A Treatise on Spacetime and Matter Duality

Gary Heen
grhdsh@gmail.com

1. Introduction

Currently there are multiple theories on the nature of the universe. The model put forth in this paper attempts at subsuming some of these theories into one encompassing model. In this model, spacetime is not a mathematical abstraction but has a basis in physical reality based on matter and spacetime being convertible states of the same quantum particle. This quantum particle is composed of D-branes and Type I strings and is termed the B-string, for brane string complex.

2. B-string Structure

Specific orientation and attachment of D-branes and Type I Strings to one another determines the physical structure of the B-string quantum.

2.1 Relating Type I strings and D-branes to B-string Structure

Planck's length [1] and Planck's time [2] quantify two of the physical parameters of the B-string. The maximally expanded B-string is a cubic hexahedron, with the length along any side equal to Planck's length (l_p), see figure 1(A). Each individual expansion or contraction of a B-string occurs in a quantum jump, and the time interval from initiation to completion of a quantum jump is equal to Planck's time and is invariant. After the first and any subsequent quantum jump contractions of the B-string, the cubic shape of the B-string distorts along multiple axes but maintains hexahedral shape with six planar faces, see figure 1(B). The range between maximally expanded and maximally contracted states of a B-string defines spacetime curvature.

D-branes were discovered independently by Petr Horava, [3] and by the team of Jim Dai, Rob Leigh, and Joe Polchinski. [4] The D-brane is named after 19th century mathematician Johann Peter Gustav Dirichlet [5]. Dirichlet's boundary conditions [6] are a set of restraints in that the Type I string ends are fixed in position, i.e. both ends of the Type I strings are attached to D-branes.

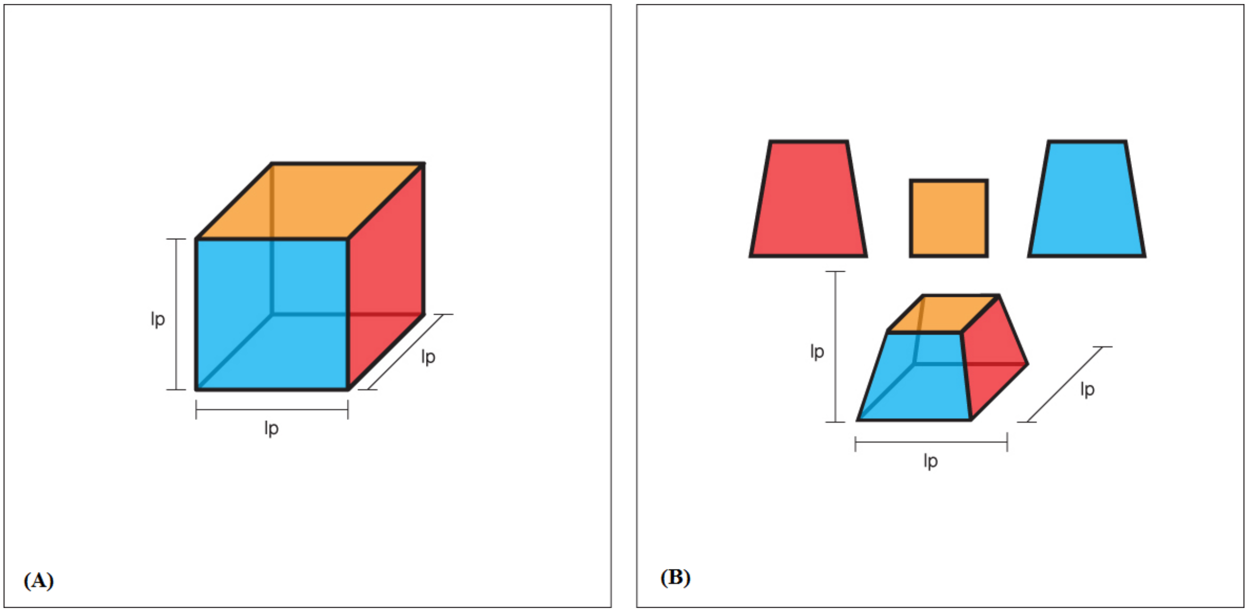

Figure 1. (A) B-string fully expanded, with each facet equaling Planck's length (B) B-string in a partially contracted state, with facet lengths less than Planck's length.

2.2 B-string model physical properties:

1. The B-string is composed of Type I strings and D-branes, and that matter and spacetime are different volumetric states of the B-string, and are convertible into one another. A fully contracted B-string is a quantum particle of matter, and an expanded B-string is a unit of quantized spacetime.
2. D-branes occupy the surface of the six facets of the hexahedral B-string.
3. The Type I strings are within the B-string and attach from one facet D-brane across to the opposing parallel facet D-brane, see figure 2(A).
4. The string attachment pattern of the two facets of an axis of a B-string is a unique stereoisomeric configuration with respect to that axis, resulting in spacetime and matter having chirality, see figure 2(B).
5. The opposing D-branes of the x, y, and z-axes are mirror image nonsuperposable enantiomers.
6. All B-strings have identical numbers and types of strings and D-branes.
7. It is known that D-branes possess charge, [[7]] but additionally in this model the mirror image D-branes of a B-string carry equal and opposite charges.
8. Mirror image D-branes align to match Type I string configurations of abutting B-strings by attraction of opposite charges.
9. B-strings spontaneously expand but never spontaneously contract. The interval from initiation to completion of an expansion or contraction of a B-string occurs in one Planck's time interval.
10. The level of contraction, or decrease in volumetric state of a B-string from the maximally expanded state, is termed the quantum level of spatial contraction (QL) of

a B-string. All B-strings undergo expansion and contraction in discrete steps, known as quantum jumps.

11. B-strings will spontaneously expand in quantum jumps to approach a maximally expanded state.
12. String lengths within a B-string equilibrate to approach or attain identical lengths when a B-string undergoes an initial geometric change along any axis.
13. Abutting B-strings with unequal contracted states will interact in quantum jumps to approach or attain equal levels of contraction.
14. Potential energy of a B-string is proportional to the level of the contracted state of the B-string; the greater the contracted state, the greater the potential energy. Particle matter, being fully contracted B-strings, has a higher potential energy state than any spacetime B-string.
15. Kinetic energy of spacetime is the geometric changes, and/or vibrations of D-branes and Type I strings of a B-string.
16. Particle matter quanta do not interact when abutting together, but there is interaction between and particle matter and spacetime, and spacetime quanta interacting with other spacetime quanta.

Notation for fully contracted a B-string matter quantum is M_q, the notation for an expanded B-string quantum of spacetime is S_t, and the notation for quantum level of contraction of a spacetime quantum, i.e. the spacetime quantum's level of volumetric state, is QL. There are no M_q-to-M_q interactions when matter quanta physically interface, but S_t-to-S_t and M_q-to-S_t interactions occur. An M_q contracts adjacent spacetime and induces a gravitational field; this field maintains the M_q in a contracted state. Restated, gravity prevents matter quanta from expanding into spacetime, without gravity an M_q would expand into spacetime.

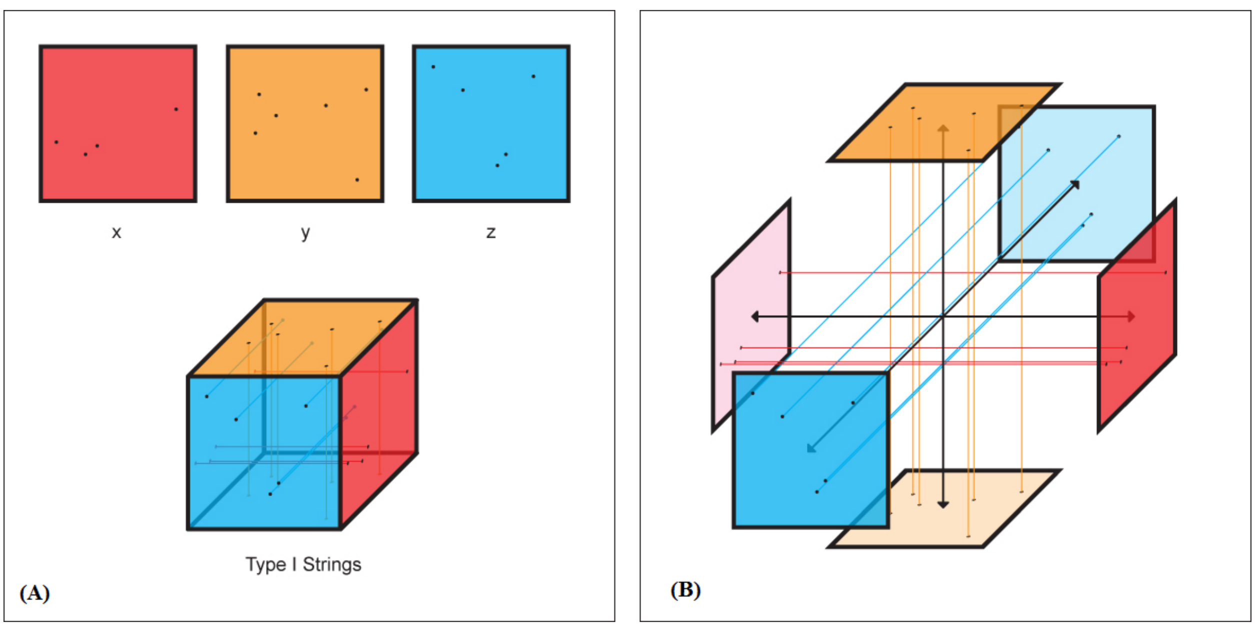

Figure 2. (A) Colored facets represent D-branes. (B) B-string exploded view, colored lines represent Type I strings.

2.3 The 10-dimensional and 11-dimensional Duality of the B-string

Type I strings constitute the three dimensions of the x, y, and z-axes. The author proffers that each of the D-branes occupying the six facets of the B-string are mathematically interpreted as distinct higher dimensions due to their attachment to the Type I string dimensions and the unique stereochemistry of each of the two-dimensional D-brane sheets. The arbitrary naming of the six D-branes on the B-string facets are: top, bottom, left, right, front, and back. The nomenclature of the 2-brane will be used to distinguish the higher dimensionality of the D-brane. The 10 dimensions of the B-string are:

1. x-axis Type I strings
2. y-axis Type I strings
3. z-axis Type I strings
4. top D-brane
5. bottom D-brane
6. left D-brane
7. right D-brane
8. front D-brane
9. back D-brane
10. time

Minkowski first proposed the linking of space and time as spacetime. [8] In this paper, time is defined as the interval from initiation to completion of a geometric change in a quantum of spacetime. Restated, since the inexorable linking of space and time as the one entity of spacetime, a change in one component of spacetime necessarily causes a change in the other; therefore, a change in the geometry of an expanded B-string (space) is required for change in time to occur.

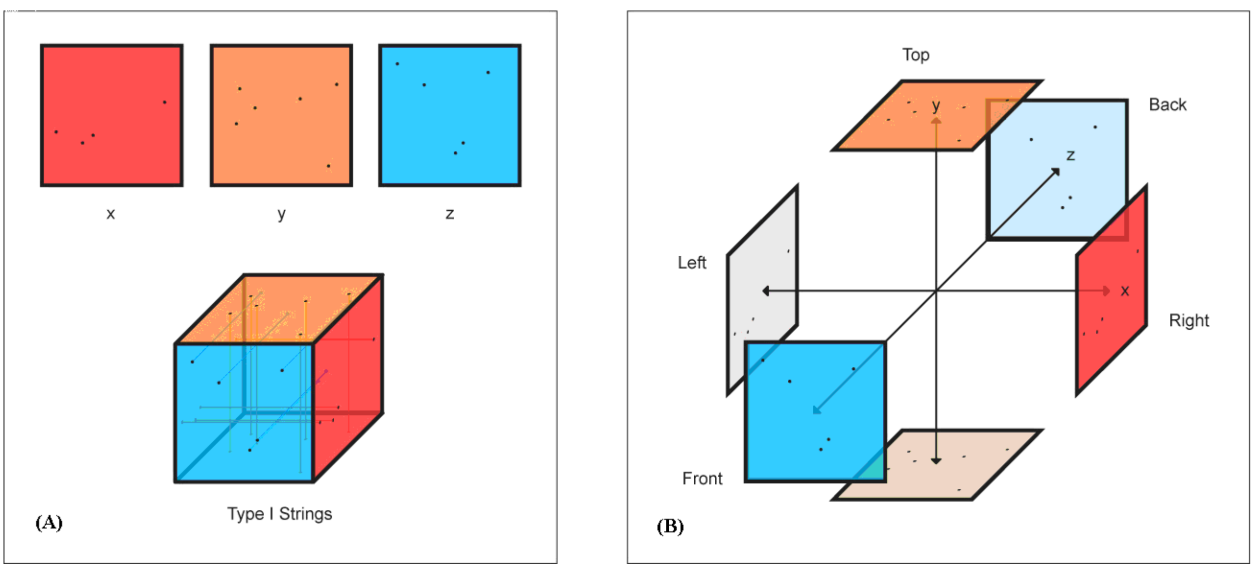

Figure 3 - The 10-dimensional B-string

The dimensionality of the B-string is also 11-dimensional by presuming the following progression of dimensionality:

(1) The linear one-dimensional Type I strings are one level of dimensionality, i.e. 1-brane.
(2) The two-dimensional D-brane sheets are a secondary higher level of dimensionality, i.e. 2-brane.

(3) Then, a three-dimensional configuration of all six D-branes of a B-string projecting into space simultaneously results in a third higher level of dimensionality, i.e. 3-brane.

Therefore, the addition of a 3-brane dimension to the ten dimensions previously outlined results in an eleven dimensional B-string. Both ten and eleven-dimensional models express the same concept of the B-string in different ways, i.e. the models are a duality. The equivalency or duality of 10-dimensional and 11-dimensional string theory has been shown mathematically. [9][10]

The interpretation of 26-dimensional B-string is possible by analyzing the maximum number of combinations of **multiple** D-branes of the B-string, see list below. These combinations of D-branes provide 15 additional dimensions to the B-string, and when combined to the previously outlined existing 11 dimensions, results in the B-string having 26 dimensions. In compiling the D-brane combinations, there can be no mirror image combinations because mirror images are anti-matter and not matter, the following section contains a more detailed discussion of matter and anti-matter. The numbering the B-string D-branes is analogous to the numbering of a dice cube, i.e. opposite sides of the cube should add up to 7. Defining matter and anti-matter is by arbitrarily designating the side #1 D-brane combinations as matter, and the mirror image side #6 D-brane combinations as anti-matter; each D-brane combination of matter must include the side #1 D-brane, and not include side #6 D-brane anti-matter. Utilizing multiple D-brane combinations an additional fifteen dimensions are constructed:

1. 1,2
2. 1,3
3. 1-4
4. 1-5
5. 1,2,3
6. 1,3,4
7. 1,4,5
8. 1,5,2
9. 1,2,4
10. 1,3,5
11. 1,2,3,4
12. 1,3,4,5
13. 1,4,5,2
14. 1,5,2,3
15. 1,2,3,4,5

D-branes and strings are contiguous; the strings being projections from the D-brane, i.e. strings are part of the D-branes. A loop model is possible by connecting any two strings of a B-string with contiguous D-branes and completing a loop. The author posits the different mathematical models of quantum mechanics dealing with multiple higher dimensions, quantum gravity, strings, D-branes, and loops are models that concentrate on individual aspects of the same physical phenomena, the B-string.

2.4 Spacetime Conversion into Matter and Anti-matter

The B-string model presupposes that a B-string in the fully contracted state defines a quantum particle of matter. The author posits that the B-string quantum particles of matter are the smallest elementary building block of matter, and are the building blocks of quarks. Quarks were first predicted by Murray Gell-Mann [11], and George Zweig. [12][13]

A quantum particle of matter has the maximal potential energy content for a B-string. However, spacetime energy varies: the greater the contracted state, the greater the energy content of the spacetime B-string, and greater increase of oscillation between quantum levels of contraction, i.e. the higher the frequency of contraction of the spacetime quantum. Opposing D-branes on any one of the three axes of a B-string are mirror images of each other, see figure 2. A photon of sufficient energy, interacting and transferring its kinetic energy into potential energy of a spacetime B-string, will contract the spacetime B-string into a quantum particle of matter. Subsequently, if enough energy is present, each axis of the quantum particle of matter generates mirror image particle pairs (matter and antimatter) from the abutting spacetime B-strings, propagating to form three stereo-chemically distinct matter and antimatter quark pairs.

Paul Dirac developed his relativistic wave equation for the electron in 1928, [14] and this equation predicted that a photon of sufficient energy could produce an electron and a particle that is the same as the electron but with an opposite charge (anti-matter). [15] Carl Anderson is credited for discovering empirical evidence for the existence of anti-matter in a cloud chamber experiment in 1932. [16]

In the B-string model, matter and anti-matter differ in that each is the physical nonsuperposable mirror image enantiomer of the other, which is contrary to Dirac's statement that the particles are identical but differ only in charge sign. If paired enantiomers possess charge, the enantiomers will possess equal and opposite charges due to their mirror image geometry. Restated, what differentiates matter and anti-matter is the geometry of enantiomeric particle pairs, and not the sign of charge of the particle, e.g. a sub-atomic particle without charge such as a neutron has an anti-matter partner.

B-string energy is sub-divided into potential and kinetic types; the kinetic is further sub-divided into geometric and vibrational:

1) The potential energy of a B-string is proportional to the level of the contracted state of the B-string; the greater the contracted state, the greater the potential energy. Particle matter consisting of fully contracted B-strings has a higher potential energy state than any potential energy of spacetime B-strings.
2) Kinetic energy of spacetime is of two types:
   a) Geometric- the process of changing the lengths and sizes of the D-branes and Type I strings of the B-string.
   b) Vibrational- the rate and magnitude of vibration of D-branes and Type I strings. The vibrational energy of a B-string can be orders of magnitude greater than any geometric or potential energy of a B-string.

The author suggests that the formation of matter and anti-matter occurs when a photon with sufficient kinetic vibrational energy interacts with a single unit of spacetime, increasing the potential energy of the spacetime B-string by contracting the D-branes and strings. Once the initial unit of spacetime has converted into a quantum particle of matter, the generation of additional quantum particle pair aggregates occurs from opposing mirror image D-branes of the initial quantum particle of matter. Therefore, three distinct quantum particle matter and anti-matter pairs serve as elemental building blocks for particle matter. Einstein’s equation for energy and mass equivalence [17] is shown in equation 2.1,

$$E = mc^2 \tag{2.1}$$

The author posits that energy, matter, and spacetime are convertible, with the conversion of spacetime into matter occurring when a B-string contracts into its maximal contracted state.

Equation 2.2 indicates the mathematical relationships of energy, matter, and spacetime. The term m is the mass of a *single* quantum particle of matter. The state of contraction of a B-string defines the quantum level of contraction (QL), which indicates the amount of potential energy present. The greater the contracted state, or increase in the magnitude of a QL, the greater the potential energy of the B-string. The potential energy of a spacetime unit may be stated mathematically by inserting a term into Einstein's equation, which expresses the QL of the spacetime unit; QL^x is the quantum level of contraction of spacetime, and QL^n represents the QL of a quantum particle of matter. Inputting energy into a B-string increases the B-string's QL. If the B-string absorbs a sufficient amount of energy, then the B-string will contract until the QL^x equals QL^n and equation 2.2 reduces to Einstein's equation, at which point spacetime converts into matter.

$$E = \left(\frac{QL^x}{QL^n} \right) mc^2 \tag{2.2}$$

Using the modern values for G, h, and c as listed in CODATA, [18] the values for Planck's natural units of length and time [19] are shown in equations 2.3 and 2.4.

$$l_p = \sqrt{\frac{Gh}{c^3}} = \sqrt{\frac{\left(6.6742\times10^{-8}\,cm^3 g^{-1} s^{-2}\right)\left(6.6261\times10^{-27}\,g\cdot cm^2\cdot s^{-1}\right)}{\left(2.9979\times10^{10}\,cm\cdot s^{-1}\right)^3}} = 4.0513\times10^{-33}\,cm \tag{2.3}$$

$$t_p = \sqrt{\frac{Gh}{c^5}} = \sqrt{\frac{\left(6.6742\times10^{-8}\,cm^3 g^{-1} s^{-2}\right)\left(6.6261\times10^{-27}\,g\cdot cm^2\cdot s^{-1}\right)}{\left(2.9979\times10^{10}\,cm\cdot s^{-1}\right)^5}} = 1.3512\times10^{-43}\,s \tag{2.4}$$

In a vacuum not under the influence of matter, a maximally expanded B-string has a length along the x, y, or z-axes equaling one Planck's length. In **maximally** expanded spacetime, one Planck's length is the smallest unit of distance because further sub-division of spacetime is not possible due to the quantization of spacetime. Therefore, the smallest possible wavelength of fully expanded spacetime also equals Planck's length. Since frequency multiplied by wavelength equals the speed of light, $c = \nu\lambda$, then $\nu = c/\lambda$, then the highest possible frequency can be expressed as

$$\nu_{\max} = \frac{c}{\lambda} = \frac{2.9979\times10^{10}\,cm\cdot s^{-1}}{4.0513\times10^{-33}\,cm} = 7.4000\times10^{42}\,s^{-1} \tag{2.5}$$

The author posits that when a photon of *sufficient* electromagnetic energy interacts with a spacetime B-string, the B-string will convert into particle matter. It now must be determined whether an individual photon can possess sufficient EM energy for spacetime to quantum particle conversion to occur. The author chooses to use the hypothetically highest frequency photon because it contains the greatest energy for possibly transforming spacetime into matter. Equation 2.6 shows the relationship of energy as a function of EM frequency. Substituting the value from equation 2.5 into the equation for energy frequency, the calculation of the maximum possible EM energy of a spacetime photon is

$$E = hf = \left(6.6261\times10^{-27}\,g\cdot cm^2\cdot s^{-1}\right)\left(7.4000\times10^{42}\,s^{-1}\right) = 4.9033\times10^{16}\,g\cdot cm^2\cdot s^{-2} \quad (2.6)$$

Substituting the energy value of a maximum frequency photon from equation 2.6 into equation 2.1 and solving for mass,

$$m = \frac{E}{c^2} = \frac{4.9033\times10^{16}\,g\cdot cm^2\cdot s^{-2}}{\left(2.9979\times10^{10}\,cm\cdot s^{-1}\right)^2} = 5.4556\times10^{-5}\,g \quad (2.7)$$

It is indeed apparent that one photon can possess enough EM energy to convert spacetime into matter. It is also interesting to note the value $5.4556x10^{-5}\,g$ *is equal to Planck's mass*, as calculated using currently accepted values for *G*, *h*, and *c* as listed in CODATA, [20] see equations 2.8 and 2.9,

$$m_p = \sqrt{\frac{hc}{G}} = 5.4556\times10^{-5}\,g \quad (2.8)$$

$$m_p = \sqrt{\frac{\left(6.6261\times10^{-27}\,g\cdot cm^2\cdot s^{-1}\right)\left(2.9979\times10^{10}\,cm\cdot s^{-1}\right)}{6.6742\times10^{-8}\,g\cdot cm^2\cdot s^{-2}}} = 5.4556x10^{-5}\,g \quad (2.9)$$

Therefore, Planck's mass is the maximal amount of mass resulting from the conversion of spacetime by a maximal frequency photon, into equal quantities of matter and anti-matter, with the combined mass totaling $5.4556x10^{-5}\,g$.

This model defines a vacuum as a volume of space devoid of particle matter, but containing spacetime B-strings that are constantly undergoing QL changes as the B-strings equilibrate to approach or attain the same QL with abutting B-strings. The expansion and contraction of the B-strings is analogous to bubbles constituting a quantum foam, [21] and within this foam energetic photons convert B-strings into matter and anti-matter pairs known as *virtual particles*. Energetic photons interacting with spacetime to form virtual particles results in a void or *wormhole* in the quantum foam, as the newly formed quantum particles combine and create aggregate masses that tunnel through spacetime. The tunneling creates a void where the converted spacetime B-strings once resided. Wormholes created by an energetic photon are only quantum sized and have a fleeting existence as adjacent spacetime expands to fill the resultant voids. This model defines the universe as being composed of a *finite* number of B-strings, in which *both* the expanded B-strings (quantum spacetime), and fully contracted B-strings (particle matter), must be present and generally contiguous. [i] Matter entering a wormhole of sufficient size as to no longer be in contiguous contact with spacetime is defined as being outside of the universe, and would not be under the constraints of known physical laws. The void between non-contiguous B-strings is to be termed sub-space.

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[i] D-brane facets of a B-string are often temporarily discontinuous when contracting, but will equilibrate with adjacent B-strings to reestablish physical contact.

The author posits that entanglement between particle pairs is facilitated by sub-space. The unresolved conflicts in quantum physics involving instantaneous communication between quantum linked particle pairs is not a result of the physics of this universe breaking down, but is the result of the additional interaction of the particles through subspace, with the sub-space interactions not bound by the physical laws of this universe, i.e. there is no speed of light barrier.

2.5 Dark Mass and Dark Energy

The question arises as to why the quantized spacetime continuum has eluded detection. Observation of the effects of the spacetime continuum does occur, but under the nomenclature of inertia and momentum. A body in uniform motion has a reference frame consisting of local spacetime in a uniform state that encapsulates the body, with the non-local spacetime of the pilot wave moving around the body, thus moving the body forward. It is the geometry and sequence of equilibration of the spacetime pilot wave function (ψ) surrounding the body that determines the body's inertia or momentum. A change in energy to the B-strings of the ψ spacetime wave must occur in order to alter the sequence of contraction of the B-strings, which in turn causes a change in velocity of the body. The author hypothesizes that of all of the B-strings that make up the universe, perhaps greater than 90%, are in the expanded spacetime state, and are unobservable, i.e. are in a "dark" mass state. However, it is likely there are other types of dark mass contributing to the total amount of dark mass, including but not limited to subatomic particles, [22][23] MACHOs, [24][25] and WIMPs [26][27]. This model defines "dark energy" as the spontaneous expansion by B-strings and subsequent release of energy.

The author proposes that the universe came into existence when a B-string expanded from the singularity core of finite mass. B-strings cannot be created or destroyed, therefore there are a finite number of B-strings, and the universe is a bubble composed solely of B-strings. "Outside" of this bubble is undefined, as are any areas within the bubble that are discontiguous with spacetime, i.e. sub-space.

In this model, a singularity consists of a solid core of quantum matter particles with no spacetime intervening between the particles. Matter accreting on a singularity appears mathematically to disappear into a point; only the gravity of the matter that was seemingly crushed out of existence appears to remain. The author posits that prior to the Big Bang [28], the equations describing the universe cannot function due to the non-existence of expanded B-strings to impart space and time dimensions, i.e. space and time do not exist. When the first B-string expanded from the Big Bang singularity, then the conditions of the B-string model are met for the universe to come into existence, i.e. both expanded B-strings (spacetime) and fully contracted B-strings (matter) must be present and generally contiguous. The universe would appear mathematically to have exploded out of a point in space.

2.6 No Physical Infinites Postulate

The last section indicates that energetic photons can convert spacetime into matter. It is proffered that spacetime also contracts into matter when interacting with the particle matter core of a black hole singularity. Arguing geometrically, the abutting spacetime unit D-branes must line up in a fully contracted state with the quantum particle D-branes of the singularity core surface. Once the abutting D-brane fully contracts, the remaining D-branes of the spacetime unit equilibrate to a maximally contracted state, resulting in the spacetime unit converting into matter.

If black holes continuously convert spacetime into matter, this eventually draws all spacetime and matter onto one final black hole singularity, and the universe ceases to exist. Time has a lifespan, beginning with the big bang and ending at the big crunch. If the universe consists of a finite number of B-strings whose physical properties are finite by the property of quantization, and there is finite time for physical interactions between B-strings, then *there can be no physical infinities*.

2.7 Oscillating Universe

If the universe contracts by the force of gravity into one singularity, then how does the singularity overcome gravity to explode and continue the oscillation process? By definition, when the matter and spacetime of the universe fully contract upon the final aggregate singularity, spacetime (gravity) no longer exists; therefore, there is no gravity to overcome. Without gravity to maintain the contracted state of the matter quanta, the singularity core explodes, and the momentum of the explosion expands the universe until the subsequent formation of black holes begins the eventual process of contraction. Hyper-expansion after the Big Bang is the mathematical interpretation of the aggregate singularity core attaining dimensionality by the conversion of some of the matter quanta into spacetime; the entire core comes into existence the moment of the Big Bang. The inflationary phase should occur in one Planck's time of the Big Bang explosion

3. Gravity

This paper's model defines gravity as the concerted interaction of matter and spacetime. Matter distorts spacetime, and the distorting spacetime simultaneously interacts with the matter creating a force moving the matter through space.

3.1 Relating B-string Volumetric State to Time, String Tension, and Spacetime Energy

The *quantum level of spatial contraction* (QL) is a number that describes the geometric dimensions of the hexahedral quantum spacetime unit. Each QL is described by the eight vertices of the hexahedron, and each vertex is described by three spatial coordinates and time, resulting in the 32 parameters that define a QL state. A QL change occurs in a quantum jump (QJ); going from the initiation to completion of a QJ requires a single Planck's time interval. The number of QJ contractions away from a maximally expanded B-string configuration defines the numeric value of the QL of that B-string, see figure 4.

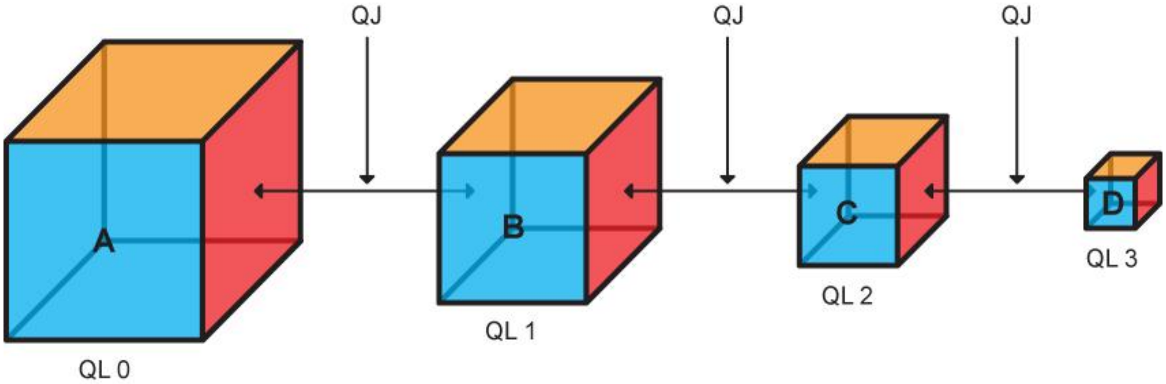


Figure 4- Quantum level changes with successive quantum jumps: Cube A represents a B-string in the fully expanded state, and cubes B, C, and D in progressive QJ contracted geometric configurations illustrate the QL of a B-string at each subsequent QJ. The final QL is the net total number of QJs from the maximally expanded state of the B-string. The sizes of the QL contractions in figure 4 are greatly exaggerated for clarity.

The QL of a B-string is a state function, i.e. the change in QL of a B-string depends only on the initial and final QLs of the B-string, and not on the path of the number of expansions and contractions of the B-string leading to the final B-string QL state, see figure 5.

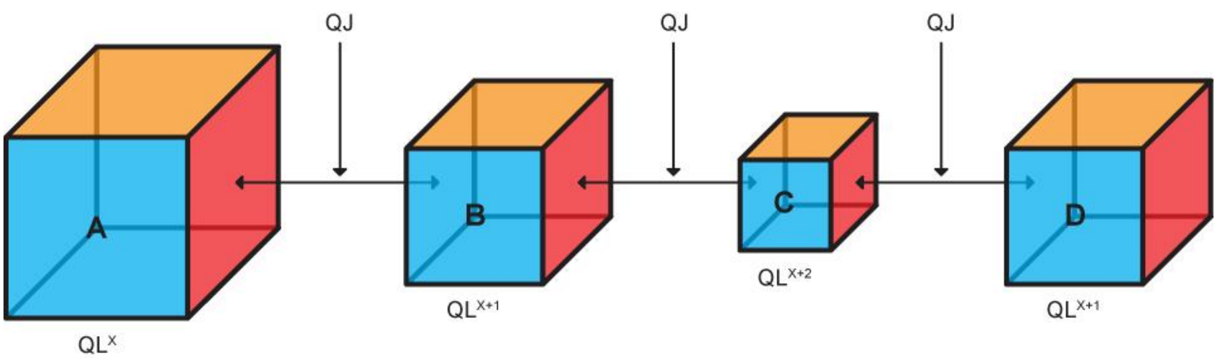


Figure 5- QL State Function of the B-string. A B-string undergoes three quantum jumps with an initial arbitrary value of x, denoted as QL^{x}, as in cube A. The B-string quantum jumps and contracts from QL to QL^{x+1} as in cube B. The B-string now undergoes a quantum jump and contracts a second time to QL^{x+2} as in cube C. Finally, the B-string Quantum jumps and expands to QL^{x+1} as in cube D. Though the B-string has undergone three quantum level changes, the net change in the B-string quantum level is one QL. It is not the *number* of Quantum jumps a B-string undergoes that determines quantum level, but it is the *net difference* in quantum jumps from the initial to the final quantum level.

3.2 Interpreting Quantized Spacetime String-to-String Tension Differentials as a Field Gradient

Paul Dirac proposed field quantization in 1929, later to be known as relativistic quantum field theory. [[29]] Paul Dirac stated, "...with the new theory of electrodynamics we are rather forced to have an aether." [[30]] The author concurs with Dirac's statement and further proposes that the aether is a physical continuum of B-strings.

The author posits that matter warps spacetime because quantum particles of matter are smaller than the abutting expanded B-strings of spacetime, i.e. B-string geometry distorts due to the process of string alignment and D-brane charge between the quantum particle of matter and the B-strings, see figure 6.

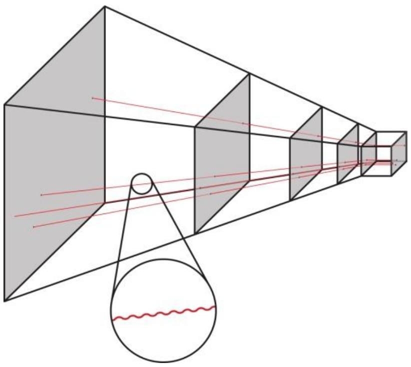
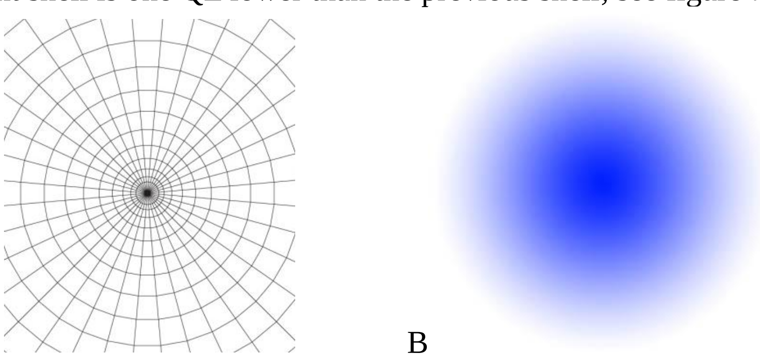


Figure 6- Spacetime warpage by Particle Matter- The cube represents a quantum particle of matter. The non-cubic hexahedrons represent the B-strings s of spacetime. The strings of the B-strings abutting the quantum particle warp the B-strings when aligning with strings of the particle matter.

The propagation of string tension from B-strings abutting a particle body to the B-strings not in direct contact with the body results in string tension radiating through the B-strings in proximity to the body. The subsequent outward-radiating string tension from the body defines a quantized *spacetime field* (SF). Restated, a spacetime field is a result of the tension of the Type I strings at the 2-brane of one B-string interacting and altering the tension of the corresponding strings and D-branes in an abutting B-string. An idealized non-rotating spherical body at rest or in uniform motion has an SF that is symmetrical along all axes of the body. The SF is composed of a gradient of abutting concentric shells of B-strings. All the B-strings of a shell have identical QLs, and the geometry of the B-strings is hexahedral in shape. Expanding outward, each subsequent shell is one QL lower than the previous shell, see figure 7.



A B

Figure 7 - (A) The 2-dimensional figure represents a spacetime field of concentric QLs of a body (QL size exaggerated for clarity). (B) The 3-dimensional graphic represents a spacetime field differential surrounding a body.

This linear reduction is expressed mathematically as, "the quantum level contraction state of spacetime exerted by a *single* body is proportional to the mass of the body, and inversely proportional to distance", as in

$$QL \propto \frac{m}{r} \tag{3.1}$$

where QL is the quantum level of spatial contraction, *m* is the mass of the body, and *r* is the radius from the center of mass of the body. The QL of a B-string is inversely related to the entropy (S) of the B-string,

$$S \propto \frac{1}{QL} \tag{3.2}$$

i.e. the greater the contracted state of a B-string, the higher the QL and the lower the entropy. The QL of a B-string is proportional to the energy level of a B-string,

$$E \propto QL \tag{3.3}$$

i.e. the greater the contracted state of a B-string, the higher the energy content of the B-string. By examination of equations 3.2 and 3.3, shows that energy is inversely proportional to entropy, as shown in equation 3.4.

$$E \propto \frac{1}{S} \tag{3.4}$$

Therefore, in a system where the B-strings expand, entropy increases and energy decreases. The entropy of a B-string is a state function, i.e. the change in entropy of a B-string depends only on the initial and final QL of the B-string, and not on the path of the number of expansions and contractions of the B-string leading to the final B-string QL state. This is a duplication of a previous paragraph.

The QL of a B-string is proportional to the gravitational strength (force) of a B-string. Therefore, an increase in QL of a B-string equals an increase in gravitational force of the B-string. The gravitational force of a *single* body can now be rewritten as Equation 3.5,

$$F_g \propto \frac{m}{r} \tag{3.5}$$

When *two* bodies gravitationally interact, exerting gravitational forces simultaneously on one another, the equation for gravitational force is equal to the product of each body's force on the other, as in

$$F \propto \left(\frac{m_1}{r_1}\right)\left(\frac{m_2}{r_2}\right) \tag{3.6}$$

Since r_1 is the distance from the center of mass of m_1 to the center of mass of m_2, it equals r_2 which is the distance from the center of mass of m_2 to the center of mass of m_1, equation 3.6 can now be rewritten as,

$$F \propto \frac{m_1 m_2}{r^2} \tag{3.7}$$

Inserting a proportionality constant of appropriate units, i.e. Newton's gravitational constant, into equation 3.7, derives Newton's universal law of gravitation, [[31]] equation 3.8:

$$F = G\frac{m_1 m_2}{r^2} \tag{3.8}$$

The potential energy level of a B-string corresponds to its QL; consequently, an increased QL corresponds to an increase in B-string potential energy, just as a decreased QL represents the reverse. B-strings spontaneously *expand* to a lower QL, but never *contract* spontaneously; this is the equivalent of the second law of thermodynamics translated into this paper's spacetime terms, i.e. a region of lower spacetime energy cannot spontaneously transfer energy to an abutting region of higher spacetime energy. B-strings undergo an increase in QL only by interacting either with B-strings having a higher QL, or with particle matter. Abutting B-strings with unequal QLs will interact in QJs to approach or equal the same QL.

In Quantum Field Theory, a graviton is a hypothetical massless particle that mediates gravity. [32] The author proffers that a graviton is not a free moving physical structure traversing an empty void, but instead the graviton is representative of B-string-to- B-string gravitational *string interaction* between abutting B-strings of the spacetime continuum. Since the graviton is a propagating string interaction, the graviton is not a discrete particle and has no mass.

3.3 Spacetime Field of a Uniformly Moving Body

The gravitational movement of any body is due to the concerted interaction of mass and spacetime, and is expressed mathematically in Einstein's field equations,

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R - g_{\mu\nu}\Lambda = -\frac{8\pi G}{c^4} T_{\mu\nu}. \tag{3.9}$$

where $R_{\mu\nu}$ is the Ricci tensor, $g_{\mu\upsilon}$ the metric tensor, R is the scalar curvature, Λ is the cosmological constant, G is the gravitational constant, c is the speed of light, and $T_{\mu\upsilon}$ is the stress-energy tensor. The left side of the equation expresses matter's warping of spacetime, and the right side expresses how matter moves through spacetime, i.e. the gravity field. Gravity is the interaction of a body curving spacetime, with the spacetime curvature determining how the body moves. The cosmological constant, once thought to be a mistake in Einstein's field equations, may in fact be a necessary mathematical term, not as a constant for a static universe, but to express the spontaneous expansion of B-strings as stated in Postulate II of this paper. The energy of spontaneous B-string expansion is dark energy.

In the case of a uniformly moving body, the author proffers an interpretation of Einstein's field equations that spacetime does not move through a body, i.e. spacetime between the particles of matter within the body remain fixed within the body. These fixed spacetime B-strings within the body mass are designated the *inertial frame of reference* spacetime field. The B-strings surrounding the reference frame sequentially contract, propagating a wave which moves the body forward, and are designated the *spacetime field wave* (ψ), see figure 11. The steady state of the reference frame of the body stabilizes and maintains the B-string equilibration process of the ψ differential, maintaining self-propagating movement and preventing the ψ wave from radiating away. A body moving uniformly through spacetime can be visualized as a stable capsule (body and reference frame) surrounded by the ψ wave which moves the body through spacetime, see figure 8. The ψ wave of this model is not an original concept; it has similarities to the *matter wave* of Louis de Broglie [33] and the *pilot wave* of David Bohm. [34]

3.4 Reference Frame Changes to a Body Under Acceleration

When the ψ wave of a body in uniform motion encounters a gravitational field, the B-strings of the ψ wave interact with the B-strings of the gravitational field disrupting the sequence of contractions of the ψ wave. The result is a change in the direction and/or speed of the body, i.e. the body undergoes acceleration. The altered ψ wave interacts with the inertial reference frame, destabilizing the reference frame's constant state, i.e. the body's B-strings of the reference frame will either contract or expand, depending on the density of the gravitational field interacting with the body.

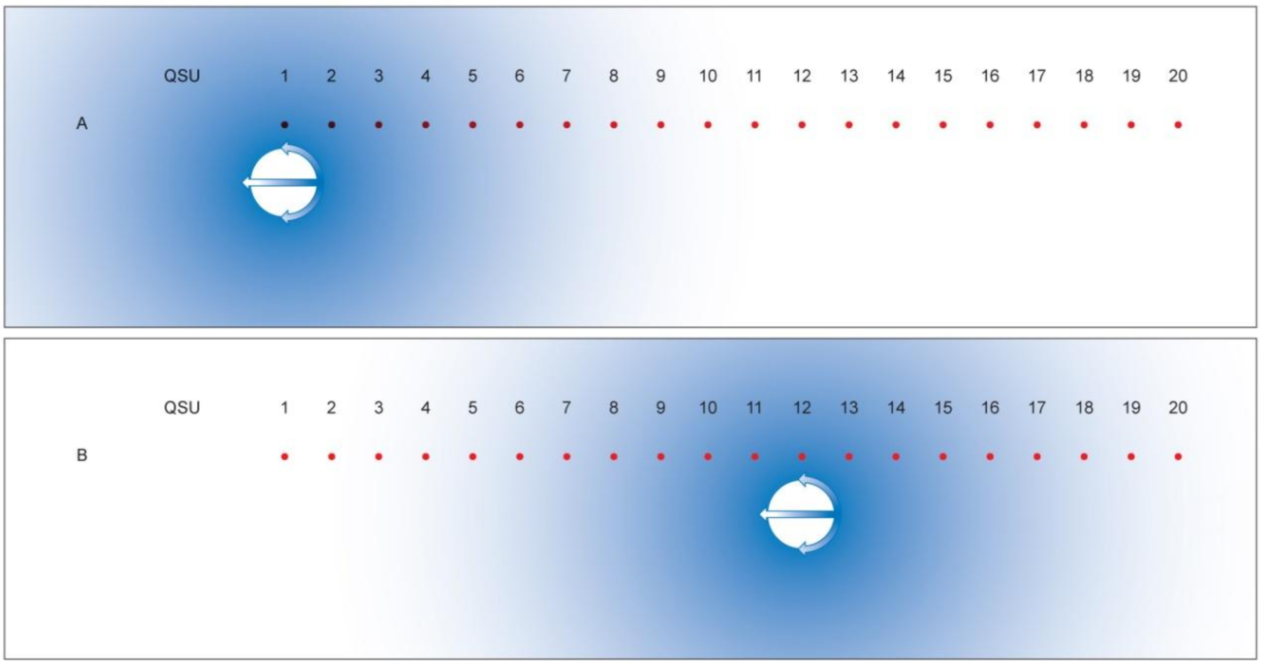


Figure 8- Reference frame and ψ motion diagram. The white dot at the center of the figure represents the reference frame, and the blue surrounding the white dot represents ψ. The blue arrows indicate the ψ contracting around the body, moving the body forward.

4. Length Contraction and Time Dilation

Variations in B-string geometry can be equated to the Lorentz transformations, relating how space and time dilations result from alterations of the physical parameters of the B-string, and that expanded B-strings are in fact physical spacetime.

The B-strings surrounding a body undergoing positive linear acceleration initially contract only in the direction of acceleration. When the body ceases to accelerate, reaching a uniform velocity, then all axial lengths of the B-strings equilibrate to approach or equal one another, forming a more contracted, stable, local B-string field around the body. The initial dimensional changes to the B-strings during acceleration are physically felt by a person seated in a vehicle undergoing acceleration as being pulled back into their seat. Once the vehicle attains a steady speed, B-strings equilibrate and the pulling force is no longer felt by the person. Since the

B-string axial lengths (space) have contracted, there must be an obligatory change to time within the field, since space and time are linked, and time slows down in the contracted reference frame of the vehicle.

4.1 Length Contraction

A body that undergoes acceleration produces localized time dilation and length contraction effects. The Lorentz transformations describe these changes, [35] as shown in equation 4.1 for time and 4.2 for length

$$t' = \gamma t\,, \tag{4.1}$$

$$l' = l / \gamma\,, \tag{4.2}$$

where t' is time in a relative moving frame, t is time in the rest frame, l' is length in a relative moving frame, l is length in the rest frame, and $\gamma = 1/\sqrt{1-(v^2/c^2)}$.

The forces of electrostatic repulsion must be considered in order to evaluate the physical interpretation of length contraction, the reason for which will be explained in the following paragraphs of this subsection. The ratio of electrostatic force to gravitational force for two electrons is 4.17×10^{42}, [36] as in

$$\frac{F_e}{F_g} = \frac{ke_1^- e_2^- / r^2}{Gm_1 m_2 / r^2} = \frac{ke_1^- e_2^-}{Gm_1 m_2} = 4.17\times10^{42}\,. \tag{4.3}$$

However, the ratio of electrostatic force to gravitational force between identical atoms or identical molecules is variable, depending on the respective number of protons and neutrons constituting the atoms and molecules. Therefore, there is no fixed value for the ratio of F_e to F_g but 10^{42} suffices as an approximation. The following paragraphs will utilize this large ratio in explaining the resistance of a body in motion to contract.

As stated in section 3.1, as a moving body’s local spacetime contracts, the body’s gravity increases. However, at speeds less than 0.99*c* the increase in gravity is relatively weak, and is insufficient to overcome the 10^{42} greater repulsive electromagnetic force, which would be required to contract the body in proportion to the Lorentz length contraction equation.

To date, no published experiment has confirmed the existence of length contraction of a moving body by *direct* observation. Well-known experiments that fail to show length contraction include Trouton-Rankine [37] and Tomaschek. [38][39][,40] Several experiments purport to confirm the existence of length contraction by *indirect* evidence, in particular Pound-Rebka [41][42] and Pound-Snider. [43] The author concurs that length contraction does occur when a body is in motion, but he proffers the current interpretation that the body contracts is incorrect, and posits it is *spacetime* surrounding a moving body that contracts, and not the body itself. The following section will elucidate B-string model length contraction and time dilation of a moving body.

4.2 Time Dilation

Length contraction of the local spacetime surrounding the body leads directly to time dilation of the body as the following example illustrates. If a body is accelerated to a uniform velocity of .866 the speed of light, the local reference frame of the body interacts with the denser ψ wave, contracting the B-strings of the reference frame of the body. Substituting .866 into Equation 4.2 yields a length contracture of 0.5. The B-strings initially contract only in the direction of motion, but the strings within the B-string undergo equilibration to approach or attain equal lengths in all axes, as assumed from "B-string Model premise 7". Therefore, B-strings of the reference frame contract along *all three axes* to one-half their initial length, which doubles the number of B-strings between any two particles of matter.

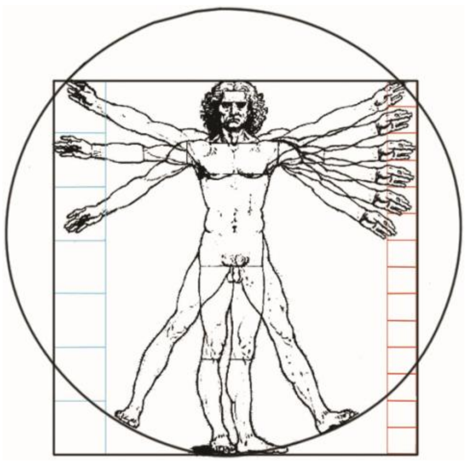


Figure 9

In Figure 9, the figure's right arm side represents a spacetime field density of seven B-strings from head to toe, and the figure's left arm side represents a spacetime field density of fourteen B-strings from head to toe. It is possible to observe time dilation between these two fields when the model raises both arms simultaneously from his navel to the top of his head. The figure's right arm traverses three B-strings at a rate of one B-string per unit time T_o, and the model's left arm traverses six B-strings at the same rate of one B-string per unit time T_o. It is apparent to a non-local observer, i.e. an observer outside of the model's local reference frame, that the model's left arm takes twice as long to traverse from his navel to the top of his head due to its passing through twice as many spacetime B-strings as the right arm.

Placing a clock in the right hand and an identical clock in the left hand, both clocks will register three time units for their respective arms to move from the navel to the top of the head. This is not a paradox because even though the figure's left side takes twice as long to travel the distance, the clock would run half as fast in the left side's denser spacetime field. This is because the figure's left side clock's moving parts would also have to pass through twice as many B-string's in the figure's left hand spacetime field and would run at half speed. Therefore, a local observer in either the left hand or right hand spacetime field will observe the clock register the passage of three units of time to move the arm from the navel to the head, but an outside observer not within either reference frame will observe the clocks running at different speeds. Physical time dilation is therefore the change in time required to move between points of matter under varying spacetime density conditions.

The linking of space and time as 'spacetime' implies that any change in space inextricably requires a corresponding change in time. If a body that has undergone acceleration produces *time* dilation, then a length change will have occurred to the *space* surrounding the body, i.e. length contraction occurs to the body's local spacetime and not to the body itself.

4.3 Relativistic Mass Increase

How does an object increase in relativistic mass? Does the object actually gain more atoms or molecules? Could the protons, neutrons, and electrons of the object somehow increase in mass? It seems unlikely to the author that any of these things occur; instead, the relativistic mass increase is not an actual increase in mass, but is simply interpreted mathematically as an increase in mass because of the increase in spacetime density, due to the contracture of local spacetime of the moving object. It is spacetime that changes and not the mass of the accelerated body.

5. Speed of light

Albert Einstein stated in his second postulate of special relativity, "Light is always propagated in empty space with a definite velocity *c* which is independent of the state of motion of the emitting body." [44] This section will attempt to elucidate the underlying physical nature of Einstein's axiomatic statement.

5.1 Planck's Units of Length and Time

Equations and original values for Planck's natural units of length and time are shown in equations 5.1 and 5.2 [45]. Note however that Planck's values for *G*, *h*, and *c* are inaccurate compared to modern accepted measurements as listed in CODATA. [46] Consequently, substitution of currently accepted values of these constants into the formulae yields a correspondingly modern value for Planck's length and time as shown in equations 5.3 and 5.4.

$$l_p = \sqrt{Gh/c^3} = 4.13\times10^{-33}cm \tag{5.1}$$

$$t_p = \sqrt{Gh/c^5} = 1.38\times10^{-43}s \tag{5.2}$$

$$l_p = \sqrt{\frac{Gh}{c^3}} = \sqrt{\frac{\left(6.6742\times10^{-8}\,g\cdot cm^2\cdot s^{-1}\right)\left(6.6261\times10^{-27}\,g\cdot cm^2\cdot s^{-1}\right)}{\left(2.9979\times10^{10}\,cm\cdot s^{-1}\right)^3}} = 4.0513\times10^{-33}cm \tag{5.3}$$

$$t_p = \sqrt{\frac{Gh}{c^5}} = \sqrt{\frac{\left(6.6742\times10^{-8}\,g\cdot cm^2\cdot s^{-1}\right)\left(6.6261\times10^{-27}\,g\cdot cm^2\cdot s^{-1}\right)}{\left(2.9979\times10^{10}\,cm\cdot s^{-1}\right)^5}} = 1.3512\times10^{-43}s \tag{5.4}$$

5.2 The Photon

The author proffers that a photon is not an individual particle traversing an empty void, but instead the photon is a B-string *vibrational interaction* between abutting B-strings of the spacetime continuum. If the photon is a propagating B-string *interaction, i.e. a process,* and not a discrete particle, then the photon has no mass. However, since the photon is isolated to one B-string at a time as it propagates, it appears as a packet (particle), and as the photon propagates, an accompanying EM SF occurs at each B-string as the EM pulse traverses through abutting B-strings, and the SF appears as a wave as it passes an observer.

More than one photon can have its EM string interactions pass simultaneously through an individual B-string, along a different EM string not occupied by another photon. Therefore, the photon, as well as other zero mass bosons, can occupy the same space (B-string) at the same time. On the other hand, fermions are not like the bosons, but are fully contracted B-strings that are solid particles of matter, and cannot occupy the same space at the same time; there is simply no space for the fermions to pass through one another because the B-strings are fully contracted.

5.3 The Speed of Light

The quantum jump contraction of the B-string occurs in the same invariant time interval (Planck's time), regardless of the contracted state of the B-string. Equation 5.5 shows the computation of the speed of light of a photon traversing maximally expanded spacetime (c_m), as

$$c_m = \frac{l_p}{t_p} = \frac{4.05 \times 10^{-33} cm}{1.3512 \times 10^{-43} s} = 2.9979 \times 10^{10} cm \cdot s^{-1} \tag{5.5}$$

By inspection of the algebraic formulae, this outcome is obvious, for it is self-defining,

$$c = \frac{l_p}{t_p} = \frac{\sqrt{Gh/c^3}}{\sqrt{Gh/c^5}} = \sqrt{\frac{Gh \cdot c^5}{Gh \cdot c^3}} = \sqrt{c^2} = c \tag{5.6}$$

However, using this model's concepts of length contraction and time dilation, we can now state the speed of a photon traversing a local reference frame of contracted spacetime (c_c) to be

$$c_c = \frac{l_c}{t_p} \tag{5.7}$$

where l_c represents the contracted length of the B-string, and $l_c < 4.0513 \times 10^{-33} cm$. Equation 5.7 shows that the speed of light is not constant in absolute distance crossed per unit time, but is *invariant* in traversing one B-string per Planck's time unit, see figure 10.

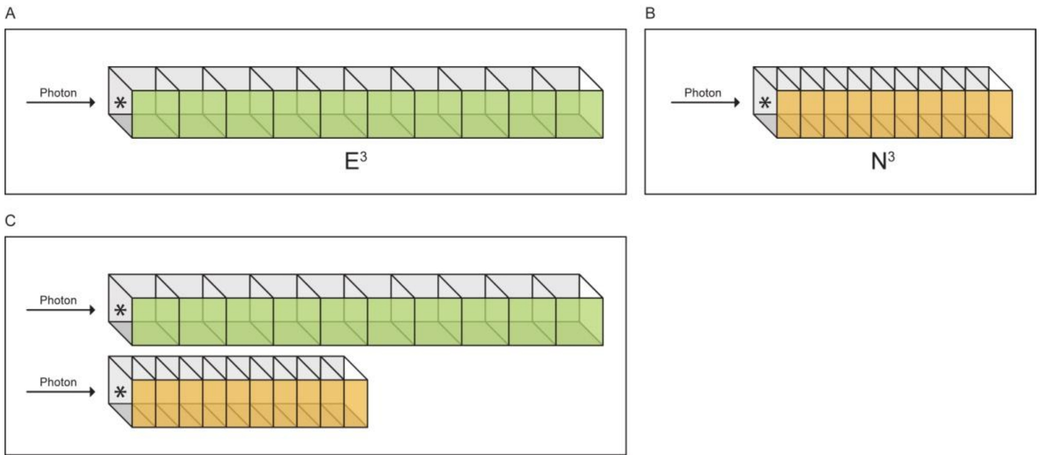


Figure 10- Euclidean (E^3) and Non-Euclidean (N^3) Geometries; (A) Euclidean reference frame with fully expanded B-strings having equal lengths along x, y, and z-axes with the time required to traverse l0 fully expanded B-strings equaling 10x T_p= 10 T_p, and the distance traversed equaling 10x L_p= 10 L_p. **. (B)** Non-Euclidean reference frame with warped or contracted spacetime with B-string axes not equal in length. The B-strings in this case are contracted ½ in direction of motion. The time to traverse ten contracted B-strings equals, 10x T_p= 10 T_p and the distance traversed equals, 10x 1/2 L_p= 5 L_p. **(C)** E^3 juxtaposed to N^3- the photon will appear to move at half the speed and move half the distance in N^3 as compared to E^3.

The speed of light within a local reference frame of a moving body always appears to be $2.9979\times10^{10} cm\cdot s^{-1}$, because an observer within a stable reference frame is surrounded by B-strings with the same contraction state or QL, resulting in the observer undergoing time dilation exactly equal to the time increase a photon requires to traverse the increased number of B-strings.

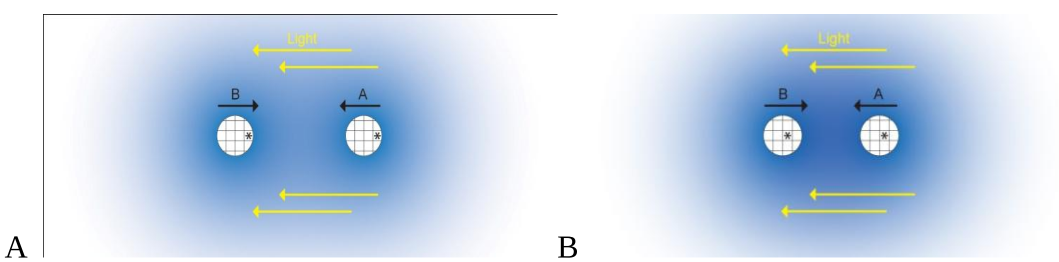


Figure 11- (A) shows two bodies **A** and **B** moving in opposite directions and at the same speed, as indicated by the black bars above the bodies. Photons from a light source coming from the same direction as body **A** enter the reference frame of body **A** and body **B** at the same instant, as indicated by the asterisk. Figure (B) shows that since both bodies are moving at the same speed, the bodies have identical spacetime densities of their respective reference frames, and the photons of both bodies propagate at the same rate of one B-string per Planck's time. An observer within the reference frame of either body **A** or **B** will observe the speed of light at the same speed, despite moving in opposite directions from the light source.

The author suggests the *null result* of Michelson-Morley's experiment [[47]] was a consequence of the false assumption that the ether (spacetime continuum) moves through the interferometer because the earth is moving through the ether. The author proposes that the arms of the interferometer used in Michelson-Morley's experiment were within a rapid equilibrating stable reference frame, resulting in uniform measurement of the speed of light, producing the null result for detecting the ether.

Concluding Remarks

The B-string model presented in this paper endeavors to elucidate a relationship for a physical structure of spacetime as another state of matter. This paper does not question the validity or accuracy of current mathematics describing quantum mechanics and relativity as put forth by Planck, Einstein, Dirac, et al. However, the mathematics does not describe the underlying physical nature of the universe. This model suggests a physical interpretation of the mathematics that describes spacetime and matter. The basis of this B-string model, i.e. that space is not empty, and is quantized, allows for the extrapolation to new interpretations for gravity, time dilation, and the speed of light; these physical interpretations offer a view of the universe based upon a possible physical quantum reality via the B-string.

The author proposes it is no coincidence that Planck's natural units describe the properties of the B-string, and puts forth that the values of G, h, and c are determined by the properties of the B-string. The calculation by Planck to determine his natural units by using G, h, and c was the mathematical process of inadvertent reverse engineering, which necessarily revealed the properties of the B-string.

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