QUANTUM LIGHT AND QUANTUM GRAVITY

By Rodney Bartlett

Abstract

Combining the wave-particle duality of quantum mechanics with $E=mc^2$ leads to the conclusion that the "speed of light" is nothing more than a convenient term to use (a convenience which this author also often adopts). There is actually no such thing – consequently, neither can there ever be a Variable Speed of Light. Special Relativity says the speed of light – all electromagnetic and gravitational waves "move" at this velocity – is the greatest speed in the universe. Combining quantum mechanics with general relativity – Einstein's theory of gravity - will result in a theory called quantum gravity. What is a theory integrating quantum mechanics with special relativity to be called? Perhaps quantum light …

Even when a successful quantum-light theory is developed, it will only be a step towards understanding reality. Special relativity, general relativity and quantum mechanics each represent a step towards comprehension of the universe. Quantum light will be another step, joining special relativity to the bizarre world of quantum mechanics via mathematics' $E=mc^2$. And quantum gravity will be yet another, possibly uniting general relativity with quantum mechanics via other branches of mathematics – proposed by this article to be those of the electronic binary digits (base-2 maths) and the topology of the Mobius strip and figure-8 Klein bottle (with attention paid to the simply- and multiply-connected issues). It will be shown that the quantum theories of light and gravity have dramatic implications for the concepts of dark energy, dark matter and universal expansion. When the quantum theories become parts of life, unification of physics may be an accomplished fact. More likely, the quantum theories will continue to be refined for centuries.

Article -

QUANTUM LIGHT

About pure maths -

Many scientists have said mathematics is a universal language because 1+1=2 no matter who you are. The trend in modern physics is towards a unified theory of the universe - starting with the unified theories of the 20th century (notably Einstein's) and extending to string theory and quantum gravity. What happens if a person in, say, the 24th century is raised believing in a unified theory that has implications in physical terms for everything in space-time? Would he or she think there is actually only one thing? Would (s)he think it's a mistake to add one apparently separate thing to another apparently separate thing to produce two, and that such addition is merely the result of the way the body's senses operate? (Our whole mathematical system is ultimately based on the idea that 1+1=2, and would therefore be incomplete in a unified universe.)

Assuming the maths humanity has developed does indeed apply to the universe, it cannot be totally in error – merely incomplete. Even Einstein's famous mass-energy equation $E=mc^2$ would be incomplete, requiring quantization ie unification with the wave-particle duality of quantum mechanics (which has also been repeatedly verified by experiment). Duality says subatomic particles also exhibit wave-like properties while waves (e.g. electromagnetic) also possess particle-like properties. Concerning the former (particles having wave-like properties), it's as if mass was composed of the coupling of the long-range gravitational and electromagnetic waves. This agrees with the mass-giving Higgs field being the result of coupling(1) (in this case, of the graviton and photon) - implied as a possibility by Einstein's paper "Do gravitational fields play an essential role in the structure of elementary particles?"(2)

Soon after the final formulation of general relativity, Einstein pointed out the need for a quantum modification of the theory.(3) In later years, Einstein hoped a unified theory of electromagnetic and gravitational fields would

explain the quantization of matter and energy. And indeed it could. The beginning of the solution proposed here is with 19th-century scientist Michael Faraday's experiments with electricity and magnetism (which, later that century, James Clerk Maxwell mathematically unified into a theory of electromagnetism that includes light). The existence of both advanced waves (which travel backwards in time) and retarded waves (which travel forwards in time) as admissible solutions to Maxwell's equations was explored in the Wheeler–Feynman absorber theory of last century. Also, the transactional interpretation of quantum mechanics (TIQM) says waves are both retarded and advanced. The waves are seen as physically real, rather than a mere mathematical device. Hypothesize that electromagnetic and gravitational fields are unified in the sense that the waves composing each field (as well as mass – more about this later) would possess both "retarded" and "advanced" components. The forwards and backwards movement can cancel to produce a quantum entanglement of all fields and masses, and thus quantization of spacetime.

About practical maths -

The wave-particle duality mentioned above can be described by starting with $v=f\lambda$ (wave velocity, m/s). Velocity of particles like a car equals distance divided by duration. Since distance is a measure that has to do with space while duration is a measure that has to do with time, it equals space divided by time.(4) Gravitational and electromagnetic wave motion (space-time motion) travels at c, the speed of light ie

$v = f\lambda$ = *distance/duration = space/time* = c

A particle's velocity, whether the particle be a boson or fermion, is directly dependent on its energy – so it may be said that

$E = v = f\lambda$ = *distance/duration = space/time* = c

This is not quite right since c represents energy alone, and space-time deals with mass-energy, so it's better to say

E = v= fλ = distance/duration = space/time = mc

What about the ^{2} in $E=mc^2$? In later papers Einstein repetitively stressed that his mass-energy equation is strictly limited to observers co-moving with the object under study.

In order for $E=mc^2$ to apply to the universe (and it does), observers must be able to co-move with anything being studied (even a light beam). Moving in the same direction is no problem but how can anyone or anything move at the same speed? Present-day observers can never move at the speed which light is reported to cover in the vacuum of space-time, so the only way for observers and light to co-move is for the nature of electromagnetism to be revised.

'Physicists now believe that entanglement between particles exists everywhere, all the time, and have recently found shocking evidence that it affects the wider, "macroscopic" world that we inhabit.' (5) Though the effect is measured for distances in space, the inseparability of space and time means that moments of time can become entangled too. (6) The link between the quantum and macroscopic worlds means the transverse wave motion of electromagnetic waves is identical to the transverse wave motion in a body of water. If a stone is dropped into a pool of calm water, many circular waves soon cover the surface of the water, and the water appears to be moving outwards from where the stone was dropped in. Actually, the particles of water simply rise then fall – it's the wave motion that moves outward. Like waves of water, electromagnetic waves are transverse. Consequently, the particles (photons) of light and microwaves etc that "travel" through space-time would have relatively little movement

themselves. It's the disturbances from the sources of electromagnetism (shock waves of fluctuating amplitudes and frequencies) that travel. (They go through the fields of energy filling the so-called vacuum). Since $E=mc^2$ only applies to photons when they're at rest, the equation can only describe photons that have no motion in one direction – the horizontal "line of propagation" in which the shock wave moves. The photons can only move in the vertical direction, perpendicular to the shock wave – if they move at all. And any conscious observer or non-conscious detector can co-move with the photons by covering the same distance. The formula then required to connect the photons and shock waves may be the extended version of Einstein's equation, called the relativistic energy–momentum relation.

$$E^2=m_0^2c^4+p^2c^2 \qquad (7,8)$$

As Paul Camp, Ph.D. in theoretical physics, writes -

"A photon is a quantum of excitation of the electromagnetic field. That field fills all space and so do its quantum modes."(9)

This is consistent with energy being transferred from one place to another as wave motion without involving an actual transfer of particles (little or no movement of photons). General Relativity says gravitation IS space-time ie the gravitational field also fills all space, so the seeming motion of gravitational waves could also be due to fluctuations of shock waves' amplitudes and wavelengths causing excitations (called gravitons) in the field. These excitations cover 186,282 miles every second. (The speed of light - or according to this article, coverage of excitations - is based on an inch of exactly 2.54 cm and is exactly 186,282 miles, 698 yards, 2 feet, and 5 21/127 inches per second.)(10)

The above ideas of gravitational and electromagnetic waves displaying little or no motion are a new interpretation of John Wheeler's geon or

"gravitational electromagnetic entity", an electromagnetic or gravitational wave which is held together in a confined region by its own nature.(11)

THE FINAL MISSING STEPS IN $E=mc^2$

Since Einstein's mass-energy equation is strictly limited to observers co-moving with the object under study, ^{2} must be added to the mass/light-speed part of this article's equation -

$$E = v = f\lambda = \text{distance/duration} = \text{space/time} = mc^2$$

Simplified by removal of the middle elements, this becomes $E=mc^2$

(any other result would suggest the inventor of Relativity was wrong).

E=mc^2 only applies to the photon at rest. Since it's plausible that the photon can indeed be at rest within what is called an electromagnetic wave, the equation seems to tell us that all distances in space, and time, can be completely eliminated (permitting us to instantly reach anywhere in space-time). Let's represent the masslessness of photons by 0 (zero), and also the masslessness of the theoretical gravitons by zero. Suppose theories developed from Einstein's 1919 paper "Do gravitational fields play an essential role in the structure of elementary particles?" are proven correct one day. Then mass could result from photon-graviton interaction, and we could replace the m with zero. This results in E=0*c^2 ie outside familiar circumstances (such as in black holes), it is possible for E to equal 0. Having reduced the equation to nothing but E, m=0 and c^2=0 which means m=c^2. At first glance, m=c^2 seems to be saying mass exists at light speed. But the absence of E (energy) refers to there being no interaction of electromagnetic energy and gravitational energy, and therefore no mass. If mass cannot be produced, Einstein's paper suggests mass-producing space-time/gravity

must be described by zero. The zero-ness of space-time/gravity does not mean it doesn't exist … it obviously does. It means we can relocate matter and information superluminally, or travel into the past and future, because distance equals zero and can be eliminated from both space and time.

If there's no movement of photons and gravitons, the universe could not be expanding. And non-expansion eliminates the need for repelling Dark Energy that makes the universe expand. Here's a bit more supporting those ideas –

GENERAL RELATIVITY DELETES DARK ENERGY, DARK MATTER AND UNIVERSAL EXPANSION

This article is suggesting that dark energy, dark matter and universal expansion are intimately related. However, they aren't viewed as revolutions in cosmology which are essential to a complete understanding of the modern universe. They are instead viewed as properties which need to be added to the cosmos when Einstein's theory of gravity (General Relativity) is apparently partially misunderstood. Science admires General Relativity. However, respect for tradition seems to prevent science from embracing Einstein's theory completely. General Relativity says gravity is a push exerted by the curvature of space-time. But the world still holds to the Newtonian view that gravity is a pull. Since Isaac Newton's mathematics works so well, it's understandable that his gravitational pull is accepted. It's time to explore ways in which gravitation as a push could produce identical physical results.

Edwin Hubble (1889-1953), the astronomer credited with discovering cosmic expansion, remained doubtful about the expansion interpretation for his entire life. He believed “expanding models are a forced interpretation of the observational results.”(12) According to astronomer Allan Sandage, "Hubble believed that his count data gave a more reasonable result concerning spatial curvature if the redshift correction was made assuming no recession.

To the very end of his writings he maintained this position, favouring (or at the very least keeping open) the model where no true expansion exists, and therefore that the redshift "represents a hitherto unrecognized principle of nature."(13)

The great majority of scientists will simply dismiss Hubble's concerns because they agree that discovery of the Cosmic Microwave Background (CMB) in 1964 by American radio astronomers Arno Penzias and Robert Wilson proved the universe is expanding from the Big Bang.(14) Explanation of why this isn't so can be summed up in one sentence - "The quantum entanglement of microwaves with all of space-time means the Cosmic Microwave Background radiation fills the entire sky and is not produced by the Big Bang as most scientists believe (quantum entanglement has been repeatedly confirmed experimentally)."

Now for a few words about redshift - according to General Relativity, gravity does not exist in space-time but IS space-time. The acceleration known as cosmic expansion is offset by the relativistic proposal that the space-time composing the cosmos IS gravitation. In astrophysics, gravitational redshift or Einstein shift is the process by which electromagnetic radiation originating from a source that is in a gravitational field is reduced in frequency / increased in wavelength, or redshifted to the red end of the spectrum. Since gravity is just another term for the curvature of space-time, the gravitational field responsible for a particular example of electromagnetic radiation and redshift is not limited to a particular star, galaxy or galaxy cluster but spans (indeed, is) the whole of space-time.

The farther away a galaxy is, the greater is the amount of gravitation which any electromagnetic radiation has to traverse. So the electromagnetism weakens more than expected and the gravitational redshift, which is larger than anticipated, naturally increases with distance. All of the redshift not due to the Doppler effect is gravitational redshift, which is always grounded in space-time-spanning gravity. It never indicates universal expansion, which would make it what is called cosmological redshift and would require space-time and gravitation to be separate things.

This gravitational redshift can be applied to anything and everything, including the type 1a supernovae used by the Supernova Cosmology Project and the High-Z Supernova Search Team when they supposedly discovered accelerating expansion of the universe in 1998 (they compared the stars' brightnesses with their measured redshifts, and attributed the apparent expansion to dark energy). (15)

Nor does Dark Matter seem to be necessary. General Relativity says gravity is a push exerted by the curvature of space-time. Here are two physicists who agree: According to James Overduin, a physicist at Towson University in Maryland, USA who specializes in gravitation - gravity is just another term for the curvature of space-time.(16) To quote from The World Book Encyclopedia:

“(Bodies) merely follow the line of least resistance through the hills and valleys of the curved space that surrounds other bodies. Objects that fall to the earth, for example, are not "pulled” by the earth. The curvature of space-time around the earth forces the objects to take the direction on toward the earth. The objects are pushed toward the earth by the gravitational field rather than pulled by the earth."(17)

The first formal inference about the existence of dark matter (18) said that some unseen matter provided the mass and associated gravitation to hold the Coma cluster of galaxies together. A galaxy or galaxy cluster would, obeying the inverse-square law which says the gravity between any two objects is only one quarter as strong if the distance between the objects doubles, tend to fly apart if its gravitation is considered to be a pull from its centre that weakens with the distance to its edge. But thinking of general relativity's definition of gravity as a push means the galaxy's or cluster's edges are being pushed towards its centre*, thus holding it together. Galactic shrinkage is offset by the orbiting speeds of bodies and / or Einstein's paper that was written four years after General Relativity was published - "Do gravitational fields play an essential role in the structure of elementary particles?" His paper can be understood as implying electromagnetism is the other contributor. (Prof. Wheeler's speculation that there's a relationship

between geons - electromagnetic or gravitational waves held together in a confined region by their own nature - and elementary particles supports this.)

* Since gravity is by far the weakest force in the universe,^ it's entirely reasonable to think that this acceleration towards the centre requires the 10^36 times more powerful electromagnetic force. In that case, the gravitational field which electromagnetic radiation originates from could be interpreted as G (gravitation) and EM (electromagnetism) constantly interacting because of their similarities. Though the graviton is very different from the photon in certain ways eg quantum spin, their constant interaction effectively produces a unified GEM force. This would be consistent with "Do gravitational fields play an essential role in the structure of elementary particles?" (remember that the paper can be understood as implying electromagnetism is the other contributor). There are two other known references to the similarities between gravitation and electromagnetism:

(a) "The motion of a set of test particles under the influence of a plane gravitational wave differs considerably from the electromagnetic case. Yet, there are similarities: not only do both have two independent polarization states, but when one includes the longitudinal motion, the surface associated with the motion of a charged particle responding to an elliptically polarized wave is similar to the constant phase surfaces of a set of particles driven by a plane gravitational wave; in both cases the latter surfaces derive their longitudinal motion from trigonometric double angle functions."(19)

(b) In (20), under the heading "Gravitomagnetism", Dr. Ron Kurtus states:

"An analogy of gravitational and electromagnetic fields is seen by comparing the Einstein Field Equations from the General Theory of Relativity with Maxwell's Field Equations for electrical and magnetic fields."

This analogy is consistent with the quantum entanglement of microwaves with all of space-time (gravitation) meaning the Cosmic Microwave Background radiation fills the entire sky and is not produced by the Big Bang as most scientists believe (quantum entanglement has been repeatedly confirmed experimentally).

^ Why is gravity the weakest force in the universe? Some scientists, including American theoretical physicist Lisa Randall, wonder if it's because gravity is "leaked" by radiating into other dimensions.(21) According to this text, that makes sense since gravity is the fabric of space-time and a unified theory of quantum gravity would unite space-time with the extra dimensions. One way of determining if the gravitational push which is part of dark matter belongs to a higher dimension would be to measure its effects in space dimensions. In three dimensions, the gravitational force drops to 1/4 if one doubles the distance. In 4th-dimensional hyperspace, it would drop to 1/8 and in 5th-dimensional hyperspace to 1/16.(22) The positive direction on the x-axis (representing the 3 space dimensions of "real" space-time) is in continuous contact with the negative direction on x (this may be called the 5th space dimension, complex space-time, providing access to the past). Therefore, real gravity is perpetually amplified by complex gravity. Using Professor Hawking's figures, the amplification equals ¼ x ¼ ie doubling the distance in 5 space dimensions causes gravity to become 1/16 as powerful. It is not ¼ x -¼ since numbers have the same property regardless of direction on the Complex Number Plane (they increase in value). To conserve this sameness, the second one must be +¼ if the first one is +¼. Alternatively, the gravity's strength is reduced 4 times and this number is multiplied by another 4 to reduce it 16 times overall. In the 4th space dimension/2nd time dimension represented by the imaginary axis, this y-axis is half the distance (90 degrees) from the real x-axis that the complex x-axis is (it's removed 180 degrees). So gravitational weakening from doubling distance in 4 space dimensions = (reduction of 4 times multiplied by another reduction of 4 times) / 2, for an overall reduction of 8 times to a strength of 1/8. About other parts of dark matter besides the push of gravity - gravitational and electromagnetic waves that have traveled back to the past could, if they constitute mass as well as space-time, also compose Dark Particles since the mass would be invisible to the present and only detectable by its gravitational influence. Why? Because General Relativity says gravitation IS spacetime (gravitational influence must persist as long as spacetime exists).

QUANTUM GRAVITY

The quantum spin of a particle cannot be explained in terms of classical rotation since it can only have certain values. Attempting to shed light on spin, this section begins with the most insightful description of quantum spin the author has ever encountered. It doesn't come from a science journal, as one might expect – but from a popular book by an exceptional physicist, mathematician and cosmologist named Stephen Hawking (1942-2018).

"What the spin of a particle really tells us is what the particle looks like from different directions."(23)

Adapting Professor Hawking's words -

Spin 1 (is like an arrow-tip pointing, say, up: a photon has spin 1).

Has to be turned round a full revolution of 360 degrees to look the same.

Spin 2 (like an arrow with 2 tips - 1 pointing up, 1 down: a graviton's spin).

Turned half a revolution (180 degrees), it looks the same.

Spin 0 (like a ball of arrows having no spaces between arrows, particles with spin 0 look like a dot: the same from every direction).

The Higgs boson has spin 0.

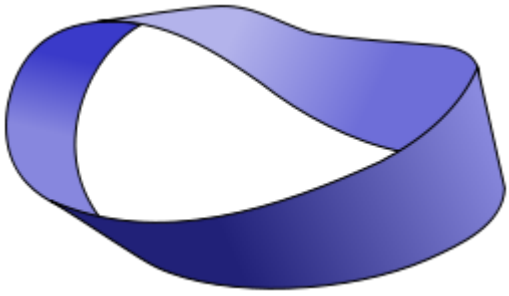
Spin 1/2 This is the spin of matter particles such as the proton, neutron, electron, neutrino and quark. (Author's opinion: they look like a Mobius Strip*).

*These particles must be turned through 2 complete revolutions to look the same, and you must go round a Mobius twice to reach your starting point.

To produce the spin of matter particles (1/2) from the photon (1) and graviton (2), 1 is divided by 2. Photon divided by graviton may equal distance/duration ie the revised electromagnetism above with shock waves (horizontal distance) and rising or falling spin-1 photons (vertical distance) divided by the time taken to traverse part of the universe's gravitational field (composed of spin-2 gravitons).

To produce the spin of the Higgs boson (0), 1 is subtracted from 1. Visualize a photon and its spin (the first 1) as not identical with, but physically connected to, a graviton: the connection results in the continuous interaction of the long-range electromagnetic and gravitational forces filling space-time. The photon pulls the graviton around with it while making a revolution that affirms its identity. During this, the graviton completes a second half-revolution and still looks the same (retains its identity). The second half-revolution is the second 1 in this paragraph's first line. Together with the first 1 its subtracted from, it forms the spin 0 of the Higgs boson. Einstein's hoped-for gravitational-electromagnetic unification is achieved by adding photons to gravitons in an inseparable (even in theory) manner. However, he never found the quantum modification he sought. So the quantum interaction and entanglement accomplished via advanced and retarded waves or the Transactional Interpretation of Quantum Mechanics is better described as subtracting gravitons from photons.

Mobius Strip (source: http://www.clker.com/cliparts/3/7/a/9/12205465347817139 51lummie_Mobius_Strip.svg.hi.png)



There are four scientists I know of that support the idea of the universe being composed of information/mathematics:

a) In 1990, John Wheeler (1911-2008) suggested that information is fundamental to the physics of the universe. According to this "it from bit" doctrine, all things physical are information-theoretic in origin.(24)

b) Erik Verlinde says gravity is not a fundamental force of nature, but an emergent phenomenon. In the same way that temperature arises from the movement of microscopic particles, gravity emerges from the changes of fundamental bits of information, stored in the very structure of spacetime.(25)

c) Cosmologist Max Tegmark hypothesizes that mathematical formulas create reality. (26)

d) “Pioneered (in the late 1980's) by Rafael Sorkin, a physicist at the Perimeter Institute in Waterloo, Canada, the theory (causal sets) postulates that the building blocks of space-time are simple mathematical points that are connected by links, with each link pointing from past to future."(27)

"The quantum spin of a particle cannot be explained in terms of classical rotation since it can only have certain values that are equal to either a whole number or half a whole number multiplied by *Planck's constant* h divided by 2(pi) (a quantity called h-bar).(28) **It seems plausible that the particular values of spin could be determined by another set of particular values viz those in electronics' BInary digiTS, which always take the form of either 1 or 0.* If a subatomic particle of matter really does look like a Mobius strip, this - when combined with the previous sentence - is a clue as to how to make particles (of light and gravity, as well as matter).** First, the 1's and 0's are programmed to form the shape of a Mobius strip, which is merely two-dimensional (2-D).

"In a holographic universe, all of the information in the universe is contained in 2D packages trillions of times smaller than an atom."(29)

("Holographic" could refer to the interference between gravitational and electromagnetic waves, while "2D packages trillions of times smaller than an atom" could refer to Mobius strips.)

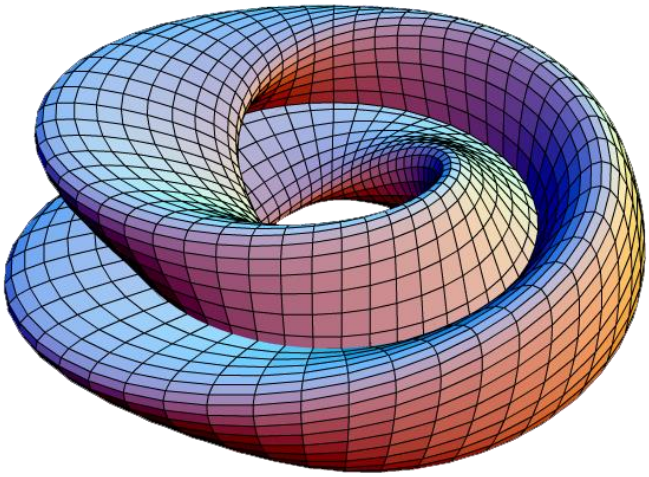
***Technology of the far future will surely discover a way to, like the infinite digits of pi, cause electronic BITS to be infinite and fill the universe. Remembering that we live in space-time, not space alone, past times existing prior to that technology's development could be accessed via advanced gravitational and electromagnetic waves that the Transactional Interpretation of Quantum Mechanics delivers to the past. These waves could, if they constitute mass as well as spacetime - and if the digital technology for producing and programming gravitons and photons is sufficiently advanced - give the cosmos Artificial Intelligence (AI) on chemical, subatomic, biological and astronomical levels. However, the true origin of life cannot be evolution and chemicals alone – it must be the brains producing AI.**

Then two strips must be joined to make a 4-D Klein bottle which has length, width, depth and the 4th dimension of movement in time.(30) The type of Klein bottle formed would appear to be the figure-8 Klein. A diagram of many figure-8 Klein bottles would show that their positive curvature (on the spherical parts) fits together with their negative curvature (on saddle-shaped parts) to cancel and produce the flat curvature of space-time ["The WMAP science team has nailed down the curvature of space to within 0.4% of 'flat' Euclidean."](31) Like the pommel protruding from the front of a saddle, negative curvature can cause an "imaginary" space – and thanks to the indissoluble union of spatial plus temporal phenomena, "imaginary" time* - to extend 90 degrees from the "surface" of real, flat space-time. When you have trillions of Mobius and figure-8 Klein elements assembled, an appropriate number of photons and gravitons must be included to give the mixture what we call mass. You can make massless photons and electromagnetic fields by omitting gravitons from the mix and changing programming of spin from 1/2 to 1. Massless gravitons and gravitational

fields can be made by omitting photons and programming spin values that are 2/1 instead of 1/2.

*Professor Itzhak Bars of the University of Southern California in Los Angeles says, 'one whole dimension of time and another of space have until now gone entirely unnoticed by us'.(32) Could Prof. Bars' second dimension of space be imaginary space which is united with imaginary time the same way ordinary space and time are joined? (Imaginary space-time is described by imaginary numbers such as *i* which equals $\sqrt{-1}$). And in the unification of a quantum gravity universe, the real and imaginary would be connected.

Figure-8 Klein Bottle (source: https://upload.wikimedia.org/wikipedia/commons/7/73/KleinBottle-Figure8-01.png) Note that, when considering many bottles, the reddish positive curvature fits together with the bluish negative curvature to produce the flatness implying space-time's infinity/eternity.



If an object in space consists of one piece and does not have any "holes" that pass all the way through it, it is called simply-connected. A doughnut (and the figure-8 Klein bottle it resembles) is “holey” and not simply connected (it’s multiply connected). "Some scientists believe that large warm

and cool spots in the Cosmic Microwave Background could actually be evidence for this kind of ... (doughnut/figure-8 Klein bottle) ... topology".(33) A flat universe that is also simply connected implies an infinite universe.(34) So it seems the infinite universe cannot be composed of multiply-connected subunits called figure-8 Klein bottles. But figure-8 Klein bottles can be made into plausible subunits of a flat and infinite universe. Positive and negative curvatures on this type of Klein bottle can complement each other's shape, and digitised images can morph to perfect the complementarity if necessary (by binary digits filling in gaps and irregularities in the same way that computer drawings can extrapolate a small patch of blue sky to make a sky that's blue from horizon to horizon). This makes space-time relatively smooth and continuous - and gets rid of holes, making these types of Klein subunits feasible.

REFERENCES

(1) M. Tanabashi; M. Harada; K. Yamawaki. Nagoya 2006: "The Origin of Mass and Strong Coupling Gauge Theories". International Workshop on Strongly Coupled Gauge Theories. pp. 227–241

(2) "Do gravitational fields play an essential role in the structure of elementary particles?" ("Spielen Gravitationsfelder im Aufbau der materiellen Elementarteilchen eine wesentliche Rolle?" by Albert Einstein - Sitzungsberichte der Preussischen Akademie der Wissenschaften, [Math. Phys.], 349-356 [1919] Berlin)

(3) "ViaLibri – The World's Largest Marketplace for Old, Rare & Out-of-Print Books": https://www.vialibri.net/years/items/1338292/1919-einstein-albert-spielen-gravitationsfelder-im-aufbau-der-materiellen

(4) Brian Greene in "Speed", part of his "Space, Time and Einstein" course at http://www.worldscienceu.com/courses/1/elements/YhF9pw

(5) 'The Weirdest Link' (*New Scientist*, vol. 181, issue 2440 - 27 March 2004, 32, http://www.biophysica.com/QUANTUM.HTM

(6) Caslav Brukner, Samuel Taylor, Sancho Cheung, Vlatko Vedral, 'Quantum Entanglement in Time', http://www.arxiv.org/abs/quant-ph/0402127

(7) "Dynamics and Relativity", J.R. Forshaw, A.G. Smith, Wiley, 2009, ISBN 978-0-470-01460-8,

(8) "Physics" - https://physics.stackexchange.com/questions/6202/does-e-mc2-apply-to-photons

(9) "How big is a photon?" - https://www.quora.com/How-big-is-a-photon

(10) Savard, John. "From Gold Coins to Cadmium Light". 2009-11-14. WebCite: http://www.quadibloc.com/other/cnv03.htm

(11) Wheeler, J. A. (January 1955). "Geons". Physical Review. 97 (2): 511 - *doi:10.1103/PhysRev.97.511*

(12) “Effects of Red Shifts on the Distribution of Nebulae” by E. Hubble, Ap. J., 84, 517, 1936

(13) Sandage, Allan (1989), "Edwin Hubble 1889–1953", The Journal of the Royal Astronomical Society of Canada, Vol. 83, No.6

(14) Penzias, A. A.; Wilson, R. W. [1965]. "A Measurement of Excess Antenna Temperature at 4080 Mc/s". The Astrophysical Journal. 142 [1]: 419–421

(15) Overbye, Dennis [20 February 2017]. "Cosmos Controversy: The Universe Is Expanding, but How Fast?" New York Times

(16) "What If There Were No Gravity?" by Natalie Wolchover | January 9, 2012 <https://www.livescience.com/17809-gravity.html>

(17) "Gravitation" by Robert F. Paton, MS PhD in "The World Book Encyclopedia" (Field Enterprises Educational Corporation, 1967)

(18) "The redshift of extragalactic nebulae", Fritz Zwicky's first paper on this topic appeared in 1933 in the obscure journal Helvetica physica acta, vol. 6, p. 110

(19) "Electromagnetic and Gravitational Waves: the Third Dimension" by Gerald E. Marsh, Argonne National Laboratory (Ret) - https://arxiv.org/pdf/1101.2247

(20) "Similarity Between Gravitation and Electrostatic Forces" by mathematician and physicist Ron Kurtus (5 December 2010 -

http://www.school-forchampions.com/science/gravitation_electrostatic.htm#.Wkw9dcs_5Ah)

(21) Randall, Lisa; Sundrum, Raman (1999). "An Alternative to Compactification". arXiv:hep-th/9906064 doi:10.1103/PhysRevLett.83.4690

(22) "A Brief History of Time" by Stephen Hawking – Bantam Press 1988, pp. 164-165

(23) "A Brief History of Time" by Stephen Hawking – Bantam Press, 1988, pp. 66-67

(24) Wheeler, John A. (1990). "Information, physics, quantum: The search for links". In Zurek, Wojciech Hubert. Complexity, Entropy, and the Physics of Information. Redwood City, California: Addison-Wesley

(25) "Emergent Gravity and the Dark Universe" by E. P. Verlinde, 7 Nov 2016 (arxiv.org/abs/1611.02269)

(26) “Our Mathematical Universe” by Max Tegmark – Random House/Knopf, January 2014

(27) “Theoretical physics: The origins of space and time” by Zeeya Merali (“Nature” **500**, 516–519 – 28), August 2013

(28) "Quantum" by Manjit Kumar (Icon Books, 2008)

(29) “From Planck Data to Planck Era: Observational Tests of Holographic Cosmology” by Niayesh Afshordi, Claudio Corianò, Luigi Delle Rose, Elizabeth Gould, and Kostas Skenderis: Phys. Rev. Lett. 118, 041301 (2017) - Published 27 January 2017(https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.041301)

(30) "Imaging maths - Inside the Klein bottle" by Konrad Polthier - http://plus.maths.org/content/os/issue26/features/mathart/index

(31) "Wilkinson Microwave Anisotropy Probe" - https://map.gsfc.nasa.gov/

(32) Tom Siegfried, 'A Two-Time Universe? Physicist Explores How Second Dimension of Time Could Unify Physics Laws', May 15 2007 https://m.phys.org/news/2007-05-two-time-universe-physicist-explores-dimension.html

(33) "What Shape is the Universe?" by Vanessa Janek: (May 11, 2015) https://www.universetoday.com/120157/what-shape-is-the-universe/#google_vignette

(34) Luminet, Jean-Pierre; Lachi`eze-Rey, Marc - "Cosmic Topology" - Physics Reports 254 (3): 135–214 (1995) www.arXiv:gr-qc/9605010