International Journal of
Science and Engineering Investigations vol. 7, issue 80, September 2018
ISSN: 2251-8843

The 4th-Dimension

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Abstract- Einstein's theory of relativity introduced the 4-dimensional space-time continuum, also the space-time fabric, to explain how matter bends the space and time. Likewise, one can think of the globotoroid space as being a 3-dimensional fabric woven by, ad infinitum, spheroid and toroid shells delicately stitched with a wormhole. The purpose of a wormhole is two-fold: The first is to prevent the dynamically awkward spindle torus formation, and the second is to keep the nest together by forming the globotoroid space continuum. The present report elucidates an unexpected behavior inside this intriguing space and shows how matter transforms this space into the 4-dimensional analog of the space-time continuum.

Keywords- *Globotoroids, Wormholes, Abgular Momentum*

I. Introduction

By enabling new insights into different scientific phenomena, the globotoroids are becoming increasingly important in mathematical sciences. They offer a simple dynamic model for expressing natural processes of inflation (expansion) and deflation (contraction) in terms of the spheroid and toroid topologies regulated by the frequency and growth parameters. The globotoroid inflation, however, is not to be confused with the cosmological inflation which happened immediately after the initial singularity expanded into the big bang [1]. Here, inflation and deflation processes proceed in cyclical manner and are free from singularities. When matter is incorporated with these processes the 4th-dimension emerges, which is the subject of the present report.

In Analysis Section A) we show how the globotoroid solutions form the phase space continuum, or fabric, which is sensitive to different computational factors. By altering integration step size and numerical resolution different, but similar, non-reversible globotoroid realizations are possible from the uniquely defined equations. To explain this, relationship between the globotoroid inflation and the wormhole is examined under different computational conditions.

Analysis Section B) introduces velocity derived from the globotoroid phase space, or the phase space velocity. It is shown that this velocity has two components; the linear velocity along the wormhole path, and the linear velocity in the plane perpendicular to the wormhole direction. The latter may be thought of as being a generalization of the linear velocity observed in solutions of equations describing the 2-dimensional circular motion.

Furthermore, by letting a mass particle follow the breadcrumb trail formed by a loxodromic trajectory, we address how linear and angular momenta are inserted in the globotoroid phase space. In addition, when the momenta are conserved we show that a particle velocity along the wormhole direction remains constant, while in the transverse direction this velocity is inversely proportional to the phase space velocity. As a result, by following the breadcrumb trail the particle spins, and the existing 3-dimensional globotoroid phase space expands into the 4-dimenssional space continuum which is analogous to the 4-dimensional space-time in general relativity. Here, however, matter does not bend the space-time fabric, instead matter brings on momentum which spins particles around the energy states defined by the loxodromic solutions. A somewhat similar conclusion was previously reported by researchers from Canada [2]. They observed the analogy between the space-time and energy-momentum fabrics by identifying “a place called phase space” as being our reality.

II. Analysis Section

A. The Globotoroid Phase Space

In [3] we introduced the ordinary differential equation (ODE) representing the globotoroid model as,

$$dX(t)/dt=\omega\, Y(t)-AZ(t)X(t)$$
$$dY(t)/dt=-\omega\, X(t) \qquad (1)$$
$$dZ(t)/dt=-B+A[X(t)^2+Y(t)^2+1]$$

where t is the time, X(t) and Y(t) are referred to as the action, or orbital, time dependent space variables, and the coefficient $\omega=2\pi f$ is the angular frequency with $f>0$ being the frequency. The time dependent variable Z(t) is the growth variable and is stimulated by the growth parameters A, B>0. The three variables form the time dependent globotoroid solutions in the Euclidean 3-dimensional space, or $\mathbf{R}^3$. In dynamical systems this Euclidean space is commonly referred to as the phase space, which from now will also be the home for globotoroids. The units of t are understood as being in seconds (s), although, in general t can be set in any time units.

As noted previously (1) has singular solutions only when A=B, [3]. They are given by the solutions X=0, Y=0 and $Z\varepsilon\mathbf{R}$, which also define the 1-dimensional singular manifold. The condition A=B implies that the phase space is densely populated with concentric spheroids surrounding this manifold. For $A\neq B$, the singular manifold transforms into the 1-

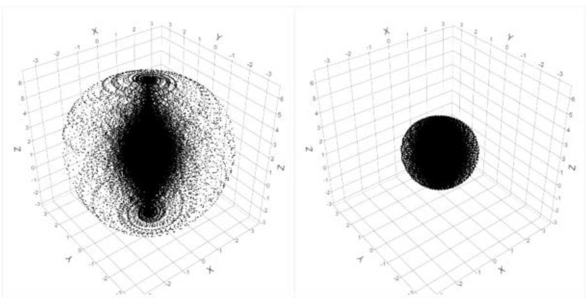
dimensional slow manifold, or the wormhole, which for B<A deflates all spheroids in the phase space, while for B>A spheroids turn into the globotoroid. For our purpose the latter is of interest.

Although (1) appears to be quite simple in formulation, it really is quite complex. First, it represents non-reversible dynamics. This results from the fact that passing through any wormhole, as defined by the 1-dimensional slow manifold, is not a reversible process. Thus, back in time journey through the wormhole will take a traveler to different globotoroid realizations.

What makes (1) also challenging is its ability to create complex phase space behavior with a single loxodromic trajectory; the time dependent space variable solutions specified by one set of initial conditions $\{X_0, Y_0, Z_0\}$ form a single trajectory. This trajectory covers delicate phase space continuum created by the spheroid and toroid topologies stitched through by the wormhole [3]. As the wormhole is a tiny opening surrounding the 1-dimenssional manifold through which the entire 3-dimensional phase space solutions must pass, it forms the region that is quite challenging for numerical computations. Theoretically, as the wormhole shrinks with time and approaches the 1-dimenssional manifold, the globotoroid inflates to infinity. In reality this can never be achieved because anything that computes globotoroid solutions has a finite numerical resolution, and inflation to infinity is just a hypothetical concept. Thus, the computed solutions will be affected as the numerical resolution changes. A high numerical resolution promotes the globe expansion, while a low resolution chokes it, Fig. 1. Whereas in Fig. 1A) the core is clearly distinguishable from the globe, in 1B) this is not the case.

The process of inflation will also depend on the integration step size Δt. The finer the integration step, the more refined the solutions. A drawback is that by refining the step size, the number of integration steps increase, which in turn increases the computation time. Hence, the demand for more computer memory goes up, while the speed of computing goes down. Despite these computational issues the most comprehensive solver for studying the globotoroid models is the Euler method, and is used to evaluate the phase space portraits in Fig. 1.

Model II with initial conditions X_0=.5, Y_0=0 and Z_0=2 and parameters ω=62.8 ; A=4.5 ; B=5 ; integration step Δt=0.002 ; total number of integration steps n=750K



A) numerical resolution=24 digits

B) numerical resolution=6-digits

Figure 1. The numerical resolution constraints.

B. The 4th-Dimension

From the model description presented it is apparent that the globotoroid defined in (1) has its wormhole aligned with the Z-axes, which is orthogonal to the plane of action variables X and Y. Thus, for any globotoroid point i in Fig. 1A, the linear velocity v_i at the time t_i is expressed as

$$v_i^2 = v_{i,\perp}^2 + v_{i,w}^2 \quad (2)$$

where $v_{i,\perp}$, or v_i-perp, is the velocity component in the action plane perpendicular to the wormhole, and $v_{i,w}$, or v_i-worm, is the velocity component in the wormhole direction. In terms of the globotoroid variables (2) is expressed as

$$v_i = [(X_i-X_{i-1})^2 + (Y_i-Y_{i-1})^2 + (Z_i-Z_{i-1})^2]^{1/2} /(t_i-t_{i-1}) \quad (3)$$

which for our model yields

$$v_{i,\perp} = [(X_i-X_{i-1})^2 + (Y_i-Y_{i-1})^2]^{1/2} /(t_i-t_{i-1}) \quad (4a)$$

and

$$v_{i,w} = [(Z_i-Z_{i-1})^2]^{1/2} /(t_i-t_{i-1}). \quad (4b)$$

For the case when the wormhole is not aligned with the Z-axis, v_i-perp and v_i-worm will have more complex expressions.

Similarly, at the time t_{i+1} we will have the linear velocity v_{i+1} defined by $v_{i+1,\perp}$ and $v_{i+1,w}$, and so on. From this one can obtain the phase space velocity expression

$$v(t) = (v_\perp(t)^2 + v_w(t)^2)^{1/2} = v_j\delta(t-t_j) \quad (5a)$$

with,

$$v_\perp(t) = v_{j,\perp}\delta(t-t_j) \quad (5b)$$

being v(t)-perp, and

$$v_w(t) = v_{j,w}\delta(t-t_j) \quad \text{for } j=1,\ldots,n \quad (5c)$$

v(t)-worm.

v(t)-perp and v(t)-worm are two velocity components easily distinguishable by their action. v(t)-perp is defined by the action variables X(t) and Y(t) which diminish as their solutions circularly approach the wormhole, forcing $v_\perp(t)\rightarrow 0$ along the path of the 1-dimensional manifold. In contrast, v(t)-worm never diminishes and keeps solutions moving along the wormhole direction.

Now, let's take a look at the 2-dimensional X,Y phase space with circular portrait defined by the constant radius $R=(X^2+Y^2)^{1/2}$, and the angular frequency ω. Here the circular dynamics has the constant phase space velocity $v(t)=R\omega$, and since there is no Z direction, v(t)-perp=v(t). The question is; Can ω in the globotoroid models be used to evaluate v(t)-perp defined in (5b)?

The answer is yes, and to show this recall that for any globotoroid point P_j, v_j-perp is in the plane orthogonal to the wormhole direction. Hence, we can always draw the orthogonal connection from any P_j to the center line (CL) emulating 1-dimensional manifold through the wormhole. This connection is depicted in Fig. 2 and represents the radius.

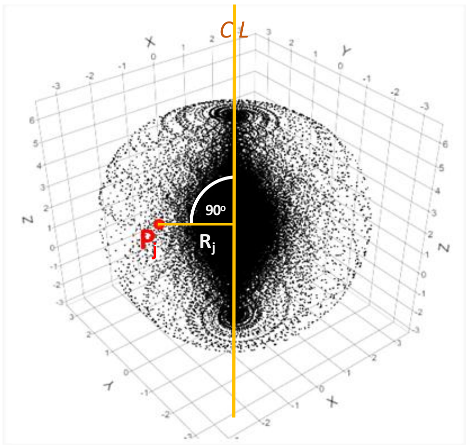


Figure 2. The figure depicts radius R_j at the globotoroid point P_j.

$$R_j = (X_j^2+Y_j^2)^{1/2} \tag{6a}$$

where X_j and Y_j are the P_j coordinates, and where

$$v_{j,\perp}= \omega R_j \tag{6b}$$

is v_j-perp. Next, by observing that

$$R(t)=R_j\delta(t-t_j) \qquad \text{for} \quad j=1,\ldots,n \tag{7}$$

and combining the result with (5b), we derive

$$v_\perp(t)=\omega R(t) \tag{8}$$

which is analog of the circular motion expression. The solutions of (5b) and (8) are compared and illustrated in Fig. 3.

What if now the point P_j acquires a constant mass M at the time t_j, call it the inception time, and begins to follow the breadcrumb trail set up by the loxodromic path in Figure 2. P_j is now a particle which at the inception time will expose two momenta;

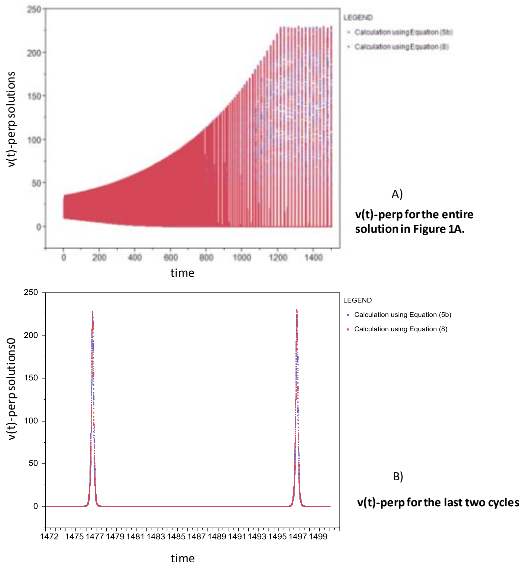


Figure 3. The comparison of $v(t)$-perp evaluations.

the linear momentum,

$$p_{j,w}=MV_{j,w} \tag{9a}$$

and the angular momentum,

$$L_j= MR_jV_{j,\perp} \tag{9b}$$

where now $V_{j\perp}$ and $V_{j,w}$ are respectively the particle linear V_j-perp and V_j-worm, while R_j is given in (6a). While following the path the two momenta remain independent, and if there is no torque acting on P_j the momenta will be conserved throughout the entire globotoroid time. For the conserved linear momentum, (9a) implies

$$p=MV_{j,w}\,\delta(t-t_j), \tag{10a}$$

and from (9b) the conserved angular momentum becomes

$$L= M[R_jV_{j,\perp}]\delta(t-t_j) \quad \text{for all} \quad j=1,\ldots,n. \tag{10b}$$

Since in (10a) p and M are constants, $V_{j,w}$ must also be a constant such that

$$V_w= V_{j,w}=M/p \qquad \text{for all } j=1,\ldots,n. \tag{11a}$$

Similarly, from (6b) and (10b) it follows that

$$V_{j,\perp}= L\,/MR_j = L\omega\,/(Mv_{j,\perp}) \text{ for } \quad j=1,\ldots,n \tag{11b}$$

which relates the particle linear velocity V_j-perp inversely to the phase space linear velocity v_j-perp. Finally, the particle V(t)-perp along the entire breadcrumb trail is

$$V_\perp(t) = V_{j,\perp}\delta(t-t_j) \qquad \text{for} \quad j=1,\ldots,n. \tag{12}$$

Generally, for globotoroids V_w can be neglected as $V_\perp(t)>>V_w$. Thus, V(t)-perp becomes the dominant velocity which exposes particle spin and assigns energy state to each globotoroid cycle, and with that establishes the 4^{th}-dimension. Without conservation of the angular momentum across the continuum of energy states this 4^{th}-dimension is imperceptible. The 4-dimension concept may be better appreciated with video animations. To illustrate this point simulated behavior of the single and binary particles are presented in the following video: [https://youtu.be/yBo0CkbahLg] [4].

For another example on how V(t)-perp acts as the 4^{th}-dimensional variable consider the particle with mass M=1kg and the momentum L=1kg m^2/s. From (11b) and (12) $V_\perp(t)$ is computed and depicted in Fig. 4 as Log_{10}[V(t)-perp]. The figure shows how the particle velocity slows at the globe, reaching minimum at the great circle, while it increases rapidly in the wormhole interior. The high energy states within the wormhole can support velocities in excess of the speed of light, but once particle is ejected onto the loxodromic orbit the speed slows down and the cycling resumes, Fig. 5A. Nonetheless, because the energy states continuum is preserved, all states containing velocities in excess of the speed of light will be inaccessible for any mass particle, Fig. 5B. This limits inflation and the size of the detectable globotoroid, Fig. 6, in the same way as resolution did in Fig. 1. Theoretically, however, massless particles have no such limitations.

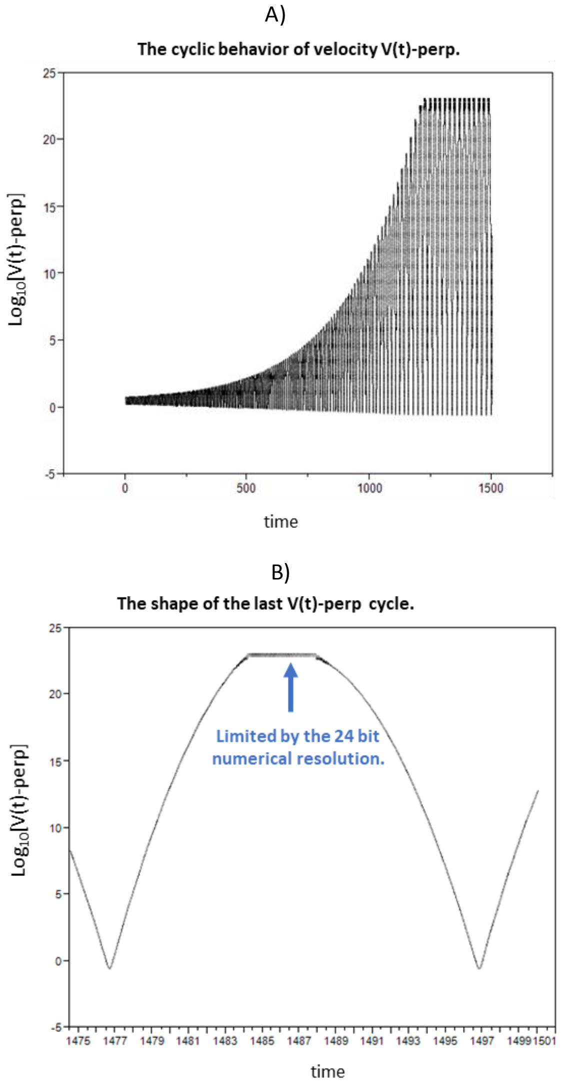


Figure 4. The comparison of v(t)-perp evaluations.

When the globotoroid contains many mass particles, or the swarm, all mass points will spin around its geometry. If in addition, the swarm densely populates the globotoroid space the entire globotoroid appears to be spinning. The spin, however, will be nonuniform as the core will contain particles with higher velocities.

III. Discussion

Before we get into any discussion it is important to mention that one needs a right set of tools to study globotoroid properties. Understanding of ODEs is a must, but not sufficient. To visualize and understand dynamics in 3-dimensional spaces with static 2D graphs is tricky enough, and by adding the 4th-dimension this task becomes even more challenging.

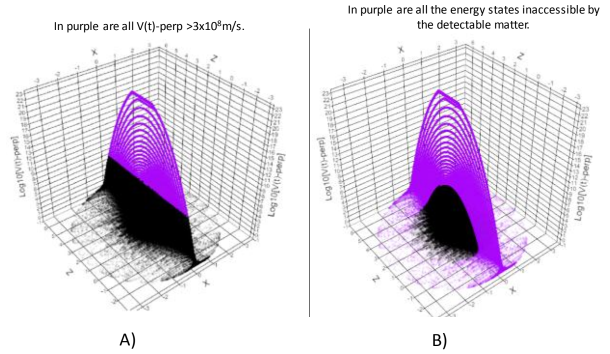


Figure 5. High energy states and the 4th-dimension.

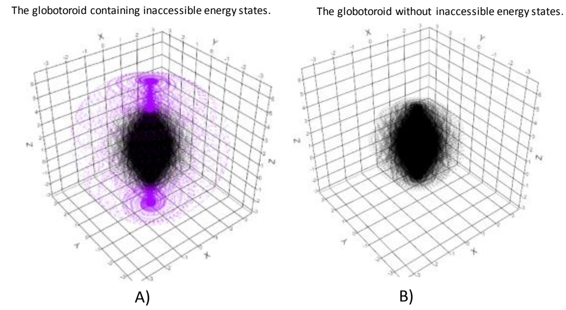


Figure 6. Mass effect on the globotoroid shape.

For instance, a core formed by a single loxodromic trajectory is depicted in Fig. 7, and to fully understand its behavior one needs a 3D simulator with rotating and scaling capabilities. Without these capabilities there will be a great number of puzzling graphs to piece together. Both, Mathematica and Maple software programs [5,6] offer these features. Furthermore, globotoroids can generate interesting sound effects which can also be helpful. For audio effects one can use an open-source program Audacity [7]. In addition, producing globotoroid videos can be quite an educational experience.

For now, as one looks at Fig. 7 a question arises: What if there are more trajectories? In this case each will show its loxodromic trail, and collectively they will braid the globotoroid phase space while never crossing each other paths. The final outcome may result into one big phase space spheroid blob.

Next, suppose each trajectory contains its own mass swarm, and the core emerges as one very dense space spinning at a high angular velocity. At this point many interesting things can occur with matter and energy. For example, some of the decaying matter may end up entering higher energy states inside the wormhole, thereby creating powerful gamma ray and neutrino bursts. This familiar scenario has been reported for coalescing neutron stars [8,9,10]. Another example may occur when the core becomes so massive it devours all the matter in its vicinity, making the core surrounding appear as a dark empty space [11,12]. This predatory act is part of the black hole behavior in which devouring is attributed to the powerful gravitational force.

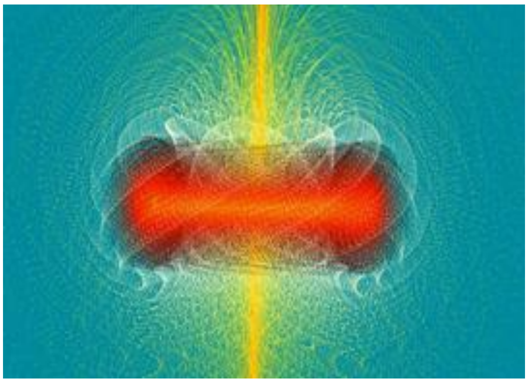


Figure 7. A single loxodromic trajectory depicting core with its surrounding.

We could go on with the examples from physics, quantum mechanics and cosmology, but the objective of this report is the 4^{th}-dimension. It was reported how matter can expand the 3-dimensional globotoroid space into the 4-dimensions, where the 4^{th}-dimension results from the angular velocity, here referred as V(t)-perp. Together with the three globotoroid variables, V(t)-perp forms the 4-dimensional space which may offer a more intuitive alternative to the 4-dimensional space-time continuum.

REFERENCES

[1] M. Wall, "The Big Bang: What Really Happened at Our Universe's Birth?", SPACE.com, 21 October 2011.

[2] A. Gefter, “Beyond space-time: Welcome to phase space,” NewScientist, 3 August 2011.

[3] N. Samardzija, “From Spheroids To Globotoroids,“ International Journal of Science and Engineering Investigations, Volume 7, Issue 76, May 2018.

[4] N. Samardzija, ”Single And Binary Particles In 4-dimensions,“ YouTube Video , 12 September 2018.

[5] Wolfram Mathematica, https://www.wolfram.com/mathematica/.

[6] Maplesoft, https://www.maplesoft.com/products/Maple/,”.

[7] Audacity, “https://www.audacityteam.org/,”.

[8] D. Eichler et al. , “Nucleosynthesis, neutrino bursts and γ-rays from coalescing neutron stars,” Nature, 13 July 1989,

[9] Nature Astronomy Collection, “Kilonovae, short gamma-ray bursts & neutron star mergers - Nature,” 16 October 2017.

[10] S. Kohler, “The Prospect of Neutrinos with Gravitational Waves,” AAS NOVA, 9 Octobar 2017.

[11] E.K. Carlson, “Astronomers Catch a Black Hole Devouring Star,” Astronomy, 14 June 2018.

[12] N.T. Redd, “Rarely Seen Middleweight Black Hole Gobbles Star,” SPACE.com, 25 June 2018.

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His professional calling led him to various research and data sciences positions at DuPont Co. and Emerson Electric Co. He published numerous papers and gave presentations at national and international conferences, primarily on the subject of nonlinear systems. He is also an inventor and has 10 patents.

In 2010 Dr. Samardzija founded an independent research initiative on exploring the subject of globotoroids. In 2011 this effort was named globotoroid.com after his web site www.globotoroid.com. Presently he is an independent researcher and manages all activities for globotoroid.com.