Time as an Emergent Phenomenon: Traveling Back to the Heroic Age of Physics In Memory of John Archibald Wheeler by Dr. Elliot McGucken

ABSTRACT

In his 1912 Manuscript on Relativity, Einstein never stated that time is the fourth dimension, but rather he wrote $x_d = ict$. The fourth dimension is not time, but ict. Despite this, prominent physicists have oft equated time and the fourth dimension, leading to un-resolvable paradoxes and confusion regarding time's physical nature, as physicists mistakenly projected properties of the three spatial dimensions onto a time dimension, resulting in curious concepts including frozen time and block universes in which the past and future are omni-present, thusly denying free will, while implying the possibility of time travel into the past, which visitors from the future have yet to verify. Beginning with the postulate that time is an emergent phenomenon resulting from a fourth dimension expanding relative to the three spatial dimensions at the rate of c, diverse phenomena from relativity, quantum mechanics, and statistical mechanics are accounted for. Time dilation, the equivalence of mass and energy, nonlocality, wave-particle duality, and entropy are shown to arise from a common, deeper physical reality expressed with $dx_4/dt=ic$. This postulate and equation, from which Einstein's relativity is derived, presents a fundamental model accounting for the emergence of time, the constant velocity of light, the fact that the maximum velocity is c, and the fact that c is independent of the velocity of the source, as photons are but matter surfing a fourth expanding dimension. In general relativity, Einstein showed that the dimensions themselves could bend, curve, and move. The present theory extends this principle, postulating that the fourth dimension is moving independently of the three spatial dimensions, distributing locality and fathering time. This *physical* model underlies and accounts for time in quantum mechanics, relativity, and statistical mechanics, as well as entropy, the universe's expansion, and time's arrows and asymmetries in all arenas.

"More intellectual curiosity, versatility and yen for physics than Elliot McGucken's I have never seen in any senior or graduate student. . . Originality, powerful motivation, and a can-do spirit make me think that McGucken is a top bet for graduate school in physics. . . I say this on the basis of close contacts with him over the past year and a half. . . I gave him as an independent task to figure out the time factor in the standard Schwarzchild expression around a sphericallysymmetric center of attraction. I gave him the proofs of my new general-audience, calculus-free book on general relativity, A Journey Into Gravity and Space Time. There the space part of the Schwarzchild 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 all up in a beautifully clear account. . . . his second junior paper . . . entitled Within a Context, was done with another advisor, and dealt with an entirely different part of physics, the Einstein-Rosen-Podolsky experiment and delayed choice experiments in general. . . this paper was so outstanding. . . I am absolutely delighted that this semester McGucken is doing a project with the cyclotron group on time reversal asymmetry. Electronics, machine-shop work and making equipment function are things in which he now revels. But he revels in Shakespeare, too. Acting the part of Prospero in the Tempest..." --John Archibald Wheeler, Princeton University, Recommendation for Elliot McGucken for Admission to Graduate School of Physics

Dr. Elliot McGucken's Biography: "Dr. E" received a B.A. in physics from Princeton University and a Ph.D. in physics from UNC Chapel Hill, where his research on an artificial retina, which is now helping the blind see, appeared in *Business Week* and *Popular Science* and was awarded a Merrill Lynch Innovations Grant. While at Princeton, McGucken worked on projects concerning quantum mechanics and general relativity with the late John A. Wheeler, and the projects combined to form an appendix treating time as an emergent phenomenon in his dissertation. McGucken is writing a book for the Artistic Entrepreneurship & Technology (artsentrepreneurship.com) curriculum he created.

Time as an Emergent Phenomenon: Traveling Back to the Heroic Age of Physics In Memory of John Archibald Wheeler by Dr. Elliot McGucken (~4,992 words)

"My solution was really for the very concept of time, that is, that time is not absolutely defined but there is an inseparable connection between time and the signal [light] velocity." —Einstein

"(Wheeler) had been the last notable figure from the heroic age of physics lingering among us — a man who could claim to be the student of Bohr, teacher of Feynman, and close colleague of Einstein." —Colby Cosh, network.nationalpost.com

"Should we be prepared to see some day a new structure for the foundations of physics that does away with time? Yes, because "time" is in trouble." –John A. Wheeler

Introduction: Einstein's Clues for Time as an Emergent Phenomenon

In his 1912 Manuscript on Relativity, Einstein never stated that time is the fourth dimension, but rather he wrote $x_4 = ict$. The fourth dimension is not time, but ict. Despite this, prominent physicists have oft equated time and the fourth dimension, leading to un-resolvable paradoxes and confusion regarding time's physical nature, as physicists mistakenly projected properties of the three spatial dimensions onto a time dimension. Such projections have resulted in curious concepts including frozen time and block universes in which the past and future are omni-present, thusly denying free will, while implying the possibility of time travel into the past, which visitors from the future have yet to verify.

By postulating that time is an emergent phenomenon resulting from a fourth dimension expanding relative to the three spatial dimensions at the rate of c, this paper shows that diverse phenomena such as relativity's equivalence of mass and energy, quantum mechanics' nonlocality, and entropy arise from a common, deeper *physical* reality which underlies concepts including the EPR Paradox, the classic double-slit experiment, and Godel's block universe, while finally uniting time's arrows with a simple *physical* model expressed with:

$$\frac{dx_4}{dt} = ic$$

The above postulate and equation, from which Einstein's relativity is derived in our 4D universe (x_1, x_2, x_3, x_4) where $x_4 = ict$, presents a fundamental model accounting for the emergence of time, the constant velocity of light, the fact that the maximum velocity through space-time is c, and the fact that c is independent of the velocity of the source, as photons are but matter surfing a fourth expanding dimension. In general relativity, Einstein showed that the dimensions themselves could bend, curve, and move. The present theory extends this principle, postulating that the fourth dimension is moving independently of the three spatial dimensions, fathering time. This model underlies and accounts for time in quantum mechanics, relativity, and statistical mechanics, as well as entropy, the universe's expansion, and time's arrows and asymmetries in all arenas.

The above equation physically accounts for quantum mechanics' action-at-a-distance and relativity's length contraction, as well as entanglement and the equivalence of mass and energy. Diverse dualities—wave/particle, time/space, and mass/energy—all originate from this same principle. The model accounts for the gravitational redshift and the gravitational slowing of

clocks, while showing why there is no need to quantize gravity as no physical entities are transferred in gravitational alterations of energy. The theory provides a *physical* model for time and its arrows—time is not the fourth dimension, but rather a phenomenon that emerges because the fourth dimension is expanding relative to the three spatial dimensions in units of the Planck length. As the measurement of time is inextricably wed to energy, which is the propagation of photons, and as photons propagate as matter surfing the fourth expanding dimension, time inherits properties of the fourth dimension in relativity's mathematics, but time, as measured on our watches, recorded in our memories, and perceived in radioactive decays and entropy, is not the fourth dimension.

Relativity freezes the expansion of the fourth dimension, only ever considering instantaneous snapshots of the universe. Quantum Mechanics treats the fourth dimension as a dynamical element, and hence quantum mechanics is a science defined by flux—by differential operators. QM's nonlocality and the relativity of simultaneity both derive from the fundamental expansion of the fourth dimension, which distributes a local point into a nonlocal probability distribution at the rate of c, invoking de Broglie's pilot waves and Kaluza-Klein geometries, where each point can be viewed as a compactified dimension, expanding in accordance with Huygens' principle. Hence a photon's motion is described by a spherically-symmetric probabilistic wave-front expanding at c; as a photon is but matter fully rotated into the fourth expanding dimension.

QM, relativity, and statistical mechanics all offer parallel clues not only into the nature of time, but into the more fundamental nature of a universe in which the fourth dimension is expanding relative to the three spatial dimensions, thusly liberating us from a block universe, while unifying time's arrows and accounting for curious phenomena in QM and relativity with a unique and simple physical model, which views time as an emergent phenomenon. The expansion of the fourth dimension is the fundamental motion underlying all motion, setting the singular velocity through space-time for every physical entity to c, while fostering Huygens' Principle—the fundamental expansive wave nature of all matter and energy—in both the quantum mechanical and classical worlds, manifesting the above postulate and equation in Feynman's many-paths interpretation and wave pools alike.

Both QM's "nonlocality"—manifested in the double-slit experiment, tunneling, and the EPR paradox, and relativity's ageless photon—which represents time dilation's limit, are founded upon a *physical reality* wherein no matter how far a photon travels in the three spatial dimensions, it yet retains a locality in the fourth dimension, implying the inherent nonlocality of the fourth dimension which is naturally accounted for by its fundamental expansion relative to the three spatial dimensions. The expansion of the fourth dimension manifests itself as an expanding 3D spherical surface, and every point on that sphere retains its original compactified locality and orthogonality, in turn expanding (Huygens' principle), as locality is "smeared." Hence two initially-interacting photons separated by the width of the universe may yet influence one-another instantaneously, as *they yet inhabit the same place in the fourth dimension*, as relativity's math also attests to by presenting us with a timeless, ageless photon whose path through the universe is defined by a null vector—a vector of zero length, which defines the radius of a photonic wave's spherically-symmetric, expanding nonlocality.

The correspondence between the *first* derivative with regards to time and the *second* derivative with regards to space in Schrödinger's Equation may be accounted for with the postulate. Time's quantum mechanical arrow, radiative arrow, and thermodynamic arrow may all be witnessed in the expansion and collapse of a photon's wave function, which expands at the rate of *c* until encountering an irreversible process whence the matter trapped in the expanding fourth dimension is brought to rest in the three spatial dimensions via a "measurement" or localization. Thus time's very direction and tangible, physical character in all arenas emerges from a fourth dimension that is expanding relative to the three spatial dimensions.

Another clue is found in length contraction—all moving objects are foreshortened in the direction of their motion. They are foreshortened via their rotation or "boost" into the fourth dimension, which is moving relative to the three spatial dimensions, and thus they experience augmented momentum and motion, in proportion to the energy component of their momenergy.

Moving Dimensions Theory—which regards time as an emergent phenomena—was inspired in part by Einstein's words pertaining to the higher purpose of physical theories: "Before I enter upon a critique of mechanics as a foundation of physics, something of a broadly general nature will first have to be said concerning the points of view according to which it is possible to criticize physical theories at all. The first point of view is obvious: 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). This point of view, an exact formulation of which meets with great difficulties, has played an important role in the selection and evaluation of theories since time immemorial."

<u>Einstein's Annus Mirabilis: The Photon Holds the Key to Time as an Emergent Phenomenon</u>

As contemplations on the photon lead Einstein to the theories of relativity and quantum mechanics that revolutionized our notions of space, time, and physical reality, this paper again turns towards the photon and Einstein's original works to shed light on time. Various phenomena in Einstein's 1905 papers can be united with a simple postulate representing an underlying physical reality from where time itself emerges—the fourth dimension is expanding relative to the three spatial dimensions at the rate of c.

Consider the emission of a photon in free space. One second later, the photon has equal probability of being found anywhere upon a sphere with a radius of 186,000 miles, as the velocity of light is 186,000 miles/second. If we covered the surface of said sphere with detectors, one, and only one detector, would detect the photon. Although having traveled 186,000 miles through space, the photon will not have aged one iota, for time stops at the speed of light. It will not have moved one iota in the fourth dimension. And there lies a clue to the reality that the fourth dimension is expanding relative to the three spatial dimensions. For how can a photon propagate 186,000 miles in the three spatial dimensions, and yet not budge an inch in the fourth dimension, unless that fourth dimension is moving right along with it, just as a wave moves right along with a surfer?

Consider two interacting photons that propagate in opposite directions, as in experiments inspired by Bell's Inequality and conducted by Aspect et al. One second later, each photon's polarization is measured at detectors separated by 372,000 miles. According to the laws of quantum mechanics and numerous supporting experiments, the measurement at one detector instantaneously affects the measurement at the second detector. It is as if the photons are yet side-by-side during the measurement. This "spooky action-at-a-distance," as Einstein called it, is not so spooky in the context of a fourth expanding dimension, for although separated by 372,000 miles, the photons yet inhabit a common locality in the fourth dimension, as the fourth dimension is expanding relative to the three spatial dimensions, distributing locality at the rate of c. So it is that both quantum and relativistic phenomena are accounted for with the simple elegance of the postulate: the fourth dimension is expanding relative to the three spatial dimensions.

Another paper Einstein penned in 1905 was devoted to Brownian motion and statistical mechanics. Drop a thimbleful of food coloring in a pool. The laws of statistical mechanics dictate that there is a high probability that the coloring will spread throughout the entire pool and never again reassemble. Entropy is a fundamental condition of physical reality which informs our perceptions and definitions of time, and entropy is physically accounted for with the current

model. As the fundamental motion of the universe is the expansion of the fourth dimension relative to the three spatial dimensions, two photons originating from a common origin will harbor a vast probability of being found one second later separated by a distance that is far greater than the distance that separated them at their origin. Recall our system of detectors placed everywhere upon the surface of a sphere with a radius of 186,000 miles—each photon has an equal chance of being found at any detector one second after they were emitted at a common origin, and chances are that the photons will be detected by detectors separated by a distance greater than approximately zero, which defined their original separation. Hence entropy. All particles undergoing thermal vibrations interact with photons, and all photons reside in the fourth expanding dimension, dragging all of entirety into random disorder.

Yet another paper published by Einstein in 1905 was devoted to the equivalence of mass and energy. Consider the fascinating physical reality implied by Einstein's most famous equation— $E=mc^2$. A kilogram of gold or lead or feathers sitting on a desktop is the same thing as 9×10^{16} joules of energy—an exorbitant amount of energy—enough to power, or to destroy, a major city. How is it that a stationary mass possesses such a great energy? It is because the mass, which appears stationary in the lab, is yet propagating through space-time at the rate of c, as is every object, as the fourth dimension is expanding at c. Matter surfing the fourth expanding dimension appears at photons.

The primary invariant is c—all matter and/or photons—be it propagating through space or time, or some combination thereof, always move at the rate of c through space-time, and this reality arises because of the deeper physical invariance of a fourth dimension that is expanding relative to the three spatial dimensions at the rate of c. To be stationary in the three spatial dimensions means to propagate at the rate of c through the fourth dimension, as a stationary clock ticks away this distance at a maximal rate, as the photons in the unwinding clock's spring travel at c relative to the stationary clock. To be stationary in the fourth dimension means to propagate at the rate of c through the three spatial dimensions, as does the ageless photon. Ergo the fourth dimension is expanding at the rate of c relative to the three spatial dimensions.

Nonlocality stems from the inherent nonlocality of the fourth dimension, which is nonlocal via its expansion. The below fundamental equation comes straight from Einstein's manuscripts, and it recognizes that *time is not the fourth dimension*, as many modern physicists have supposed, but that *time is a phenomenon that emerges because a fourth dimension is expanding relative to the three spatial dimensions*:

$$\frac{dx_4}{dt} = ic$$

The fourth dimension is inherently nonlocal. In the photoelectric effect, the photon's wave distribution *immediately* collapses in the act of measurement. This is because although the expanding wave-front is distributed as spherically-symmetric wave-front in 3D, it yet defines a locality in the fourth dimension. The ultimate goal of *physics* is to provide *physical* models of reality which support diverse phenomena with a logically-simple *physical* explanations—as simple as possible, but not more-so.

The *instantaneous* collapse of the wave function in quantum mechanics parallels the notion of simultaneity in relativity. Both of these concepts derive from the fact the fourth dimension is expanding relative to the three spatial dimensions. Relativity tells us that two photons emitted from a common origin will remain at the same place in time—they will never age, and their coinciding spherical wave-fronts will define a sphere of simultaneity. A compactified fourth dimensional sphere expands in a spherically-symmetric manner, obeying Huygens' principle while underlying all of its manifestations throughout nature. Quantum mechanics tells us that no matter how far apart two photons travel, they will be connected in a local manner until one is measured, whence the measurement on one instantaneously effects the other. So it is that the current theory $dx_4/dt = ic$ underlies both relativity and quantum mechanics.

The time on a watch or clock, whether linked to an oscillating circuit, quartz crystal, or unwinding copper spring, is based on changes in energy, which is based on the emission and propagation of photons. Photons surf the fourth expanding dimension, and thus time inherits properties of the fourth dimension, but time is not the fourth dimension. Past, present, and future are but states contained in our mind—past is what we remember—order stored in our brains. The present is physical change that creates the order in our brain. The future is but in our imaginations—changes we can potentially effect which will be recorded in the order of our memories.

In relativity we often equate one second of time with $3x10^8$ meters—the distance traveled by a photon in one second. This is because photons are matter surfing the fourth dimension which expands at c.

Deriving Relativity from dx4/dt = ic

Let us travel on back to *Einstein's 1912 Manuscript on the Special Theory of Relativity*, where we see that he does not say that time is the fourth dimension, but rather, inspired by Minkowski, he stipulates that the fourth coordinate u or x_4 is defined by ict. Einstein writes,

If, in three-dimensional geometry, a new orthogonal coordinate system with the same coordinate origin is introduced alongside the original system (x, y, z) (rotation of the coordinate system), then the laws of this coordinate transformation are possible from the following two stipulations:

- (1) The transformation equations are linear and homogeneous with respect to the coordinates
- (2) The distance of an arbitrary point from the coordinate origin is the same with respect to both systems

For, according to (1), the transformation is determined by equations of the form

$$x' = \alpha_{11}x + \alpha_{12}y + \alpha_{13}z$$

$$y' = \alpha_{21}x + \alpha_{22}y + \alpha_{23}z$$

$$z' = \alpha_{31}x + \alpha_{32}y + \alpha_{33}z$$

Where the quantities α are independent of x, y, z. According to (2), these equations must make the equation

$$x^{2} + y^{2} + z^{2} = x'^{2} + y'^{2} + z'^{2}$$

into an identity. . .

If we compare this with the considerations leading to the general Lorentz transformation, then we see that the transformation equations holding between x, y, z, u = ict and x', y', z', u' = ict' of two justified space-time reference systems satisfy the same conditions and are constructed in the same way as in the just considered three-dimensional case. The only difference is that we now have four coordinates instead of three. We can formulate this in the following way: All of the "justified" time-space reference systems to which the four-dimensional manifold of events is referred are orthogonal coordinate systems to which the four-dimensional manifold of events is referred are orthogonal coordinate systems with four axes that can be transformed into each other by mere rotation. One has to keep in mind that the fourth coordinate u is always purely imaginary. (Bold italics added)

Einstein definitively states $x_4 = ict$, and time and ict are very different entities. Einstein states, "One has to keep in mind that the fourth coordinate u (which Einstein sometimes writes as x_4) is always purely imaginary." It is imaginary because the expansion of the fourth dimension is

orthogonal to the three spatial dimensions in every direction, just as the radii of an expanding sphere are perpendicular to its surface at every point.

Let us derive the Lorentz Transformations and Einstein's relativity, including time dilation, length contraction, and the equivalence of mass and energy from our simple postulate that the fourth dimension is expanding relative to the three spatial dimensions and its representative equation:

$$\frac{dx_4}{dt} = ic$$

$$\int_a^u \frac{dx_4}{dt} dx_4 = \int_a^u icdx_4$$

$$\int_a^u \frac{dx_4}{dt} dx_4 = x_4(u) - x_4(a)$$

$$\int_a^u icdx_4 = icu - ica$$

$$x_4(u) - x_4(a) = icu - ica$$

$$x_4(u) = icu - ica + x_4(a)$$
Let D be the constant $-ica + x_4(a)$ and re-label u with t . Then we have $x_4(t) = ict + D$
Dropping the arbitrary constant, we get:
$$x_4(t) = ict$$
Or
$$x_4 = ict$$

Armed with this simple result, we are ready to return to Einstein's 1912 manuscript and provide the motivation for a four-dimensional coordinate system where the fourth dimension is written as $x_4 = ict$. When Einstein wrote $x_4 = ict$, inspired by Minkowski's work, he never qualified the fundamental motivation for this—the fact that the fourth dimension is expanding relative to the three spatial dimensions. When Einstein penned his 1912 manuscript, he did not perceive that relativity's equivalence of mass and energy and QM's wave-particle duality—time dilation and the EPR paradox—entropy and length contraction— $E=mc^2$ and the double slit experiment—could all be accounted for with a fourth expanding dimension. Nor did he recognize that while relativity considers instantaneous frozen snapshots of the universe, quantum mechanics acknowledges the fundamental flux of the expanding fourth dimension, and is thus based on differential operators and probabilistic wavefronts, which acknowledge the perpetual smearing of locality into non-locality, and the emergence of time.

In Einstein's 1912 Manuscript on the Special Theory of Relativity, Einstein writes:

The principle of the constancy of the velocity of light demands the existence of a reference system Σ relative to which every light ray propagates in vacuum with velocity c. According to the relativity principle, all reference system Σ in uniform translation motion to Σ must possess the same property. Together with Laue, we call each such system "justified." Now we ask: What kind of transformation equations must obtain between the space-time coordinates x, y, z, t (with respect to Σ) and x', y', c', t' (with respect to Σ) of the same point event so that the principle of the constancy of the velocity of light would hold with respect to both systems? . . .

... Suppose that at this moment of the coincidence of the two origins a vacuum light signal is sent from O or O', which, according to the principle of the constancy of the

velocity of light, propagates in a spherical wave with respect to both systems then the spatial points that are just reached by the signal at times t and t' with respect to \sum and \sum' , respectively, will be determined by the equations

$$\sqrt{x^{2} + y^{2} + z^{2}} = ct$$
and
$$\sqrt{x^{2} + y^{2} + z^{2}} = ct'$$
This means that the equations
$$x^{2} + y^{2} + z^{2} - c^{2}t^{2} = 0$$
and
$$x^{2} + y^{2} + z^{2} - c^{2}t^{2} = 0$$

must be equivalent. Thus, the transformation equations that we are seeking must be so constituted that the second equation turns into the first one if x',y',z',t' are replaced by their expressions in terms of x,y,c,t. The transformation must therefore make the equation

$$\lambda^{2}(x^{2}+y^{2}+z^{2}-c^{2}t^{2})=(x^{2}+y^{2}+z^{2}-c^{2}t^{2})$$

into an identity, where all that we know about the factor λ^2 for the time being is that it must not vanish. But one can see that λ^2 must be independent of x, y, z, t, for otherwise the right-hand side divided by λ^2 could not be a homogeneous, complete function of second order in x,y,z,t after the substitution is carried out. For now we will examine the substitution for the case $\lambda^2 = 1$ and we will show later that from a physical point of view this is the only case deserving of consideration. Instead of (15), we then have:

$$x^{2} + y^{2} + z^{2} - c^{2}t^{2} = x^{2} + y^{2} + z^{2} - c^{2}t^{2}$$

If one introduces the variable u = ict or u' = ict' in place of the time variables t, where i denotes the imaginary unit, one obtains, instead of (15a), the form

$$x^{2} + y^{2} + z^{2} + u^{2} = x^{2} + y^{2} + z^{2} + u^{2}$$

Note that when Einstein states "If one introduces the variable u = ict or u' = ict' in place of the time variables t," he states no motivation. Moving Dimensions Theory presents the deeper reasons why this substitution works—the fourth dimension is expanding relative to the three spatial dimensions. It works because:

$$\frac{dx_4}{dt} = ic$$

Which implies: $x_4 = ict$. Einstein continues in his 1912 Manuscript:

As is well known, this choice of time variables derives from Minkowski. Its great significance consists in the fact that by means of it, equation (15a), which governs the substitution that we are seeking, is brought into a form into which the spatial coordinates and the temporal coordinate enter in the same manner.

Let the coefficients of the substitution that we are seeking be denoted as in the accompanying array; the second horizontal row, for example, shall signify that the equation:

$$y' = \alpha_{21}x + \alpha_{22}y + \alpha_{23}z + \alpha_{24}u$$

Obviously, those from among these coefficients that do not contain the index "4" or contain it twice are real, the rest being purely imaginary. . .

And replaces x', y', z', u' by their expressions in terms of x, y, z, u then one obtains x as the result. The situation is analogous with the other vertical rows of the above array. Thus, the array also yields the inverse substitution, which expresses x etc.

by means of x',y',z',u'. Hence, the quantities α must also satisfy those conditional equations that are analogous to equations (16) in that merely the vertical and the horizontal rows change their roles.

As we already can see from equation 15b which determines them, the transformations we seek are exactly the same as those we have to apply to the spatial coordinates when passing from an orthogonal coordinate system to another one with the same origin, the only difference being that here one deals with a four-dimensional manifold rather than with a three-dimensional manifold as in the other case. This knowledge forms the basis of Minkowski's four-dimensional treatment of the theory of relativity, which brought about a splendid simplification of the system of the theory of relativity. We shall go into this in greater detail in the next chapter, while in this chapter we will derive the most important results of the theory of relativity in the most elementary way, in order for its physical relationships to emerge more clearly.

So it is that by providing the motivation for representing a fourth coordinate with x4 = *ict*, our simple postulate and equation underlies the Lorentz Transformation, Minkowski's four-dimensional treatment of the theory of relativity, and Einstein's relativity, while also liberating us from a block universe and providing *physical* interpretations for quantum mechanical phenomenon and statistical mechanics.

Time's Arrows and Asymmetries Unified:

Time's arrows are time's messengers, manifesters, and definers. Time, as measured by the ticking seconds on a clock, the melting of a snowman, the propagation of an electromagnetic wave, or the dissipation of a drop of food coloring throughout a pool, is an emergent phenomenon, which results because the fourth dimension is expanding relative to the three spatial dimensions, carrying energy in the form of matter rotated into the fourth expanding dimension. This principle, which naturally suggests time's radiative and entropic asymmetries, may also account for the preponderance of matter over anti-matter. The vast majority of matter sees the fourth dimension as expanding. While a central point that receives shrinking spherical waves from a spherically-symmetric emitter consisting of numerous point emitters can be imagined, such central points, or positrons, are unstable, and adversely-susceptible to small imperfections, perturbations, and asymmetries in the incoming waves of the fourth dimension.

The Radiative Arrow of Time: As photons surf the fourth expanding dimension, radiation is fundamentally denoted by expanding spherical wave-fronts, and not shrinking spherical wave-fronts. Two photons originating from a common origin will harbor a vast probability of being found at great distances from one-another one second later—distances far greater than the distance that separates them at their emission. Hence entropy.

Entropy—Time's Thermodynamic Arrow: Consider two or more particles in close proximity. The fourth dimension is expanding as a spherical wave-front relative to the three spatial dimensions. Two particles in close initial proximity have a greater chance of moving further apart as opposed to closer together. All particles will have a probability of being caught in the fourth expanding dimension in proportion to their energy, and thus increased energy correlates with increased motion. Hence a drop of food coloring dropped in a swimming pool will dissipate and effectively never converge.

The Cosmological Arrow of Time: As all motion derives from the fundamental motion dx4/dt=ic, the universe's general motion is expansion. If the absolute rate of c changes, the rate of expansion of the universe will appear to change. Hence an accelerating/decelerating universe.

The Causal Arrow of Time: The causal and psychological arrows of time are related to the capability of our minds to record events, as well as imagine future events, based on the cause and effect logic learned via our empirical existence. However, neither the past nor the future exist out there. There is but one present, though observers may disagree on its nature, due to the inextricable, tautological relationship between measurement and light, light and time, and time and measurement.

The Quantum Arrow of Time: The Copenhagen interpretation sees quantum evolution to be governed both by the Schrödinger equation, which is time-symmetric, and by the time-irreversible collapse of the wave function. Up until now, the mechanism of wave function collapse was philosophically obscure, but the current theory proposes that the wave function collapses as momenergy is removed from the fourth expanding dimension and localized, as when a photon is measured or localized as a blackened grain on a photographic plate. At quantum, microscopic distances, and as *t* approaches zero, there is still a probability that an emitted photon can yet be found at its origin—that it has not moved—and thus entropy's thermodynamic arrow is not as apparent, and time symmetry can appear intact in the quantum world in the realm of Planck times and distances. But as the fourth dimension expands at the rate of *c*, as *t* grows, so does entropy, thusly dominating time's arrows and our concept of time in the macroscopic world. Time travel to any significant degree is impossible because the fourth dimension never reaches deeper than Planck's length. One could only go back in time by Planck's time.

Conclusion & Moving Away From Godel's Block Universe:

In 1949 Godel published a paper showing that within the theory of relativity, time as we understand it does not exist. Einstein recognized Godel's paper as "an important contribution to the general theory of relativity." Since then, physicists have not been able to find any logical shortcomings in Godel's work, and nobody has quite been able to account for the existence of time, nor divorce relativity from a block universe. The current model accounts for time in both GR and QM by showing that it is not the fourth dimension, but that it is an emergent property of the underlying dimension's intrinsic relative movement. While we lose the eternal recurrence of a frozen past and future, we gain our free will, as well as a physical model that supports both GR and QM, as well as the time we perceive in this universe we inhabit. And so it is that "there is an inseparable connection" between time and light, as time naturally emerges from the physical expansion of the fourth dimension relative to the three spatial dimensions, and light, by which we measure time and distance, is but matter caught in the fourth expanding dimension.

"More intellectual curiosity, versatility and yen for physics than Elliot McGucken's I have never seen in any senior or graduate student. . . ." –John Archibald Wheeler, Princeton University