Abstract

The model of this paper presupposes that space-time is not a mathematical abstraction, but that space-time is an expanded state of matter. The fundamental quantum of matter is designated the B-string, (for Brane/String complex). The B-string quanta of particle matter and space-time differ from one another only in the volumetric state of the B-string. It is demonstrated how the B-string can be interpreted as 10-dimensional, 11-dimensional, and 26-dimensional. The relationship of the B-string quanta to Planck's natural constants is shown, and a mathematical argument is presented demonstrating the conversion of space-time into particle matter.

Space-time as an Expanded State of Matter with a Physical Structure Interpreted as Simultaneously Exhibiting 10, 11, and 26 Dimensions

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1. Introduction

Modern theory states that matter and energy in their most basic form exist in discrete amounts, or quanta. The author proffers that space-time also exists as discrete quanta, and derives a physical model of space-time and elemental particles of matter. The hypothesis for this model is that the quanta for matter and space-time are convertible states of the same hidden variable elementary building blocks composed of D-branes and Type I strings: the B-string.

2. B-string Structure

The structure of the B-string is determined by a specific orientation and attachment of D-branes and Type I Strings to one another forming the physical 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 an 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 space-time warpage or curvature.

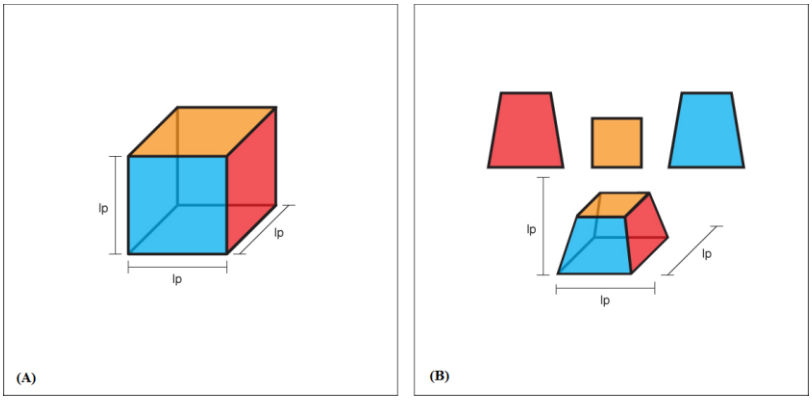

Figure 1. (A) B-string fully expanded, with each facet equaling Planck's length (B) B-string in a partially contracted state, with facet lengths less than Planck's length.

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.

2.2 B-string model postulates:

1. The B-string is composed of Type I strings and D-branes, and that matter and space-time 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 space-time.
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 space-time 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 and bond to one another by attraction of opposite charges.
9. B-strings spontaneously expand but can never spontaneously contract, and 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 space-time B-string.
15. Kinetic energy of space-time is the geometric changes, and/or vibrations of D-branes and Type I strings of a B-string.

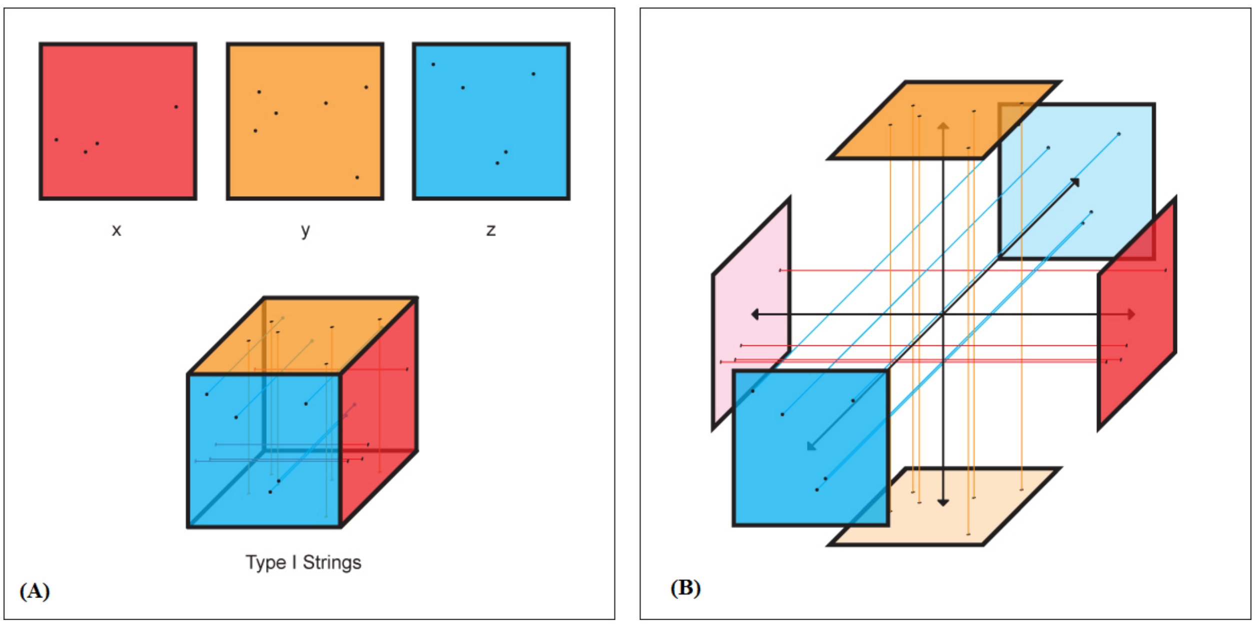

Figure 2. (A) Colored facets represent D-branes. (B) B-string exploded view, colored lines represent Type I strings.

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

The Type I strings constitute the three dimensions of the x, y, and z-axes. The author proffers that the D-branes are an extension and continuation of the Type I strings, i.e. the D-branes are Type I strings are the same physical entity in different spatial configurations. The x, y, and z axial Type I strings extend their dimensionality to the D-branes, resulting in mathematical interpretations of more dimensions than the conventional four-dimensional physical universe. The six D-branes on the B-string facets are arbitrarily named 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 space-time. [8] In this paper, time is defined as the interval from initiation to completion of a geometric change in a quantum of space-time. Restated, since space and time are inexorably linked as the one entity of space-time, a change in one component of space-time 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.

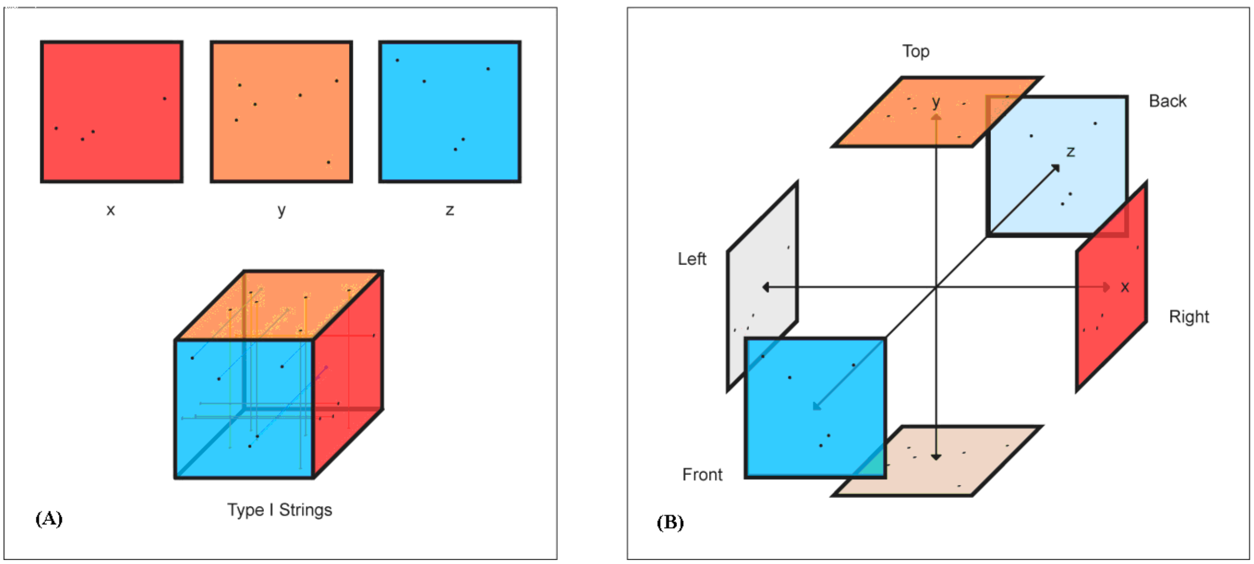

Figure 3 - The 10-dimensional B-string

The dimensionality of the B-string can also be considered 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 can be considered 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 B-string can also be interpreted as 26-dimensional. The required additional 15 dimensions are revealed 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 added to the previously outlined existing 11 dimensions, results in the B-string having a total of 26 dimensions. In compiling the D-brane combinations, no mirror image combinations are allowed, this is because mirror images are anti-matter and not matter. To clarify, the numbers on the cube should be numbered like dice, i.e. opposite sides should add up to 7. Side #1 combinations are to be considered matter, and the mirror image Side #6 combinations are anti-matter. Each D-brane combination of matter must include side #1, and anti-matter must include side #6 in the combinations, this results in a **maximal** number of fifteen dimensions.

The additional fifteen dimensions are made apparent by utilizing multiple D-brane combinations interpreted as a single dimensions:

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. 1,2,5
9. 1,2,4
10. 1,3,5
11. 1,2,3,4
12. 1,3,4,5
13. 1,2,4,5
14. 1,2,3,5
15. 1,2,3,4,5

2.4 Space-time Conversion into Matter and Anti-matter

The B-string model presupposes that an B-string in the fully contracted state defines a quantum particle of matter. The quantum particles of matter are posited as 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 an B-string. However, space-time energy varies: the greater the contracted state, the greater the potential energy content of the space-time B-string. Opposing D-branes on any one of the three axes of an 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 space-time B-string, will contract the 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 space-time 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 an 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 space-time B-strings.
2) Kinetic energy of space-time 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 an B-string can be orders of magnitude greater than any geometric or potential energy of an 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 space-time, increasing the potential energy of the space-time B-string by contracting the D-branes and strings. Once the initial unit of space-time has converted into a quantum particle of matter, additional quantum particle pair aggregates are generated 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,

$$E = mc^2 \qquad (2.1)$$

The author posits that energy, matter, and space-time are convertible, with the conversion of space-time into matter occurring when an B-string contracts into its maximal contracted state.
Equation 2.2 indicates the mathematical relationships of energy, matter, and space-time. The term *m* is the mass of a *single* quantum particle of matter. The state of contraction of an 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 space-time unit may be stated mathematically by inserting a term into Einstein's equation, which expresses the QL of the space-time unit; QL^x is the quantum level of contraction of space-time, and QL^n represents the QL of a quantum particle of matter. Inputting energy into an 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 space-time converts into matter.

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

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.

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

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

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 space-time, one Planck's length is the smallest unit of distance because space-time is quantized and cannot be further sub-divided. Therefore, the smallest possible wavelength of fully expanded space-time 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

$$\nu_{\max} = \frac{c}{\lambda} = \frac{2.9979 \times 10^{10} cm \cdot s^{-1}}{4.0513 \times 10^{-33} cm} = 7.4000 \times 10^{42} s^{-1} \qquad (2.5)$$

It has been posited that when a photon of *sufficient* electromagnetic energy interacts with a space-time 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 space-time 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 space-time 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 space-time photon is

$$E = hf = \left(6.6261 \times 10^{-27} g \cdot cm^2 \cdot s^{-1}\right)\left(7.4000 \times 10^{42} s^{-1}\right) = 4.9033 \times 10^{16} g \cdot cm^2 \cdot s^{-2} \qquad (2.6)$$

Substituting the energy value of a maximum frequency photon from equation 2.6 into equation 2.1 and solving for mass is shown in equation 2.7,

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

It is indeed apparent that one photon can possess enough EM energy to convert space-time 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,

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

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

Therefore, Planck's mass is that amount of mass that can be converted from space-time into equal quantities of matter and anti-matter totaling $5.4556x10^{-5}g$ by a maximum frequency photon.

Concluding Remarks

The B-string hidden variables model presented in this paper endeavors to elucidate a relationship for a physical structure of space-time 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 nature of the universe. This model suggests a physical interpretation of the mathematics that describes space-time and matter

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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