make physical sense and do not necessarily mean that such a device can actually be built. (But later we will see that such a device can actually be built using metamaterial). The proposed mechanism of the Alcubierre drive implies a negative energy density, and thus requires exotic matter to be used (e.g. the negative status photons of the Casimir energy). Therefore, if exotic matter of the appropriate properties does not exist, then, in practice, an Alcubierre drive cannot be built. However, in his original paper, Alcubierre claimed (following a discussion by physicists analyzing wormhole travel) that the Casimir vacuum created between the two parallel plates would satisfy the Alcubierre drive's load and energy requirements. However, through the examination of the mathematical form of the Alcubierre drive in this paper, it was found that there are differences in the working principles of the drive and the wormhole.

1.2. Special Relativity

Einstein's special theory of relativity explains why there is no difference between the effects of gravity and acceleration. It also explained how gravity is related to the curvature of space and time. Using mathematics, Einstein pointed out that objects curve the surrounding space and time. When the object has a large relative mass (such as a star), this curvature can cause the surrounding space to bend. Anything else that passes next to it, even light, changes its path.

1.3. General Relativity

Einstein's general theory of relativity states that the curvature of space-time will create gravity. When light passes through some massive celestial body, its path is curved. This is due to the curvature of space-time formed by it following the massive object. The cosmic gravity is everywhere in the universe and accelerates all matter, while the inertial frame of special relativity strictly has no acceleration. In 1905, Einstein both resurrected the particle theory of light and defended the correctness of Maxwell's electromagnetic theory. However, these two concepts about

radiation are contradictory: if light is composed of particles, then according to the law of universal gravitation, it will be affected by other substances.

1.4. The Interesting Movie: Star Trek

Science fiction often uses "faster-light navigation" [2] to represent a variety of virtual propulsion methods, most of which have nothing to do with the Alcubierre metric (engine) or other physical theories. Fans of "Star Trek" point out that in "Star Trek", Alcubierre's theory is widely accepted because of the proportionality of the nouns, and is used to explain the apparent violations of the laws of physics on most occasions in the series. The paper written by Alcubierre on the physics of space distortion was published in 1994. At that time, the author of this paper was still in high school in Taiwan region. In 1991, Paramount Pictures was working on the virtual warp engine in the drama. After the physical settings are complete, the essential similarities between the two can be said to be extremely coincidental. This reminds us of the conjecture of curved space.

1.5. Warp Space (Warp Drive)

The warp space is the space experienced when making the space-time transformation [3]-[8]. In this space, one can perform teleport. The warp space is defined. Theoretical research is Special Relativity, time and space conversion, the teleport, the bending theory, the mathematical theory, the theory test, space folding. We must first understand the concept of classical gravitational field. If we want to coordinate gravity with the electromagnetic space-time of special relativity, one must first re-understand the concept of "force" itself. Newton's law of universal gravitation requires that all objects have an intrinsic property called gravitational mass, which is used to measure the gravitational force that each object can exert. In addition, Newton also used three basic laws to summarize the behavior of objects under the influence of any force (gravitational or other). The first, second, and third laws state the equality of action and reaction: for each force (such as a person pushing on a wall), there is an equal and opposite force. Newton's force is what causes an object to deviate from its inertial motion. An object always resists changes in its inertial state, and this resistance is measured by its inertial mass. According to this idea, gravity is a force such as other forces, and gravitational mass is to gravity just as electric charge is to electricity. Objects with the same inertial mass but different charges are accelerated differently in the same electric field, so there is no reason in Newton's theory to assume that gravitational mass and inertial mass must be equal. But the fundamental property of gravity that Galileo and Newton observed is that gravity accelerates all objects equally, regardless of their inertial or gravitational mass.

2. Discussion and Results

2.1. Partition Functions

In statistical mechanics, one considers the famous Boltzmann distribution as be-

low:

$$\frac{N_i}{N}=\frac{\mathrm{e}^{-\frac{\varepsilon_i}{kT}}}{\sum_{j=1}^{M}\mathrm{e}^{-\frac{\varepsilon_j}{kT}}} \tag{1}$$

And, the undetermined expression is shown as

$$\frac{N_i}{N}\overset{(?)}{=}\frac{x_i}{x}=\frac{y_i}{y}\quad \text{BCC [110]} \tag{2}$$

where ε_i means the energy of state i, ε_j means the energy of state j which averaged distributes[1] in the crystals of Alconi, and N_i means the particle-numbers which occupied the state i, N is the total numbers of particles. In scientific sensitivity, the best option for a bulk-region to analysis, in which the Boltzmann distribution is necessary. Due to the reasonable causes, the parameters of the space can completely represent as that of the particle numbers (*i.e.*, $x_i=N_i$, $y_i=N_i$), this is under the situation of the equipartition theorem of energy where the indicated energy is denoted as the surface energy by one bulk of Alconi in nano-scales as below:

$$\gamma=\frac{E_{slab}-NE_{bulk}}{2A},A\ll 1\,\mathrm{m}^2 \tag{3}$$

Widely-known the data of metals[2] $E_{slab}=-25.56\ \mathrm{eV}$ and the second term of Equation (3) is:

$$NE_{bulk}=6\times\frac{1.38\times10^{-23}\,\mathrm{J\cdot K^{-1}\cdot mol^{-1}}\times\overbrace{1064.15\,\mathrm{K}}^{\text{Alconi.Curie.T.}}}{2}\approx 4405\,\mathrm{J\cdot mol^{-1}} \tag{4}$$

Furthermore,

$$2A\approx 2\left(0.1\,\mathrm{nm}\times 0.3\,\mathrm{nm}\right)=0.06\,\mathrm{nm}^2 \tag{5}$$

Totally surface energy in *nano-scales* is[3]:

$$\begin{aligned}&\left(-25.56\,\mathrm{eV\cdot mol^{-1}}=-40.9\times10^{-19}\,\mathrm{J\cdot mol^{-1}}\right)\\&\gamma\equiv\left|\frac{E_{slab}-NE_{bulk}}{2A}\right|=\left|\frac{-\left(40.9\times10^{-19}\,\mathrm{J\cdot mol^{-1}}+4405\,\mathrm{J\cdot mol^{-1}}\right)}{0.06\,\mathrm{nm}^2}\right|_{slab},\\&\gamma\approx\frac{4405\,\mathrm{J\cdot mol^{-1}}}{0.06\,\mathrm{nm}^2}\approx 0.12\,\mathrm{J\cdot m^{-2}},\\&\gamma\approx 0.12\,\mathrm{J\cdot m^{-2}}\approx 7.49\times10^{17}\,\mathrm{eV\cdot m^{-2}}\end{aligned} \tag{6}$$

Pay attention to Equation (4), utilizes of a citerior: *N = 0.1 nm/0.1 nm*, so that also *N = 6 = 0.6 nm/0.1 nm* which can work in Equation (2) and makes sense. By the way, the surface energy of the one bulk made of Alconi has calculated by Equa-

[1]Namely the principle of partitions or the Virial theorem. If the surface energy is by averaged distributed the uniform magnetic fields so that the energy density is pointed of six-section (*i.e.*, the hexagram).

[2]VASP (Vienna ab-initio Simulation Package) were used.

[3]The place of slab must have positive energy. Hence here taken the absolute value.

tion (6).

Remark 1.

Set the structure: *Aconi* (*0.3 nm*)-*Cr* (*0.1 nm*)-*Alconi* (*0.3 nm*) as shown in Figure 1. In this paper, we attempt the atomic spaces to instead of the particle-numbers N_i and N for discussion convince, exceptions of arbitrary $x_i = N_i, y_i = N_i$ being forbidden. And to be avoided the chemical bounds of complexities of any compounds we ignore the abilities of chemical bound actions through the crystals. In this paper, besides special notification, in general contexts, the atoms are indicated as *Al*, *Co*, *Ni*, *Cr*.

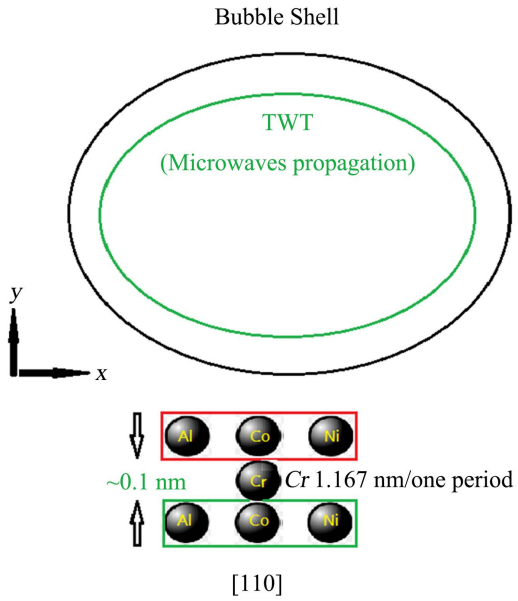


Figure 1. The illustration for Meta-Electronic Conductor (MEC, which fits the torus equation) where the microwaves work is shown. This is a potential matter of metamaterial, because of the potential index of refraction could be changed, of course, spacecraft is aimed the purpose on flying but not nonlinear optics.

Remark 2.

The atom *Cr* is just an atom that is evaporated later, and Alconi with BCC structures should retain to be used as the criterion for Equation (2).

2.2. Thought Experiments: Building the Feasible Structure of Spacecraft

"*With large mass shifts one might be able to build a structure that had a small or zero inertial mass, which could be readily accelerated.*" Claimed by G. Jordan Maclay and Robert L. Forward, on p-495 of Ref. [9]. Based on this thus we attempt to build the possible structure of any spacecraft. Here let us image that one goes a deposition of *Cr* onto two Alconi surfaces, and where remains the spacing in 0.1 nm quantum vacuum. This works on excitation (or extracting) the Casimir energy from the quantum vacuum. Define that 0.1 nm is the fixed measurement and is referred to any magnifying scales (e.g. 0.7 nm). Therefore,

$$\frac{y_i}{y}=\frac{\mathrm{e}^{-\frac{\varepsilon_i}{kT}}}{\sum_{j=1}^{\sigma}\mathrm{e}^{-\frac{\varepsilon_j}{kT}}}=\frac{0.1\,\mathrm{nm}}{0.7\,\mathrm{nm}},$$
$$\mathrm{e}^{-\frac{\varepsilon_i}{kT}}\Big/\sum_{j=1}^{\sigma}\mathrm{e}^{-\frac{\varepsilon_j}{kT}}=\frac{1}{7} \tag{7}$$

where $\sum_{j=1}^{\sigma}\mathrm{e}^{-\frac{\varepsilon_j}{kT}}$ the numbers of particles are $\sigma=3$ (Al, Co, Ni). The surface energy is denoted by

$$\varepsilon_i=K_{Cr}+\varepsilon_{Cas.}=K_{Cr}+\frac{1}{2}\hbar\omega,\omega\neq 0 \tag{8}$$

where the Casimir energy in cosmic vacuum is given by

$$\hbar\omega/2\equiv kT_{C'}/2 \tag{9}$$

and is undoubtedly [10].

$$\frac{\mathrm{e}^{-\frac{\varepsilon_i}{kT}}}{\mathrm{e}^{-\frac{\varepsilon_1}{kT}}+\mathrm{e}^{-\frac{\varepsilon_2}{kT}}+\mathrm{e}^{-\frac{\varepsilon_3}{kT}}}=\frac{1}{7} \tag{10}$$

Another respects, due to *Virial theorem*, the surface-energy is obviously averaged by each atom (Al, Co, Ni ($\varepsilon_1,\varepsilon_2,\varepsilon_3$)). Assuming that

$$\mathrm{e}^{-\frac{\varepsilon_1}{kT}}=\mathrm{e}^{-\frac{\varepsilon_2}{kT}}=\mathrm{e}^{-\frac{\varepsilon_3}{kT}}\equiv\mathrm{e}^{-\frac{\varepsilon_J}{kT}} \tag{11}$$

Therefore,

$$\mathrm{e}^{-\frac{\varepsilon_i}{kT}}\Big/\mathrm{e}^{-\frac{\varepsilon_J}{kT}}=\frac{3}{7},$$
$$\mathrm{e}^{\frac{\varepsilon_J}{kT}-\frac{\varepsilon_i}{kT}}=\frac{3}{7}, \tag{12}$$
$$\frac{\varepsilon_J-\varepsilon_i}{kT}=\ln\frac{3}{7}\approx-0.85$$

Obviously,

$$\frac{\varepsilon_i-\varepsilon_J}{kT}\approx 0.85$$
$$\varepsilon_i-\varepsilon_J\approx 0.85kT \tag{13}$$

It occurs at the displacement of a oscillating of Alconi-CrAlconi plates. The result fits the statement of "*Harmonically oscillating mirror the displacement*" (t/T as x-axis at point 0.85). See Fig. 2 of the Ref. [9] (notice that it is not coincident but the structures of atoms). In the respect of *x*-components, thus we have

$$\frac{x_i}{x}=\frac{\mathrm{e}^{-\frac{\varepsilon_i}{kT}}}{\sum_{j=1}^{3}\mathrm{e}^{-\frac{\varepsilon_j}{kT}}}=\frac{x_i}{7\,\mathrm{m}},$$
$$\mathrm{e}^{-\frac{\varepsilon_i}{kT}}\Big/3\mathrm{e}^{-\frac{\varepsilon_J}{kT}}=x_i/7\,\mathrm{m}, \tag{14}$$
$$\mathrm{e}^{\frac{\varepsilon_J-\varepsilon_i}{kT}}=3x_i/7\,\mathrm{m}$$

Thus we obtain the *Cr*-*Cr* spacing given by

$$x_i = \frac{7\,\mathrm{m}}{3} \mathrm{e}^{\frac{\varepsilon_J - \varepsilon_i}{kT}} \tag{15}$$

Notice that the spacing cannot be arbitrary distributed, since that the ship hull of the spacecraft must connect to the cosmic fields of the Casimir effect (named as *Casimir Sea*), where this way can complete follow the boundary conditions. And this expression (Equation (14)) states such peculiar relationships. In artificial, there must be a structure to layout manipulates of *Cr* atoms. For instance, by using the evaporator to deposit or nano-technology. The former way is simpler and much widely-favored.

Justification: The Casimir effect occurs at *Casimir Sea* at all times, and this type of sea can be sensitively connected to the cosmic energy (*i.e.*, the quantum vacuum).

2.3. The Layout of Atoms

The correct layout of atoms is crucial since that the Casimir force is extracted (excited) via two suitable parallel metals from vacuum. Let the surface energy of Alconi-Alconi equal to *Cr* kinetic energy, hence $3\varepsilon_i = K_{Cr}$. Utilize the Taylor's expansion:

$$\begin{aligned} x_i &= \frac{7\,\mathrm{m}}{3}\left(1 + \frac{\varepsilon_J - \varepsilon_i}{kT} + \frac{1}{2!}\left(\frac{\varepsilon_J - \varepsilon_i}{kT}\right)^2\right), \\ x_i &\approx \frac{7\,\mathrm{m}}{3}\left(1 + \frac{\varepsilon_J - \varepsilon_i}{kT}\right)\Bigg|_{T=T_{C'}}, \\ x_i &\approx \frac{7\,\mathrm{m}}{3}\left(1 + \frac{\varepsilon_J - \varepsilon_i}{kT_{C'}}\right), \end{aligned} \tag{16}$$

Using the principle of conservation of the energy:

$$\varepsilon_J - \varepsilon_i = \varepsilon_J - K_{Cr} - \varepsilon_{Cas.} = \varepsilon_J - K_{Cr} - \frac{1}{2}\hbar\omega \equiv -\varepsilon_i/2 \tag{17}$$

Yields

$$\begin{aligned} \varepsilon_J - \varepsilon_i &= -\varepsilon_i/2, \\ \varepsilon_J &= \varepsilon_i/2 \end{aligned} \tag{18}$$

where

$$\varepsilon_J \approx K_{Cr} \text{ with Casimir effects} \tag{19}$$

Apparently, the negative energy (negative mass timing C^2) is presented as:

$$-\frac{1}{2}\hbar\omega \approx -\varepsilon_i/2 < 0 \tag{20}$$

We obtain the absorption term $\varepsilon_i \approx \hbar\omega$ (*i.e.*, the photon energy in wavelengths of microwaves)[4]:

[4]This result shows that it is reasonable, namely the kinetic energy of total atoms is $Nhv, N \gg 1$. Equation (21) is similar with the behaviors of Einstein's photoelectron effects.

$$\varepsilon_i \approx \hbar\omega = h\nu + \phi_0 \tag{21}$$

Therefore,

$$\begin{aligned} x_i &\approx \frac{7\text{ m}}{3}\left[1-\left(\frac{1}{2}kT_{C'}\Big/kT_{C'}\right)\right] = \frac{7\text{ m}}{6} \approx 1.167\text{ m, Macro} \\ x_i' &\approx \frac{7\text{ nm}}{6} \approx 1.167\text{ nm}\ \ (\text{micro, concentric honeycombs}) \end{aligned} \tag{22}$$

In results we conclude that *Cr* atoms are plated at an interval of *1.167 nm* on the aluminum-cobalt-nickel plate, and the evaporation is completed in about six cycles (hexagonal structures). Next, our work focuses on the importance in search of the hexagonal structures.

3. Outer Structures of Mental Shells of Spacecraft

3.1. Honeycombs: Hexagonal Structures of Metals Made of Alconi-CrAlconi

Based on Section 2, the structure made of hexagonal shape (*i.e.*, honeycombs) is crucial and necessary. This is efficiently working on any engines. The current spacecraft's engine is generally given by the thrust of rockets, however, if one desires to improve the efficiency on flying through stars, the structures stated by this section are important, which is connected to the cosmic Casimir forces via the surface energy of the metals made of *Alconi-CrAlconi*.

3.2. Layouts of Atomic Structures

A. The Transverse Portion (Made of Alconi-CrAlconi Exitation Casimir Forces)

The Casimir force is widely-known due to the vacuum and the Casimir battery [9] is verified as the energy storage and is at the highly-energy scales shown on PDF of the work done by Belén Gavela[5]. Its appearance is observed by the triangle plotted by the LHS point of $\hbar$ and RHS point of C (light-speed). The two points and the vertical axis (*i.e.*, *y-axis*, so-called "*running couplings*" at high energy scales) [11] enclosed by a rectangle triangle. The reality will be focused on the performance of the energy extracted from the rectangle triangle (*i.e.*, the total energy of the cosmic vacuum where the spacecraft travels through interstellar), and to overcome its technology of manufacture is not under consideration of discussion by this paper. Another respect, according to Equations (19) and (22), *Cr* atoms have to be deposited onto enclosed-surfaces of the outer shell of Alconi, and the spacing around *1.167 nm*, *i.e.*, 6·Cr occupied per *7 nm*, as shown in Figure 2.

B. Structure Layouts of Honeycombs Which Makes Casimir Energy Lead to Alcubierre Metric

[5]See PDF: Axion and ALP couplings Belén Gavela Univ. Autónoma de Madrid and IFT H2020 Granada, p-103 (2019).

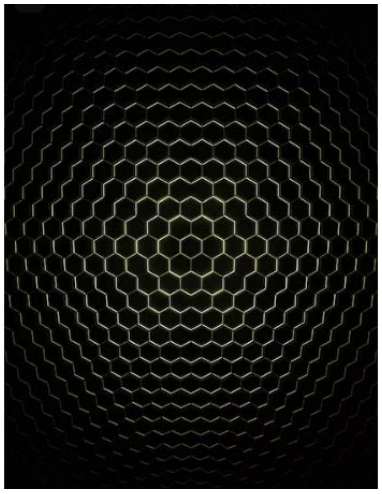


Figure 2. Illustration of the *xy*-plane concentric honeycombs is the good option for outer of spacecraft, since that this periodic design can excite the Casimir force at nano-scales around 1.167 nm (~1 nm) at constant temperature 0.00206 K. *Cr* located on the six top-pints for each honeycomb. This design is convincing that the negative energy required by a spacecraft can be decreased so much. See the important **Appendix B**.

Particular the shape of hexagonal structures, the concentric honeycombs is permitted, since that the Casimir temperature $T_{C'} = 0.00206\,\mathrm{K}$ is located on the Higgs fields bottom sections [10], due to the naturalness of the inflation $\left(\left(3\times10^{8}\right)^{2} T_{C'} \approx 0.2\times10^{15}\,\mathrm{K}\right)$ of the Casimir temperature, the potential abilities of concentric honeycombs is permitted. And this type of structures of deposed-*Cr* is tolerable.

C. The Vertical Portion (Made of Alconi-Alconi Against Gravity)

This section involves the anti-gravity since that the spacecraft is required to be held itself to be above the earth, for its complete performance of flying. So, the correct design of this type of structure is closer to disciplined work in Section 3.2.A, thus far, we suggest it is worthy to try. This section actually involves the theoretical hypothesis graphiphotons, but due to its difficulty of fields theory, here ignores it.

4. Conclusion

Such as nuclear bombs, mobile phones, computers and other high technology devices used in modern, these matters were not optimistic at first and were generally considered to be science fiction. However, everything has been presented and practiced in reality. While the Alcubieer metric was first proposed in 1994, it was not regarded. However, as time goes by, this concept is not only more and more widely discussed, but also attracted the favor of many researchers because of its attractive concept. The content discussed in this paper can help the development of space technology. There has been a breakthrough in developments, because we have proposed the material properties of the outermost metal of the spacecraft that can create the space-time bubble. Due to the atomic configuration (with Alconi-CrAlconi crystal structures [110] where the spacing of plates is around 1 nm,

and *Cr* is deposited in a period of 1.167 nm), it can easily absorb negative energy from the vacuum due to Casimir effects, making it possible to be by wrapping in a negative energy space-time bubble and distorting space-time, such that we obtained the appropriate warp drive (*i.e.*, apparent velocity $v_p > c$), thus realizing a superluminal motional spacecraft ($v = 0$) that does not violate Einstein's special theory of relativity.

Acknowledgements

Upon completing this work, we would like to sincerely thank Mr. Ben Jieu for his valuable suggestions and kind generosity.

Claims

This paper has never discussed any theory of worm-holes, since that the mathematical forms are basically different. The authors' contribution equaled.

Conflicts of Interest

The authors have no interest conflicts.

References

[1] Alcubierre, M. (1994) The Warp Drive: Hyper-Fast Travel within General Relativity. *Classical and Quantum Gravity*, **11**, L73-L77. https://doi.org/10.1088/0264-9381/11/5/001

[2] Wragg, D.W. (1973) A Dictionary of Aviation. 1st Edition, Osprey, 200,

[3] Alcubierre, M. (1994) The Warp Drive: Hyper-Fast Travel within General Relativity. *Classical and Quantum Gravity*, **11**, L73-L77. https://doi.org/10.1088/0264-9381/11/5/001

[4] Stableford, B.M. (2006) Science Fact and Science Fiction: An Encyclopedia. Taylor & Francis.

[5] Prucher, J. (2007) Brave New Words: The Oxford Dictionary of Science Fiction. Oxford University Press.

[6] Musha, T. and Minami, Y. (2011) Field Propulsion System for Space Travel: Physics of Non-Conventional Propulsion Methods for Interstellar Travel. Bentham eBooks, 58. https://doi.org/10.2174/97816080527071110101

[7] Krauss, L.M. (2007) The Physics of Star Trek. Basic Books.

[8] Gardiner, J. (2008) Warp Drive-From Imagination to Reality. *Journal of the British Interplanetary Society*, **61**, 353-357.

[9] Maclay, G.J. and Forward, R.L. (2004) A *Gedanken* Spacecraft That Operates Using the Quantum Vacuum (Dynamic Casimir Effect). *Foundations of Physics*, **34**, 477-500. https://doi.org/10.1023/b:foop.0000019624.51662.50

[10] Su, H.H. and Lee, P. (2024) On a Heuristic Point of View about the Generalization of Curie Law to Cosmic Higgs Fields with the Casimir Effect. *Journal of Applied Mathematics and Physics*, **12**, 3135-3147. https://doi.org/10.4236/jamp.2024.129188

[11] Su, H.H. and Lee, P. (2024) A Model of Grand Unified Theory: Suggested Solution for CP-Violation Using Ideas of Phase Paths. *Journal of High Energy Physics, Gravitation and Cosmology*, **10**, 1878-1902. https://doi.org/10.4236/jhepgc.2024.104105

[12] White, H. (2011) Warp Field Mechanics 101. NASA Johnson Space Center.

[13] Su, H.-T.H. and Lee, P.-H. (2024) Navier-Stokes Equation's Existence and the Smoothness Established by Using Globular Protein at The Casimir Temperature. *Applied Physics Research*, **16**, 26-34.

[14] Mahaffy, P.R., Donahue, T.M., Atreya, S.K., Owen, T.C. and Niemann, H.B. (1998) Galileo Probe Measurements of D/H and 3He/4He in Jupiter's Atmosphere. *Space Science Reviews*, **84**, 251-263. https://doi.org/10.1023/a:1005091806594

Appendix A: The Tube of Microwave Wave-Guides: Connection to Warp Drive

In the context of this article, the above sections mentioned the structures of the avenue of the excitation the Casimir energy from the vacuum, since that the Casimir temperature involved is connected to the wavelength of microwaves, therefore the waveguides are required to be discussed. The mechanism of the flying in generally is relevant to the four interactions: the thrust, the resistance (the drag), the lift, and the gravity. Here we pay attention to the gravity. Due to the repulsive forces produced by the Casimir effect, the Casmir force can also induced to another utilizes. If one designs a tunnel of the waveguide carried on the microwaves, this will be useful to against the gravity at its rest status. Namely the Casimir force once acts the ship hull of the spacecraft, the Casimir force can be such as the lift and completely cancels the gravity. Since that the net weight of the spacecraft in gravitational fields, the inflation of the microwave waves by a tunable guides (*i.e.*, the microwave amplifier) is crucial. The waveguides are generally obtained from the Travelling Wave Tubes (TWT), like the normal matters (the electrons) the gravity acts on them makes fall down. But in contrast the microwaves are travelling in the opposites. This is ingeniously produced the scenario of "negative (exotic) matters" in a TWT system. In general cognition, the negative matters are the origin of the *warp drive*[6], whose energy sources are due to the *Casimir Sea*, namely the total cosmic energy occupied per lattice:

$$\lim_{N\to 1/0.1\,\mathrm{nm}} N\cdot\frac{\hbar c}{2}\equiv 10^{11}\,\mathrm{GeV}\approx 1.6022\times 10^{7}\,\mathrm{J}\approx 3.8\,\mathrm{kg\ TNT},\ 0.1\,\mathrm{nm} \tag{A.1}$$

(TNT: Trinitrotoluene)

But here we discuss the *negative matters* as the energy sources of the spacecraft, which is extracted from vacuum. The negative energy must apply on the spacecraft, to be formed as a space-time bubble to enclose the spacecraft. Equation (A.1) is not ideal enough to be used to fly because of its formulism has no clarity.

Appendix B: Physics: Compressible Jupiter Mass-Energy That Warp Drive Uses

Interesting that in Equation (18) of Ref. [10], the atoms have once involved in Casimir Effect, the atoms against the gravity actually imply one that curvature of space-time. For the cosmic global regions, one can do the integral by r-space:

$$\lim_{h\to\infty}\int_{r=0}^{\infty}E(h)\mathrm{d}r\approx\frac{C^4}{const\cdot U_{earth}}\int_{r=r_{\min}=0}^{\infty}\frac{r^2-r_{\min}^2}{2}\mathrm{d}r+\int_{r=0}^{\infty}E(h_0)\mathrm{d}r=const, r>r_{\min},$$

$$const'-\underbrace{\int_{r=0}^{\infty}E(h_0)\mathrm{d}r}_{=0\because rest}\approx\frac{C^4}{const\cdot U_{earth}}\frac{r^3}{3\cdot 2}\bigg|_{r=0}^{\infty},$$

$$const'\approx\lim_{r\to\infty}\frac{C^4r^3}{const\cdot 3U_{earth}\cdot 2}, r\to\infty \text{ means that a spacecraft runs to infinity} \tag{B.1}$$

[6]See work archived by NASA [12].

where $U_{earth} = m_{earth}C^2$ therefore it is useful to be expressed as the estimation below (with one of the components in Jupiter is ^{3}He is recognized)[7]:

$$\begin{aligned} & const \cdot \left(3U_{earth}\right)(2) \\ & \approx const'' \cdot \left(2.8\times 10^{-26}\right)\left(1.89\times 10^{27}\right)\cdot 6U_{earth}, \text{where units are fed into } const'' \\ & \approx const'' \cdot \left(317.52U_{earth}\right) \end{aligned} \tag{B.2}$$

Therefore this is as the same as the conclusion by astrophysics observation data. Thus we have rights to conclude that the spacecraft by using the Casimir energy from the vacuum which actually works. It is not fictional at all. Notice that the energy spacecraft uses does not extract all energy of such as Jupiter but in amounts of lattices of the density of the spacecraft occupied because of $const''$ can be adjusted. Equation (B.2) just illustrates such possibility works in practice. We guess that $const''$ in Equation (B.2) might lead to the warp bubble and in a suitable way it can directly lead to warp ring to save the partial energy, regards how to design it. Due to Equation (B.1) first line (here the minimal is not set to zero, because of a real object is presented):

$$\lim_{h\to\infty}\int_{r=0}^{\infty} E\left(h\right)\mathrm{d}r \approx \frac{C^4}{const\cdot U_{earth}}\int_{r=r_{\min}}^{\infty}\frac{r^2-r_{\min}^2}{2}\mathrm{d}r + \int_{r=0}^{\infty} E\left(h_0\right)\mathrm{d}r = const, r > r_{\min} \tag{B.2.1}$$

The energy-volume-density is then:

$$\begin{aligned} \rho_{Energy} &= \frac{C^4}{const\cdot U_{earth}}\int_{r=r_{\min}}^{\infty}\frac{r^2+\left(ir_{\min}\right)^2}{2r_s^3}\mathrm{d}r \\ &= const - \frac{1}{r_s^3}\int_{r=0}^{\infty} E\left(h_0\right)\mathrm{d}r, r_s^2 = \left(r_s\left(t\right)\right)^2 \neq fixed, \\ const\cdot U_{earth} &= K'\cdot 16\pi G g^2 v_s^{-2}, K' \equiv \frac{R_{earth}}{\left(\sigma M_{earth}\right)^2}, \sigma > 0 \end{aligned} \tag{B.3}$$

$$\begin{aligned} \rho_{Energy} &\equiv \frac{1}{r_s^3}\int_{r=0}^{\infty} E\left(h_0\right)\mathrm{d}r \\ &= -\frac{C^4}{K'\cdot 16\pi G g^2 v_s^{-2}}\int_{r=r_{\min}}^{\infty}\frac{r^2+\left(ir_{\min}\right)^2}{2r_s^3}\mathrm{d}r + \frac{C^4}{K'\cdot 16\pi G g^2 v_s^{-2}} \end{aligned} \tag{B.3.1}$$

Thus obtained an approximation (the latest term is much smaller than the former one),

$$\rho_{Energy} \approx -\frac{C^4}{K'\cdot 16\pi G g^2 v_s^{-2}}\int_{r=r_{\min}}^{\infty}\frac{r^2+\left(ir_{\min}\right)^2}{2r_s^3}\mathrm{d}r < 0 \tag{B.4}$$

Apparently, the energy-volume-density ρ_{Energy} is negative large (huge). Obviously the origin of $r_{\min}$ is the globular protein running through the minimal path

[7]Where ultilizes Equation (3) of Ref. [10] (the naturalness of D and then taken the reciprocal of Equation (3) therefore matching the naturalness of Jupiter mass in degrees of orders 10^{27}) and Equation (B.1) by this paper. Carefully we exam the data from Ref. [13], ^{3}He actually exists in Jupiter and supports our points of view [14].

in liquid ^{3}He [10]. Based on this, the spacecraft flies through the cosmic shortest path in which regarded it as $ir_{\min}$ and which means that the spacecraft is at rest but still flies with a mechanism (*i.e.*, the warp bubble). On some context, Equation (B.3.1) does fit Alcubierre metric undedoubted.

Equation (B.4) implies one that $\int_{r=r_{\min}}^{\infty} \frac{r^2+\left(ir_{\min}\right)^2}{2r_s^3}\mathrm{d}r$ indicates the spacecraft as the bubble boundary $\left(r_{\min}\right)$ and the outer space of the ship hull is enclosed by an energy surface made of *light circle* (its shape shall be torus, the equation is $r_s=\pm\sqrt{\left(\sqrt{x^2+y^2}-R\right)^2+z^2}$ where R = *fixed*, in Cartesian coordinate, and in Higgs fields in which z-symmetry and z is generally 100 GeV such that the naturalness of z-axis is 100 G scaled).

$$\mathrm{Re}\left\{\int_{r=r_{\min}}^{\infty}\frac{r^2+\left(ir_{\min}\right)^2}{2r_s^3}\mathrm{d}r\right\}=\pm\int_{r=r_{\min}}^{\infty}\frac{r^2\mathrm{d}r}{2\sqrt{\left(\sqrt{x^2+y^2}-R\right)^2+z^2}^3}\mathrm{d}r$$

(Negative is banned) (B.5)

If the ring extracts the Casimir energy from the vacuum, this ring shall be made of shapes of an aspect of donuts, the equation is exactly corresponding to torus, by artificial manufacture of spacecraft, the size is then fixed. Therefore,

$$\sqrt{\left(\sqrt{x^2+y^2}-R\right)^2+z^2}^3=const \tag{B.5.1}$$

Such obtains

$$\lim_{r\to\infty}\left(6\sqrt{\left(\sqrt{x^2+y^2}-R\right)^2+z^2}^3\right)^{-1}r^3\Big|_{r=r_{\min}}^{r} \tag{B.6}$$

This is to say that, interstellar far travelling, the far distance the more energy required. If one desires to fly to 4.2 L.Y. start(s) (e.g. Proxima Centauri), the Casimir energy is (of course the ship hull width is roughly to set as $R\approx 7.0$ m)[8]

$$\rho_{Energy}\approx-\frac{C^4}{K'\cdot 16\cdot 6\pi G g^2 v_s^{-2}}\frac{1}{\sqrt{10^9}^3}\left(4.2\text{ L.Y.}\right)^3 \tag{B.7}$$

Use Equation (B.2) hence

$$\rho_{Energy}\approx-\frac{C^4}{317.52U_{earth}}\frac{1}{31622776601683}\left(40\times10^{12}\text{ km}\right)^3 \tag{B.8}$$

where (in MKS units)

$$317.52U_{earth}\approx U_{Jupiter}=C^2\left(1.9\times10^{27}\right) \tag{B.9}$$

Therefore[9],

[8]Due to this paper does not focus on the Aerospace Engineering therefore we have made the rough calculation is permitted any way. We pay attention to focus on the respect of physics.

[9]The process of Equations (B.10) to (B.11) can be kindly-called as "compressible Jupiter" and is much better than cases of the matter so-called "ring(s)".

$$\begin{aligned}
&\rho_{Energy} \approx -\frac{C^4}{6\cdot C^2\left(1.9\times10^{27}\right)}\frac{1}{31622776601683}\left(64000\times10^{36}\left[\mathrm{km}\right]^3\right),\\
&\rho_{Energy} \approx -\frac{C^2}{6\cdot1.9}2\frac{\left[\mathrm{kg}\right]}{\left[\mathrm{km}\right]^3} \to \text{huge!}\\
&\rho_{Energy} \approx -\frac{C^2}{6\cdot1.9}2\times10^{-36}\frac{\left[\mathrm{kg}\right]}{\left[\mathrm{nm}\right]^3}
\end{aligned} \tag{B.10}$$

Namely the spacecraft flying 1 km through the vacuum it must use the Casimir energy very huge (around 2.5 nuclear bomb equivalents) but the convert is the performance of faster-than-light (FTL). However, not worrisome about it, since that the Casimir energy is inexhaustible in conditions of honeycombs structures leading the Jupiter mass-energy decreased to nano-scaled orders (in volume of 10^{-27} m^{-3} orders, each *comb* mentioned in the context). So, Equation (B.10**)** can be rearranged as the shift quantity:

$$\begin{aligned}
&\rho'_{Energy} \approx -\frac{1}{6}C^2\times\left(1.89\times10^{27}\right)\frac{\left[\mathrm{kg}\right]}{\left[10^{12}\ \mathrm{nm}\right]^3}, \quad \text{for each honeycomb,}\\
&\rho'_{Energy} \approx -2.83\times10^{7}\frac{\left[\mathrm{J}\right]}{\left[\mathrm{nm}\right]^3}
\end{aligned} \tag{B.11}$$

The comb can extract mass-energy of Casimir energy density around $-2.83\times10^{7}\left[\mathrm{J}\right]/\left[\mathrm{nm}\right]^3$ (quite as the 11.20% of the THSR speed at 300 km/hr stuffed in a honeycomb within *1.167 nm* at the Casimir temperature) for maintaining the light circle to enclose the spacecraft completing travel to Proxima Centauri, obviously the curvature is extremely grant and is amazing, difficult, since that the energy density is huge. But if one uses the Lie group of $\mathrm{SU}(3)\times\mathrm{SU}(2)\times\mathrm{U}(1)$ suggested by the authors, the problem can be excluded. The protection of Stars-Destructives: spacecraft travels in the space although is enclosed by a light circle which is a Yukawa shield, there must be an insurance of a large amount of planets collision to spacecraft, the safety shall be regarded. The way for protecting spacecraft's equipment is to open the artificial force-fields of *Yukawa turning points* that everything can extremely low-probably meet spacecraft. And this type of field can also fit the torus equation, since that $r_{\min}$ exactly and correctly equals to the numerical values of Yukawa turning points *~2.997 m* calculated by the authors.

Appendix C: Exam: Alcubierre Metric $\left(\mathrm{df}/\mathrm{dr_s}\right)^2$

The origin expression by Alcubierre Metric is widely-known as

$$f\left(r_s\right)=\frac{\tanh\left(\sigma\left(r_s+R\right)\right)-\tanh\left(\sigma\left(r_s-R\right)\right)}{2\tanh\left(\sigma R\right)} \tag{C.1}$$

where σ means the shell thickness parameter of the ship, and R means shell size parameter of the ship. Making derivatives, therefore,

$$\frac{\mathrm{d}f}{\mathrm{d}r_s}=\frac{2\left[\tanh\left(\sigma\left(r_s+R\right)\right)-\tanh\left(\sigma\left(r_s-R\right)\right)\right]'\tanh\left(\sigma R\right)}{4\tanh^2\left(\sigma R\right)}-\frac{\left[2\tanh\left(\sigma R\right)\right]'\left[\tanh\left(\sigma\left(r_s+R\right)\right)-\tanh\left(\sigma\left(r_s-R\right)\right)\right]}{4\tanh^2\left(\sigma R\right)} \tag{C.2}$$

Therefore,

$$\frac{\mathrm{d}f}{\mathrm{d}r_s}=\sigma\frac{1-2\tanh^2\sigma\left(r_s\right)+\tanh\left(\sigma R\right)\tanh^2\sigma\left(r_s\right)}{4\tanh^2\left(\sigma R\right)} \tag{C.3}$$

Cosmic horizon (hyperplane) rearward expansion, so, $r_s\gg R$

$$\frac{\mathrm{d}f}{\mathrm{d}r_s}=\frac{2\left(\sigma\left(1-\tanh^2\left(\sigma\left(r_s+R\right)\right)\right)-\sigma+\sigma\tanh^2\left(\sigma\left(r_s-R\right)\right)\right)\tanh\left(\sigma R\right)}{4\tanh^2\left(\sigma R\right)},$$
$$\frac{\mathrm{d}f}{\mathrm{d}r_s}=\frac{2\sigma\left(\left(1-\tanh^2\left(\sigma\left(r_s+R\right)\right)\right)-1+\tanh^2\left(\sigma\left(r_s-R\right)\right)\right)\tanh\left(\sigma R\right)}{4\tanh^2\left(\sigma R\right)} \tag{C.4}$$

If $\tanh\left(\sigma R\right)=1$,

$$\frac{\mathrm{d}f}{\mathrm{d}r_s}=\sigma\frac{1-\tanh^2\sigma\left(r_s\right)}{4},$$
$$\left(\frac{\mathrm{d}f}{\mathrm{d}r_s}\right)^2\equiv\frac{\sigma^2}{16}\left(1-\tanh^2\sigma\left(r_s\right)\right)^2 \tag{C.5}$$
$$=\begin{cases}0,\tanh^2\sigma\left(r_s\right)=\left(\pm1\right)^2=1\\ \dfrac{\sigma^2}{16},\tanh\sigma\left(r_s\right)=0,\sigma>0,r_s=0\left(\text{spacecraft located on warp bubble}\right)\end{cases}$$

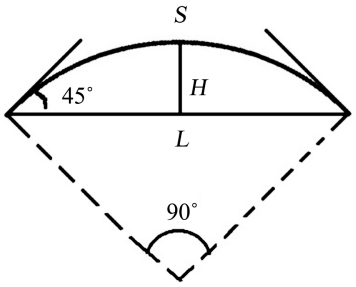
Equation (C.4) fits the *catenary equation*, since that

$$\lim_{r_s\to0}\tanh\sigma\left(r_s\right)\approx\sinh\sigma\left(r_s\right)\approx\sigma\left(r_s\right),\sigma>0 \tag{C.6}$$

where shell's bubble thickness parameters $\sigma=4$ (Cr, Al, Co, Ni) is suggested to be able to save half-energy (*i.e.*, the Casimir energy), but moves much far while flying in the curved space-time), such as the aspect of the double arched bridge shown as Figure A1. Via the conversion by $\tan\left(i\sigma\left(r_s\right)\right)=i\tanh\sigma\left(r_s\right)$, $i\tan\sigma\left(r_s\right)=\tanh\left(i\sigma\left(r_s\right)\right)$, one can see that infinite travelling to stars (see Figure A1: $i\lim_{\sigma(r_s)\to\infty}\tan\sigma\left(r_s\right)=\lim_{\sigma(r_s)\to\infty}\tanh\left(i\sigma\left(r_s\right)\right)=\pi/2$) is actually established on the basis of the hypersurfaces above, since that obviously, the hypersurface rear of spacecraft is presented as viewed angle of $\pi/2$.

Appendix D: Changing of Lorentz Transformations of Space-Time

While the *apparent velocity* (or: phase velocity) $v_p>c$ (*i.e.*, the warp speed using the Casimir energy driving a spacecraft presented FTL (superluminal)). Actually, it is at rest without any inertial changing, the matter moves is the warp bubble nearby the spacecraft:



$$H/0.5L = 0.41$$

$$S/L = 1.1$$

Figure A1. Chinese Anji Bridge. The elevation and arch-to-span ratio of a 1/4 circle arch bridge. It is proposed that the spacecraft operates within a spacetime framework defined by its local light cone, such that the relevant hypersurface structure becomes observable from within the spacecraft (see **Figure A2**). Further details are provided in **Appendix C**.

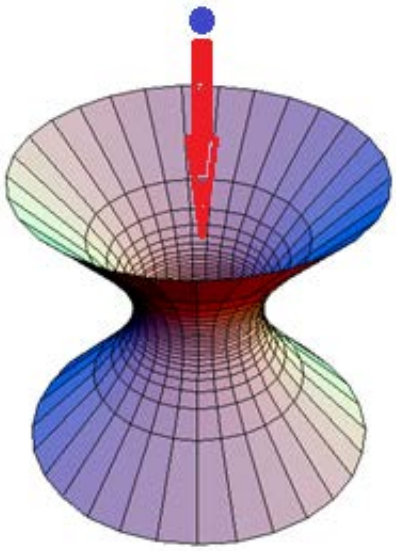


Figure A2. Space folded. Such as Anji Bridge, the spacecraft indeed creates the cone point S and then retains the rearwards space-time presented the angle of 90˚ expanded, and in the process, spacecraft uses large amounts of Casimir energy to keep the bridges open. Notice that the bridges are double directional. (The cone point S is $ir_{\min}$ and is the bubble radius).

$$\left.\begin{aligned} t &= t_0\left(1-v^2/c^2\right)^{-1/2} \in R\cdot it_0, v = v_p > c \\ t' &= t_0'\left(1-v^2/c^2\right)^{-1/2} \in R\cdot it_0', \\ L &= L_0\left(1-v^2/c^2\right)^{1/2} \in R\cdot iL_0, \\ L' &= L_0'\left(1-v^2/c^2\right)^{1/2} \in R\cdot iL_0' \end{aligned}\right\} \quad \text{(D.1)}$$

where R is a sets of real numbers. The observer and the grounded ones see each other only images presented. Equation (D.1) fits Equation (B.3) and Equation

(B.3.1). Based on this the paper actually justifies itself. Particularly,

$$\sum_i m_i = m_0\left(1-v^2/c^2\right)^{-1/2} = 0, v = v_p \in R, T = T_{C'} = 0.00206\ \mathrm{K} \qquad (D.2)$$

where i means that the warp drive works on the component species (particles) where the inertial is frozen in Higgs fields (*i.e.*, massless particles). Besides, the warp drive must be operated at the Casimir temperature. Equation (D.2) actually makes-up the weakness of descriptions of the *Alcubierre metric*. And, in Equation (2) where R means that spacecraft maintains its rest-location ir_m at the light cone (*i.e.*, *the top pint of hypersurface of the present*, therefore the causality is not violated).