On Relating a 10-dimensional and 11-dimensional Duality Model of Quantized Space-time to Elementary Particles

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Abstract

It is suggested in this paper that space-time and matter are both derived from a common entity, the quantum mass unit. A 10-dimensional and 11-dimensional duality model of the quantum mass unit is presented diagrammatically, and a mathematical argument is put forth indicating how energetic photons interact with space-time, converting space-time into virtual particle pairs of matter and anti-matter.

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 elementary particles. The hypothesis for this space-time model is that the quanta for matter and space-time are convertible states of the same elementary building block: the quantum mass unit.

2. Physical Model of Quantized Space-time

Minkowski first proposed the linking of space and time as space-time.[1] This paper presents a model of space-time that seeks to explicate a physical structure of space-time.

2.1 Postulates

Postulate I: *Space-time and matter are physical entities of a common elemental structure, the quantum mass unit* (QMU).

The QMU is composed of Type I strings and D-branes. It is proposed that matter and space-time are different volumetric states of the QMU, and are convertible into one another. A fully contracted QMU is a quantum particle of matter, and an expanded QMU is a unit of quantized space-time (QSU). This model defines the universe as being composed of a *finite* number of QMUs, in which both the expanded QMUs (quantum space-time), and fully contracted QMUs (particle matter), must be present and generally contiguous.

Postulate II: *QSUs expand spontaneously, and contract only by interacting with particle matter, or by interacting with abutting QSUs having a greater degree of contracture.*

The level of contraction, or decrease in volumetric state of a QSU from the maximally expanded state is termed the quantum level of spatial contraction (QL) of a QSU. All QSUs undergo expansion and contraction in discrete steps, known as quantum jumps.

2.2 Relating Type I strings and D-branes to Quantized Space-time Morphology

Planck's length[2] and Planck's time[3] quantify two of the physical parameters of the QSU. The maximally expanded QSU 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 QSU occurs in a *quantum jump* (QJ), 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 QSU, the cubic shape of the QSU distorts along multiple axes but maintains hexahedron shape with six planar faces, see figure 1(B). The range between maximally expanded and maximally contracted states of a QMU defines space-time curvature.

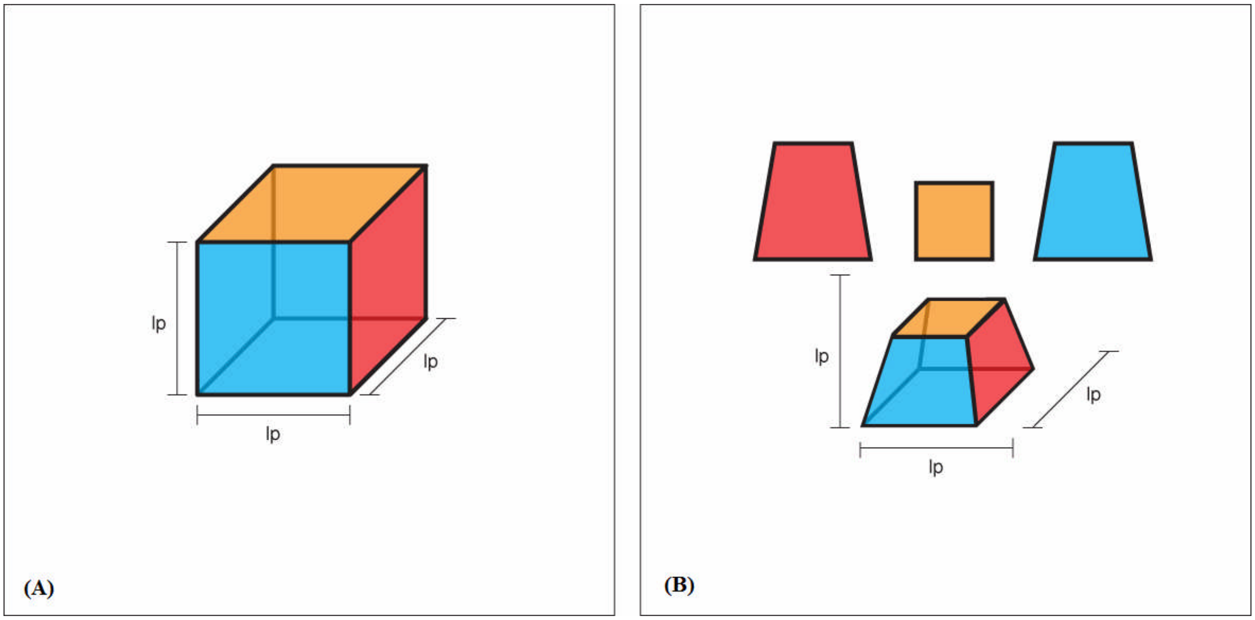

Figure 1. (A) QSU fully expanded, with each facet equaling Planck's length (B) QSU in a partially contracted state, with facet lengths less than Planck's length.

This paper's physical model of quantum space-time utilizes Type I strings and D-branes as the functional components of a QMU. D-branes were discovered independently by Petr Horava,[4] and by the team of Jim Dai, Rob Leigh, and Joe Polchinski.[5] The D-brane is named after 19th century mathematician Johann Peter Gustav Dirichlet[6]. Dirichlet's boundary conditions[7] 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 the D-branes. The following properties of Type I strings and D-branes are hypothesized in this paper:

1. D-branes occupy the surface of the six facets of the hexahedral QMU.
2. The Type I strings are within the QMU and attach from one facet D-brane across to the opposing parallel facet D-brane, see figure 2(A).

3. The string attachment pattern of the two facets of an axis of a QMU is a unique stereoisomeric configuration with respect to that axis, resulting in space-time and matter having chirality, see figure 2(B).
4. The two opposing D-branes of any of the three axes are mirror image nonsuperposable enantiomers.
5. It is known that D-branes possess charge,[8] but additionally in this model the mirror image D-branes of a QMU carry equal and opposite charges.
6. Mirror image D-branes align to match Type I string configurations of abutting QMUs and bond to one another by attraction of opposite charges.

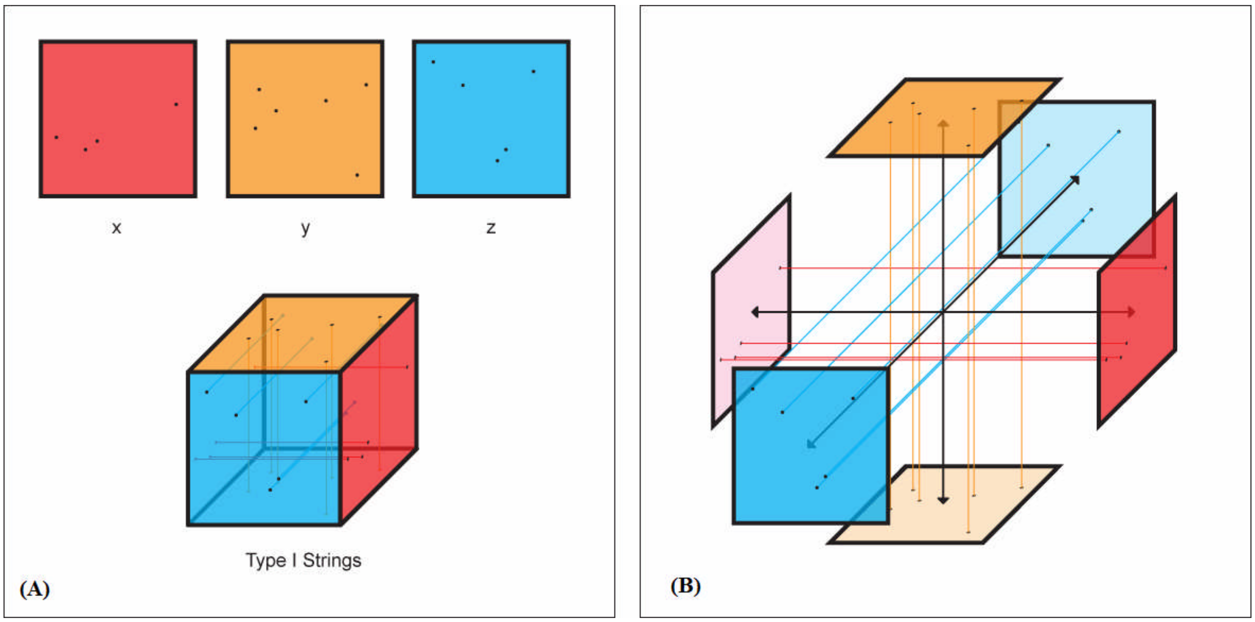

Figure 2. (A) Colored facets represent D-branes. (B) QMU exploded view, colored lines represent Type I strings.

2.3 The 10-dimensional and 11-dimensional Duality of the Quantum Mass Unit

The one-dimensional 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 QMU are mathematically interpreted as distinct higher dimensions due to the unique stereochemistry of each of the two-dimensional D-brane sheets. The six D-branes on the QMU facets are arbitrarily named top, bottom, left, right, front, and back. The nomenclature of 2-brane will be used to distinguish the higher dimensionality of the D-brane. The 10 dimensions of the QMU 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

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 the 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 a QMU (space) is required for a change in time to occur.

The dimensionality of the QMU 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 QMU projecting into space simultaneously can be considered a third higher level of dimensionality, i.e. 3-brane.

With the addition of a 3-brane dimension to the ten dimensions previously outlined results in an eleven dimensional QMU. Both ten and eleven-dimensional models express the same concept of the QMU 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]

3. Space-time Conversion into Matter

It is presupposed in this model that a QMU in the fully contracted state results in the formation of a *quantum particle of matter* (QP). The QPs are posited as the elementary building blocks of matter, and are the precursors to quarks. Quarks were first predicted by Murray Gell-Mann[11], and George Zweig.[12][13]

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 exactly 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 this 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 are charged, 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. A sub-atomic particle without charge, e.g. a neutron, has an anti-matter partner, which is an enantiomer of the neutron.

The author suggests that the formation of matter and anti-matter occurs when a photon with sufficient energy interacts with a QMU of space-time, and generates particle pair aggregates from opposing mirror image D-branes of any one of the three axes of the QMU. Therefore, three distinct QP 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 3.1,

$$E = mc^2 \tag{3.1}$$

The author posits that energy, matter, and space-time are convertible, with the conversion of space-time into matter occurring when a quantum space-time unit contracts into its maximal contracted state.

Equation 3.2 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 a QSU is defined as the quantum level of contraction (QL). The energy of a space-time unit may be stated mathematically by inserting a term into Einstein's equation, which expresses the quantum level of spatial contraction of the quantum space-time unit; QL^x is the quantum level of a QSU, and QL^n represents the *QL* of particle matter. Inputting energy into a QSU increases the QSU's QL, and if enough energy is absorbed by the QSU, the QSU will contract until the QL^x equals QL^n then equation 3.2 reduces to Einstein's equation, at which point space-time converts into matter.

$$E = \left(\frac{QL^x}{QL^n} \right) mc^2 \tag{3.2}$$

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 3.3 and 3.4.

$$l_p = \sqrt{\frac{Gh}{c^3}} = \sqrt{\frac{\left(6.6742\times10^{-8} cm^3 g^{-1} s^{-2}\right)\left(6.6261\times10^{-27} g\cdot cm^2\cdot s^{-1}\right)}{\left(2.9979\times10^{10} cm\cdot s^{-1}\right)^3}} = 4.0513\times10^{-33} cm \tag{3.3}$$

$$t_p = \sqrt{\frac{Gh}{c^5}} = \sqrt{\frac{\left(6.6742\times10^{-8} cm^3 g^{-1} s^{-2}\right)\left(6.6261\times10^{-27} g\cdot cm^2\cdot s^{-1}\right)}{\left(2.9979\times10^{10} cm\cdot s^{-1}\right)^5}} = 1.3512\times10^{-43} s \tag{3.4}$$

In a vacuum not under the influence of matter, a maximally expanded QSU has a length along the x, y, or z-axes equaling one Planck's length. If one Planck's length is also the smallest unit of distance because space-time is quantized and cannot be further sub-divided, then the smallest possible wavelength 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 equals,

$$\nu_{\max} = \frac{c}{\lambda} = \frac{2.9979\times10^{10} cm\cdot s^{-1}}{4.0513\times10^{-33} cm} = 7.4000\times10^{42} s^{-1} \tag{3.5}$$

It has been posited that a photon of *sufficient* electromagnetic energy interacts with a QSU, the QSU will convert into particle matter. It must be determined whether an individual photon can possess sufficient EM energy for QSU-matter 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 3.6 shows the relationship of energy as a function of EM frequency. Substituting the value from equation 3.5 into the equation for energy frequency, the calculation of the maximum possible EM energy of a space-time photon is

$$E = hf = \left(6.6261\times10^{-27}\, g\cdot cm^2\cdot s^{-1}\right)\left(7.4000\times10^{42}\, s^{-1}\right) = 4.9033\times10^{16}\, g\cdot cm^2\cdot s^{-2} \quad (3.6)$$

Substituting the energy value of a maximum frequency photon from equation 3.5 into equation 3.1 and solving for mass is shown in equation 3.7,

$$m = \frac{E}{c^2} = \frac{4.9033\times10^{16}\, g\cdot cm^2\cdot s^{-2}}{\left(2.9979\times10^{10}\, cm\cdot s^{-1}\right)^2} = 5.4556\times10^{-5}\, g \quad (3.7)$$

It becomes apparent that one photon can possess enough EM energy to convert space-time into matter. It is 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 3.8 and 3.9,

$$m_p = \sqrt{\frac{hc}{G}} = 5.4556\times10^{-5}\, g \quad (3.8)$$

$$m_p = \sqrt{\frac{\left(6.6261\times10^{-27}\, g\cdot cm^2\cdot s^{-1}\right)\left(2.9979\times10^{10}\, cm\cdot s^{-1}\right)}{6.6742\times10^{-8}\, cm^3 g^{-1} s^{-2}}} = 5.4556x10^{-5}\, g \quad (3.9)$$

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.

It is proposed in this model that a vacuum is a volume of space devoid of particle matter, and that volume is occupied by QSUs constantly undergoing QL changes as the QSUs equilibrate to approach or attain the same QL with abutting QSUs. The expansion and contraction of the QSUs is analogous to bubbles constituting a quantum foam,[21] and within this foam energetic photons convert QSUs into matter and anti-matter pairs known as *virtual particles*.

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