

On the Emergence of QM, Relativity, Entropy, Time,  $i\hbar$ , and  $ic$  from the Foundational, Physical Reality of a Fourth Dimension  $x_4$  Expanding with a Discrete (Digital) Wavelength  $l_p$  at  $c$  Relative to Three Continuous (Analog) Spatial Dimensions

Dr. E. McGucken

ABSTRACT

The photon is used to *physically* probe and trace the discrete, digital, dynamic nature of  $x_4$  as the quantum nature of physical measurement is examined, while the foundational papers of Planck, Bohr, Heisenberg, *et al.* are exalted, lead by Einstein's statement that physics "*starts from experience and ends in it.*" In its simplest case, a photon oscillates while propagating at  $c$  as a probabilistic wave-front expanding through the three spatial dimensions in a spherically-symmetric manner, as demonstrated by the classic double-slit experiment, leading to the natural conclusion that  $x_4$ , in which the photon remains stationary according to relativity, must thusly be oscillating and propagating at  $c$  as a spherically-symmetric expanding wavefront. Relativity informs us that *all* of a photon's motion is through the three spatial dimensions, thusly dictating that the timeless, ageless photon remains stationary in the fourth dimension  $x_4$ . As electromagnetic radiation (the photon) is quantized, while there is no evidence for quantum gravity, we may conclude that  $x_4$  is quantized and digital in nature, while the three spatial dimensions are continuous and analog in nature.  $qp-pq=i\hbar$  (Born & Heisenberg) and  $x_4=ict$  or  $dx_4/dt=ic$  (Einstein & Minkowski) are fundamental relationships of QM and relativity. Both equations have differentials on the left and an  $i$  on the right, as Bohr noted, suggesting that a *foundational change* is occurring in a "perpendicular" manner, implying a fourth moving dimension.  $qp-pq = i\hbar$  reflects the discrete increment and quantum action— $\hbar$ —that emerges from the dynamic, discretely parceled space-time geometry born by the discrete wavelength of  $x_4$ 's expansion; while  $dx_4/dt=ic$ , from which relativity and its postulates derive, sets the velocity of the expansion of  $x_4$  to  $c$ . A *physical* model encompassing both Einstein's "elementary foundations" of relativity and Schrodinger's "characteristic trait" of QM—entanglement—is presented.

**1. Quantum Mechanics & Relativity @ Princeton with Wheeler, Peebles, & Taylor**

Three of my fondest, and most definitive, memories at Princeton University occurred during my junior year in the offices of P.J.E. Peebles, J.A. Wheeler, and the now Nobel Laureate J. Taylor. Peebles was letting us use the galleys for his forthcoming book *Quantum Mechanics*<sup>i</sup>, and after one of the first classes, I visited his office and asked, "So when a photon is emitted from a source, all we can say is that the photon is represented by a spherically-symmetric wavefront of probability expanding at  $c$ ?" "Yes," he said, "The photon has an equal chance of being detected anywhere defined by the area of a sphere's surface, which is expanding at  $c$ ." How crazy was that! Couple this with the fact that Wheeler had just described to me how the photon remains stationary in  $x_4$ , and one had a physical tracer for the movement of the fourth dimension<sup>ii</sup>! The second most definitive memory (of many!) derives from when I walked into my junior paper advisor J.A. Wheeler's office in Jadwin Hall and found him staring out his window. He heard me come in, and he slowly turned with his effervescent smile and that twinkle in his eye, and stated, "*Today's world lacks the noble. . . and it's your generation's duty to bring it back.*" Talk about the classic "*Call to adventure!*" And the third definitive memory came in J. Taylor's office, when while working on my JP on quantum nonlocality/entanglement<sup>iii</sup>, Taylor stated, "Schrodinger said that entanglement is the characteristic trait of QM. Figure out the source of entanglement, and you'll figure out the source of the quantum, as nobody really knows what, nor why, nor how  $\hbar$  is." Wheeler wrote<sup>iv</sup>: "I

gave (Dr. E) the proofs of my... *A Journey Into Gravity and Space Time*... the space part of the Schwarzschild geometric is worked out by purely geometric methods. “Can you, by poor-man’s reasoning, derive what I never have, the time part?” He could and did, and wrote it up in a beautifully clear account. . . his second junior paper . . . was done with another advisor (J. Taylor), and dealt with . . . the Einstein-Rosen-Podolsky experiment and delayed choice experiments... this paper was so outstanding...” And so *Moving Dimensions Theory* (MDT) would be born as a unifying, foundational *physical* model for *both* the “elementary foundations” of relativity that Einstein yet sought and Schrodinger’s “characteristic trait” of QM—entanglement, showing that *both* relativity and the discrete, digital nature of energy and measurement arose from the discrete geometry carved into space-time by  $x_4$ ’s expansion, which parcels mass and energy in discrete units proportional to  $\hbar$  as it propagates at  $c$ .

Wheeler oft referred to the direction of particle physics as “ino-itus” whence more and more funding was spent pursuing smaller and smaller particles and details, void of novel grand ideas or new *physical, foundational* insights. The LHC is a noble accomplishment, as is the mathematics of String Theory some say, but when history is written, it is likely that a patent clerk named Einstein will have made a greater contribution to physics in 1905<sup>v</sup> with naught but a pencil, a piece of paper, a courageous and free imagination, and an unyielding loyalty to *physical* phenomena and a *physical* interpretation of the mathematics. Wheeler, like the heroic physicists of yore, was in physics for the *big physical ideas*, as was Einstein, who wrote, “I want to know God’s thoughts; the rest are details.”<sup>vi</sup> Colby Cosh saluted the late J.A. Wheeler: “At 96, he had been the last notable figure from the heroic age of physics lingering among us. . . the student of Bohr, teacher of Feynman, and close colleague of Einstein. . . Wheeler was as much philosopher-poet as scientist, seizing on Einsteinian relativity early . . . He was ready to believe in the new world before most physicists. . .”<sup>vii</sup>

And so Fig. 1 presents an illustration from a paper<sup>viii</sup> by Wheeler’s teacher Bohr from Wheeler’s compilation *Quantum Theory and Measurement*<sup>ix</sup>, which I first happened upon in my freshman dorm. The illustration pertains to the classic double-slit experiment, of which Wheeler’s student Feynman was fond of stating, “The whole of QM can be gleaned from pondering the implications of the double-slit experiment.”<sup>x</sup>

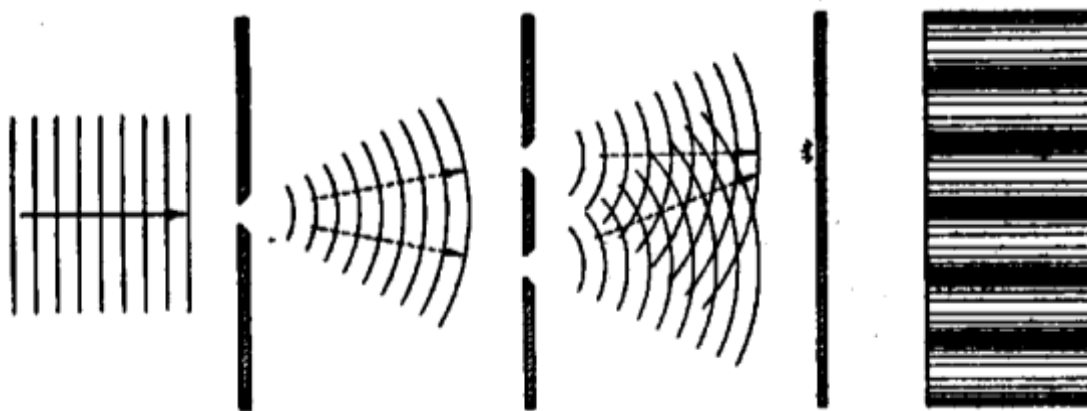


Fig. 1: Bohr’s rendition of the classic double-slit experiment.

The above double-slit diagram illustrates the wavelike nature of all particles, including the photon. But what Bohr, Einstein, Feynman, *et al.* seemed to have missed was that they were looking not only at the motion and character of the photon, but they were looking at *the motion and character* of  $x_4$ , as relativity dictates that the ageless photon remains stationary in the fourth dimension, thusly providing an

ideal tracer following the movement of  $x_4$ . Thus we can conclude that not only is  $x_4$  a spherically-symmetric wavefront expanding at  $c$ <sup>xi</sup>, distributing locality into nonlocality and giving rise to entanglement and entropy as well as time and all its arrows and asymmetries, but it is also oscillating in a quantized manner, thusly quantizing (digitizing) all energy it carries in discrete packets, which in turn quantizes (digitizes) all measurement, as measurement hinges upon the propagation of energy—photons.

## 2. How the Quantum $\hbar$ arises from the Physical Geometry of $x_4$ 's Expansion

The velocity of  $x_4$  is also apparent in the *physical* interpretation of  $x_4=ict$ —a relationship first proposed by Minkowski which appeared in Einstein's famous 1912 manuscript<sup>xii</sup>. But just as Planck at first failed to accept the *physical* interpretation of  $E=h\nu$ , diminishing the grandeur of his discovery of the quantum by labeling  $E=h\nu$  “a purely formal assumption,” admitting, “actually I did not think much about it...”<sup>xiii</sup>, so too did Einstein *et al.* miss the grander interpretation of their magnificent equation  $x_4=ict$ . It was Einstein who first recognized the *physical* significance of Planck's  $E=h\nu$ , which Einstein applied to the photoelectric effect in his 1905 paper<sup>xiv</sup>, resulting in a Nobel Prize. And it is I who have realized the *physical* significance of  $x_4=ict$ , which can be rewritten as  $dx_4/dt=ic$ ,<sup>xv</sup> naturally implying that  $x_4$  is moving and expanding at  $c$ . Once we realize this, it logically follows that since a photon remains stationary in  $x_4$ , and yet oscillates in a quantized manner,  $x_4$  itself must also be oscillating in a quantized, digital manner in addition to moving at  $c$ , as that is the only manner the photon can be stationary relative to  $x_4$ , and yet propagate at  $c$  while oscillating. Couple all this with  $qp-pq=i\hbar$ , and it can be seen that  $x_4$  is expanding with a fixed wavelength of the  $l_p$ , with the spacetime geometry generated by the fourth expanding dimension giving rise to the discrete unit of  $\hbar$ , thusly quantizing all energy and measurement, while providing a deeper foundation for the double-slit experiment and relativity, as well as entropy, and time and all its arrows and asymmetries<sup>xvi</sup>.

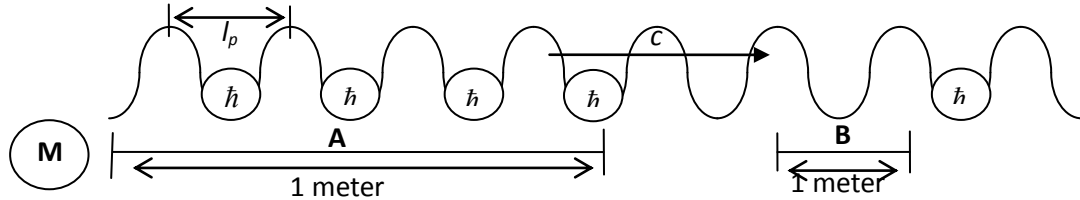


Fig. 2: The invariant expansion of  $x_4$  creates the geometry which carries mass in units of action  $\hbar$  at the velocity of  $c$  in the form of photons.

In Fig. 2, we superimpose the universe's fundamental invariant— $x_4$ 's expansion, represented by a sine wave (in reality it is a spherically symmetric wave-front, defining the propagation of all photons)—over the regions **A** & **B** which represent space curved and stretched by the mass **M**. The expanding  $x_4$  carries all photons, quantizing them in units of  $\hbar$  via the geometry of its very wave nature, as its fixed wavelength “chops” discrete intervals in the fixed width of  $l_p$ , giving rise to the discrete geometry in which discrete parcels (*corpuscles*) of mass/energy are carried. The invariance of the expansion of  $x_4$  is the *foundational invariant underlying the invariance of  $c$  and  $\hbar$* . Energy is quantized and digitized by the space-time geometry generated via the fixed wavelength of the fourth dimension expanding dimension expanding at  $c$ . Photons are but mass surfing the fourth dimension's partitioning geometry at  $c$ , echoing Einstein's words: “There is no essential distinction between mass and energy. Energy has mass and mass represents energy. Instead of two conversation laws we have only one, that of mass-energy.”<sup>1</sup>

The standard light clock in region **B**, discussed further by Dr. E<sup>xvii xviii</sup>, will tick about four times every time the clock in stretched region **A** ticks once. This is because  $x_4$ 's expansion has to travel four fundamental wavelengths in stretched region **A**, while only a single one in region **B**. Thus, if the two clocks from **A** and **B** are reunited, all will agree that clock **A** registered less time, and thus that stronger gravitational fields slow time. Both **A** and **B** represent lengths of one meter, and the mass **M** stretches the space in region **A**. Note also that a photon with a certain frequency in **A**—one that oscillates four times as it traverses the distance of one meter, will only oscillate once while traversing the distance of one meter at **B**. Thus the frequency of the wave is higher in **A** and lower in **B**, while the wavelength is lower in **A** and longer in **B**, just as the gravitational redshift dictates.

### **3. Why Electromagnetism is Quantized (Digital) in Nature, while Gravity is Continuous (Analog)**

Fig. 2 and the Fig.1 at the end of my earlier paper<sup>xix</sup> bring to light several remarkable features of MDT. MDT explains why energy is quantized and why clocks run slower in stronger gravitational fields where space is stretched. Time, as measured on a light clock, is also stretched, but only because of a foundational invariant which never stretches—the expansion of  $x_4$  relative to the three spatial dimensions—a foundational invariant which maintains the invariance of both  $c$  and  $\hbar$ , while curving the measurement of time in proportion to the curvature of space. Even though time and space are stretched, the expansion of  $x_4$  remains invariant:  $dx_4/dt=ic$ . Space is continuous (analog), while quantization (the discrete, digital character of energy and measurement) arises from the quantized invariant expansion of  $x_4$  relative to the three spatial dimensions in units of  $l_p$ . The invariant wavelength of the expanding  $x_4$  “chops” measurements of space—of time, energy, and momentum—into discrete geometrical units proportional to the Planck action  $\hbar$  and  $l_p$ , while also providing the fundamental wave nature that gives rise to Heisenberg's Uncertainty Principle and Huygens' Principle (seen in Fig. 2) across all realms, as well as the fundamental space-time geometry which parcels action and energy in discrete units proportional to  $\hbar$ , exalting the quantum. It is enough for  $x_4$  to be wavelike in nature, while the three spatial dimensions are continuous, to give rise to the quantum, digital features of QM, and the classical, continuous nature of gravity. In the electromagnetic field, force hinges upon the transfer of physical particulates—photons, while in the gravitational force, no particles are transferred, as gravity arises via the geometrical curvature of space-time, as my mentors Wheeler<sup>xx</sup> and Taylor taught.

Freeman Dyson writes<sup>xxi</sup>, “(Brian) Greene takes it for granted, and here the great majority of physicists agree with him, that the division of physics into separate theories for large and small objects is unacceptable. General relativity is based on the idea that space-time is a flexible structure pulled and pushed by material objects. QM is based on the idea that space-time is a rigid framework within which observations are made. Greene believes there is an urgent need to find a theory of quantum gravity that works for large and small objects alike. . . As a conservative, I do not agree that a division of physics into separate theories for large and small is unacceptable. . . I propose as an hypothesis that it is impossible in principle to observe the existence of individual gravitons.” MDT sides with Dyson and Occam's Razor, as well as Einstein and Planck. Let us first see a graviton, or find a consistent, unique theory that predicts gravitons, before we conclude that gravity must be quantized.

### **4. The Heroic, Unifying, Foundational, Physical Glory of MDT**

Albert Einstein: A theory is the more impressive the greater is the simplicity of its premises, the more different are the kinds of things it relates and the more extended the range of its applicability.<sup>xxii</sup>

MDT's foundational, unifying *physical* model exalts the *physical meaning* of Born's/Heisenberg's  $qp-pq=i\hbar$  and Einstein's/Minkowski's  $x_4=ict$ , which emerge from MDT. Dr. E's rephrasing of the relationship  $x_4=ict$  as  $dx_4/dt=ic$ <sup>xxiii</sup> gives rise to the simple premise that  $x_4$  is expanding relative to the three spatial dimensions, thusly relating an extended range of hitherto disparate phenomena in a simple, *physical* model, as MDT unfreezes time and liberates us from the block universe, weaving change into the fundamental fabric of spacetime for the first time in the history of relativity, while finally providing a fundamental model for the inherent change and differentials in QM, alongside the quantum, discrete nature of all energy and measurement, whose discreteness arises from the discrete geometry created via  $x_4$ 's expansion. As relativity dictates that a photon remains stationary in  $x_4$ , MDT's simple model also provides a *physical* model for the digital, discrete nature of QM via  $x_4$ 's wavelength, as well as for Huygens' Principle and all wave behavior, entropy, time and all its arrows and asymmetries, and all the dualities—space/time, mass/energy, wave/particle,  $E/B$ , and digital/analog; setting the universe's maximum velocity to  $c$ , while providing a *physical* model for quantum nonlocality and entanglement, as well as the quantization of energy and thus the discrete, digital nature of all measurement, as the expansion of  $x_4$  distributes locality in a discrete manner as implied by  $qp-pq=i\hbar$ .  $dx_4/dt=ic$  provides a foundational physical model for time and all its arrows and asymmetries, entanglement, and entropy, while also establishing an absolute frame of rest—the three spatial dimensions, and an absolute frame of motion—the expanding  $x_4$ , thusly finally resolving the GPS/twins paradox.<sup>xxiv</sup>  $dx_4/dt=ic$  presents a more concise, fundamental way of phrasing relativity, as instead of beginning with Einstein's two postulates, one can merely write, "Suppose a 4D universe wherein  $dx_4/dt=ic$ ," and both of Einstein's postulates, as well as all of relativity, naturally emerge<sup>xxv</sup>. While there is no physical evidence for strings, nor multiverses, and while the mathematics for such speculative entities never adds up in a definitive manner, MDT is supported by *the physical reality* of the double slit experiment, entanglement, nonlocality, entropy, the quantization of energy, and all relativistic phenomena, as well as by the mathematics of  $x_4=ict$  and  $qp-pq=i\hbar$ . MDT adheres to Einstein's, Bohr's, Planck's, Galileo's, *et al.*'s views on what physical theory is and ought to be—below I have underlined and italicized the Greats' emphasis on *physical, empirical reality*, which MDT exalts:

Einstein: But before mankind could be ripe for a science which takes in the *whole of reality*, a second fundamental truth was needed. . . Pure logical thinking cannot yield us any knowledge of the empirical world; all knowledge of reality starts from *experience* and ends in it. . . Because Galileo saw this, and particularly because he drummed it into the scientific world, he is the father of modern physics—indeed, of modern science altogether.<sup>xxvi</sup>

Planck: Let us get down to *bedrock facts*. The beginning of every act of knowing, and therefore the starting-point of every science, must be our own personal *experience*.<sup>xxvii</sup> (All physicists have personally experienced the double-slit experiment, and as relativity tells us that photons remain stationary in  $x_4$ ,  $x_4$  must thus be propagating at  $c$  with both a wavelike and quantum nature!)

Einstein: Mathematics are well and good but *nature* keeps dragging us around by the nose.<sup>xxviii</sup>

Einstein: The theory must not contradict *empirical facts*. . . The second point of view is not concerned with the relation to the material of observation but with the premises of the theory itself, with what

may briefly but vaguely be characterized as the “*naturalness*” or “*logical simplicity*” of the premises of the basic concepts and of the relations between these which are taken as a basis.<sup>xxix</sup>

Planck: That we do not construct the external world to suit our own ends in the pursuit of science, but that vice versa *the external world forces itself upon our recognition* with *its own elemental power*, is a point which ought to be categorically asserted again and again . . . From the fact that in *studying the happenings of nature* . . . it is clear that we always look for *the basic thing behind* the dependent thing, for what *is absolute* behind what is relative, for *the reality* behind the appearance and for *what abides* behind what is transitory. . this is characteristic not only of *physical* science but of all science.<sup>xxx</sup> ( $dx_4/dt=ic$  is the “basic, abiding thing” behind all relativity, entropy, and QM!)

Einstein: Truth is what stands the test of *experience*.<sup>xxxi</sup>

Heisenberg: Science. . . is based on personal *experience*, or on the *experience* of others, reliably reported. . . Even today we can still learn from Goethe . . . trusting that *this reality* will then also reflect the essence of things, *the ‘one, the good, and the true’*.<sup>xxxii</sup>

Since we experience both particles and waves, and since the Greats agree that physics *begins and ends in experience*, MDT follows the Greats in providing a foundational model underlying the physical, experiential reality of waves and particles—of the analog and digital—of relativity, QM, and entropy, as well as time and all its arrows and asymmetries. MDT agrees with the Greats:

Schrodinger: *The world is given but once*. . . The world extended in space and time *is but our representation*. *Experience* does not give us the slightest clue of its being anything besides that.<sup>xxxiii</sup>

Bohr: The classical concepts, i.e., “wave” and “corpuscle” do not fully describe the real world and are, moreover, complementary in part, and hence contradictory. . . . Nor can we avoid occasional contradictions; nevertheless, the images help us to draw nearer to the real facts. *Their existence* no one should deny. “Truth dwells in the deeps.”<sup>xxxiv</sup>

Schrodinger: Everything—anything at all—is at the same time particle and field.<sup>xxxv</sup> (This is because MDT’s expanding  $x_4$  is continually spreading and distributing locality.)

Einstein: Time and again the passion for understanding has led to the illusion that man is able to comprehend the *objective world* rationally by pure thought without any *empirical foundations*—in short, by metaphysics.<sup>xxxvi</sup> (MDT begins and ends with empirical foundations!)

$qp-pq=i\hbar$  and  $dx_4/dt=ic$  are fundamental equations of QM and relativity. The first equation reflects the discrete increment and quantum action— $\hbar$ —in which  $x_4$  is expanding relative to the three spatial dimensions, and the second equation, from which relativity and its postulates derive, sets the velocity of the expansion of  $x_4$  to  $c$ . Note the differentials on the left side of the equations, suggesting the fundamental, foundational change from where time and all of its arrows and asymmetries arise, and the  $i$  on the right hand side of both equations, which reflects the perpendicular nature of the change relative to our three spatial dimensions, thusly requiring an  $x_4$  moving relative to the three spatial dimensions. When one is solving equations and an  $i$  appears, it represents an orthogonality. As both QM and relativity were

brought forth in the context of the three spatial dimensions, the  $i$  emerged, representing  $x_4$ . Bohr made note of the curious occurrence of  $i$  in QM and relativity<sup>xxxvii</sup>:

Notwithstanding all differences between the physical problems which have given rise to the development of relativity theory and quantum theory, respectively, a comparison of purely logical aspects of relativistic and complementary argumentation reveals striking similarities . . . Even the formalisms, which in both theories within their scope offer adequate means of comprehending all conceivable experience, exhibit deep-going analogies. In fact, the astounding simplicity of the generalization of classical physical theories, *which are obtained by the use of multidimensional geometry and non-commutative algebra, respectively, rests in both cases essentially on the introduction of the conventional symbol  $\sqrt{-1}$* .

As both QM and relativity naturally emerge from the quantized expansion of  $x_4$ , both QM and relativity needed the notion of  $i$ —representing a moving  $x_4$  perpendicular to our three spatial dimensions ( $dx_4/dt=ic$ ). Both relativity and QM deal with realms not always obvious—the very fast, the very large, and the very small, and as both fields advanced, both required—in Bohr’s words, “not directly visualisable symbolism.” Both relativity and QM exalted  $i$ —the notion of  $x_4$  which was not quite as obvious the three spatial dimensions. And now, we see that  $x_4$  is moving and expanding in a quantized manner.  $dx_4/dt=ic$  and  $pq-qp=i\hbar$  offer the foundational bedrock of all QM and relativity—a fact I touched in the concluding words to an appendix to my 1998 physics Ph.D. dissertation<sup>xxxviii</sup> with: “As physics concerns itself at all levels with changes relative to both space and time, it makes sense that all physics, time, motion, reality, life, and consciousness itself are founded upon a stage which is endowed with intrinsic motion. **The underlying fabric of all reality, the dimensions themselves, are moving relative to one another.**”  $i\hbar$  represents the discrete unit of  $x_4$ ’s expansion, and  $ic$  represents its invariant velocity.

## **5. MDT Rescues Godel, Einstein, and Time**

P. Yourgrau writes<sup>xxxix</sup>, “Godel was quick to point out that if we can revisit the past, it never really “passed.” But a time that fails to pass is no time at all. Einstein saw at once that if Godel was right, he had not merely domesticated time: he had killed it. . . . **But now something amazing took place: nothing.** . . . A conspiracy of silence descended on the Einstein-Godel friendship and its scientific consequences.” Indeed, the great Godel is oft not cited in contemporary treatises on time, as sure as physics’ Founding Fathers are forgotten in treatises on reality, but  $dx_4/dt=ic$  saves the day by showing that both Godel and Einstein are right. Godel showed how Einstein’s interpretation of relativity froze time, and MDT’s  $dx_4/dt=ic$  unfreezes time, weaving change into the fundamental fabric of space-time for the first time in the history of relativity, while also providing the fundamental foundation for all of relativity which Einstein yet sought, as well as entropy and entanglement.

Time travel would be possible were time  $x_4$ , but time, as measured on our watches, is not a dimension, but rather it is an emergent scalar that arises from the fact  $x_4$  is expanding relative to the three spatial dimensions in a quantized manner. Schrodinger wrote, “The world extended in space and time is but our representation,”<sup>xli</sup> and Wheeler echoed this with, “The four-dimensional space-time manifold is only a fabrication, only a theory.”<sup>xlii</sup> Yes! The  $t$  axis, when drawn on a space-time diagram, is a purely mathematical construct, but the past and future do not exist, even though one may measure someone’s past in the present or the future as distant photons take time to propagate. Never does Einstein say that  $t$  is  $x_4$ , but rather he writes  $x_4=ict$ , and  $t$  and  $ict$  are very different entities. As  $t$  increments, so must  $x_4$ . As

clocks are based on physical change, and as change requires the propagation of energy, physical change and clocks thus rest upon the motion of  $x_4$ , upon which energy and photons propagate. So it is that time inherited properties and characteristics of  $x_4$  in the equations of relativity, but time, as a scalar quantity measured on our clocks, ought not be confused with the actual fourth dimension, which is a physical entity expanding at  $c$  relative to the three spatial dimensions as a spherically-symmetric wave-front with a wavelength of  $l_p$ .

## **6. Curiosity lead to MDT's Unifying, Foundational Model Underlying QM, Relativity, Entropy, & Time**

Millions saw the apple fall, but Newton was the one who asked why.<sup>xliii</sup> –Baruch

Einstein wrote, “The important thing is not to stop questioning. Curiosity has its own reason for existing. . . Never lose a holy curiosity.”<sup>xliii</sup> Wheeler was fond of saying, “No question, no answer,”<sup>xliv</sup> and MDT asks *and answers* the following questions with a simple, unifying, novel *physical* model:  $dx_4/dt=ic$ .

From what foundational reality does relativity emerge? Why the quantum? Why entropy? Why the double slit experiment results? Why no graviton? Why the discrete, digital nature of energy? What foundational model can provide the “elementary foundations” for Einstein’s relativity & Schrodinger’s “characteristic trait” of QM—entanglement? What foundational model can unfreeze time & liberate us from the block universe, exalting free will? How can we weave change into the fundamental fabric of space-time for the first time in the history of relativity? Why quantum entanglement (QM’s characteristic trait) and nonlocality? Why the dualities—space/time, energy/mass, wave/particle, E/B, analog/digital? Why is  $c$  invariant—both independent of the source and the observer? Why is a photon defined by a spherically-symmetric expanding wave-front of probability? What single model resolves the EPR & Twin Paradoxes? How do we resurrect time/change after Godel ended time/change? Why can nothing can move faster than  $c$ ? Why does length-contraction accompany motion? Why is a photon ageless (in relativity—nonlocality in time) and nonlocal in space (in QM)? Why the gravitational slowing of time and the gravitational redshift? What common, *foundational* physical model underlies QM, relativity, entropy, and time and all its arrows and asymmetries?

The physical “*why?*” leads the way as we seek the foundational character of physical reality, with Heisenberg writing<sup>xlv</sup>, “When a definite mass  $m$  is given, in our everyday physics it is perfectly understandable to speak of the position and the velocity of the center of gravity of this mass. In QM, however, the relation  $pq-qp=-i\hbar$  between mass, position, and velocity is believed to hold. Therefore we have good reason to become suspicious every time uncritical use is made of the words “position” and “velocity.” . . . ***The question therefore arises*** whether, through a more precise analysis of these kinematic and mechanical concepts, it might be possible to clear up the contradictions evident up to now in the physical interpretations of QM and ***to arrive at a physical understanding of the quantum-mechanical formulas.*** (bold italics added by author).” MDT provides a *physical* understanding of the foundational formulas of relativity and QM by presenting a deeper *physical* model underlying both, which shows that  $x_4$  is expanding in a discrete manner proportional to  $\hbar$  at the rate of  $c$ , leading to the quantum and thus the discrete, digital nature of all energy and measurement, as well as to relativity, entropy, nonlocality, entanglement, and time and all its arrows and asymmetries.



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- <sup>ii</sup> E. McGucken, *Time as an Emergent Phenomenon: Traveling Back to the Heroic Age of Physics*, <http://fqxi.org/community/forum/topic/238>, August, 2008
- <sup>iii</sup> E. McGucken, *Within a Context*, Princeton Junior Project in Physics, 1990
- <sup>iv</sup> J.A. Wheeler rec. for Dr. E, [http://www.fqxi.org/data/forum-attachments/ja\\_wheeler\\_recommendation\\_mcgucken2.jpg](http://www.fqxi.org/data/forum-attachments/ja_wheeler_recommendation_mcgucken2.jpg)
- <sup>v</sup> A. Einstein, *On a heuristic viewpoint concerning the production and transformation of light.* (light quantum/photoelectric effect paper) (17 March 1905), *Annalen der Physik*, 17(1905), pp. 132-148
- <sup>vi</sup> A. Einstein, C. Seelig, *Ideas And Opinions* (Paperback), Three Rivers Press/Random House (June 6, 1995)
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