Article

Model for Local and Non-Linear Time and Space

Martin Alpert [1,*]

[1] Universal Empowering Technologies 1; maalpert88@gmail.com
* Correspondence: maalpert88@gmail.com

Abstract: In this theory, duration is differentiated from time and length is differentiated from space. This theory proposes that space is generated by relationships which is quantified by entropy at each present time and time is quantitatively related to entropy changes. That is, relationships are the basis of each configuration which result in space and changes between relationships results in time. One example is Bell's inequality violation where an interpretation of observations is that it confirms the Copenhagen interpretation of quantum mechanics so properties only exist when observed. In contrast, this theory proposes that the same results are obtained for real properties in nonlinear local time and space. Hidden variables are the generated time and space. Physical phenomena are typically described in background spacetime which, per this theory, is a statistical average of a large number of relationships and relationship changes. A consequence of this theory demonstrated in this paper is that superposition in double slit systems and entanglement observations in Bell's inequality are explained by the same quantum mechanical mechanism. This theory is applied to the twin paradox, mass change with speed, the origins of the Pauli Exclusion Principle, particle decay, deBroglie waves, black holes, inflation post-big bang and how space and time are related to the four forces. Experiments are proposed that could validate this theory.

Keywords: Time; Space; Entropy; Entanglement; Superposition; Hidden Variables; Bell's Inequality; Inflation; Black Holes

1. Introduction

Duration, which is based on an interval of time, is not time. Length, which is based on an interval of space, is not space. Time, like space, is necessary for existence. Most physics is related to duration and spatial dimensions, either directly or indirectly. It is important to differentiate what happens in time (background duration) from what time is and what happens in space (background spatial distance) from what space is. Time direction is related to increased entropy through the Second Law of Thermodynamics [1–6]. This theory is based on entropy increase not only being related to the direction of time, but the magnitude of time as well. Entropy, a function of the number and type of possible relationships, is only in space at one instant, the present. Per this theory, entropy generates local space and changes in entropy generates local time; they do not occur in space and time. This theory is based on background space and time not existing independent of relationships and relationship changes, that is, background spacetime is generated. When relationships do not exist, spacetime does not exist.

Relationships generate space. Physical relationships in quantum mechanics can be either distinguishable (commuting relationships) or indistinguishable (non-commuting relationships). The number of possible discrete relationships in a system include available information (resulting in distinguishable states) and bilateral additional possible (superposition) relationships between distinguishable states that exist due to unavailable information resulting in indistinguishable states at each present. The greater the difference between the number of observers capable of making an observation and the number of states in a system, the greater the unavailable information so the number of possible configurations in the system increases (increased entropy). The amount of missing information is determined

Citation: Alpert, M. Model for Local and Non-Linear Time and Space. *Journal Not Specified* **2024**, *1*, 0. https://doi.org/

Received:
Revised:
Accepted:
Published:

Copyright: © 2025 by the authors. Submitted to *Journal Not Specified* for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

by the number of bits that need to be added to the system so the inputs can be uniquely determined from the outputs. Therefore, entropy (energy) change is inversely related to information change in a system. Per this theory, **time is a change in relationships (space)**, i.e., each change is an event that generates time. Each event is not in time. This hypothesis basically reverses the current thinking that relationships and changes in relationships exist in a background of uniformly changing time in uniform space and considers space and time a function of local relationships and changes in relationships with a simultaneous change in the probability distribution of future events.

The consequence of the following assumptions will be investigated:

1. Relationships generate local physical space, which is quantified by entropy: no universal background space.
2. Changes in relationships (events) generate local time which is quantified by changes in entropy (transition of information): no universal background time.

Per this theory, space is independent of observed length and time is independent of observed duration. That is, space and time are not functions of external observations of distance and duration. Time is not an external natural process but an internal natural process. Thus, time is not regular, so it is not the same for all that exists. Rather, time becomes an individual function of each process. Based on these assumptions, certainty, as perfect information with no entropic changes exists only in the present and defines the present. The present is a limit for complete information of states (constrained by uncertainty) so entropy is approximately zero. Future is defined by missing information (multiple possible states that can arise from the present) that is characterized by a decrease from certainty so entropy is positive. Each future possible relationship has an associated probability, a relational probability. Probability is the independent variable; time is the dependent variable. As an example, per this theory, a completely entangled property is a minimal relationship (space increment) generating local space and time, modeled as being local and not dependent on the length between them or time duration for a transfer of a signal in the length between them. That is, spacetime, per this theory, is a different mechanism for modeling Bell's inequality experimental results (based on local nonlinear spacetime) than the current mechanism that is based on background spacetime. In this theory Bell's inequality observations are postulated to be a result of changes in relationships generating nonlinear spacetime for existing properties. Conventionally, the duration for changes between the relationships of entangled particles/properties when one state is observed is approximately instantaneous, i.e., approximately simultaneous even over large distances between entangled particles/properties. Per this theory, there is one space increment between entangled states so a change in one state generated by observation affects the non-observed entangled state instantaneously. This is analogous to states in adjacent space where a change in one space affects the other space instantaneously. A consequence of this theory is that particles and properties are real, even if not observed in contradistinction to the prevalent view of the Copenhagen interpretation of quantum mechanics [7]. This theory validates Einstein's premise that particles and properties are real and a result of hidden variables, the non-linear time and space generation [8,9].

Space relationships can be categorized as "comparable" and "incomparable." "Comparable" states are defined as relationships with the same property characteristics. For example, an electron mass is a set of "comparable" internal relationships, identified as a property. "Comparable" states are not capable of being in superposition with "incomparable" states. "Incomparable" states are between a different set of relationships that have different property characteristics such as spin and charge and cannot be in superposition with each other. A boundary can exist between "incomparable" states, two different sets of relationships that have different characteristics. "Comparable" states can be observed by the same observers, for example, spin+ or spin- can be observed by the same "type" observers. "Incomparable" states require different "type" observers (capable of observing different characteristics) to make observations.

Entanglement exist between "comparable" relationships. There are four relationships for an entangled system generating four space increments. Two are generated from the independent relationship of each entangled state with the local environment and two are generated from the bilateral missing information between the states (superposition). Comparable four relationships exist in double slit systems which, later in the paper, is used to demonstrate that they are the same quantum mechanical mechanism. Other properties within particles that are not entangled or in superposition have different relationship and generate different independent local spacetime that have classical relationships with the environment (or with each other) in spacetime. There are no additional relationships like those between entangled particles/properties or double slit system without a path information observer. The classical local relationship change with the environment for non-entangled particles/properties has a similarity to entanglement, in that the local change is also approximately instantaneous (two balls colliding) because like entanglement, the local space is adjacent.

Per this theory, spacetime is based on two natural discrete limits in determining relationships, Boltzmann and Planck states. A Boltzmann states is one bit of information, a relationship generating space. The number of Boltzmann states in a system is the number of possible space relationships (one bit of information per relationship). Change in space is not a necessary condition for Boltzmann states. For no change in Boltzmann states (such as in black holes), time would only be of the present which, in the universe (states exist), is still time. Per this theory, mass exists in increments based on Boltzmann states (bits), and differ in other variables such as the number, type (non-mass characteristics such as spin or charge), and density of relationships.

Particles, as field interactions, are still a result of hidden variables, that is, a result of relationships and relationship changes. Particles are real whether they are interactions with Higgs field [10] or material, and not just probability waves until observed. A fundamental particle is a specific set of field interactions. If any of the four fundamental forces within a mass change, changing the properties of the mass that result in emission or absorption of a particle or energy, it is not fundamental. Fundamental mass (particles) would be a relationship between mass states with properties such as spin, charge, color, flavor with no exchange between internal states and the external environment. For example, electrons are modeled as a mass that incorporates all electron properties such as spin and charge. All electrons with the same properties have the same relationship with the environment. The properties such as spin may be in two states but the electron, then, is two different fundamental particles when observed. Thus, a change in electron orbital relative to a nucleus is due to local spacetime changes, and not a fundamental change in the electron.

Stationary states can occur in mass but not in waves (energy). Non-present time generation is a necessary condition for waves. There is a necessary condition for change at each present in EM waves where change is between internal increments of a wave (internal space within the wave). Each increment consists of a number of indistinguishable Planck states [11]. The number of Planck states per increment is constantly changing even though the total number of Planck states in an EM wave of a given energy is constant, resulting in the frequency of the wave:

$$v = \frac{E}{h} \tag{1}$$

Planck states are a scalar at Planck's constant magnitude that generate non-gravitational, minimum external spacetime. Planck states are not considered to be a limit on the ability to make a perfect observation as part of the measuring process but is a fundamental increments of change and has an independent physical significance. Even though there is no spacetime within each Planck increment, changes between EM wave increments composed of Planck states generate spacetime. Everything in the universe is made of components which can be subdivided into discrete relationships between Planck states. Planck state increments, as the minimal cell size, maximize the number of states in a system.

The number of Planck states increments are in constant transition generating time which have an observable effect as energy, but only when emitted or absorbed and is not observable between emission and absorption. Observation would require the transfer of wave energy to the observer at wave absorption [11]. The emission and absorption (observation) of an EM wave is a local relationship change so generated time would, therefore, also be local. **In this theory, spacetime, as relationships and changes in relationships, and energy are simultaneous and equivalent.** Boltzmann states interactions with Planck states include emitting, absorbing or reflecting Planck states. Boltzmann tells Planck where to go.

Note, in this paper, n is used for the number of Planck states and m is used to specify the mass equivalent in Planck states. N is used for the number of Boltzmann states and M is used to specify mass in Boltzmann states.

2. Background

Philosophizing about time can be traced to the Egyptian Ptahhotep (c. 2600 BCE) [12] whereas early theories can be traced to Indian/Hindu ideas of time cycles in the second millennium BCE [13]. Later theories were developed by Greeks such as Parmenides and Heraclitus [14] followed by Plato and Aristotle. Aristotle described time as "... the measure of change. If nothing changes, there is not time [15]." Later, In Book XI of St. Augustine's Confessions insightfully referred to time as: "What then is time? If no one asks, I know: if I wish to explain it to one who asks, I know not [16]." The unexpressed insight was that St. Augustine could define duration, but not the source of duration. That is, the difference between duration and time was not recognized. Still later, in the eleventh century, Galileo Galilei considered time change to be the same for everyone [17,18].

Space, likewise, was a subject with many different views. In Greece space was discussed in the Timaeus of Plato: "...the place of a thing is what surrounds that thing [19]" and in the Physics of Aristotle where "...space is only the spatial order of things" – so empty space cannot exist [15]. Alhazen in the tenth century considered space geometrically as place [20]. Descartes considered space Cartesian and contained but did not originate matter and attributed information about the world to a person's ability to think rather than to experiences, a non-empiricist approach [21–23]. Since relationships are between discrete objects, space was considered discrete [24], that is, objects are necessary for relationships to exist so space is not independent of these objects [25] .

These debates and concepts continued through the Renaissance culminating in what was developed by Newton, an empiricist, as classical mechanics. However, even classical mechanics did not settle these issues. A controversy between Newton and Leibniz ensued. Newton believed space exists independent of matter and is therefore permanent. Per Newton, "...what surrounds each thing, is called 'relative, apparent and common...absolute, true and mathematical' space in itself, which exists even where there is nothing" so for Newton: "empty" space exists. Similarly, per Newton: "...time would continue to pass...unaffected and equal to itself [15]." Newton referred to "mathematical time...from its own nature flows equably without regard to anything external...called duration... [26]." Newton hypothesized that since non-inertial frames based on time and space exist in space, space must be absolute [15,26]. In this formulation, time varies linearly. Leibniz differed and considered space relationships between objects [27]. Kant did not concur with either of these interpretations of space and time but described space and time as a result of experience, that is, they are subjective [28].

These and other concepts developed into the current classical formulations in physics where space and time are considered fundamental, not definable by other quantities, but rather are used to relate other quantities to each other. Einstein synthesized these disparate views in that time and space are real but not absolute. Derived spacetime which is fundamental as proper time (combined changes in spatial dimensions and duration) is invariant spacetime. "Every phenomenon that occurs has its proper time... [15]." even though space and time have fundamental differences in that movement in space is bidirectional but movement in time is unidirectional [15]. In Special Relativity there is no unique present;

each point in the universe can have a different set of events that are in its present moment. The extension provided by General Relativity demonstrated that gravity could change the structure of spacetime which has been subsequently verified experimentally [29]. These theories define relationships between spatial dimensions and the duration dimension but do not define space and time.

Predating and then simultaneous with macroscopic considerations of space and time, were microscopic considerations advanced by Clausius that incorporated disorder to describe the decreasing free energy in Carnot engines [2,30]. This was extended by Boltzmann whose entropic theory established an arrow of time based on the Second Law of Thermodynamics [1]. Einstein referred to this as "It is the only physical theory of universal content which I am convinced that, within the framework of applicability of its basic concepts, will never be overthrown [31]." Irreversible processes established the arrow of time on a physical basis. "In order to leave a trace, it is necessary for something to become arrested, to stop moving, and this can happen only in an irreversible process – that is to say, by degrading energy 'into heat'... The absence of any analogous traces of the future produces the sensation that the future is open [15]." Thus, the direction of time becomes associated with energy as described by: "Between energy and time there is a closed bond...knowing what the energy of a system may be – how it is linked to other variables – is the same as knowledge how time flows, because the equations of evolution in time follow from the form of its energy [15]." The direction is eliminated in thermal equilibrium since "In a state of thermal equilibrium...there isn't a direction to time identified by causality [15]."

In contemporary physics, there are many theories of time and space without experimental proof so the physics of time has become more philosophical than science which is an indication of how little about time and space is understood. Some of the theories include:

1. Emergent: Spacetime may not be fundamental, but emergent [32,33] .
2. String theory: Space points are replaced by one-dimensional interacting strings that propagate [34].
3. Loop quantum gravity: "It is reciprocal interactions in which quanta manifest themselves in the interaction, in relations to what they interact with...the probabilities that something will happen – given the occurrence of something else... [15,35–37]."
4. Relational Theory: Relationships have reference observers. "We describe how the world evolves in time: we describe how things evolve in local time, and how local times evolve relative to each other [38–43]."
5. Wheeler-DeWitt: There are discrete changes in the universe that do not incorporate time. "The theory describes how things change one in respect to others [without time],..., that's all there is to it [15]." "It describes possible events and the correlation between them, and nothing else... [15]." "To speak of the world 'seen from outside' makes no sense, because there is no 'outside' to the world [15] ."
6. Conformal Field Theory (CFT): Emergent space comes from entanglement in anti-de Sitter (AdS) space where distance in AdS space are entangled components of CFT. However, we do not live in an AdS space [44,45].
7. Causal set theory (CST): Fundamentally, spacetime is discrete "causal sets" of spacetime where finite space volume has only a finite number of causal set elements consistent with Lorentz invariance [46].
8. B-theory of time: Time is an illusion. That is, time is tenseless and the past, present and future are equally real [47,48].
9. Endurantiasm: This is a three-dimensional theory where objects are wholly present at every moment of their existence [49].
10. Perdurantism: In contrast to Endurantiasm, this is a four-dimensional theory where objects are extended in time and, therefore, are a series of temporal components [49].

Currently, time in physics is defined functionally, not based on basic principles, which relates time to a scalar as the number of events in periodic phenomena. Historically, time is a measurement of increments in "the duration of 9,192,631,770 (cycles) of the radiation corresponding to the transition between two hyperfine levels of the ground state of the caesium 133 atom" in the International System of Units (SI) system [50]. Length for space is also defined functionally based on the speed of light in a vacuum [51] .

3. Materials and Methods

3.1. Quantum and Thermal Entropy:

Consider the following four particle systems in two dimensions:

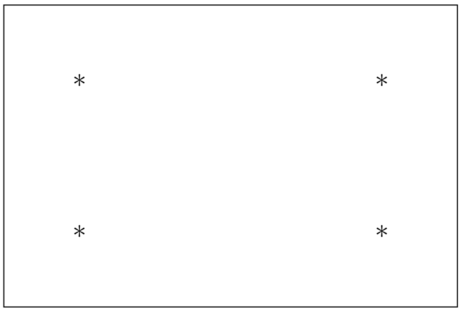

Figure 1. Classical thermal system showing four particles arranged in a rectangular configuration.

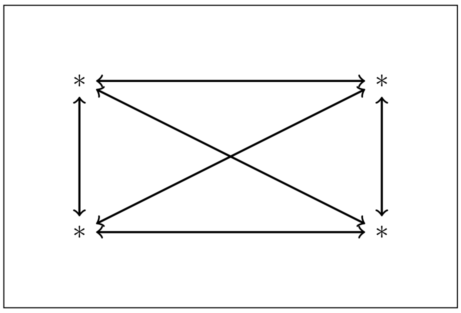

Figure 2. Quantum system showing four particles with all-to-all interactions represented by double arrows.

Quantum mechanics is a description of all potential allowed possible relationships, each with an associated probability, which also applies to statistical thermodynamics. In quantum and thermodynamic systems, the distribution of distinguishable and indistinguishable states tend toward a maximum, the largest multiplicity and, per this theory, generates time in the system as configurations changes. Each configuration is a unique set of relationships. The accumulation of each set of relationships in a system at each present is a configuration that is theorized to generate space. Classical thermodynamics is based on the distribution of independent particles that interact through contact whereas in quantum mechanics particles, in addition to having an independent relationship with the local environment, are capable of having superposition (entangled) non-contact relationships with each other.

Each configuration has a probability of being observed. The set of configurations at each time instant is associated with entropy through $S = \frac{\Delta E}{T} = k_B \ln W$ where S is entropy, ΔE is the change in energy, T is temperature in degrees Kelvin, k_B is Boltzmann's constant and W is the multiplicity, a measure of the number of possible system configurations. This is frequently expressed as the sum of finite probabilities: $S = -k_B \sum_i p_i \log p_i$ where p_i is probability that the system is in state i.

Currently, in quantum mechanics, the total number of distinguishable and indistinguishable relationships are all possible relationships in a system at each present. The number of quantum distinguishable states is limited by the number of possible environmental interactions. Distinguishable states also limit the number of possible indistinguishable states since indistinguishable states are non-commuting, unobservable, binary reciprocal relationships between two distinguishable states. Indistinguishable states, although not independently observable, have an effect such as in double slits without a path information observer resulting in the observed interference pattern [52,53]. That is, indistinguishable states contribute positively to entropy which has an observable effect that can be experimentally determined. See "Verification of Theory." This is in contrast to the current classical thermal determination of entropy where indistinguishability is defined as non-observable differences in a state's relationship with its local environment so entropy decreases (fewer possible configurations) as the number of indistinguishable states increases [1]. Unlike quantum entropy considered here, where indistinguishable states are between distinguishable states, determination of thermal entropy does not require distinguishable states for indistinguishable states to exist.

For closed thermal classical systems with a large number of possible configurations, entropy is determined from the internal number of possible configurations which depend on the number and ratio between the distinguishable and indistinguishable states (not dependent on distinguishable states existing) that can exist at different "present" times. Since thermal entropy is based on the observable effect of individual independent particle interactions, only classical influences of one particle on any other particle is considered. Quantum distinguishable systems also have observable classical relationships (distinguishable slit/environmental interactions) and, in addition, can have unobservable superposition binary relationships between those distinguishable states (binary slit-slit interactions) when information in the system is missing (indistinguishable case). This is the basis of the difference between classical (no superposition/entangled interactions) and quantum (with superposition) entropy.

In thermal systems, for N distinguishable particles, different environmental interfaces result in the number of configurations, $W_{Thermal\ Distinguishable}$ as:

$$W_{\text{Thermal Distinguishable}} = N! \tag{2}$$

In quantum systems such as multi-equal-sized slit systems, each slit is interfaced to the same external environment but each slit has an "assigned" location which establishes distinguishability, i.e., one interaction per source. The number of distinguishable configurations in quantum systems is equal to the number of slits where each state (possible interactions with environment) is one bit of information (two alternatives – interaction (1) no interaction (0)) so the number of configurations is:

$$W_{\text{Quantum Distinguishable}} = 2^{\frac{N!}{(N-1)!1!}} = 2^{N} \tag{3}$$

In the quantum case, additional superposition states can exist between binary combinations of distinguishable states when the number of states is greater than the number of observers. For N distinguishable states, each capable of being in two states and no additional (path) information observer in the system, indistinguishable case, the additional number of superposition configurations is:

$$W_{\text{Quantum Indistinguishable}} = 2^{\frac{N!}{(N-2)!1!1!}} = 2^{N(N-1)} \tag{4}$$

The total number of configurations in the quantum system is:

$$W_{\text{Quantum Total}} = 2^{N+N(N-1)} = 2^{N^2} \tag{5}$$

and entropy, S, is:

$$S = k_B \log 2^{N^2} = N^2 k_B \tag{6}$$

3.2. Mathematical Representation of Space and Time:

The derivation of the theoretical framework for relationships generating space, quantified by entropy, and relationship changes generating time, quantified by entropy changes, for a physical system with a finite possible number of states is addressed here. These mathematical formulations have testable effects. See "Verification of Theory."

3.2.1. Von Neumann Entropy:

The quantum system model is described by a diagonalized density matrix, ρ. so it can be expressed as a linear summation of the projectors onto the relative eigenvector.

$$\rho = \sum_i p_i |\psi_i\rangle\langle\psi_i| \tag{7}$$

p_i - eigenvalues of probabilities

ψ_i - corresponding eigenvectors

Therefore, the entropy relationships generating space is:

$$S = -k_B Tr(\rho \ln \rho) \tag{8}$$

For a change due to an operator $\hat{M}$ in a free evolution, the state transforms so:

$$\rho = \frac{\hat{M}\rho\hat{M}^\dagger}{Tr(\hat{M}\rho\hat{M}^\dagger)} \tag{9}$$

For pure states, the projective measurement $\hat{M} = \langle m|m\rangle$:

$$\rho' = \frac{|m\rangle\langle m|\rho|m\rangle\langle m|}{\langle m|\rho|m\rangle} = \langle m|m\rangle \tag{10}$$

Entropy is zero for these pure states. States that are generated only locally are separable. The number of states change for mixed systems resulting in observable changes, i.e., multiplicity is changed. Entropy becomes:

$$S' = -k_B Tr(\rho' \ln \rho') \tag{11}$$

This change in entropy is a result of relationship changes in the system which, per this theory, relates the absolute value of the change to time as:

$$Time = |\Delta Space| = k_B |Tr(\rho \ln \rho - \rho' \ln \rho') \tag{12}$$

3.2.2. Statistical Mechanics Entropy:

An alternative analyses incorporating previously determined quantum distinguishable and indistinguishable states will now be considered. Each set of relationships in a system is a configuration and, per this theory, the number of possible local relationships in the system, W, at a given temperature, T, quantified by entropy, generates local system space at each present ($t = 0$). Hence, space is relationships in its own present. Each system consists of local distinguishable and indistinguishable states. Each state is one bit in Boltzmann state increments (as defined earlier) where distinguishable states are a result of available information (observers previously reset) and indistinguishable states are a result of missing information (missing observers). For N possible states for a given energy and uniform temperature where each state is represented once with equal probability to all other states $p_i = \frac{1}{N}$, the Gibbs entropy, S_G, is:

$$S_G = k_B \sum_i p_i \ln p_i \tag{13}$$

The equivalent entropy determination under the same conditions for N states (such as slits in multi-slit systems) is:

$$S = k_B log_2 W \tag{14}$$

Multiple changes in an external environment, such as changing the number of observers, results in changes to the number of possible configurations in a system, changing ρ and W. Thus, for the same entropy under the above conditions:

$$S = -k_B Tr(\rho \ln \rho) = k_B lnW \tag{15}$$

From equation 3, the number of distinguishable configurations is $W = 2^N$. For no observers of distinguishable states (maximum number of indistinguishable states), equation 4 results in $W = 2^{N(N-1)}$ configurations. Per Eq. 5, the total number of configurations is $W = 2^{N^2}$. For R observers of distinguishable states, the number of configurations for indistinguishable states is:

$$W = 2^{(N-R)(N-R-1)} \tag{16}$$

Each relationship changes in bit increments and space in a system is theorized to be due to the local number of relationships. Therefore, it is not length measured by external observers determining the number of preset length increments between states.

Time is generated by a change in the number or distribution of states within the system (change in number and/or ratio between distinguishable and indistinguishable states) which results in a change in entropy. It there is no entropic change in a system, the system is only in the present, not related to the duration external observes measure. The absolute value of the change in the number of distinguishable states from an initial N_i to a final N_f and the number of observers from an initial R_i to final R_f generates time as:

$$Time = |\Delta Space| = |(N_i + (N_i - R_i)(N_i - R_i - 1)) - (N_r + (N_f - R_f)(N_f - R_f - 1))| \tag{17}$$

Time is generated as the absolute value of the number of distinguishable state changes (removed or added) from an initial N_i, to a final N_f ($N_i \neq N_f$) even if $R_i = R_f$ (with the same number of observers) or, for the same initial and final number of distinguishable states ($N_i = N_f$), if $R_i = R_f$, or if both change.

To demonstrate this, consider space between two entangled and two not entangled spin properties of particles. There are two distinguishable relationships ($N = 2$) between each property (Spin+ and Spin-) and its local environment generating local space. Each is one space increment. For entangled states there are opposite unobserved relationships between the properties so the interactions are Spin+ $\rightarrow$ Spin- and Spin-$\rightarrow$Spin+. There are two indistinguishable states since there are no observers ($R = 0$) generating an additional two space increments. Determination of one local relationship by observing one property ($R = 1$), referred to as "collapse of the wavefunction," results in transferring the entangled indistinguishable states from the system to the environment, generating time through changes in space. There is no change in the number of distinguishable states in this case.

In summary, any change in the number of information bits in a system changes the generated system space resulting in generated time. Furthermore, this formulation explains why both entanglement and double slit interference, seemingly distinct phenomena, are affected similarly by measurement. In both cases, measurement reduces the number of indistinguishable relationships in the system, transforming the system from quantum to classical behavior.

3.3. Boltzmann Time – Approximate Instantaneous Time Change:

The number of Planck states (defined as microstates) in one stationary Boltzmann state (defined as ministates) bit energy change, $\Delta E = k_B T$, for a given temperature, T, is determined from:

$$\Delta E = hv = k_B T \ln W \tag{18}$$

So:

$$W = e^{\frac{\Delta E}{k_B T}} = e^{\frac{hv}{k_B T}} \tag{19}$$

Even conventionally, in this representation, the multiplicity is expressed as a relationship to frequency relating entropy to time as the number of bits change. Each change of one bit generates time at a frequency based on the number of Planck states in one Boltzmann state.

Frequency:

$$v = \frac{E}{h} = \frac{k_B T \ln 2}{h} \approx 2.08 \times 10^{10} \text{ T cycles/sec} \tag{20}$$

Time generation for one bit change in one wave period:

$$\Delta t = \frac{1}{v} = \frac{0.48 \times 10^{-10}}{T}\, sec \tag{21}$$

Length change for an EM wave is:

$$\lambda = 1.44 \times 10^{-2} \left(\frac{1}{T}\right) meters \tag{22}$$

($\lambda = c\Delta t$; for one bit energy change)

This is within the bound defined as the speed of entanglement. (Approximate 30 meter distance change at 10^5 speed of light, $3 \times 10^8 \frac{m}{sec}$, so the time change is $\frac{3X10}{(3\times10^8)(10^5)} = 10^{-12}$ *sec* and for $T = 3 \times 10^{2o} K$, $\Delta t = \frac{.48\times10^{-10}}{T} = 1.6 \times 10^{-13}$) [54]. Time is a function of temperature in this case which can be determined experimentally.

If a Boltzmann state change is required to make an observation, the minimum time for this change needs to be included in the observed time for state changes between entangled particles at observation of one particle. This can also be determined experimentally. Reference to approximately instantaneous in this document is a change in one Boltzmann time increment.

3.4. Duration and Length:

The measurement of duration (interval) involves an external observer counting events (change in local space) of a predefined time interval (physically limited by Planck's time), a "Descriptive Number," between external start/stop triggers.

Descriptive Number (predefined intervals) → Observed Duration ← Observed Triggers.

Wavelength, as the predefined length interval, is used to determine length and wave period (frequency) is used to determine duration. Duration is required to communicate, transfer information, "value" ("meaningful") information from one space to another. Time, as defined in this theory, does not communicate "value" information since it is local, that is, time is a component for generating "value" information (an event) that can then be transferred (communicated). For example, time is generated by the observation of one of the entangled states determining its "value" such as the value of a spin state which can then be transferred (communicated in duration) to other space locations at or up to the speed of light so observers at two space locations would have the same "value" information.

For conventional time observations (duration), there is a very high probability that each "comparable" measuring system, based on using the same energy (frequency) for the predetermined time interval (not considering the uncertainty limitation), has approximately the same number of changes (wave periods) as the previous and next measurement between the same trigger events. Thus, the measured duration is approximately the same.

System local time and space are inversely related to external measurements of duration and conventional spatial dimensions. The difference between time and space and duration and spatial dimensions, respectively, is most evident at the extremes of space and time generation. Ideal considerations are used in the following models. One extreme occurs at black hole densities where the maximum number of "comparable" (distinguishable) relationships is thought to exist (maximum density space generation of minimal cell-size relationships) with no change in relationships, so time is always in the present (no time generation) but is observed as infinite time duration for external observers. The other extreme is EM waves characterized by the maximum time generation, maximum number of changes between increments within a wave for the least space generation (minimum number of Planck states for a given energy) but observed externally as the maximum length change for the least duration change between emission and absorption of the EM wave, $\Delta x/\Delta t$ maximized. See "Speed of Light.

3.5. Background Spacetime:

As the system becomes large, many relationships and multiple simultaneous relationship changes can occur where the net change between the number and changes in the number of indistinguishable and distinguishable states is approximately constant between identical classical trigger events, that is, generates the same magnitude of space and time. The distribution of relationships and changes in relationships in a large system is approximately uniform (randomized) and, therefore, has characteristics of background time (duration) and space (length). That is, the bigger the system (more relationships and changes in relationships), the less variation in observed duration even though the local changes are still generating local spacetime. Time, as proposed here, would increase asynchronously at different locations, unlike background duration which is modeled as changing synchronously. For example, increased EM wave frequency generates increased spacetime. However, to an external observer, a higher frequency is more periods with smaller wavelength in a constant duration and a constant length between the same start/stop triggers (emission and absorption).

The universe will appear to have background space and time unless the system is specifically designed to observe one change in relationships such as in entanglement or for each source in double slit systems. The difference between space and time and length and duration can be demonstrated for multi-slit systems. For double slit systems with no change in the system (constant slit size, distance between slits, distance between slits and final detector screen, frequency of emission), the observation on a final detector screen for multiple single source emissions is observed as an interference pattern (wave characteristics) or no interference pattern (particle characteristics). That is, each spacetime change at the final detector screen are observed as individual time generating events, one relationship change between source particle and final detector screen (for each source emission). For a very large number of simultaneous source emissions of different frequencies and a very large number of slits where slits are added/removed, slit width changes and distance between slits are all randomly changed at a high rate, the pattern would not be observable on a final detector screen. To an external observer, the pattern would appear to increase uniformly on a final detector screen, appearing as background space and time even though each source absorption generates local time.

3.6. Property Spacetime:

Per this theory, local spacetime is generated differently for each property, i.e., a "property spacetime" given existence of the property relationship (present exists), which itself is information, although not always recognized as such. See "Creation Dimension" in "Verification of Theory." Time is local in space and property specific, that is, there is different time generation for different properties, even within the same system space (even within one atom), i.e., property spacetime specific. The configuration for each property tends toward a maximum distribution of states in a given system. This tendency results in property spacetime relationship changes which generates property specific time. Even at the maximum distribution (highest probability configuration), random local fluctuations in the system generates time but, typically, changes around an equilibrium generates less time per observed duration. In summary, multiple properties can exist in a system simultaneously (each present), and each property tends toward the maximum distribution (maximum entropy), generating a "property spacetime." For an atom, internal atomic relationships generate different spacetime for different properties so, for example, electron relationship changes relative to the nucleus generate charge local spacetime (EM) or subnuclear quark/gluons color relationships generate color spacetime (strong force) or quark/flavor relationships generate flavor spacetime (weak force). See "Four Forces. "

Space is specific to the type and magnitude of the relationships between "comparable" states, which vary with cell size. A local space for finite crystals is generated by the difference at the interface (boundary) between the crystal's "comparable" states and the "incomparable" states of the external environment of the crystal. There are many relationships internal to the crystal generating space although they are not changing. Since entropy depends on the unit of measure, then for crystals, composed of thermally indistinguishable atoms, using an atomic unit of measurement, there are no changes in the configuration. If the boundary relationships do not change, then, per this theory, the relationships are local space that is always in the "present" time which is observed as infinite duration by external observers. A model for this is a chamber with equal-sized sub-chambers where the sum of all sub-chambers equals the size of the chamber. Each of these chambers is an external environment to identical particles internal to each chamber. No external observations will be able to elucidate changes in the configuration since the atoms in the subsystems are indistinguishable so thermal energy change is zero and entropy change is zero. The crystal will not age for a macroscopic external observer of the whole crystal in atomic cell size "comparable" increments, no time generation. However, internal atomic "incomparable" relationship changes will generate local internal atomic time. That is, the space and time for the crystal system is different than the space and time for each of the components (atomic sub-systems) within the system. These internal atomic relationships may be changing rapidly, generating local interior atomic spacetime per this theory. Thus, the components within the crystal may be "aging" whereas the crystal which is in atomic increments does not change. Internal atomic aging is observed in radiation decay. See "Particle Decay." If radioactive atoms in the lattice of the crystal decay, time generation exists internal to the crystal system and crystal aging is proportional to the number of decayed atoms. See "Verification of Theory."

3.7. *Space and Time:*

"Time is ignorance: a reflex of our incomplete knowledge of the state of the world [55] ."

3.7.1. Time and Information/Entropy:

Five possible time-information/entropy change relationships will be discussed here:

1. Observational time (duration): This is the determination of the number of artificially predefined time intervals the measuring observer counts in an independent measuring system between observed start/stop trigger events.
2. Inherent relationship: This is an event in a system, independent of external events such as external resets/observations (not influenced or observed by external observers) and is a result of inherent relationship changes in a system. These changes can be a result of internal decoherence which is equivalent to internal resets/observations, changing space relationships and generating time. This theory hypothesizes that inherent relationships are based on the number and discrete ratio between distinguishable and indistinguishable states in a closed system that occurs in nature and time is generated as a change in this number or ratio. For example, radioactive particle decay (with a certain probability), independent of external events (no external reset/observation), is hypothesized to be due to changes in the ratio between the number of indistinguishable and distinguishable states in the internal atomic components. Although the effect of internal changes that result in decay is observable, the internal changes resulting in the decay effect are not observable. However, internal interactions can be affected by external interactions (such as Zeno or Anti-Zeno effect) which can be quantified and related to time generation. See "Verification of Theory."

3. Present relationships: Relationships are changed between the past and present and between present and future but there is no change in relationships in the present although the present is a result of change. Without a change to a different quantum configuration, a different set of relationships, the present is all there is. The present exists for each relationship (property) in space. There is no change in the number of distinguishable and indistinguishable relationships or the ratio between them so no time is generated. Each possible relationship in the present is certain within the uncertainty constraint. That is, perfect information exists in the present (no missing information) where a property state is certain (realized possible relationships in a system) with probability 1, $S = k_B \ln\frac{x!}{x!} = k\ln 1 = 0$. For the not realized relationship, the state is no longer possible, probability 0. That is, potential realizable possible states exist before the present that, with certainty, do not exist in the present; entropy becomes $S = k_B \ln\frac{0!}{0!} = k\ln 1 = 0$. Zero entropy is a reference point. See "Momentum." For the present, the arrow of time is zero, that is, there is no direction in time corresponding to zero quantum entropy change. The number of possible states equals the number of existing states so space is completely determined as well. In the multi-slit system example, the information at each slit is available and complete at the slits and the entropy at each slit is zero even if an external observer determines a positive entropy because the external observer is missing information. The present cannot be measured since there is always a delay (duration) in a measurement of "value" information.
4. Future – relationship changes (time): Positive entropy exists when there are multiple alternatives for changes in relationships that exist in the present so probability for change (future event, not what exists in the present) does not equal 0: $\Delta S = k_B \left(\ln W_f - \ln W_i\right)$ where $\left(\ln W_f - \ln W_i\right) \neq 0$. The future potential in a system includes all possible changes in relationships in space based on the relationship in the present, that is, the trajectory for each field generating local time and a new present. If there is no probability of change, relationships exist (space) but will always be in the present. Each possible change has a probability and time is generated when there is a change from the present to one of these other possible relationships. As information changes, time increases. The number of changes can never decrease so time is unidirectional and is based on the absolute value of the number of changes. Every change results in spacetime (energy) change so configurations that revert to previous configurations is a change in the space configuration, bidirectional, but each change is still an increase in time.
5. Past relationships: Observation of a previous relationship, "value" determination, remains constant for the observer until the observer is reset [56]. "Value" information is a transfer of information between an emitter (source) and observer. Each observation is a change, generating local time but then remains its own present in the observer (local), so the probability remains one until the observer is reset. The past is not reversible because undoing an event, going from the present relationships (zero entropy) to the previous relationships would require negative probability which does not exist.[1] Not having negative probabilities is the basis of the absolute value of changes generating time. Likewise, negative net space (less than zero relationships) cannot exist in the physical universe.

   Unobserved relationships prior to the present observation have no record of existing in the observer's new present. For example, there is no information that another slit exists from observations of the source-slit interaction that register an output from one slit on a final detector screen (transducer) in double slit distinguishable systems. Each observation is independent and only probabilities exist of past states based on

[1] In the example of particle decay, discussed later as an example of time generation, negative probability would be due to the number of not decayed particles being greater than the total number of particles.

multiple observed information of the system in the present as is the case in double slit systems where multiple observations reveal a pattern.

3.7.2. Space and Information/Entropy:

Five space-information/entropy relationships that correspond to the time-information/entropy relationships will be discussed here:

1. Observational space (spatial dimensions: length, width, height): This is the determination of the number of artificially predefined space intervals the measuring observer counts in an independent measuring system between observed start/stop relationships.
2. Inherent relationships: These are existing relationships in a system generating space in every present, independent of external events such as resets/observations (not influenced or observed by external observers). They are inherent to the system as a result of the distinguishable and indistinguishable states that occur in any system in nature and, like the time-entropy relationship, can be affected by internal decoherence. For example, a radioactive particle is theorized to have internal distinguishable and indistinguishable states that exist at each present time generating space and when the ratio changes (time) to a certain configuration, a decay particle is emitted, changing space internal to the particle and environment. See "Particle Decay."
3. No change in relationships (present): The relationships in a system (distinguishable and indistinguishable states generating space) in the present is a limit on future space relationships. The minimum space relationship is a difference that either exists (1) or does not exist (0), which is a function of the cell size and type (property), either inherent internal to the system or relationships between the system and environment (boundary of generated space). Information is defined as the existence of a difference. A field can be used as a model for space. Conventionally, a field is considered values in space. In this formulation, space exists because there is a field (value of local relationship), that is, the field generates space since relationships exist (and is not in space) and is quantified by the number and type of relationships, a magnitude for each type of relationship (different field) in the present. Interactions between different fields generate bound space. A fundamental particle, then, is a set of specific field interactions. The higher the probability of the specific set of field interactions, the more particles of the same type are generated.
4. Gradient (Direction) in space relationships: The number of relationships is a scalar, proportional to the generated local space. Direction in space is due to a gradient in the number or a difference in type of relationships, a difference in density for "comparable" relationships or between "incomparable" relationships at a generated boundary. That is, there is no spatial direction unless there is a different density or change in type of relationships between generated space locations, the space equivalent of time being in the present without a change in relationships, no direction in time. Space of a bounded system increases or decreases, becomes denser or rarified, with an increase or decrease in the number of relationships even as length, width and height of the bounded system do not change. Unlike time, where the number of changes can only increase, changes of space can change bidirectionally for any non-zero probability of a configuration change to return to a previous configuration. This leads to consideration of two irreversible process that generate time:
    (a) Irreversible irreversible: Probability of a system returning to the initial state after a change is zero such as occurs after radiation decay; a radioactive atom cannot return to the pre-decayed state. No amount of energy will return the system to the initial state.
    (b) Reversible irreversible: Positive probability for spacetime of a system to return to the previous state with the addition of energy such as in irreversible thermodynamic systems.

The latter is reversible in space but not time, that is, the reversible change in the system can revert to the previous configuration in space (with the addition of spacetime) but not previous time (time increases with each change).

5. Past space: Addition of an observer (reset) and observation (registering "value" information) changes space in the observed and observer. There is a theorized change in space relationships at the observed in quantum systems, generating time when the observer is reset. Reset enables the observer to change state if value information is observed. That is, the relationships of the past space of the observed ("value" information) remains as the present space of the observer at observer observation until the observer is reset. Observer observation is also theorized to change space relationships at the observed [56]. The "value" information ("meaning") generated by the change remains in its present and can be transferred over any distance.

Relationships generate space and more relationships generate more space implying space is a storage medium of states [57]. There are more bits within a boundary, i.e., more space generation, as information in the system increases. As previously theorized, mass exists in Boltzmann state increments ($M = N\frac{k_B T}{c^2}$ where N is the number of Boltzmann states). Since Shannon's information theory is also based on the magnitude of Boltzmann's constant the number of bits generating mass is storage of bit information (a storage medium) [58]. That is, space is endowed by a bookkeeping device that keeps track of the amount of information (number of relationships of given properties) for a given mass distribution (the number and type of relationships that exist) generating local space quantified by entropy at each instant. Since the energy distribution is related to the probability distribution provided by Newton's potential where Newton's constant is a measure of the number of microscopic degrees of freedom, it can be used to determine entropy. It allows direct "contact" interactions between degrees of freedom associated with one material body and another [59]. Since General Relativity has been derived from entropy and, per this theory, entropy models quantum relationships, entropy can be used to relate General Relativity to quantum mechanics.

Space is where relationships exist in three dimensions independent of an observer. There are three different relationships in physical material space dimensions: x, y, z. There is potentially a different number of relationships between each bounded $2-D$ surface interface with its environment for each of the binary dimensional combinations (xy, xz, yz), generating different space for different surfaces and possible different changes at the surfaces in each direction generating different times: t_x, t_y, t_z. Time is generated independently for "comparable" states in each of the three space dimensions for a "bounded" object in spatial transition proportional to the number of state changes in that direction, that is, magnitude of different space relationship changes in each dimension can be different which would result in asymmetric changes. For a noncompressible physical object moving at a constant speed, the changes are simultaneous but the number of changes in different dimensions can vary. See "Verification of Theory." The changes that generate time in each dimension is also a function of the shape of the object that is moving. Movement of $3-D$ symmetrical objects such as a non-compressible sphere generates symmetrical spacetime in these physical dimensions. A sphere with a given non-relativistic velocity in the x direction will generate the same magnitude of time in each space dimension. The changes in the projection of movement in the x direction (yz plane) will equal the change in the projection in the y direction (xz plane, sides of sphere generating equal time changes) and projection in the z direction (xy plane, top and bottom of sphere generating equal time changes). Asymmetrical objects in at least one dimension, such as a cylinder, generates asymmetrical spacetime in the physical dimensions of the moving object (x dimension spacetime generation in contrast to y and z dimension for a cylinder with velocity in the x direction). A cylinder with radius r and lateral dimension L will have face area $Area_{\text{Face}} = \pi r^2$ and the surface area of the lateral dimension is $Area_{Length} = 2\pi rL$. For $r > 2L$, there is more time and aging on the face than in the lateral dimension with the reverse for $r < 2L$. The larger face dimensional surface area exposed to a corrosive environment would degenerate, more time is generated, i.e., age, faster than the sides. For the narrow cylinder, the net number of changes in the 2-D face area is less than changes in the surface, Area $= 2\pi rL$, so there would be greater time generation in the lateral dimensions than the face dimensions.

A symmetric electromagnetic wave generates the same time in each space dimension, three orthogonal dimensions exist that change simultaneously; electrical (E) wave, orthogonal magnetic (B) wave and orthogonal spacetime generation as the wave propagates. Each increment internal to the wave are relationships and these relationships necessarily change simultaneously within the wave generating internal spacetime. Local space is generated and eliminated for each half wave period serially but no net space is generated between wave periods from wave emission to wave absorption when there is no external force acting on the wave so propagation does not change the energy of the wave [11]. There is no net energy change in a whole period during propagation, theorized to be the basis of observed massless photons and since EM wave propagation generates its own environmental space with no net spacetime change, no background external environment is necessary for EM propagation. Therefore, for EM waves, since the same number of relationships change synchronously in each dimension, time generation would be the same for each dimension.

3.8. Speed of Light:

The speed of light is theorized to be the maximum limit on local spacetime generation emitted from a source. Maximum emission is a function of the density of the external environment, number of relationships at the border of emission. Per this theory, this is the maximum rate of transition between distinguishable wave increments internal to the wave. That is, the number of Planck state changes between internal wave increments generate the maximum spacetime (energy) for a given EM emission (constant number of Planck states in a wave of energy E) [11]. Energy (spacetime) is decreased in the emitting system generating the maximum environmental spacetime and vice versa at absorption.

Planck states and the speed of light are related. A decrease in Planck's constant would result in an increased frequency (decreased wave period with no change in ΔE increment) for the same energy (same spacetime). For:

$$c_{\text{Current } h} = \frac{\Delta x_{\text{Current } h}}{\Delta t_{\text{Current } h}} \tag{23}$$

and for example with:

$$h_{\text{Decreased}} = \frac{1}{2}h \tag{24}$$

the increased frequency:

$$v_{\text{Decreased } h} = \frac{2E}{h} \tag{25}$$

so the period is decreased T:

$$T_{\text{Decreased } h} = \frac{h}{2E} \tag{26}$$

Therefore, for the same generated space as the original wave, propagating at the current speed of light, c, there would be more waves (increased maximum changes in relationships) resulting in an observed higher speed of light for the same generated space. A system where the Planck constant is decreased results in supraluminal changes which have similar physical characteristics to the effect of higher dimensions for observations in the lower dimensions [60,61].

The effect of variations in Planck's constant on the speed of light [11] can be applied to Varying Speed of Light (VSL) theories which have been proposed to explain certain phenomena such as cosmologic expansion and dark matter/energy. The variations in the speed of light could be a consequence of variations in generated local spacetime [62]. It will be shown to be a possible origin for the inflationary phase of the initial universe expansion immediately after the big bang. See "Expansion of the Universe; Inflationary Phase."

3.9. Property Changes with Speed (Special Relativity), Observations of Time for Observers at Different Velocities

3.9.1. Time Dilation at Relative Speeds:

Per this theory, time dilation [1,63] for relativistic particle motion relative to stationary particles is due to different number of changes in relationships for the two cases between two same external events. The twin paradox [1] is an example of the effect of local time for each twin. The time difference due to the relative velocity of the twins results in observable different aging. The increment between internal events for the moving twin is greater than for the stationary twin so the number of changes for the moving twin is less than the number of changes for the stationary twin between the same start/stop locations. Time generation decreases as velocity increases; there will be fewer changes for the moving twin. At a speed of 80% of the speed of light, $v = .8c$, the stationary twin would have experienced 10 internal relationships changes for every 6 internal relationship changes in the moving twin when the twins reunite (external event) so the stationary twin would have aged more.

3.9.2. Mass Change with Speed:

Multiple mechanisms for the observed change in mass with speed (Lorentz transformation) [64] have been proposed [65]. Per this theory, the effect of speed on mass is interpreted as a result of the mass interaction with the external environment [1,66]. To demonstrate this, assume:

1. Rest mass is invariant [67].
2. Mass is a measure of resistance to acceleration [1,66].

Two observers moving at different velocities will measure two different magnitudes for the same mass so these observations do not represent an intrinsic property of the mass. As the particle's velocity increases in the observer's frame, external changes (changed spacetime) will be observed as increased mass since the resistance to acceleration is observed as continuously increasing even though there is no change in the mass' inertial frame (no change in mass). An external observer only observing this mass will not be able to differentiate the change in mass due to the mass acceleration from change in the relationship between mass and the external environment.

An analysis follows to determine the observed number of relationship changes (number of Boltzmann state changes) for relativistic particle velocity changes consistent with Special Relativity [68]:

M_o - intrinsic mass

M' - relativistic mass

v - velocity

T_{Particle} - Temperature of particle in Kelvin

N - intrinsic number of relationships in mass

ΔN - observed change in number of relationships in mass

Observed number of intrinsic relationships (mass), ΔN, continuously increases as velocity increases. Relativistic Mass:

$$M' = \frac{M_o}{\sqrt{1-(\frac{v}{c})^2}}$$

$$M' = M_o + \Delta M$$

$$M_o = \frac{N_{\text{Particle}} k_B T_{\text{Particle}}}{c^2}$$

$$\Delta M = \frac{\Delta N_{\text{Observed}} k_B T_{\text{Particle}}}{c^2}$$

Example, $\mathbf{v} = .5c$:

$$\sqrt{1-(\frac{v}{c})^2} = .86$$

$M' = 1.16M_o = M_o + \Delta M$

$\Delta M_o = 0.16M_o$ so

$\Delta N_{\text{Observed}} = 0.16N_{\text{Particle}}$

In this example, there would be additional Boltzmann state changes that external observers observe as increased resistance to acceleration without intrinsic change in the number of Boltzmann states.

3.10. Nuclear Temperature:

If the mass is one fundamental nucleus of an atom (no emission or absorption interactions with the environment), the temperature here is internal to the atom. Internal atomic temperature is unknown but a nuclear or subnuclear temperature due to mass and energy interactions such as between proton and neutron or between quark and gluon interactions is assumed to exist. There are multiple subatomic particles and a large number of interactions in a very confined generated space theorized to result in a temperature. Atoms, where electrons absorb or emit photons (or changes in spacetime in the vicinity of the electron) change ambient energy (external to the nucleus) but not the energy of the nucleus. That is, the nuclear temperature without radioactive decay would remain constant or change would be insignificant (below the current ability to measure) since rest energy does not appear to change (number of relationship interactions generating internal temperature are approximately constant) and the nucleus does not loose energy (does not radiate net energy). Since nuclear mass does not change, there is no change in internal atomic temperature during acceleration in cyclotrons, even where electrons do not surround the atomic nucleus. The added energy would increase its velocity.

Temperature is based on statistical observations and statistical mechanics which can be applied across different sizes. While statistical quantities like temperature are typically used for large ensembles, statistical methods remain valid for small systems. That is, statistical methods is not categorically precluded by system size. Rather, smaller systems exhibit larger fluctuations around mean values and require more careful considerations of statistical uncertainties. This principle is applied here. Despite the small number of particles (nine quarks) within a fermion, the high energy density and strong confinement create conditions where temperature conditions exist and are amenable to statistical analysis.

3.11. Particle Decay:

Among property probabilities for change in radioactive particles is the particle's probability to decay, a change in the mass property resulting in time generation in the particle and environment. It is modeled here as a result of constant atomic internal changes generating internal (inherent) time that occasionally results in generating external time (decay event). When the internal entropic state of the particle has a change of relationships resulting in a different configuration (a certain subset of relationships from the full set of possible relationships), a particle is emitted. There is a theorized change in the number and distribution of distinguishable and indistinguishable states (entropy change) within the atom that has a corresponding change in local energy within the atom. When this internal local energy change is greater than or equal to the energy of the emitted particles and has a certain set of properties such as charge associated with weak force carriers, particles can be emitted, that is, spacetime is transferred from the particle to the environment. For the same radioactive particles where one particle decays, the "internal mass property" for the decayed particle is different than for the not decayed particle.

For N_o total particles, the observed half-life, $t_{\frac{1}{2}}$ and τ, is the mean lifetime duration between a large number of decay events, $N(t_p)$ for exponential decay where $t_{\frac{1}{2}} = \tau ln2$, the number of observed particle decays in duration t_p is $N(t_p) = N_0 - N_0 e^{\frac{-t_p}{\tau}}$ for one decay per external observer reset/observation.

Probability of inherent particle decay is:

$$p(t_p) = \frac{N(t_p)}{N_o} = \frac{\text{\# decayed particles}}{\text{Total \# particles}} = 1 - e^{-t_p/\tau} \tag{27}$$

The conventional background duration, t_p, to determine mean lifetime duration, τ, for this case is:

$$t_p = -\tau \ln(1 - p(t_p)) \tag{28}$$

External observer probability equal to zero ($p(t_p) = 0,\ t_p \to 0$) means that there can be no observed decayed particles, interpreted as zero observer duration and no external time generation event (no probability of change in zero time generation). For probability equal to one ($p(t_p) = 1,\ t_p \to \inf$) means all particles are externally observed to have decayed. This is only certain in infinite external duration and for N_o particles the external time generated local events is maximized and equals the discrete changes of each decay event when all radioactive particle are decayed. Since a large number of internal changes are theorized to generate local internal subatomic time resulting in an observed small number of discrete changes generating time between the particles and environment, the external background duration (a change with each decay) is different than local internal (inherent) atomic time generation.

The theorized number and distribution of distinguishable and indistinguishable changes, resulting from changes in external observer resets/observations, affect the half-life as demonstrated by the Zeno and anti-Zeno effect. That is, external observer resets/observations at a given repetitive rate or addition of external energy affects internal system relationships, changing the probability of decay. If observer reset/observation is continuously occurring ($\Delta t_o \to 0$) where Δt_o is the duration between observer resets and observations, the decay events would be approximately zero (Zeno effect) [69]. The effect of externally induced internal changes (Zeno and anti-Zeno effect) on duration between radioactive decay is another indication that inherent mass property time is related to changes in internal relationships. See "Verification of Theory." Internal decoherence can have an analogous effect to an external Zeno effect affecting the internal (inherent) particle spacetime and the number and distribution of distinguishable and indistinguishable states that can result in radioactive decay.

Setting the number of internal changes in the radioactive particle to ΔN bit increments of discrete entropic cell size, $\Delta E = k_B T$, the energy change, ΔE_D, for the decay (D) in a radioactive particle is $\Delta E_D = \Delta N k_B T$. Let N_i, N_f be the number of states in the initial and final states of the radioactive particle before and after decay, respectively. The pre- and post- decay are two different entropic space conditions of the radioactive particle due to the different number of states at different instants of "present" time. The mass equivalent of the particle is a combination of all distinguishable and indistinguishable states (Boltzmann states) and energy transfer (Planck states) occurring between states. The energy change, for simplicity and as a representative approach to such problems, are modeled as the mass equivalent of a number of Boltzmann states. The internal state of the atomic nucleus is modeled as N distinguishable and $N(N-1)$ indistinguishable state equivalents of a multi-slit, indistinguishable system (N^2 total states). In this case where $E_i > E_f$ (mass energy of particle decreases after decay), the initial and final number of possible configurations, W_i, and W_f at temperature T_i, and T_f (temperature change is due to less internal interactions and fewer number of configurations after decay) respectively, can be determined:

$$\Delta E_D = E_i - E_f = k_B(T_i \log_2 W_i - T_f \log_2 W_f) = kT_B \log_2\left(\frac{W_i}{W_f}\right) \tag{29}$$

For insignificant internal nuclear temperature changes:

$$\Delta E_D = E_i - E_f = k_B(T_i \log_2 W_i - T_f \log_2 W_f) = k_B T \log_2\left(\frac{W_i}{W_f}\right) \tag{30}$$

$$W_i = \frac{{N_i}^2!}{({N_i}^2 - (N_i(N_i-1)))!(N_i(N_i-1))!} = \frac{{N_i}^2!}{(N_i)!(N_i(N_i-1))!} \tag{31}$$

$$W_f = \frac{{N_f}^2!}{({N_f}^2 - (N_f(N_f-1)))!(N_f(N_f-1))!} = \frac{{N_f}^2!}{(N_f)!(N_f(N_f-1))!} \tag{32}$$

3.12. Superposition/Entanglement Applied to Bell's Inequality and Double Slit Systems:

States, as defined here, cannot just disappear (energy is conserved) so any changes between states are due to states either being emitted or absorbed (open system) or internal distribution changes (closed system). The transfer of relationships between states across a boundary, such as transfer of indistinguishable states between the slits (system) and environment is a transfer of relationships, system space, to adjacent space, generating local time. This contrasts with determining value, "meaningful" information, observed externally as duration and length between the source and observer.

A decrease in the number of observers results in an increase in the number of indistinguishable states (increasing missing information) which changes the number of relationships and how they can interact. See Appendix for the relationship between imaginary numbers and missing information in multi-slit systems for wave/particle duality determination. Per this theory, the same quantum mechanical mechanism can be applied to entanglement of particles/properties and superposition in double slit system. Both are a function of relationships and relationship changes. A well-defined state cannot be assigned to each of the slit interactions in double slit systems without a path information observer or entangled photons (or spin states) without a polarization (spin) observer, respectively. The addition of observers increases information in the system so with an equal number of states and observers the inputs can be uniquely (within uncertainty constraint) determined from the outputs.

Superposition/entanglement is a reciprocal (interdependent) binary, non-observable, relationship between two distinguishable states. Each distinguishable state is one bit of information, that is, can be in one of two states as a function of interaction between the state and environment. In the double slit or entanglement (spin) distinguishable system (number of observers equals number of configurations) there are two possible states of environmental/slit (spin) configurations. If the number of states is greater than the number of observers, an indistinguishable system, there are additional slit-silt or spin-spin (superposition/entanglement) interactions increasing the number of configurations due to the inability to obtain information. The missing information results in all binary "allowed" phase differences so although not observable, the resulting superposition/entanglement interactions affect what is observed (interference). Reset, per this theory, or observation ("value" information transfer), per convention, provides additional information which completely establishes the state of the system and changes the superposition/entangled indistinguishable system (double slits or spin) to a distinguishable system; the inputs can be recreated from the output [56]. In superposition (double slit systems), but not entanglement, states are reversibly transferred from the environment to the system at observation if no additional observers are reset. Reset reverses the process. This is in contrast to entangled states where states are irreversibly transferred to the environment so post-observation there is only relationships between the states and environment with no additional entangled states (no spin-spin states).

Spin entangled states, double slit systems and EM phase interactions with polarizers will be shown to have related mechanisms. In entangled spin systems, the additional information provided by observer reset/observation is provided by one observer. If one spin is observed as +, the other will be observed – or in double slit systems with the addition of a path information observer that observes one source/slit interaction, the observation of interaction with the other source/slit is eliminated. There is complete information since the final detector screen is an additional observer. In entangled systems, information that system states are entangled is one bit of information. That information is not available for double slit systems, i.e., the information that there are two states with opposite environmental interactions is not available. The only way of "knowing' there are only two slits with opposite interactions at the observation of the outputs is through observation of both slits. This is unlike entangled systems, where the relationship between them is known, so only one observation is required. That is, if the final detector screen observer in double slit systems has information (one bit of information) that there are only two slits (second bit of information) and one source analogous to entanglement (relationships information is available), the information is complete, two inputs and two outputs, and no interference would be observe at the observation of the final detector screen, but the final detector screen does not have this information. It is only obtained when a path information observer is added.

The different system/environmental interactions between EM wave phases and polarizer angle for each binary entangled photon is comparable to the phase between the number of Planck states per increment interacting with positions within each slit for one source wave [56]. In both cases, particles/properties in transit are real. The observation in Bell's inequality experiment is analogous to the negative EM half period [56]. That is, an observation in Bell's inequality experiment, (+), (photon phase is parallel to the polarizers), is analogous to the observer's absorption of negative EM half period, the EM wave half period that is observable (+) as it decreases the number of Planck states in the environment. Not observing an output (-) after the polarizer is analogous to the positive EM half period which is emitted from the source but is not observable (-). The not transmitted wave is reflected at the polarizer so there is no change in the number of Planck states emitted from the source to the environment.

The analogy between Bell inequality type experiments and double slits can be summarized as:

Bell Inequality	**Double slit system**
Entanglement	Superposition
+: observation post-polarizer -: no observation post-polarizer	+: negative half EM wave observable -: positive half EM wave not observable
Angle difference between source phase and polarizer	Angle difference between source phase and position in slit (varies with intersection of source with internal slit location)
Phase difference between polarizers	Distance difference between source signal interaction at locations within each slit[2]
Detectors at output of polarizers	Virtual detectors (theoretical – cannot detect independent number of Planck states per increment within EM wave exiting each slit)
Number of outputs of one polarizer correlated with outputs at other polarizer	Number of observations from outputs of one slit correlated with outputs of other slit in the indistinguishable case (interference)
Post-observer reset, no information regarding previous entanglement	Post-observer reset, no information regarding previous superposition state
Post-observation, no entanglement	Post-observation, reestablished superposition

Table 1. Comparison between Bell Inequality and Double Slit System characteristics

Equivalence of entanglement and superposition: There are theorized four possible binary interactions in the entangled particle/property pre-reset/observation in analogy to double slit, indistinguishable systems. Entangled spin states will be used as a model. Two are distinguishable spin interactions with the environment ($spin+ \rightarrow spin+$, $spin- \rightarrow spin-$) and two are indistinguishable binary interactions between the spin states ($spin+ \rightarrow spin-$, $spin- \rightarrow spin+$). As previously stated, these are analogous to the two slit/environment interaction ($slit1 \rightarrow slit1$, $slit2 \rightarrow slit2$) and the binary indistinguishable interactions ($slit1 \rightarrow slit2$, $slit2 \rightarrow slit1$). At reset/observation of an observer of one entangled state, the indistinguishable (entangled) relationships are eliminated and theorized to be transferred to the environment. That is, there is a theorized change in the number of possible relationships (bits) between entangled particles/properties with an observer reset/observation of at least one spin state [56,70] decreasing the four (distinguishable plus indistinguishable) states to two distinguishable states in the system. The equivalent process in double slit systems is the addition of a path information observer reset/observation, a second observer which provides additional system information, eliminating interference by transferring indistinguishable (superposition) states to the environment [56]. A method has been presented to determine whether the change in the number of states occurs at reset or observation in multi-slit systems since the path information observer reset/observation can be physically separated from the slit being observed and occurs before the results of slit-environmental interactions are observed on a final detector screen [56] as in delayed choice experiments [71,72]. An energy difference in an enclosed system is predicted to increase with observer reset/observation in multi-slit systems or multiple entangled particles that would not occur for observations of distinguishable slits or non-entangled particles. See “Verification of Theory.”

Post-observer reset/observation of one of the states, the previously but no longer entangled particles have no information of past entanglement, that is, there is no relationship between the previously but not now (present) entangled spin states. However, each of the distinguishable spin state relationships with the local environment continues to exist in the present. That is, since entanglement is not re-established post-observation the two previously entangled states have relationships only with the environment. Post-spin observation, since there is no longer a relationship between the previously entangled states, there is no space generation between them. The only space generation for them is with the local environment so length between them is what an external observer would observe, not related to entanglement. In contrast to entangled states, in the double slit distinguishable case, with observation at the final detector screen, the system again returns to an indistinguishable system (superposition) since there are again more states than observers. Observation in double slit systems is theorized to result in the energy of indistinguishable states formerly transferred to the environment, transferred back from the environment to the double slit system changing distinguishability back to indistinguishability. This is in contrast to entangled systems where entanglement post-reset/observation does not exist and the entangled energy transferred to the environment is not transferred back to the system so there is no re-generated entangled state (no entanglement so no indistinguishable/superposition states). The difference in post-observation changes in double slit and entangled systems and the inability to independently observer the number of Planck states exiting each slit is the major reason they are considered as two different quantum mechanical mechanisms.

[2] Interaction of source wave increments with same relative position within each equal-sized double slit system results in observed peak at center position between slits. Source binary interactions with different locations in different slits results in non-zero phase difference as the signals propagate, that is, different length for each wave increment from each slit to reach the final detector screen.

The relationship between distinguishability and indistinguishability for entanglement and double slit systems can be summarized as:

Entanglement		**Double slit system**	
Two entangled states (source, polarizers, and detectors)		Two equal sized slits, source, final detector screen interaction	
4 states 2 distinguishable 2 indistinguishable		4 states 2 distinguishable 2 indistinguishable	
Observe one entangled state		Path information reset/observation of slit/environmental interaction	
Approximate instantaneous change in not observed state		Approximate instantaneous change in not observed slit/environmental interaction (no interference)	
Reset/Observation - eliminates entanglement		Reset/Observation – eliminates superposition	
Location1	Location 2	Slit 1	Slit 2
Spin+	Spin-	Interaction	No interaction
Spin-	Spin+	No interaction	Interaction
No entanglement post-observation		Re-established superposition between slits	
No generation of entangled states		Transfer of indistinguishable states to system	

Table 2. Comparison of Entanglement and Double Slit System States

Per this theory, non-entangled properties within entangled particles have no relationship with each other but still have a relationship with the environment. The approximately zero-time relationship for the change of state of the "other" not observed entangled particle with observation of one entangled state only applies to completely entangled particles. Observed duration between two locations for non-entangled, partially entangled and completely entangled property (state) relationship changes will be different with observer reset/observation of one state. The dependence of externally observed duration between changes of the two separated particles/properties for these different levels of entanglement is an indication that space and time are local. See "Verification of Theory." Observation of an entangled property would change the reciprocal entangled state approximately instantaneously even after the information of an observation of a non-entangled property "value" information is in transit.

The analysis for entangled particles/properties in Bell's inequality experiment can be applied to interactions in double slit systems, indistinguishable case. The state vector for a source emitting two photons with different frequencies, v_1 and v_2 is given by:

$$|\psi(v_1, v_2)\rangle = \frac{1}{\sqrt{2}}(|x, x\rangle + |y, y\rangle) \tag{33}$$

Per this theory, this can apply to double slit systems where v_1 and v_2 are outputs from each of the slits. In both cases $|x\rangle$ and $|y\rangle$ are linear states that interact binarily. The previously proposed model for internal characteristics of EM waves modeled as varying distinguishable increments, each composed of a different number of indistinguishable Planck states, results in the ability for different EM wave increments to interact with different slits until observed [56]. The final observed result on a detector screen is determined by the source momentum. That is, how the individual, discrete EM wave increments from each slit reach the final detector is a function of the distribution of internal EM wave increments emitted from the source in the same direction and consequently observed at the same location on a final detector screen [56]. Although discrete wave increments from different slits transfer momentum serially and are separated in space, the distance between increments and momentum transfer occurs in approximately one wave period. The distance between the two slits and, therefore, between wave increments is approximately one wavelength so is observed as one "whole" photon.

Coincident probability (correlation coefficient) of wave increment interactions in double slit systems or outputs of polarization requires multiple observations. The correlation coefficient changes sinusoidally. Without entanglement or superposition, the result of the correlation coefficient as a function of orientations is linearly related (classical) [73]. This is the basis of observations that violate Bell inequality experiments. That is, sinusoidal correlation coefficients as a function of orientation includes the additional effect of simultaneous binary bilateral relationships between states (entanglement or superposition) that results in the observed increase of the quantum mechanical limit over the classical limit.

Consider binary measurements in Bell's inequality: A_o and A_1 for location A and, similarly, B_o and B_1 for location B [73]. Locations within slits in double slit systems are also designated as A_o and A_1 for slit 1 and B_o and B_1 for slit 2. The measurements for A_o and A_1 can be either $+1$ or -1 and for B_o and B_1 can also be either $+1$ or -1. Conventionally, propagation and state changes occur in background time, so A_o measurement of 1 is of a "real" particle/property, a_o, that is, independently interacts with the environment and assumed to exist independent of being observed. In this case, neither of the entangled particles/properties influence the other particle or interactions at one slit influences the other slit (no entanglement or superposition). This is the distinguishable, classical case for both systems. Per this theory, a limit is determined for the case with "real" local particles/properties existing (distinguishable) in linear background spacetime. Values of a_o and a_1 are ± 1, and values for b_o and b_1 are ± 1 so $a_o = a_1$ or $a_o = -a_1$. For the case, $a_o = a_1$ the result is $(a_o - a_1)b_1 = 0$ and for the case, $a_o = -a_1$ the result is $(a_o + a_1)b_o = 0$. The limit is determined by considering the combination:

$$a_o b_o + a_o b_1 + a_1 b_o - a_1 b_1 = (a_o + a_1) b_o + (a_o - a_1) b_1 \tag{34}$$

Since only one of the two above cases can be realized, the classical value limit is ± 2. Only one of these four observations can be obtained per experiment so multiple experiments are necessary to determine this limit. Based on the assumption of "real" particles, the limit is ≤ 2.

This classical expectation value limit is violated with entanglement and superposition indicating the classical assumption is incorrect. That is, observations correlating outputs of coincidence polarizers at intermediate polarization angles or phase differences between unobserved slits is inconsistent with classical results. The assumption of "real" particles in the conventional interpretation of Bell's inequality formulation assumes this assumption is violated, i.e., properties are not "real" until observed [73]. An underrecognized assumption in these experiments is that the analysis of these experiments assume a continuously changing background spacetime. A modified mechanism is proposed here that describes Bell's inequality is due to the nonlinear and local nature of spacetime based on relationships defining "local." In such a case, particles and properties are "real," not dependent on observations.

To demonstrate this, consider single probabilities, where **a** is either orientation of interactions of an EM wave with polarizer **a** or relationships between source wave and slit **a** with a similar consideration for a second polarizer and slit **b** (path information observer observing each slit independently) resulting in probability $P_+(\mathbf{a})$, $P_-(\mathbf{a})$, $P_+(\mathbf{b})$, $P_-(\mathbf{b})$:

$$P_+(\mathbf{a}) = P_-(\mathbf{a}) = \frac{1}{2} \tag{35}$$

$$P_+(\mathbf{b}) = P_-(\mathbf{b}) = \frac{1}{2} \tag{36}$$

This is the case for each independent polarizer in Bell's inequality experiments and each independent equal-sized slit in double slit systems. Polarization or source/slit interactions cannot be assigned to each photon so each measurement post-polarizer or double slit systems results in random observations. Observing orientation **a** and **b** in $+$ or $-$ channels exiting the two polarizers or slits are equal.

Next, consideration is for the coincidence probability for observation from parallel ($++$,$--$) or perpendicular polarizers ($+-$,$-+$) or double slit distinguishable case for each slit ($++$,$--$) or correlated observations from both slits ($+-$,$-+$):

$$P_{++}(\mathbf{a},\mathbf{a}) = P_{--}(\mathbf{a},\mathbf{a}) = \frac{1}{2} \tag{37}$$

$$P_{+-}(\mathbf{a},\mathbf{a}) = P_{-+}(\mathbf{a},\mathbf{a}) = 0 \tag{38}$$

This is considered the distinguishable case, for parallel polarizers ($\mathbf{a} = \mathbf{b}$), 0^o phase, and for distinguishability in double slit systems, 0^o phase, the same number of Planck states per increment at each space and time (local) interacting simultaneously with only one slit resulting in observation from the output at one slit with no observation at the other slit.

Superposition requires consideration of joint probabilities. Application of Malus law [74] for Bell's inequality experiments and relationships between EM wave increments interacting with different locations from each slit results in joint detection probabilities:

$$P_{++}(\mathbf{a},\mathbf{b}) = P_{--}(\mathbf{a},\mathbf{b}) = \frac{1}{2}\cos^2(\mathbf{a},\mathbf{b}) \tag{39}$$

$$P_{+-}(\mathbf{a},\mathbf{b}) = P_{-+}(\mathbf{a},\mathbf{b}) = \frac{1}{2}\sin^2(\mathbf{a},\mathbf{b}) \tag{40}$$

This includes the entangled and superposition possible interactions in addition to the distinguishable interactions.

The following demonstrates the correlation coefficient for double slit systems is the same as that for entanglement in Bell's inequality experiments. Consider a double slit system where d is distance between slits, L is the minimum distance between slits and final detector screen (midline), y is the location of the observation on a final detector screen with origin at the projected midpoint between slits on the final detector screen, wavelength is λ, A is the amplitude, and $k = \frac{2\pi}{\lambda}$ based on the input signal wavelength. The outputs exiting the two slits are harmonic wave motion and the observation is the sum of the phasors exiting each slit. The distance from slit 1 to y, r_1, and slit 2 to y, r_2, respectively is:

$$r_1 = \sqrt{L^2 + \left(y - \left(\frac{d}{2}\right)\right)^2} \tag{41}$$

$$r_2 = \sqrt{L^2 + \left(y + \left(\frac{d}{2}\right)\right)^2} \tag{42}$$

For the wave leaving each slit with amplitude A and same phase (which can be and is assumed to be 0^o), the interference at the final detector screen is:

$$\frac{A}{\sqrt{r_1}}e^{ikr_1} + \frac{A}{\sqrt{r_2}}e^{ikr_2} \tag{43}$$

Intensity, the square of amplitude, is:

$$I \propto \left(\frac{A}{\sqrt{r_1}}\cos(kr_1) + \frac{A}{\sqrt{r_2}}\cos(kr_2)\right)^2 + \left(\frac{A}{\sqrt{r_1}}\sin(kr_1) + \frac{A}{\sqrt{r_2}}\sin(kr_2)\right)^2 \tag{44}$$

Assuming $y \ll L$, $\frac{A}{\sqrt{r_1}} \approx \frac{A}{\sqrt{r_2}} \approx \frac{A}{\sqrt{L}}$, probability is proportional to $\frac{I}{I_o}$ where $I_o = \frac{4A^2}{L}$, is the maximum observation limit for $\left(\frac{kr_1 - kr_2}{2}\right) = 0$. In this case, the probability for coincident observation is:

$$P_{++} \propto \cos^2 \frac{kr_1 - kr_2}{2} = \cos^2(\mathbf{a}, \mathbf{b}) \tag{45}$$

where $(\mathbf{a}, \mathbf{b})$ is the angle between $\left(\frac{kr_1}{2}\right)$ and $\left(\frac{kr_2}{2}\right)$ The correlation magnitude is given by the correlation coefficient determined from:

$$E(\mathbf{a}, \mathbf{b}) = P_{++}(\mathbf{a}, \mathbf{b}) + P_{--}(\mathbf{a}, \mathbf{b}) - P_{+-}(\mathbf{a}, \mathbf{b}) - P_{+-}(\mathbf{a}, \mathbf{b}) \tag{46}$$

which reduces to:

$$E(\mathbf{a}, \mathbf{b}) = \cos 2(\mathbf{a}, \mathbf{b}) \tag{47}$$

Clauser, Horne, Shimony, Holt inequality (BCHSH inequality) representation of Bell's inequality [75], defined a quantity:

$$S(\mathbf{a}, \mathbf{a}^{'}, \mathbf{b}, \mathbf{b}^{'}) = E(\mathbf{a}, \mathbf{b}) - E(\mathbf{a}, \mathbf{b}^{'}) + E(\mathbf{a}^{'}, \mathbf{b}) + E(\mathbf{a}^{'}, \mathbf{b}^{'}) \tag{48}$$

The maximum of $S(\mathbf{a}, \mathbf{a}^{'}, \mathbf{b}, \mathbf{b}^{'})$ occurs at the angle for the four polarizations and slit-environmental interactions at angles: $\mathbf{a} = 90^o$, $\mathbf{b} = 67.5^o$, $\mathbf{a}^{'} = 45^o$, $\mathbf{b}^{'} = 22.5^o$ so $S = 2\sqrt{2}$. At the difference between these angles, the hidden-variable assumption is violated per conventional interpretation of Bell's inequality experiments and double slit systems but does not violate the hidden variable assumption if spacetime is local and non-linear as theorized here. That is, per this theory, considering local space (relationships) and non-linear time (relationship changes), particles/properties are real and result in the same correlation coefficient as determined and observed in Bell's inequality experiments. Thus, the same quantum mechanical mechanism applies to entanglement in Bell's inequality experiment and equal-sized double sit systems.

The strong analogy between double slit systems and entangled particles/properties decreases as the number of slits and number of entangled particles/properties increase since superposition between all binary interactions between slits in multiple slits is possible whereas entanglement is between one binary entangled state. For a N multi-slit system there are a total of N^2 distinguishable plus indistinguishable states. However, for N entangled pairs ($2N$ particles) there are $4N$ distinguishable plus indistinguishable states ($2N$ independent, distinguishable, particles/properties plus $2N$ entangled, indistinguishable, states per entangled pair). These result in different energy changes in the systems as observer reset/observations are introduced into the system. See "Verification of Theory."

3.13. *Time and Temperature:*

Since space and time are functions of entropy per this theory, temperature is necessary for spacetime to exist. Time, based on changes in entropy, would be a function of the change in W and/or temperature for $S = \frac{\Delta E}{T} = k_B \ln W$. The temperature dependence that is expected with state changes is demonstrated by Planck's law; observed intensity as a function of frequency-temperature relationship which models observations of black body radiation [1]. Since frequency is related to spacetime generation per this theory, this time-temperature-probability relationship can be interpreted in terms of local temperature and related quantitatively to entropy of internal EM wave characteristics at the instant of observation [11].

Time at $0^o K$: As temperature decreases, energy, changing relationships between particles and between particles and environment, decreases. At zero absolute temperature, the changes in relationships of external particle interactions approach zero, that is, there is no change in information, so state changes and time approach zero and duration approaches infinity even as internal atomic or subatomic interactions have a finite probability of changing so inherent time is being generated.

4. Discussion

Consideration of the presented concepts to other physical theories and observations will be discussed here.

4.1. Black Hole Entropy:

Multiple possible different microstates have been proposed for black hole entropy [76]. An additional possibility is proposed here where each distinguishable state is a microstate, that is, mass is defined in Boltzmann increments (conventional microstates are equivalent to ministates as defined here). The density of the Boltzmann states is maximized in black holes. These are determined as the maximum number of minimal mass differences between "comparable" states for a spherical surface at Schwarzschild's radius. It is computed as the minimum two-dimensional surface for a number of existing states. The following is for idealized black holes, that is, for stationary, spherically symmetric black holes (Schwarzschild black holes) where angular momentum is zero, no electric charge and the cosmological constant is zero so only mass has a macroscopic observable effect. This model consists of a large number of two-dimensional distinguishable surfaces (generating 2-D spherical surface analogous to a linear 1-D multi-slit system). However, whereas the 1-D slits generate a 2-D pattern, the 2-D surface generates a 3-D pattern which has previously been related, in the literature, to a holographic model of the universe [77]. If angular momentum and charge are considered, there would be more states based on differences and changes in differences of these properties, changing spacetime of the black hole. In this ideal black hole case, the number of possible states is maximized so thermal (no indistinguishable states) and quantum entropy (number of distinguishable states with zero indistinguishable states) are the same.

The minimal incremental area within the sphere is $4l_p^2$ [78]. Based on previously determined entropy of Schwarzschild black holes in $4l_p^2$ increment, the entropy would be:

$$S = k_B \log_2 2^{\frac{A}{4l_p^2}} \tag{49}$$

or

$$S = \frac{A}{4l_p^2} k \tag{50}$$

where A is the Schwarzschild area. Each $4l_p^2$ increment can be modeled as l_p^2 area increments in four possible bit configurations: $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 1 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 0 \\ 1 & 1 \end{pmatrix}$. The spaces generated by each of these minimal area relationships has a distinct position (each angle and change in angle between adjacent increments is unique) within the system so each minimal area increment is distinguishable and has a distinguishable effect on gravity. That is, the interaction between each two-dimensional increment of the three-dimensional surface of the black hole sphere and environment is unique (distinguishable), similar to distinguishable different one-dimensional spaces in multi-slit systems. Thus, there is only one mass configuration equivalent for any given mass that affects externally observed gravity. An element of mass transferred between a black hole and environment changes the number of internal states of the black hole in $4l_p^2$ area increments changing the observable gravitational effect. This is modeled as transfer (time) of space (bits) which changes the Schwarzschild surface area. For information defined as the existence of a difference (distinct relationships exist) conservation of energy (spacetime) is maintained because the number of states (bits) that can be transferred to the environment (spacetime) is the same number of states previously transferred from the environment to the black hole so there is no loss of information. The bilateral transferred "type" bits are all mass states in the ideal case so the information is the number of differences in Boltzmann states. Without transfer of states between the black hole and environment, internal black hole entropy change would be zero (no time generation – constant present) and, per this theory, externally determined duration would be infinite.

The total number of distinguishable Boltzmann states in a black hole (BH), N_{BH}, that result in the observed gravity in a surface of area A in increments of $4l_p^2$ can be determined from two representations. Let:

Gravitational constant: $G = 6.67 \times 10^{-11} Nm^2/kg^2$
Planck length: $l_p = 1.6 \times 10^{-35}$meters
T_{BH} – black hole temperature in degrees Kelvin, ^oK
M_{BH} – black hole mass in Kg.
N_{BH} - number of bits in $4l_p^2$ increments in black hole
$W = 4$ - number of configurations per increment

The number of Boltzmann states in mass of a Black hole is determined from:

$$E_{\text{BH}} = N_{BH} k_B T_{BH} \log_2 W = N_{BH} k_B T_{BH} \log_2 2^2 = 2 N_{BH} k_B T_{BH} = M_{BH} c^2 \tag{51}$$

$$M_{BH} = \frac{E}{c^2} = \frac{2 N_{BH} k_B T_{BH}}{c^2} \tag{52}$$

$$N_{BH} = \frac{M_{BH} c^2}{2 k_B T_{BH}} \quad \text{where} \quad T_{BH} = \frac{\hbar c^3}{8\pi G M_{BH} k_B} \tag{53}$$

so

$$N_{BH} = \left(\frac{M_{BH} c^2}{2 k_B}\right)\left(\frac{8\pi G M_{BH} k_B}{\hbar c^3}\right) = \frac{4\pi G M_{BH}^2}{\hbar c} \tag{54}$$

Bits in Schwarzschild sphere is determined from:

$$N_{BH} = \frac{A}{4 l_p^2} \tag{55}$$

where

$$A_{BH} = 4\pi r^2 = \frac{16\pi G^2 M_{BH}^2}{c^4} \tag{56}$$

since

$$r_{Sch} = \frac{2 G M_{BH}}{c^2} \tag{57}$$

and since

$$l_p = \sqrt{\frac{\hbar G}{c^3}} \tag{58}$$

$$N_{BH} = \left(\frac{16\pi G^2 M_{BH}^2}{c^4}\right)\left(\frac{1}{4 l_p^2}\right) = \left(\frac{4\pi G^2 M_{BH}^2}{c^4}\right)\left|\frac{c^3}{\hbar G}\right| = \frac{4\pi G M_{BH}^2}{\hbar c} \tag{59}$$

The similarity between the number of Boltzmann states determined from the mass and from the Schwarzschild area indicates that the mass equivalent of Boltzmann states are fundamental mass states since black holes are the maximum number of minimal mass states. Mass, then, is an accumulation of Boltzmann states.

4.2. Temperature in neutrons and neutron stars:

Given the number of Boltzmann states or internal quark/gluon mass and energy, an internal nuclear temperature is expected to exist. The following is a basic, classical analysis that would indicate internal subatomic temperature exists. The specific temperature is not considered realistically modeled here for many reasons, including the analysis is classical for an ideal gas, not quantum mechanical. A neutron will be used as an example since there is no charge to consider and its relationship to neutron stars. The ideal gas law constraints are incorporated in the determination of the internal neutron temperature:

1. Consider neutron as a $3-D$ well, a box with constant volume, V_{Neutron}.
2. Box is thermally insulated so there is no thermal transfer to the environment. Electrons shield the nucleus from environmental photons (external energy change results in change in orbital state, but no nuclear thermal change).
3. Each Boltzmann state is modeled as a mass within the volume so there are a large number of masses: Thermodynamic gas models apply to a container with volume, $V = V_{\text{Neutron}}$ and a large number of identical particles with mass, which in this case, is Boltzmann mass, M_{Boltz}, where $M_{\text{Boltz}} = \frac{k_B T}{c^2}$. There are two unknowns, T, and the number of Boltzmann states, N, in the neutron mass as: $M_{\text{Neutron}} = \frac{N k_B T}{c^2}$.
4. Boltzmann states are modeled as being in constant motion and collide elastically with the nuclear wall which is considered stationary (infinite mass).
5. The number of Boltzmann states per unit volume, $\left(\frac{N}{V_{\text{Neutron}}}\right)$, is considered to be uniform.
6. Energy transfer between quarks (strong and weak nuclear forces) are converted to mass states in increments of Boltzmann states so the entire sub-nuclear mass and energy is in Boltzmann increments. That is, the energy of quark/gluon interactions are incorporated in the number of Boltzmann states.
7. Gravitational force is not considered.

For a neutron:

radius is $r_{\text{Neutron}} = 0.8 \times 10^{-15}$m [79] ;

volume is: $V_{\text{Neutron}} = 2.14 \times 10^{-45} m^3$

Neutron mass is $M_{\text{Neutron}} = 1.67 \times 10^{-27}$Kg [1].

Using $E = N k_B T = M c^2$:

$$T = \frac{Mc^2}{N_{\text{BoltzmannState/Neutron}} k_B} = 10.9 \times 10^{12} \left(\frac{1}{N_{\text{BoltzmannStates/Neutron}}} \right) \tag{60}$$

This is the internal neutron temperature for a given number of Boltzmann states.

The relationship between the number of Boltzmann states and temperature can be applied to a neutron star with the assumption that the neutron's temperature is in equilibrium with the neutron star's temperature. The initial neutron star temperature is approximately $T = 10^{11} - 10^{12 o} K$ [80]. Using the average temperature $T = 0.5 \times 10^{12 o} K$, for one neutron increment $(N = 1)$, the equivalent mass can be determined: $M_{\text{Neutron}} = \frac{k_B T}{c^2} = 0.77 \times 10^{-28} Kg$. At this temperature approximately 22 Boltzmann states constitute the currently observed neutron mass implying that at this extreme a neutron is a limited number of Boltzmann state mass increments.

4.3. Interpretation of Material Wave:

The deBroglie representation of particle mass as a wave [1] enables energy transmission from a source to observer with the same probability distribution as waves, that is, interference is observed in double slit systems for particles [81,82]. However, differences exist between deBroglie matter waves and electromagnetic (EM) waves. For example, matter waves do not consist of electrical (E) and magnetic (B) fields. EM waves transmit radiant energy whereas matter waves transmit the particle momentum. EM waves always travel at the speed of light whereas matter waves have variable velocities at subluminal speed. EM waves are massless whereas matter waves have a mass and internal structure.

The deBroglie wavelength corresponding to a frequency is for a mass with momentum analogous to EM wave spacetime generation where spacetime generation is consistent with EM wave spacetime generation. That is, even though deBroglie waves are not EM waves, per I-Wave Theory [56] as waves, they are modeled as also having a positive half-wave cycle that generates spacetime in the environment and a negative half-wave cycle that removes spacetime from the environment. In further analogy to EM interference in the double slit indistinguishable case, phase differences between the number of Planck states is equivalent to binary deBroglie wave increment interactions also resulting in an interference pattern in double slit systems.

The nonrelativistic case is considered here where the frame of reference is not accelerating. For example, consider an electron of kinetic energy, KE, of 100eV. The momentum is:

$$p = \sqrt{2M_{e^-}KE} = 1.7 \times 10^{-23}\frac{KgM_{e^-}}{s} \tag{61}$$

$$M_{e^-} = \text{electron mass } (9.11 \times 10^{-31}Kg) \tag{62}$$

Therefore, deBroglie wavelength is:

$$\lambda = \frac{h}{p} = 3.87 \times 10^{-11}m \tag{63}$$

Velocity, $\mathbf{v}$, is the group velocity of the wave in an isotropic media where the wavelength depends on the velocity of the particle. The matter wave transmits the energy so from the momentum equation, the velocity can be determined:

$$\mathbf{v} = 1.87 \times 10^{7}\frac{m}{s}[KE = \frac{M_{e^-}\mathbf{v}^2}{2}, M_{e^-}\mathbf{v} = 1.7 \times 10^{-23}\frac{Kgm}{s}] \tag{64}$$

which corresponds to a frequency of:

$$\upsilon = \frac{\mathbf{v}}{\lambda} = 4.8 \times 10^{17}\text{Hz} \tag{65}$$

Per deBroglie's formula, $h = \lambda p$, the product of wavelength with the corresponding momentum generates one Planck state. That is, the momentum due to particle motion associated with the corresponding wavelength of matter can only change in Planck state increments.

4.4. DeBroglie wave and probability wave velocity

The deBroglie wave is assumed to propagate at velocity, $\mathbf{v}$, whereas a theorized probability wave [71] would propagate at the same velocity or could be decoupled, independent of the deBroglie wave velocity, and propagate at a different velocity. The probability wave speed maximum, per relativity, would be limited by the speed of light. However, as shown in the Appendix, probability is a real number (no imaginary component) so a wave is not a good model for the probability wave. Thus, the probability can also be modeled as an entangled process, so probability is approximately instantaneously available with observer reset/observation. Unlike entanglement of one binary reciprocal interaction (between entangled states), as discussed above, the probability wave would entail multiple possible binary state interactions between the source and each possible observer (point on a final detector screen), where each interaction has a given probability.

The probability is changed by additional external interactions such as observer reset/observation of an entangled component or path information observer. The scenario in this case would be a particle emission, probability entanglement or a change in the probability wave trajectory changing the observed particle interaction with the environment such as positions on the final detector screen. Path information observer reset/observation, even post-slits as in delayed choice experiments changes the probability wave, changing observations between interference and no interference. This may be related to the Zeno and anti-Zeno effect changing the probability of decay where an external effect changes internal probability theorized to be due to changes in the number or ratio between distinguishable and indistinguishable internal atomic states which would have the effect of changing the interference pattern as in multi-slit systems.

4.4.1. Experiment 1: Observation of probability wave effect

The effect of the probability wave (differentiated from deBroglie wave) on observation of a particle such as electron interference can be experimentally investigated:

1. Assuming delayed choice interactions apply to deBroglie waves, the limitation on the delay that changes wave interference pattern to a particle pattern can indicate if interference is determined by the probability wave propagating at the deBroglie wave velocity $\mathbf{v}$, at the speed of light or instantaneous if entangled. This is dependent on reset/observation of the path information observer timing relative to the change from interference to no interference [56] in double slit systems. There is a longer delay duration after reset/observation of the path information observer for the lower velocity deBroglie waves, compared to waves propagating at the speed of light or being entangled. That is, timing of path information observer reset/observation for probability waves and deBroglie waves would affect delayed choice observations differently.
2. Determine the transit time (duration) between a mass such as an electron source emission with velocity $\mathbf{v}$: $\Delta t_{\text{Mass}} = \frac{\Delta x}{\mathbf{v}}$ to slits and independently from slits to final observation. Duration, measured by Δt_{Mass} for each segment and total duration would indicate whether deBroglie waves are material subluminal waves or propagate as probabilistic luminal waves or a combination of both such as may occur for slower propagation from source to slits and luminal propagation from slits to final detector screen.

The observed interference pattern in multi-slit systems will be different for each of the following different characterizations of deBroglie waves:

1. EM waves equivalent to mass.
2. Boltzmann state waves, i.e., interference due to phase differences between the number of Boltzmann states per increment (equivalent to Planck states per increment in EM waves).
3. A function of EM wave equivalents for each Boltzmann state, i.e., each Boltzmann state generates a wave at the Boltzmann state frequency which interact.

4.4.2. Experiment 2: DeBroglie wave affected by capacitance

A double slit system with electron sources can be performed within a capacitor so the effect of external energy on the pattern at the detector can be determined. This experiment can also be performed with protons or neutrons so insights into possible relationships between internal atomic structures and deBroglie waves can be determined from the effect on the interference pattern.

4.4.3. Gedanken Experiment 3:

Since up quarks are theorized to be one Boltzmann state, there would be no internal mass structure for up quarks which would result in different patterns in interactions with slit systems than for masses with complex internal structures, either no interference or interference resulting from the Boltzmann frequency. No interference would imply that the deBroglie frequency is due to Boltzmann states interference. Interference would imply that the effect is due to the EM wave equivalent.

4.5. Analogy between Particle/Anti-Particle and Positive/Negative Planck States:

The deBroglie frequency corresponding to an electron will be modeled using the wave model described previously, that is, as an initial emission of the positive half of the wave increasing the number of Boltzmann states into the environment, increasing the spacetime (energy) in the environment and decreasing the energy in the emitter. Anti-particles, the positron in this case, is modeled as having the opposite effect where the initial emission is of the negative half wave which decreases spacetime (energy) in the environment decreasing the number of Boltzmann states from the environment, that is, phase shifted by 180^o from the electron wave. A hole model as the negative half wave can be thought of as a vacancy of the electron state which has the opposite charge of an electron identified as a positron [83]. Thus, the initial emission of a positive half of the deBroglie wave is modeled as the electron which "pushes" spacetime into the environment. The initial decrease of a negative half of the deBroglie wave is modeled as a positron where absorption precedes emission which "pulls" spacetime from the environment. The observed matter greater than anti-matter in the universe would then be attributed to the excess in emissions over absorptions, i.e., emission preceded absorption so the initial emission results in the dominance of matter.

The mechanism by which mass is converted to energy during annihilation between particles and anti-particles is a result of superposition (same spacetime) in the same space of the electron (added to the environment) and 180^o phase shifted electron, the positron (removed from the environment). Mass in space is transformed to environmental spacetime. If spacetime and energy are the same, as theorized, then conservation of energy is equivalent to conservation of spacetime resulting in increased environmental spacetime when particle/anti-particle mass annihilate. The particle/anti-particle system are two equal magnitude positive mass systems in spacetime that each independently adhere to the Pauli Exclusion Principle, whereas the EM waves, generated spacetime through the annihilation of the combined particle/anti-particle pair, does not adhere to the Pauli Exclusion Principle demonstrating that the Pauli Exclusion Principle applies to what is in spacetime, not what happens to spacetime.

This is also applied to EM waves where the positive half wave period increases the number of Planck states in the environment and is defined as positive Planck states, analogous to an electron mass with a "positive" effect in the environment preceding the "negative" environmental effect. The EM negative wave half period has the opposite effect; decreases the number of Planck states in the environment and is, thus, modeled as negative or anti-Planck states.

4.6. Fermions and Bosons:

4.6.1. Relationships between spin's different repeating values for bosons and fermions and the Pauli Exclusion Principle:

Fermions and bosons generate spacetime differently and, therefore, have different properties resulting in different observed energy probability distributions and different repetitive spin cycles. Boson integer spin values repeat every 360^o where the proposed wave model incorporates a positive half wave which increases spacetime followed by a negative half wave cycle which decreases spacetime propagating in two dimensions (assumed here to be the xy plane). Planck states can only be indistinguishable (minimum spacetime increment) which can be in superposition (even between different waves) that generate simultaneous multiple time in approximately the same space, enabling multiple waves to generate denser spacetime. Since EM waves generate time, they can never have stationary states other than in the present. All the waves in the two dimensions can be superimposed in the z-plane so the two dimensional polarizer plane for the electric wave can be superimposed in the third dimension plane and likewise for the orthogonal two-dimensional (xz plane) magnetic wave superimposed in the y plane. The ability to superimpose propagating EM waves in the "unused" orthogonal electric and magnetic dimensions, per this model, is the basis of the inapplicability of the Pauli Exclusions Principle to bosons. The effect of maximum superposition is observed in lasers where multiple, same number of indistinguishable Planck states per increment from multiple sources generate simultaneous same space at the same frequency, 0^o phase difference between waves, increasing the magnitude of spacetime, energy (multiple simultaneous $E/\Delta E$) at absorption.

Fermion half integer spin values repeat every 720^o. Spin is essentially a wave property "... generated by a circular flow of charge in the wave field of the electron [84]." Spacetime is still modeled to increase in the positive half wave cycle and decrease in the negative half wave cycle but this occurs while the wave is rotating through the dimensions orthogonal to propagation as demonstrated by the Dirac Belt Trick [85]. This rotation has the additional effect that spacetime generation is simultaneous in all three spatial dimensions so there is no ability for superposition of waves as in bosons, i.e., all space is "occupied." In propagating fermions, the projection of positive and negative propagating elements in the xy plane results in reciprocal inverse sinusoidal changes spacetime generation in the orthogonal xz and yz planes resulting in an asymmetric wavefunction. That is, there is a continuously changing phase of propagating elements between planes (xy with respect to xz and yz). Without the ability to superimpose waves, the Pauli Exclusion Principle must apply [86].

Spin in fermions is theorized to be a result of internal force changes in the three-dimensional distribution of internal components (time generation in each dimension). The continuously rotating sinusoidal changes in three dimensional space is observed as a spiral (relative phase changes as a spinor). Spinors are path dependent so are sensitive to how the gradual coordinated rotation occurs. Opposite quantum phase occurs every 360^o for spin ½ spinor with $\pm$ sign, double value wavefunction ($\Psi \rightarrow -\Psi$). In contrast to fermions, the Pauli Exclusion Principle does not apply to states that generate constantly changing spacetime in two dimensions such as in bosons (symmetric wavefunction when $+\Psi$ and $-\Psi$ are the same states). The combined effect of Planck states (boson exchange between quarks) with Boltzmann states in the distribution of internal components of the spin of the subatomic particle repeat every 720^o. That is, for a typical three-dimensional three quark system consisting of internal Boltzmann and Planck states, a unidirectional (clockwise or counter-clockwise) net effect of rotation would repeat every 720^o, i.e., a 90^o rotation will be rotated between two axis (180^o total).

Space boundaries are generated from multiple different particle properties that are different than the external space environment. Static relationships (discrete fundamental elements) are distinguishable spaces. Distinguishable Boltzmann states (fundamental mass increments), analogous to slits in double slit systems, necessarily generate different space so cannot be superimposed (same space at same time). Multiple binary indistinguishable Boltzmann states are distinguishable between different distinguishable Boltzmann states. That is, Boltzmann indistinguishable states exist simultaneously but only as binary interactions between two distinguishable states, distinguished by different space, i.e., multiple binary indistinguishable interactions between different distinguishable Boltzmann states are all distinguishable (slit 1 binary relationships with slit 2 is distinguishable from slit 2 binary relationships with slit 3) so each non-observable, superposition (indistinguishable) binary relationship is a unique relationship between two different spaces (distinguishable states). Multiple spaces can generate simultaneous time for simultaneous changes in relationships, generating parallel time for different spaces. Without a change in relationships but with relationships existing, the present exists but additional time would not be generated.

Bosons, unlike fermions, have few distinct properties and no static properties, i.e., limited number of different types of relationships with the environment. They are a result of the effect of one fundamental force, the EM force. EM waves consist of only one type of relationship that changes in Planck states increments. The generated spacetime of bosons have only two properties, two degrees of freedom. These are the number of Planck states in each wave increment (space as amplitude) and the changes in the number of Planck states per wave period (time as frequency), i.e., the number of Planck states per wave increment are necessarily constantly changing. Fermions, in contrast, incorporate all the fundamental forces and generate multiple different relationships such as mass, charge and spin.

4.7. Relationships between mass and energy:

The change from static to dynamic relationships of mass with the environment generates spacetime changes. Spacetime changes of a wave interacting with a stationary mass (bound) is transferring spacetime from the wave to the spacetime external to the mass of a fundamental particle (not capable of absorbing a boson) such as occurs with a change in the orbital of electron relative to the nucleus or absorption of the wave if the mass is not a fundamental particle (capable of absorbing wave). That is, emission/absorption of a wave is primarily converting mass (static relationships) to energy (changed relationships) or vice versa. This is demonstrated by a two-chamber system with a particle known to be in one chamber (mass as differences, a relationship) that, when randomized (changed relationship), results in energy [87]. The conversion of relationships (differences) in space (mass) to changes in relationships generating time (energy) is theorized to be the basis of $E = mc^2$.

4.7.1. Momentum:

Conservation of momentum requires reciprocal (equal and opposite) binary changes in spacetime when a mass/energy is emitted from another mass. The following classical analysis is for emission of an EM wave (spacetime changes generating time) from a mass that has reciprocal (opposite) spacetime generation due to changes in the relationships between the mass and environment. The photon momentum (mass m equivalent) and particle (mass M) generate equal and opposite momentum. The spacetime change due to emission of a photon, the positive half EM wave, results in recoil spacetime change of mass M. An opposite spatial recoil will occur when the wave is absorbed but in this analysis only emission will be considered. The component in spacetime generation of the emitted EM wave at the speed of light, c, is reciprocated by changes in the relationships between the number of Boltzmann states and environment at velocity v.

Assume an ideal case where there are no additional forces acting on the mass-photon system. Emission of only one photon from the particle mass to the environment will initially be considered. This photon is modeled as being emitted from the left surface parallel and opposite of a particle "box" moving only along the x-axis. Each photon emission reduces mass M.

m - mass of photon

v - frequency of wave

E - energy of photon

M - mass of particle "box"

v - velocity of particle "box"

L – distance change in photon motion in Δt_m duration: $L = c\Delta t_m$

Δt_m – externally observed photon duration for a change in distance of L.

Δx_M is the change in position of the mass M

For the photon: $\Delta t_m = \frac{L}{c}$. For this duration in mass M: $\Delta t_m = \Delta t_M = \frac{L}{c}$. The velocity of the particle in the time the photon changes space by length L is $\mathrm{v}_M = \frac{\Delta x_M}{\Delta t_M} = \frac{\Delta x_M}{L}c$. The momentum of the photon and particle are:

$$p_m = \frac{E_m}{c} = m\frac{L}{\Delta t_m} = \frac{hv}{c} \tag{66}$$

$$p_M = M\mathrm{v} = M\frac{\Delta x_M}{\Delta t_m} = M\frac{\Delta x_M}{L}c = m\frac{L}{\Delta t_m} \tag{67}$$

An interpretation of $\frac{E_m}{c}$ in this case is that it is the energy at which the momentum is minimized for a given frequency while maintaining the speed of light.

Each event, where photon energy is ejected from mass, M, results in the mass equivalent of the photon energy in M decreasing. Since photon mass equivalent is $m = \frac{hv}{c^2}$, there are n photon energy mass equivalents (assuming all emitted photons are of the same frequency) in mass M so $n = \frac{\Delta Mc^2}{hv}$. For n photon emissions, the change in the energy of mass M is $nhv = nmc^2 = \Delta Mc^2$ and for the case where the entire mass M is converted to energy, the final mass, $M_f = 0$ so $\Delta M = M$. Therefore, $\frac{nh}{\lambda} = \Delta Mc$ since $n\frac{E_m}{c} = n\frac{hv}{c} = \Delta Mc$ (so $E = mc^2$).

This is interpreted per this theory as a transfer of spacetime from mass M to the environment at ejection of an EM wave from mass M generating time. For one photon transfer at a given frequency (wavelength), $n = 1$: $\frac{h}{\lambda} = \Delta Mc$. However, the emitted EM waves may consist of multiple frequencies so, in this case, $\sum_i \frac{n_i h}{\lambda_i} = Mc$, where λ_i is the wavelength for frequency v_i and n_i is the number of waves emitted at this frequency.

4.8. Entropy as reference frame for inertial systems:

Per this theory, if there is no change in entropy (no time generation), external length change is $\Delta x = 0$ and duration change is $\Delta t = \infty$, so observed velocity is zero and momentum is zero. It is theorized here that zero entropy is a general reference for momentum. Inertial reference frames describe time and space with no acceleration, homogeneously, isotropically, that is, no external forces on the system. Inertial frames are, by definition, relative [1]. That is, motion is described relative to something. In this proposal, space is quantified by the number of relationships which relates space to an entropy. There is no inertial motion without a change in entropy. Momentum is thus related to entropy and entropy changes, that is, entropy is a reference frame that describes absolute space for no motion. In summary, per this theory, the momentum is the local number of relationships and relationship changes which is quantified by entropy and entropy changes relative to zero entropy and no change in entropy (as a baseline), not to external mass and space such as distant stars [88].

4.9. Observation:

Without a transfer of information at a boundary, nothing can be said about what exists. An observation requires observer reset (generates the ability to observe). Based on spacetime being local, external systems are equivalent to outside the "universe" of the system. An external observer cannot determine the relationship or changes in relationships internal to the system without being part of or interacting (reset or observation) with the system. Local spacetime in the observer and in the system are changed at observer reset/observation. There is no change in space and time for the system without interaction at or through the external boundary. Hence, system spacetime does not exist for external observers of different local systems, consistent with Wheeler-DeWitt predictions [89].

An observer is limited by the "type" and magnitude of increments (cell size) for observable relationships. Observer reset is a change that establishes the type of relationship the observer is capable of observing which continues to exist in the present until observer observation. The "type" (for a given property) is specific for what is assumed to exist so the observer can only observe that which it has previously been designed to observe, properties based on the available or predicted information of the assumed properties of that which is to be observed. These are based on some event, an interaction, which has previously been observed or can be predicted from other observations. That is, observers are not designed for what has not been previously observed or predicted. Local spacetime exists for the observer and observed only for the properties the observer is capable of observing, i.e., observer/observed interaction generates local spacetime. Relationships without an observer cannot be distinguished as having properties but those properties, per this theory, still exist, that is, time and space as local properties exist so properties are assumed to exist for the observed, even without observer reset/observation. The information that the observed exists is at least one bit of information which has physical consequences such as in entanglement where the one bit is that entanglement exists.

4.10. Effect of path information observer eliminating interference:

Based on the model for internal characteristics of EM waves previously described [11], a path information observer reset in double slit systems transforms the effect of non-zero phase differences between the number of Planck states originating from different wave increments outputted from different slits to zero phase difference interaction between wave increments outputted from one slit [56]. Per this theory, the addition of a path information observer reduces the number of relationships, that is, decreased space, within the double slit system even as the conventional length between slits observed by external observers does not change. The distinguishable plus indistinguishable four possible relationships are reduced to two distinguishable possible relationships; one slit/environmental relationship observed at the final detector screen and one reciprocal not observed slit/environmental relationship. The decreased space changes the phase so that the increment with a larger number of Planck states per increment for the same frequency (more positive or less negative) at each instant decreases due to the decrease in system space to equal the fewer number of Planck states per increment at each instant in the corresponding binary increment resulting in zero phase difference between wave components. In this case, the number of Planck states per increment of the wave at each location and each time instant are equal. This difference in magnitude (number of Planck states) between the binary wave increments propagating from different slits is speculated to explain which slit-environmental (slit 1 or slit 2) interactions is observed in the distinguishable case (particle). The decreased system space decreases the positive half wave or increases the negative half wave number of Planck states to match the fewer Planck states at each instant. For indistinguishable states that are transferred to the external environment, the observable effect of the change in energy in the external environment is approximately zero since there are a large number of states in the environment but there are few changes in the system so spacetime changes are observable [56].

The conventional consideration for a change from wave characteristics (interference) with path information observation to particle characteristics (no interference) will be reinterpreted per this theory. Let p be the total momentum of the source particle such as an electron that is the same for multiple emitted source particles (needed to determine a pattern) and, as previously, d is the distance between slits, L is the minimal distance between the plane of slits and final detector screen where $L \gg d$, λ is the wavelength of the source and y_{P-P} is the distance between intensity peaks. With observations, there is a difference between the momentum of the wave/particle interaction between slit 1 and slit 2 where there is a small deviation, ∂p, approximately perpendicular to the original momentum so the deflection angle is $\approx \frac{|\partial p|}{|p|}$. This is a consequence of the energy change which changes the particle's momentum. Per convention, the energy change is due to the observation. Per this theory, the energy change is due to a transfer of energy from the system to the environment, changing the spacetime (energy) in the system and consequently changing the momentum of the particle. This has the same consequences as the energy change due to observation. The angle difference from the exits of slit 1 and slit 2 at a point y on the final detector screen due to this change of momentum is $\approx \frac{d}{L}$ so the small deflection caused by the change in momentum corresponds to $\frac{|\partial p|}{|p|} \approx \frac{d}{L}$. The distance between peaks on a final detector, y_{P-P}, can be derived using:

$$\frac{d}{L} = \frac{\lambda}{y_{P-P}} \tag{68}$$

and since $p = \frac{h}{\lambda_{P-P}}$:

$$y_{P-P} = \frac{h}{\partial p} \tag{69}$$

which reduces the interference pattern and, at the limit results in no interference pattern [90]. In summary, per this theory, the transfer of indistinguishable states to the environment with observer reset decreases the space within the system affecting the momentum resulting in the overlapping of Planck states per increment.

4.11. Zero-Point Energy/Virtual Particles:

Relationships are necessary and sufficient for space to exist. If there is no space, devoid of relationships, nothing can exist, so there can be no possible change in relationships, no time generation. In this case, there is no space or time, and since there are no possible physical distinguishable states, it is not of the physical universe. Therefore, relationships and changes in relationships (spacetime/energy) is required for the post-big bang physical universe, and results in zero-point energy [91]. Even in a vacuum, random quantum fluctuations generate spacetime. Extracting this energy is essentially conversion of spacetime to different forms of energy/matter. As an example, virtual particles can be modeled as a transfer of spacetime from the environment to a local system, the virtual particle [92], which is based on increments of minimal change in spacetime, Planck states. Virtual particles are a local energy change (change in zero-point energy) quantified by the number of Planck state changes, $E = hv$.

4.12. Big Bang:

Relationships and changes in relationships that generate spacetime is related to the initial generation of spacetime at the big bang. Pre-big bang is modeled as a large number of distinguishable states and indistinguishable states between these distinguishable states that are unobservable and not changing. There are no external observers and therefore, no observer resets/observations pre-big bang. Consistent with this theory, the big bang could be characterized as the beginning of at least one observable change in relationships, generating the first change in space (which could be a quantum fluctuation such as tunneling), the first time generation resulting from a reset/observation which subsequently generates a direction(s) in space. This generated the first external boundary. That is, space exists pre-big bang with no time generation; space only exists in the present (past and future cannot be differentiated from the present). The big bang was the generation of past and future in addition to the present. This first change in relationships is equivalent to the addition (reset) of a path information observer in multi-slit systems. If there is a change in one state, equivalent to reset of an observer initiating the big bang, the internal state relationships of the system change, transferring energy to the environment, and, in this case, generating the universe. The pre-big bang and post-big bang are characterized by different system and environmental entropies, different number and ratio between distinguishable and indistinguishable states in the pre-big bang internal space, post-big bang internal space and the generated universe space.

A very large number of distinguishable states pre-big bang with nothing external (no external observer so no boundary) and, therefore, a large number of possible indistinguishable state changes (all possible reciprocal binary interactions between each combinations of two distinguishable states) would result in a very large entropy change with observer reset/observation. The entropy cannot be infinite since infinite entropy "cannot be localized in space." It requires "arbitrary small amounts of probability... dispersed into an infinite number of states..." so finite distinguishable states must exist and change can only occur in increments of this minimal size change [93]. This cell size finite limitation (minimal amount of missing information in the physical universe due to not having information, the uncertainty limit) is a necessary restriction on infinite entropy and infinitely small entropy cell size so external relationships (space) and changes in relationships (time) exist. Therefore, uncertainty as the combined minimum time change for a given energy change (minimal Δt requirement for a change in energy, ΔE), is required for the universe to exist. That is, the finite uncertainty cell size is the minimal limit of change. It is the uncertainty that is generated shortly after the big bang (post-inflation) and is a limit on future relationships in the universe. The initial non-gravitational uncertainty generating the non-gravitational forces is a cause that is the basis of all subsequent changes, effect, which cannot be less "uncertain" than the cause for non-gravitational changes in the post-inflationary phase of the universe.

A modified black hole model will be used to analyze the big bang as an entropic process. This is modeled as a large static multi-slit system with no source emission so there are no interactions. However, similar to distinguishability in multi-slit systems (for equal-sized slits) where each slit is based on a unique interface (in space) with the environment, distinguishability in black holes is also generated by the unique location of each elemental surface. The origin of the big bang in this model does not begin with a singularity since multiple distinguishable states exist pre-big bang. However, unlike black holes, where there are environmental observers for each distinguishable state, since there is no environment per this pre-big bang black hole model, each 2-D distinguishable element is in (binary) superposition with every other $2-D$ element. There are relationships between the black hole and the internal surface but no external interactions.

The total number of states for N distinguishable surface elements with no external observer is N^2. Per this theory, for one observer reset observing one state of the black hole, all binary indistinguishable interactions between the observed state ($(N-R)(N-R-1)$ where $R=1$) and all other states of the black hole would be externally transferred. That is, with one observer reset/observation, a large amount of energy would be released for large N. This transfer would simultaneously and spherically generate the external universe resulting in an expanding universe. Spacetime would be generated where it does not exist (or adding spacetime to any existing environment after the big bang). The number of distinguishable states continue to exist as do slits with transfer of indistinguishable states at observer reset/observation. Continuously adding observer reset/observation where $R=2...N$ results in $(N-R)(N-R-1)$ indistinguishable elements transferred externally and spherically up to $(N-1)$ observers where all indistinguishable information would have been transferred and all information in the system is distinguishable, i.e., a conventional black hole. That is, creation would be continuous until only N distinguishable states remain. As the number of indistinguishable states in the system decreases, there is a continuous decrease in the effect of each additional observer reset/observation resulting in a continuously decreasing generated spacetime (as more information is added, missing information decreases, less indistinguishable states) so subsequent spacetime generation from the initial black hole continuously decreases.

The first force carrier generation (change in number of states) at the big bang is assumed to be a wave in less than (gravitational wave) or equal to Planck state increments. The number of indistinguishable states emitted at the big bang is theorized to be spherical radiation in increments related to a value of uncertainty (and may be different than that based on the current Planck's constant value) at initiation of the big bang which may change through the inflationary phase of the universe's expansion as discussed herein to the current uncertainty value. That is, the uncertainty relationships at the initial big bang emission is theorized to be a local limit of the energy/time relationship and is related to an initial gravitational energy or, alternatively, gravitational energy may be generated simultaneously with other changes. As previously demonstrated, the value of uncertainty is related to the speed of light [11] so if the uncertainty limit (Planck states) changes (decrease), the speed of light would also change (increase) [11]. See "Expansion of the Universe: Inflationary Phase" below.

Based on emission of indistinguishable states with observer reset, per this theory, or observation, per convention, three models can be speculated to result in current observations of the universe's expansion. The first model is where a large energy is radiated external to the black hole, generating the universe external to the black hole. The second model is where a large amount of energy is radiated internal to the black hole, generating the universe internal to the black hole. A third possible model is a combination of both, where changes are radiated externally and internally from the surface of the black hole. In the first case where energy is released external to the black hole as described above, the universe would appear to be expanding from the black hole's initial state resulting in the observed redshift. In the second case, where energy is released internally to the black hole, as energy concentrates to the center, the observation of the changes in energy at the periphery, approaching the Schwarzschild radius, decreases. Thus, for observations of conditions of previous states, the decrease in density toward the Schwarzschild radius of the black hole would appear as the universe expanding. In the third case, if the emission were bidirectional, the number of indistinguishable states emitted bidirectionally from the Schwarzschild sphere would be approximately equal at the Schwarzschild sphere, no observable change at the boundary, and appear transparent to observers, that is, a continuous processes. The signal from any point in the universe would be observed as though the frequency is continuously red shifted. There are certainly difficulties with this speculation, but these are possibilities to consider in future work.

4.13. Expansion of Universe:

4.13.1. Inflationary Phase:

A non-linear spacetime expansion in the early universe may explain the "inflationary phase" of the early universe. This can be attributed to non-linear, positive feedback between relationships and changes in relationships, spacetime generation, which then affects the externally observed spacetime generation. Variations in space per time generation would generate different densities of space. The previously theorized smaller minimum increment of spacetime generation (lower Planck state value) would result in a greater number of changes in generated space compared to post-inflation, i.e., speed of light as the maximum spacetime generation would be greater during the inflationary phase. That is, for $\Delta E \Delta t < h$ there would be more space generation per time generation for the comparable current duration and the externally observed speed of light would be greater than that of the current speed of light and appear as inflationary spacetime [56]. Planck's constant during the inflationary period would then progressively increase to the current value at the end of the inflationary period.

An inflationary phase model would require determining this non-linear entropy change (spacetime change) and relating this to subsequent changes in feedback gain which would be observed as a change in space and time generation. The ratio of relationships (space) and relationship changes (time) in the initial universe post-big bang compared to the magnitude of space and time much later would be different since statistical averages of background spacetime would be different resulting in differing observations of the same event.

Current mass distribution in the universe may be due to small differences in local feedback gain post-big bang, i.e., a decrease in relative expansion would result in a "kernel" to which other matter gravitates. In the later stages of the universe, conventional spacetime evolution becomes linearly related as a statistical average (background spacetime) and/or the effect of feedback is minimal (not observable with the precision of current instruments). The inflationary phase of the universe (positive feedback) may still be occurring at the extremes or different areas of the universe. That is, the current universe expansion may not only be due to the initial or local change in Planck's constant but also a combination of multiple feedback loops at different gains in different regions. The statistical average of a large number of changes generating what appears as background spacetime to external observers may be the same throughout the universe or is "relatively" local, over different large, although currently undefined, generated local spaces in the universe. Local expansion and compression (crunch) could exist simultaneously in different local spacetimes, analogous to different gravitational wave internal contraction and orthogonal external expansion but on a large scale [94].

In analogy to the theorized gravitational waves phase transition generating Planck states at a certain level of the universe's expansion, EM wave transition generate mass (Boltzmann states) states at a different level of the universe's expansion [95–98]. Since not all gravity or EM waves would phase transition or transitions are bidirectional, gravity and EM waves would continue to exist simultaneously after the phase transition. It would be interesting to determine if concentrated or compressed gravitational waves, as in the initial radiation after the big bang, can generate EM waves which would relate gravity to other fundamental forces, that is, can gravitational waves generate virtual or real photons.

Local time is theorized to be a function of temperature due to the temperature effect on changes in entropy during the inflationary phase of the universe. After the inflationary period, when the current constants are stabilized, the time-temperature relationship can be determined from the current value of Planck's and Boltzmann's constant. (See "Boltzmann Time – Approximate Instantaneous Time Change.") The temperature has been theorized to drop from 10^{27}K to 10^{22}K during the supercooled expansion of the universe [99]. The final time for the inflationary phase at $T = 10^{22}$K, using the previous formula relating Planck states and Boltzmann states, is $\Delta t = \frac{.48\times10^{-10}}{10^{22}} \approx \times10^{-32}$sec. This is consistent with the theorized 10^{-32} to 10^{-33}sec end of the inflationary period [100]. The similarity to the assumed post-inflationary time indicates that the constants had been established by the end of the inflationary phase. Immediately after the big bang and during the inflationary period, these relationships would be unknown. Based on this approach, since the temperature is estimated at $10^{27}K$ at initiation of the inflationary period, $\Delta t \approx 4.8 \times 10^{-36}$sec which is similar to the current estimated beginning of the inflationary period at 10^{-36}sec [101]. The difference can be attributed to changes in the ratio between Planck and Boltzmann constants during the inflationary phase and other factors such as the gravitational effect or they are the same and the approximations for duration and temperature may be different than current estimates.

To compare the energy/temperature relationship near the big bang and currently, let $\Delta E_{BB} = k_B T_{BB} \log_2 W_{BB}$ be the energy change at or near the big bang (BB) (when statistically significant number of relationships exist) for W_{BB} multiplicity at temperature T_{BB}. If the same energy change would occur in the current universe (Now), $\Delta E_{Now} = \Delta E_{BB} = k_B T_{Now} \log_2 W_{Now}$ for W_{Now} at temperature T_{Now} so $T_{BB} \log_2 W_{BB} = T_{Now} \log_2 W_{Now}$, $\frac{T_{BB}}{T_{Now}} = \frac{\log_2 W_{Now}}{\log_2 W_{BB}}$. As the temperature ($T_{Now}$) decreases as the universe expands, W_{Now} would increase (for a constant initial T_{BB} and W_{BB}), increasing space, possibly resulting in an expanding universe at a lower temperature.

Up quark: The observed initial high energy wave frequency decrease to the Boltzmann frequency would generate the initial minimal increment of mass, considered here to be the up quark at $E_{\text{Up}} = (2.3MeV)$J, with energy mass equivalent [102,103]: $E_{\text{Up}} = 3.7 \times 10^{-13}$J.

After the quark-gluon plasma epoch, the temperature of the universe during the generation of hadrons that separate the up quark mass from the gluon energy (confinement period) is within a range that incorporates $T \approx 1$MeV (or approximately 10^{10}K) [104–106]. The energy of one Boltzmann state ($n = 1$) at this temperature is:

$$E_{Boltzmann} = k_B T \approx \times 10^{-13} J \tag{70}$$

Thus, the energy for one up quark and one Boltzmann mass state increment (the theorized minimal mass state) are approximately the same energy (mass) at the initial temperature of the up-quark generation when independent of gluon energy. This is a further indication that Boltzmann states are the minimal incremental mass state. Heavier quarks would be generated at different temperatures.

Neutrino generation: An analysis based on the minimal mass state (Boltzmann state) for a relativistic neutrino will be considered. The decoupling temperature of a neutrino is $T_{Neutrino} = 10^{10}$K [107]. One Boltzmann state mass at this temperature is: $m_{Boltzmann} = \frac{k_B T}{c^2} = 1.53 \times 10^{-30}$Kg. The approximate energy of a neutrino is maximally limited at $E_{Neutrino}$= .8eV [108,109] with a mass equivalent of: $m_{Neutrino} = \frac{(.8eV)\left(1.602\times10^{-19}\frac{J}{eV}\right)}{9\times10^{16}} = 1.42 \times 10^{-36}$Kg. Based on this neutrino mass, one Boltzmann state rest mass is larger than one neutrino rest mass but neutrinos are relativistic particles so, to determine the speed of a neutrino at its origin, that is, determination of the velocity at which the neutrino mass equals one Boltzmann mass equivalent requires: $1.53 \times 10^{-30} = \frac{1.42\times 10^{-36}}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$ or v = $(.99999999999957)c$. The deviation from the speed of light is 4.3×10^{-13}c. The upper limit for deviation of the speed of the neutrino from the speed of light of approximately 10^{-9} [110] is within that deviation. Since this mass is the upper limit of neutrino mass, a lower mass would result in a lower velocity but still within the proposed deviation since the difference is approximately three orders of magnitude less than this upper limit. That is, the lightest neutrino mass at the decoupling temperature could be approximately three orders of magnitude lower and still be within the proposed deviation of the speed of light. Since mass is limited by Boltzmann states, per this theory, the neutrino, if it is characterized as a fundamental mass of one Boltzmann mass at the decoupling temperature must have a velocity close to the speed of light. An up quark can be modeled as a stationary Boltzmann mass and a neutrino can be modeled as a mass state that necessarily has a relativistic velocity. A neutrino is here speculated to be a hybrid particle-wave, referred to as a mave since it is a particle (relationships generating space) that necessarily generates time (changes in relationships) to maintain fundamental (Boltzmann) mass.

4.14. *Dimensionless physics:*

Per this theory, space and time and matter and energy that depend on space and time would be replaced by scalars, the number and changes in the number of discrete Planck states and how they change. Currently physics, based on dimensioned quantities, relies on ratios that depend on arbitrary defined standards used to determine the magnitude of parameters such as a second or meter as previously discussed. Per this theory, external observation of duration, length, mass and energy would depend on the number and changes in the number of Planck states as the physical fundamental minimal cell size (limit on minimal spacetime generation) that exist in the physical universe. Time and space are vestiges from the big bang where Planck states define minimal change (spacetime generation) and the up quark at equivalent mass of one Boltzmann energy (which depends on Planck states) is the minimal mass. Planck states and Boltzmann states are, therefore, physical constants of the universe. Other natural constants represent limits that can be expressed as functions of Planck and Boltzmann states. The speed of light is the limit on maximum spacetime generation, a limit on Planck state's ability to change, and Boltzmann states are a limit on matter generation (increments of bits).

4.15. *Four Forces:*

The proposed mechanism for space and time can be applied to model the four forces as different environmental relationships and interactions, a different spacetime generation. That is, transformations (different set of space and time relationships) of the initial relationships and relationship changes generate the four forces [111]. Thus, this theory can be related to the standard model. Additional fundamental spacetime forces may exist. These include those that currently may exist but have not been detected [112], additional phase transformation that may arise spontaneously as the universe continues to mature or generated artificially in the lab.

Consideration here is only for the ideal case; no change in Planck's constant or Boltzmann's constant and one Boltzmann state change per one information change. Each current force carrier is modeled as a result of interaction between properties within masses (strong and weak forces), between masses with charge (EM) or generated by changes of forces (gravity). This theory proposes that each fundamental force is dependent on specific properties such as charge, color and flavor and each of these properties generate independent local property spacetime. Although there are no externally observable changes in fundamental particles with respect to each fundamental force, local internal spacetime changes such as changes in the distribution of mass or charge or spin within the particle still occur generating inherent time. Charge interactions mediated through photons generate spacetime of the EM force. Color interactions of quarks mediated through gluons generate spacetime of the strong force. Flavor interactions of quarks mediated through flavor force carriers generate spacetime of the weak force. These properties depend on mass existing. Energy change and spacetime change are equivalent per this theory so each fundamental force change generates gravitational waves (spacetime change). Effects of spacetime generation by different fields and their interactions (events) such as the effect of an electromagnetic field on a charged mass (particles) are observable. This is characterized as the interaction between "incomparable" spacetimes.

4.15.1. Electromagnetic Force:

An electron is modeled as a fundamental particle existing within a boundary separated by "incomparable" states of the environment. In this case, photons are not emitted or absorbed by the electron. The change in the orbital size of an electron in an atom is due to spacetime change between the electron orbital and nucleus and is proportional to the absorbed or emitted photon frequency as is currently observed. Current observations of electron orbital behavior cannot differentiate "absorption" or "emission" of a photon from an electron changing spacetime in the environment of the electron. Future experiments can be designed to differentiate these differences. See below. If the particles (electron) is not fundamental, the EM force carrier is between fundamental components within the particle. However, since mass of fundamental particles such as electrons is considered to be invariant, electrons are theorized to be fundamental particles.

Stability of interaction of EM force between the positive charges of a nucleus and negative electron charge is modeled as dynamic multiple, three-dimensional, spacetime generation in equilibrium with spacetime elimination for a given number of relationships in any given orbital [11]. The result is a three-dimensional interference pattern at the spacetime orbital of the electron resulting in the observed probability distribution of an electron position (a three-dimensional analogue equivalent to the two-dimensional probability distribution of an interference pattern in observations on a final detector screen in multi-slit systems) [56]. When spacetime is changed between the electron and nucleus, a new equilibrium is established. The average distribution pattern in spacetime between the nucleus and electron in the ground state orbital is constant and spherical (Bohr's orbital for hydrogen atom) [113].

Experiment: Determining mass of electrons in different orbitals would determine whether electrons are fundamental. If mass does not change, as is expected, electrons may be fundamental and indicate that the spacetime of the environment of the electron changed. However, a change in electron mass would indicate electrons are not fundamental. This would imply rest mass can change resulting in an electron orbital change. Most current models consider rest mass of fundamental particles are invariant which would imply that electrons are mass fundamental [114,115] and, therefore, change would occur in spacetime external to the electron.

For two unlike charged fundamental particles (or field interactions) the potential energy increases as distance (conventional observed length) progressively decreases between them. This is modeled as an exchange of symmetric virtual EM fields (virtual photons) where the energy of the interaction is proportional to the combined magnitude of charges. For simplicity, this model will consider only virtual photons with the same frequency from two paths, one from each particle to the other (at a given length between particles). Per this theory, the number of Planck states in the negative half wave cycle (equivalent to absorption), increases faster (asymmetrically) than the number of Planck states in the positive half wave cycle increase (equivalent to emission) as space between charges continuously decreases. Per the previous discussion, there are more anti-Panck states than positive Planck states. The increase in the number of Planck states in the negative half wave is compensated by an increase in the number of positive Planck states in the next wave resulting in progressively increasing EM wave frequency/energy as distance decreases. Per this theory, environmental spacetime between unlike charges decrease as more Planck states are transferred from the environment to the virtual photons between the charges at the higher frequency (or to more waves or both). The net number of Planck states in the environment plus waves between the charged particles is constant in this model. That is, given a constant spacetime between the environment and virtual EM waves between unlike charges, as the environmental spacetime decreases, the wave spacetime (energy) increases. The opposite occurs with increased transfer of Planck states from virtual photon fields to the environment between like charges, decreased frequency of waves between charges (decreased virtual photon energy) resulting in increased space generated between like charged particles.

The number of Boltzmann state increments (space) at each instant (present) between charges can be determined for a given temperature, T. For N Boltzmann states between two electrons separated by $d = 3$ Angstroms in a vacuum N is determined from:

$E = k_{Coulomb} \frac{Q_1 Q_2}{d} = 7.67 \times 10^{-19} J, k_{Coulomb} = 9 \times 10^9 \frac{Kgm-m^3}{sec^4 \text{Area}^2}$.

For $E = Nk_B T : 7.67 \times 10^{-19} J = N(1.38 \times 10^{-23})T$ so $N = \frac{5.6 \times 10^4}{T}$.

As length increases the number of Boltzmann states generating space decreases and energy decreases. That is, the number of linear relationships between charged particles decreases so local space decreases even as conventional measure of length increases. That is, the fewer number of relationships results in a decrease in the number of relationship changes between the charges which is associated with a lower EM virtual photon frequency between charges.

4.15.2. Strong Force:

Per this theory, bidirectional transfer of gluons generates color spacetime in subnuclear particles while striving to maintain quark color neutrality without net color transfer between the environment outside of the subnuclear particles. In analogy to fundamental particles such as an electron previously discussed, if quarks emit and absorb color, they may not be fundamental with respect to color. If the change is in the environment of the quark, and not internal to the quark, than they are fundamental particles with respect to color. The domain of each color is all possible binary color interactions (superposition) mediated by gluons until observed (absorbed) color space is changed in two or three quark systems in mesons or baryons, respectively.

Per this theory, gluon exchanges require dynamic, multiple, bidirectional continuous processes of color transfer between quarks to maintain quark color neutrality. Each set of binary relationships is a configuration in the subatomic particle that has a given probability of existing in the present (color space) and has a probability of changing to another configuration (color time). Gluon emission and absorption can keep the same colors or change the color of the emitting quark and the environmental quark/color interaction, resulting in a change at the "absorbing" quark color. As an example, a Blue-Anti-Red gluon can be emitted changing color in the emitting and absorbing quarks. To maintain color neutrality, either other color sources must be added or removed from the environment or there is a continuous exchange of color between quarks. However, in this model, quarks outside the subatomic particle system do not affect the system's internal states.

Superposition between gluon color interaction for baryons [92] can be modeled as a two-dimensional three gluon color system within each of the three quarks [116]. One change results in a cascade of multiple changes which is required to maintain color neutrality. That is, the two-dimensional model (illustrated below) requires constant gluon exchange (color time generation) to maintain color neutrality at each node (quark).

The color distinguishable states are Red (R), Green (G), Blue (B). Binary interaction between the same colors within one quark is analogous to the distinguishable case in multi-slit systems. The binary distinguishable states for each color (designated by "c") relationship for c1 and c2 are c1↔c1 and c2↔c2. Within each quark (intraquark), there are 3 distinguishable color states, 0^o phase difference. For the right quark, these are $R_r \leftrightarrow R_r$, $G_r \leftrightarrow G_r$, $B_r \leftrightarrow B_r$ (9 distinguishable states for the 3 quarks). There are also indistinguishable states between different colors in each quark. Per this theory, pre-emission

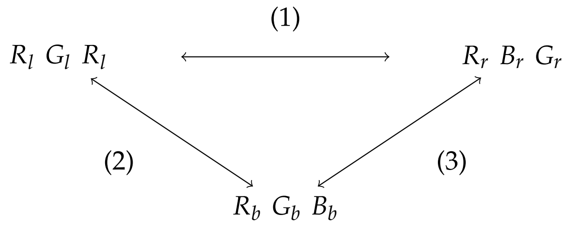

Figure 3. Two-dimensional representation of gluon color exchange in a three-quark system. The nodes represent quarks (labeled as left, right, and bottom) with their respective color states (R=Red, G=Green, B=Blue). Bidirectional arrows (1,2,3) indicate continuous gluon exchange required for color neutrality maintenance. Each quark maintains a three-color composition (RGB) with specific positional subscripts (l,r,b) denoting spatial configuration within the baryon structure.

of a gluon, all binary possible color relationships between the same color or unlike colors between different quarks are separate indistinguishable cases (superposition). That is, superposition is modeled to exist between 1) each possible interaction between unlike R, B, G colors within each quark (intraquark) and 2) interaction between each R, B, G color of the other quarks in its domain (interquark) within one subnuclear particle. In analogy to double slit systems, there are four states for each binary color interaction. The binary indistinguishable superposition relationships for two colors are between c1 and c2 and simultaneous relationships between c2 and c1: c1→c2, c2→c1. For example, Blue left is one distinguishable relationship ($B_l \rightleftarrows B_l$), Red Right is another distinguishable relationship ($R_r \rightleftarrows R_r$) and the superposition (indistinguishable) relationships are ($B_l \rightarrow$ anti-R_r, anti-$R_r \rightarrow B_l$). This results in substitution of B for R and R for B in two different quarks which would violate color neutrality so additional quark color changes in the l and r quarks are required to maintain color neutrality, a cascade of changes.

Different color increments may exist for exchange between different colors in gluons from different quarks affecting the observed gluon probability distribution so the probability of observing color-anti-color observations may vary for each combination similar to the change in observed probability for unequal-sized slits in double slit system. Also, the energy increment of color observer reset/observation may be different than Boltzmann or Planck state increments, that is, a different incremental color energy relationship (different cell size).

There are $N = 9$ colors in three quarks, 9 distinguishable states and $N(N-1) = 72$ indistinguishable states ($N^2 = 81$ total states). Unlike EM force where one charge exists between the same type particles so only one type of energy exchange (charge) is required, there are three colors for the strong force, charge equivalents, between three different quarks, electron equivalent, resulting in the 72 types of indistinguishable energy exchanges between unlike colors in the same quark or between unlike quarks, i.e., 81 different possible energy exchanges per baryon. Since exchange of color may occur between different subnuclear particles (protons and neutrons), and multiple sub-exchange loops between color exchanges, the number of states may be much larger. The larger number of possible indistinguishable states than distinguishable states result in a greater energy contribution to the subnuclear particle from the emitted indistinguishable gluon states than the energy in distinguishable quark states. That is, gluon exchange between quarks contribute a greater percentage of the energy to a subnuclear particle than quark energy, as has been theorized [117]. The rapid, constantly changing gluon exchange occurs in the short distances between quarks [118] so there is a large magnitude time and, therefore, spacetime generation, a large energy, observed as a strong force (dense gluon spacetime between quarks). Quarks are very closely spaced so a high frequency wave would be required to interact with both quarks, analogous to an external wave interacting between two closely spaced slits separated by approximately the wavelength of the source in double slit systems.

Superposition states in mesons are different than superposition states in baryons. Color and anti-same color states exist to maintain color neutrality [119]. In this model, meson's superposition (indistinguishable) states are between two distinguishable states of each color: R_r $\leftrightarrow$anti-R_r, G_r $\leftrightarrow$anti-G_r, B_r $\leftrightarrow$anti-B_r. There are, for example, no Red-anti-Blue states. Information that only two states exist with one relationship is available in mesons, similar to entangled spin states, so only one bit of additional information between quarks is required to have complete information between the two states. The one relationship is the color of the quark (R,G,B) existing simultaneously with its anti-same color (analogous to spin+ and spin-). The additional bit occurs at emission (equivalent to observing either of the possible entangled spin states), so information is complete (two bits of information for two possibilities). However, unlike entanglement where, after observation, entanglement is not reestablished between the two previously entangled states, color superposition is reestablished after color observations (after gluon transfer) since the quarks continues to have the ability to interact with each other.

4.15.3. Weak Force

Flavor (6 flavors) are also associated with quarks. Weak force carrier's interaction is mediated by Z^o and $W^{\pm}$ particles, generating a "flavor spacetime." The change due to flavor in quarks is unique since this is the only force that changes the identity of a particle resulting in a transfer (time) of energy (mass) to the external environment in radioactive decay. There are, then, spacetime change in the particle and the external environment [120]. For example, at radiation decay, the emitted indistinguishable states generate internal changes (neutron is transformed to a proton in beta decay) and external spacetime (electron and electron neutrino emission in beta decay).

To emit a relatively massive $Z^o/W^{\pm}$ particle equivalent would require relationship changes. The number of Boltzmann states in a $W^{\pm}$ force carrier, m_W, for $E_W = 80\text{Gev}$ [121,122], can be determined from: $E_W = 80\text{Gev} = N_W k_B T = N_W \left(1.38 \times 10^{-23} \frac{J}{K}\right) T$, $N_W \approx \times 10^{15} \left(\frac{1}{T}\right)$, which would indicate the weak force is a function of internal temperature. See previous discussion of internal subatomic temperature. The weak force is theorized to separate from electroweak epoch at a temperature of $\approx \times 10^{15}$K [123]. Since $N_W \approx \times 10^{15} \left(\frac{1}{T}\right)$, this would occur when $n_W \approx 1$, that is, the initial strong force carrier particle is an individual Boltzmann state. The Z^o boson mass is 90Gev, similar to $W^{\pm}$ force carriers. At the epoch, the difference could be related to different internal temperature at separation from the electroweak epoch for $W^{\pm}$ and Z^o particles. Both particles could then be considered to initially be fundamental particles, consisting of one Boltzmann fundamental mass.

After the electroweak epoch, as temperature decreased, the weak force bosons consisted of multiple Boltzmann state. Therefore, the mechanism for radioactive decay [56] involve multiple Boltzmann simultaneous state changes in the internal subatomic environment transferring energy to the local environment. Each of the six flavors are associated with quarks and, in this theory, are distinguishable states with superposition, indistinguishable states between them, i.e., superposition exists between sets of flavors. When a W^- boson is emitted or a W^+ boson is absorbed, a d (down), s (strange) or b (bottom) quark systems with $-\frac{1}{3}$ charge is converted to a quark system with u (up), c (charm) or t (top) quarks with $+\frac{2}{3}$ charge. There is a degeneracy in this reaction so superposition exists between these two quark systems. For example, any of the up system quarks can be become a down quark system with W^+ bosons emission or W^- boson absorption; taking only d flavor, the superposition states are d$\leftrightarrow$u, d$\leftrightarrow$c and d$\leftrightarrow$t. This can be modeled as three double slit systems between unequal size slits (that reflect different probabilities of interaction). There is a theorized change in the ratio between distinguishable and indistinguishable states where the energy of multiple indistinguishable binary states emitted to the internal subatomic particle environment is equal to or greater than the energy equivalent of the emitted Z^o or $W^{\pm}$ force carrier particles.

As is the case for the strong force, weak force incremental change may be different than Planck or Boltzmann state increments. However, based on the previous discussion of the similarity between Boltzmann states and, considering only the mass changes at the electroweak epic mass changes, Boltzmann states is theorized to be the increment cell size. Also, different "flavor" interactions result in different probabilities of change. The weak force distance is shorter than even the strong force [124,125] so there would be more time generation than in the strong force resulting in even a greater flavor spacetime energy.

4.15.4. Gravity:

Unlike any of the other force carriers that can be modeled to exist independent of the other carriers, gravity interacts with these other force carriers which requires a different model for the mechanism of gravity, i.e., gravity cannot be modeled independently in contrast to the other fundamental forces post-epoch separation. Gravity is related to each of the other forces since all the other forces depend on mass, the basis of gravity. Any change in the magnitude or distribution of the other force carriers is theorized to generate gravitational waves [60]. Radiated gravitational energy is a small fraction of the energy change of the force generating the gravity and the changes are bilateral so the net change is even smaller. That is, all force carriers generate their own spacetime and simultaneously generate gravitational spacetime as they change so gravity waves are generated by changes in atomic and even subatomic particle's local energy changes. Subatomic particles, even though they are small, are speculated to have high mass density and curve local spacetime at a microlevel at their boundary [126] resulting in a local gravitational effect and changes in the gravitational effect commensurate with changes in the subatomic particle. A static or symmetric system such as a non-changing mass, including non-changing internal states (no non-gravitational force carrier changes so is not a physical system), will not generate gravitational waves. The "value" change in the force carriers due to a redistribution of mass/energy (spacetime change) whether at the subatomic or large astronomical events will alter gravitational spacetime. The information of the "value" change, an event, will be communicated (transferred) at the speed of light [P-1] and affect the spacetime of distant masses. Since gravity, per this formulation, is a result of energy changes, it is related to time generation and, therefore, gravity relates space (mass) to time, generating gravitational background spacetime.

Unlike bilateral interactions between the environment and states in other forces, such as positive and negative charges, gravitational waves are the environment, generated by all the other force carriers. Since gravity does not exist independent of other force carriers, they cannot be modeled like other force carriers. This may be the origin of the theorized graviton spin 2 gravity boson force carriers which incorporates the effect of simultaneous spin of the other force carriers (so is a multiple of each of the other spins) and requires a model different than EM waves [73,127]. Since spin 2 particles repeat every 180^o, not 360^o for bosons or 720^o for fermions, a graviton spin can be considered a subset of the other spins. They continuously and unidirectionally change environmental spacetime as they propagate, not cyclically changing spacetime as in a complete EM wave or fermion period (positive and negative partial waves), i.e., gravitons return to their initial state every 180^o. Therefore, unlike EM or deBroglie waves, there is no positive and negative wave superposition so the phase differences between waves cannot interfere or cancel. A model of spin 2 waves is a wave that rotates 180^o and then reverses so the next wave is the mirror image of the previous wave. Graviton generation can be modeled as a spacetime emission radiated to the environment from discrete changes in atomic and subatomic particles that then propagates. Therefore, although the energy of a graviton is small [127,128], the accumulated energy for the constantly increasing positive graviton spacetime effect is considerable.

Even though gravitational energy increases environmental spacetime, it is attractive between two masses, that is, decreasing length between the masses. The attraction of two masses per this theory is modeled as a distortion of spacetime between the two masses that manifest as squeezed spacetime between masses which is offset by a perpendicular expansion of spacetime so spacetime is conserved [129]. Greater density of relationships (increased number of states) increases spacetime density within a mass, a larger number of "comparable" states that can interact with "incomparable" environmental space at the generated boundary (limited at the black hole density for a given mass). As the density of the four forces increases (increased storage of states) within a boundary, the number of changes increase which is radiated symmetrically and observed externally as a continuously changing distortion (acceleration) of spacetime, greater conventional dimensional changes per bit space change as the "value" of the change radiates. That is, the effect on external interactions changes omni-directionally as conventional dimensions increase from the origin of the change described by General Relativity. There are changes in space expansion and simultaneous changes in cell size that result in a theorized change in change of spacetime (acceleration of entropy). The same number of changes are radiating, increasing cell size of each initial bit (rate of change of initial entropic change) as it radiates increasing length but at a decreasing rate changing the effect of acceleration of spacetime (decreasing the effect of gravitational force on external matter/waves entering the gravitational field at increased distance from the source) [11]. There is a change in the number of configuration in conventional dimensions as the increment size changes and the increment size changes as the density of the mass changes and the distance from the mass resulting in the externally perceived change in spacetime. In summary, the environmental effect of each generated gravitational increment on adjacent spacetime radiates from the origin at the boundary at a decelerating rate observed as changes in the external environment spacetime. This gravitational accelerated vector field, generated by mass, influences any mass/wave that interacts with the field, i.e., affected by the gravitational potential field spatial gradient. It is dependent on the stress, pressure, shear and momentum in each generated spacetime region [130,131] in addition to the distributed matter that describes the generated spacetime curvature, the equivalence principle [132]. There is no background (invariant) spacetime as is evident by the effect on generated time in a gravitational field (observed duration change, time dilation) [133].

The geometry of spacetime generation results in varying the externally observed trajectory of mass/waves entering the field. A photon that enters a gravitational field generated by a large mass will follow the null geodesic trajectory [134]. Since gravitational waves can interact with all "incomparable" force carrier increments, spacetime generation by a large mass results in a large number of gravitational waves that affect the EM force. Even though gravitational energy is small, the accumulated effect of gravitational energy in a large mass can be comparable to the relatively larger EM energy and affect its observed trajectory. The low energy positive gravitational waves result in a small increase in the positive EM wave and an asymmetric larger energy (although still small) decrease in the negative EM wave resulting in the change in trajectory of the EM wave in a strong gravitational field as the EM waves transitions between smaller increments closer to the source of the gravitational waves.

The gravitational force, $F = G\frac{M_1 M_2}{r^2}$, per this theory, is interpreted as a result of the proportionality gravitational constant, G, multiplied by the mass equivalent of the number of Boltzmann states in each mass (M_1 consists of N_1 bits: $M_1 = N_1\frac{kT}{c^2}$ and mass, M_2, consists of N_2 bits: $M_2 = N_2\frac{kT}{c^2}$), divided by the square of the generated space between them. This can be considered as mass, M_1, affecting M_2 at distance r, $\frac{M_1}{r}$, and M_2 affecting M_1 at distance r, $\frac{M_2}{r}$, where the combined effect is proportional to $\frac{M_1 M_2}{r^2}$. The gravitational constant, G, in this formulation can be interpreted as the acceleration of the inverse density of spacetime: $\left(\frac{\text{m}^3}{\text{Kg}-\text{sec}^2}\right)$ or $G \propto \left(\frac{1/\rho}{\text{sec}^2}\right)$. This is a constant of the universe (that is a function of relationships and relationship changes in Planck and Boltzmann states) and is independent, therefore, of the attraction between the masses. Density is theorized to be average effect of the universe's mass in the volume of the universe. For the gravitational constant, G, the ratio of inverse density to sec^2 must remain constant. As the density increase, the accelerated inverse density decreases to maintain the constant G. Although this is a somewhat abstract concept (volume per mass) for an increase in inverse density, the universe would be observed to expand at an accelerating rate, decreasing density. Local variations in density have a different local effect which is related to General Relativity.

Compared to equal masses at equal temperatures, gravitational attraction for equal masses at different temperatures increase when one mass is heated (increased number of internal interactions) while the other mass is cooled to approximately absolute zero (decreased number of internal interactions) which is attributed to the additional kinetic energy in the hotter mass. There would be a small difference in gravitational attraction from the equilibrium temperature case. These are interpreted here as an indication that internal interaction changes affect spacetime which affects gravity.

5. Verification of Theory:

5.1. Determination of energy change due to observer reset/observation:

1. For an enclosed isothermal chamber at temperature T containing a N multi-slit system with no path information observers (indistinguishable system), the energy change with the addition of N path information observers can be determined:

   Initial: $T = 10^6$, $N_i = 10^4$, $\Delta E_i = 0$J
   Final: $T = 10^6$, $N_f = 10^4$, $\Delta E_f = (N(N-1))k_B T \approx \times 10^{-9}$TJ

   A crystal may be used to generate a large number of slits and a CCD camera as observers.
2. For a large number N initial entangled spin states enclosed in an isothermal chamber at temperature T, with the addition of N spin observers (where, unlike multi-slit systems where superposition exists between binary slit combinations, superposition exists only between two states), the energy change can be determined:

   Initial: $T = 10^6$, $N_i = 10^4$, $\Delta E_i = 0J$
   Final: $T = 10^6$, $N_f = 10^4$, $\Delta E_f = 2Nk_B T \approx \times 10^{-13}$J

5.2. Time/duration in entanglement and observation:

An indication that time is local and dependent on relationship changes that is distinct from duration is that an observed change in completely entangled properties occurs approximately instantaneously between particles/properties separated by length whereas other changes between non-entangled particles/properties are observed as a transfer of "value" information at or up to the speed of light.

1. A method to evaluate this theory of time would involve using partially entangled particles/properties. The degree of particle/property entanglement can be determined from deviation from the expected $2\sqrt{2}$ of Bell's inequality [135]. The degree of entanglement ranges from zero entanglement where relationships between individual particles/properties are independent of each other to completely entangled where relationships include superposition states. For external observers determining minimal duration, $\Delta t_{\text{Duration}}$, for particles separated by Δx communicating via EM waves: $\Delta t_{\text{Duration}} = \frac{\Delta x}{c}$. For completely entangled relationship, when an external observer observes the state of one of the entangled particles/property, there would be an approximately instantaneous change in the other entangled particle/property, $\Delta t \approx 0$ duration (one space incremental change so there is approximately zero duration). Duration for relationships with partial entanglement can be modeled as being between no relationship and a completely entangled relationship so $\frac{\Delta x}{c} > \Delta t > 0$. Since partial entanglement may not be uniquely determined for one interaction, a statistical analysis will be required. Duration that is inversely proportional to the degree of entanglement would indicate time is dependent on changes in relationships.
2. The entangled observation is theoretically limited by observed time for observations (change in observer) which is theorized to require a minimum (one Boltzmann time increment) for a one bit change which can be determined experimentally. The observed change in the observer independent of the entangled change is theorized to occur within $\Delta t_{\text{Duration}} = \frac{1}{v} = \frac{4.8 \times 10^{-11}}{T}$ and be temperature dependent.

5.3. *Effect of number of relationship changes:*

A measure of the number of relationship changes that is correlated with observable changes in a property, an aging, compared to a control not experiencing relationship changes, not aging, would indicate that relationship changes generate local spacetime. For example, differences in duration between decays in radioactive atoms correlated with changes in the ratio between the number of distinguishable and indistinguishable states internal to the atomic nucleus would indicate local time is a function of relationship changes and types of relationship, mass in this case. The determination of this ratio is difficult, but there are other situations where changes in the ratio are more observable.

1. In a transition between two $9Be^{+}$ ground state hyperfine levels, the probability "decreases monotonically toward zero as n, the number of changes in relationship of observer goes to infinity [69]." This is a demonstration that increased number of changes in relationships in an external observer affects local time in the observed, that is, lower probability of observed external changes, increased duration between transitions. That is, an infinite number of changes (resets/observations) in the observer, infinite amount of time generation, results in no net observable external space change due to radioactive emission, infinite duration. Thus, time is different for the system (multiple internal changes with externally applied repetitive resets/observations) and third party observer of environmental interactions (no decay). As previously theorized [56], reset results in indistinguishable states transferred from the observed system to the local (intra-subatomic) environment of the system and observation results in indistinguishable state transfer from the same local environment to the observed system. This would be a continuous process in the case of infinite number of reset/observation changes in the observer. In practice, the reset rate cannot be infinite since it is limited by energy changes needed to reset the observer and uncertainty.

   An experiment to determine if parallel resets from N observers would result in an increase in duration between decays (Zeno effect) would indicate that the change in the observed is due to resets of the observer. This assumes there are multiple internal distinguishable and indistinguishable (Boltzmann states relationships for mass) states that can be reset by multiple parallel external observers. If N parallel resets have the same effect as serial changes up to a given N where additional parallel resets do not increase duration between decays then this would indicate how many distinguishable/indistinguishable state changes result in particle decay.
2. Since expectation value is a measure of the probability for change, it can be considered related to the probability for time generation per this theory. A greater probability of time generation would result in an increased probability of aging. Expectation values proportional to aging would indicate that change is related to time when determined for the same duration. No aging or no entropy change (such as a crystal at 0^{o}K) would be a reference for determining aging.
3. Demonstrating that different aging in each dimension for a given property that has components in each spatial dimension is proportional to the number of changes in the aging property of each dimension would indicate time is local. A source with asymmetrical radiation in different dimensions would result in asymmetric property changes in different dimensions, i.e., different aging in each dimension.

5.4. *Relationship between time changes and entropy in macroscopic systems:*

1. There is a coarse analogy between internal atomic quantum changes leading to radioactive decay and macroscopic changes due to metal fatigue. Both represent a mass distribution change within the system and, per this theory, involves internal entropic changes attributed to a change in the distribution of distinguishable and indistinguishable states. However, macroscopic changes in metal are observable. Duration, measured time between fatigue failure, is an indirect measure of entropy changes: "entropy generation can be used as a natural measure of fatigue degradation

[136]." Also, consistent with this model: "Entropy generation [change] at the fatigue fracture point has a constant value which is independent of geometry, stress state and loading frequency and directly related to material type [136]." This can be related to the present model where the greater the number of changes (greater time generation) leads to increased fatigue and the number of changes is related to the mass "type", different radioactive atoms.

2. Time and relationship changes have been demonstrated to be related to biologically perceived time. The changes in the brain are decreased, saving brain function (slower aging) during cooling of the brain in neurosurgical procedures [137] or after cardiac arrest [138] even though externally observed duration is not affected. Furthermore, people's perception of time has been shown to be related to physical changes in different regions of the brain and, therefore, different perceived physical time in these different regions, a local regionally-based activity [139,140].

5.5. Creation Dimension:

Dimensions are defined as what is necessary for existence. Newtonian mechanics is based on length, width, breath being the only requirements for something to exist. Einstein added time as a necessary requirement for existence. Unlike spatial dimensions that are bidirectional, time is only unidirectional (absolute value of number of changes) which results in the change of sign between spatial and temporal dimensions in determination of proper time, τ, in Special Relativity. An additional dimension is theorized here to be required for something to exist; it must be created and the minimal limit on spacetime generation is theorized to be in discrete increments of non-dimensional, normalized Planck states, h_{nor}, where $h_{\text{nor}} = \frac{\Delta E \Delta t}{h}$ as a standard of existence (value 1). That is, Planck states are interpreted as the minimum limit on generation (time) of relationships (space) in the physical universe (generated spacetime), a minimal energy $\times$ time change expressed non-dimensionally (h_{nor}:0 $\rightarrow$ 1). Unlike space which changes bidirectionally or time which changes unidirectionally, the creation dimension is an impulse. Without a change in time, Δt, and energy, ΔE, there is no creation (value 0). Planck states are indistinguishable states between temporal distinguishable states: one distinguishable state is not existence that temporally becomes a distinguishable state as existence. The temporal discrete relationships are observed as virtual particle generation (h_{nor}:0 $\rightarrow$ 1) and destruction (h_{nor}:1 $\rightarrow$ 0) function is a reversal of the creation function. Creation/destruction increases time as a change in space as relationships change (change in entropy).

Unlike the other dimensions that can be observed as being transferrable between each other, creation affects all the other dimensions simultaneously as a multiplicative factor. Since gravity is a result of changes, there would be no gravity generated without creation, i.e., gravity is not independent and is, thus, related to the creation function at and after the big bang. That is, the initial creation change from non-existence to existence, i.e., relationships that did not previously exist at the big bang, generated gravity and continues to do so with additional creation/destruction.

Consider the relationship between a creation dimension and current dimensions of length and duration for only one dimension, x:

x' - Observable dimension for observer at rest (post-creation)

x - Creation relationship (0 pre-creation, 1 post-creation)

$h_{\text{nor}} = \frac{\Delta E \Delta t}{h}$ – Normalized Planck state

$h_{\text{nor}-\alpha}$ is the normalized Planck states in each of the dimensions ($\alpha = x, y, z, t$)

Let n be the number of changes, then:

$$x' = n\frac{\Delta E \Delta t}{h}x \quad \text{where} \quad \frac{\Delta E \Delta t}{h} = [1,0] \text{ for } n = 0, 1, 2..., \infty \tag{71}$$

For one Planck state change, $n = 1$ (post-creation), $\Delta E \Delta t = h$, x changes from not being created to being created so $x' = x$, consistent with current observations, i.e., x' exists.

As previously discussed, uncertainty is a requirement for the creation dimension resulting in existence. That is, observers only observe that which exist, limited by a minimum change of at least one Planck state increment.

Including the creation dimension in proper time for Special Relativity:

$$\tau = fn\left(x, y, z, t, h_{\text{nor}-\text{x}}, h_{\text{nor}-\text{y}}, h_{\text{nor}-\text{z}}, h_{\text{nor}-\text{t}}\right) \tag{72}$$

so, a possible consideration is:

$$\tau^2 = (x^2 + y^2 + z^2 - c^2t^2)(h_{\text{nor}-\text{x}})\left(h_{\text{nor}-\text{y}}\right)(h_{\text{nor}-\text{z}})(h_{\text{nor}-\text{t}}) \tag{73}$$

This is summarized in the theorem: "If a certain one of the components of a 4-vector is 0 in every frame, then all force components are 0 in every frame [141]."

For $\frac{\Delta E_\alpha \Delta t_\alpha}{h} = 1$, $(\alpha = x, y, z, t)$, the results are the same as that of Special Relativity. However, a creation function may be generated with $n_\alpha \Delta E_\alpha \Delta t_\alpha > h$ where n_α is a different number of changes in the respective dimension. Therefore, the observed proper time in different dimensions would be different. The observed distribution of a radiating three-dimensional wave would be asymmetric. This asymmetry from creation results in different aging in each dimension of the three-dimensions (such as wave asymmetry). The asymmetry due to continuous asymmetric wave generation and that due to the creation function can be differentiated. The asymmetry due to continuous asymmetric wave generation would continuously change as measured by duration, whereas the asymmetry due to the creation function would result only from the origin of the wave, the initial change, not thereafter. Variations in observations of asymmetry as a one-time change in the origin as a function of different values of initial n_α would indicate that the creation function has a physical effect.

6. Conclusions

This theory is based on the relationship between time and entropy not only resulting in a qualitative arrow of time, but quantitative, which leads to the conclusion that relationships generate local space and changes in relationships, events, generate local time. Per this theory, events do not occur in spacetime but generate spacetime. There is no requirement for universal background space and time. Background space and time is a statistical average of the number of relationships and changes in the number of relationships an external observer counts between start and stop events using predetermined artificial standards, which is itself a measure of predetermined standards between start and stop events. (Turtles all the way down.) An indication that time is local and based on relationships is that local time is zero, always in the present, for propagating photons and pure crystals at $0^o K$ where there is net zero entropic change. This is different than the duration that external observers measure between counts of the number of artificially created increments (seconds).

Space, time, and the universe only exist where relationships exist. Time and space, per this theory, are local properties such as mass that incorporates other internal unique local relationships (space) and changes in relationships (time) as properties such as spin, charge, etc., a property spacetime. Observations, such as Bell's inequality, are attributed to local, nonlinear spacetime changes. The hidden variables are time and space. That is, particles are real between observations, even if created through field interactions. Experiments are proposed that would verify space is due to local relationships and time is a result of local relationship changes demonstrating that spacetime is local, nonlinear and, therefore, variable.

If local relationships do not exist (no space, no mass), time (change in relationships) does not exist so particles and any other property (such as spin or charge) that depend on a particle existing (created) as a result of the creation dimension (value 1), also does not exist. Outside the universe, relationships do not and cannot exist so there is no observable spacetime and the concept of the end or edge of the universe would be undefined.

This differentiates existence, the present universe, from non-existence, not of the present universe.

Author Contributions: All contributions by Martin Alpert. Martin Alpert agrees to published version.

Funding: No external funding.

Institutional Review Board Statement: Not Applicable.

Informed Consent Statement: Not Applicable.

Data Availability Statement: Not Applicable.

Acknowledgments: I would like to acknowledge the appreciation of the multiple conversations and help from the Late Professor Isaac Greber, the multiple conversations over the years with Yeheng Wu, PhD Physics and Jordan Lanctot, PhD Candidate in Physics.

Conflicts of Interest: Declare conflicts of interest or state "The authors declare no conflicts of interest." Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. Any role of the funders in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. If there is no role, please state "The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results".

Appendix A. Missing Information Applied to Complex Amplitude in Multi-Slit Systems

Appendix A.1. Introduction:

In multi-slit systems, probability of observation is based on the magnitude of the complex amplitude, i.e., product of a complex number $A = x + iy$ and its conjugate $A^* = x - iy$. The probability is $AA^* = x^2 + y^2$ which is real even though it is based on complex numbers since there is no missing information in the probability. Since both terms in the probability are squared, each term is binary, which is consistent with, and can be related to Born's Rule [142]. The effect of any equations that incorporate square or square root terms have a degree of degeneracy, i.e., two bits of information are necessary to differentiate between constants in the terms, similar to the requirement in double slit systems or spin systems. The complex number and its conjugate can be rewritten as a 90^o rotation of real and imaginary coordinates, so $A' = ix + y$, $A'^* = -ix + y$, has the same effect as $A = x + iy$ and $A^* = ix - y$, i.e., interchanging the real and imaginary parts cannot be differentiated from the observed probability amplitude. Each binary possible interaction is one state in multi-slit systems and is quantified as one Shannon bit of information [56,143].

The probability for each state (each term of the probability equation for a multi-slit system) is a result of the effect of the observed possible binary environmental interactions associated with that state as a fraction of the total number of possible binary interactions. The probability changes with the number of external observers relative to the maximum number of states with no observers in the system. If the number of observers equals the number of states, the information in the system (each binary interaction) is completely observable (the inputs can be reconstituted from the outputs). These are specified as distinguishable states where particle characteristics are observed in multi-slit systems. The information at each slit is maximized and the number of states in the system is minimized. If the number of states is greater than the number of observers (the inputs cannot be reconstituted from the outputs), specified as indistinguishable states, wave characteristics are observed in multi-slit systems. With no path information observers, the observational information at each slit is minimized and the number of observable states in the system is maximized. Based on the entropic model for quantum mechanics, the combined number of distinguishable and indistinguishable states maximize the multiplicity in the system at each instant of time [56]. When there are no observers or known relationships in the system, no information can be inferred about the system including its existence, which is at least one bit of information. In this work, at least one observer, a final detector screen (or equivalent), in multi-slit systems is assumed to exist and as such, an observation is in the real domain.

As observations are independent events, the probability for serial occurrences is multiplicative in time. The real terms are distinguishable (not in superposition) and are quantified as independent probabilities of environmental interactions at each slit. Superposition in general, and specifically in the indistinguishable (missing information) case for multi-slit systems, is based on parallel (simultaneous), and symmetrical (equal in magnitude and opposite in direction) dual binary interactions in space, quantified by imaginary terms, ixy and $-ixy$, a quantification of missing information. These are unobservable, hence imaginary, superposition terms for each possible binary interaction even though they have an observable effect (interference). In this case, the slit-slit interactions with an EM sinusoidal source wave are not observable so the phase difference can vary between 0^o and 360^o. The $+ixy$ and $-ixy$ terms do not apply when information is complete (no superposition).

Appendix A.2. Information Affects Probability Distribution:

In a N multi-slit systems, as path information observers are added up to N observers, the number of states is decreased (and therefore, probability amplitude per state increased), since information in the system is increased and is complete with N observers. Missing information is decreased, decreasing or eliminating imaginary terms, since, by adding observers, the possible binary unobserved slit-slit interactions are decreased.

To demonstrate that two bits are required to eliminate the binary imaginary terms due to missing information, consider $e^{i\theta} = \cos\theta + i\sin\theta$, where one value is determined by observation and the relationship between this value and the second value is known. The real and imaginary components are based on the same available information, θ, but from information of the real component ($\cos\theta$), the imaginary component ($\sin\theta$) cannot be determined. As such, $e^{i\theta}$ cannot be determined unless the trigonometric relationship between them is known which is a second bit of information. This is similar to an entangled spin system described in the body of the paper. That is, the effect of a known relationship as one bit of information is applicable to entangled spin+ and spin- states in superposition (spin-spin relationships) so only one observer and this known relationship (opposite spin) are necessary to determine the spin/environmental relationships eliminating spin entanglement. In the case of only one observer of the binary interaction and even if the binary relationships and the difference $(x_1 - x_2)$ or $(x_2 - x_1)$ are known as in formulas describing observations in double slit systems, for $e^{ip(x_1-x_2)/h} = \cos(p(x_1 - x_2)/h) + i\sin(p(x_1 - x_2)/h)$, missing information exists, since x_1 and x_2 cannot be uniquely determined. In double slit systems, this missing information results in the indistinguishable case (interference with wave characteristics).

Appendix A.3. Number of States in Multi-Slit Systems:

The total number of possible binary interactions (states) in multi-slit systems are the summation of all possible interactions within and between slits. Let N be the number of slits and k and l be components of the binary slit/environmental interactions with each slit. Binary interactions are between each k and l: $k = 1, 2..., N$, $l = 1, 2, ..., N$. In the distinguishable case (complete information), environmental binary interactions are only within each slit where $k = l$, so for N observers, there are N binary terms.

In the indistinguishable case with no path information observers (other than final detector screen or equivalent); there is incomplete information, environmental binary interactions are both within each slit as well as binary contributions between different slits. For N slits with no path information observers, there are N states for $k = l$ and $N(N-1)$ observers for $k \neq l$ so the total number of states is $N + N(N-1) = N^2$.

The probability of observing each source is one in an ideal system and is distributed equally (equally probable) among the maximum number of states for equal-sized slits in multi-slit systems.

Appendix A.4. Multi-Slit Distinguishable Case:

For one source in a N slit system and N path information observers, each possible slit-environmental interaction is observable. There are N^2 possible states when there is no information added to the system so the probability amplitude for each slit as a percentage of the total possible environmental interactions is minimized at $x^2 = \frac{1}{N^2}$. The y^2 term quantifies the effect of the increased probability as information is increased (missing information decreased) due to the added path information observers. The probability of observation of each state is increased since the number of states in the system is decreased. The probability of observing environmental interactions at the slit associated with the x term increases by $y^2 = \frac{N-1}{N^2}$ due to the not observed but observable possible interactions at other slits where information is complete. The probability of observation at each slit, based on the total information in the system, is $P_{N-\text{slit}_{\text{Distinguishable}}} = x^2 + y^2 = \frac{1}{N^2} + \frac{(N-1)}{N^2} = \frac{1}{N}$. Thus, since there are N possible interactions, the probability of observing each possible interaction is $\frac{1}{N}$. Each slit/environmental interaction is independent of other slit/environmental interactions. This is the classical case which is based on complete information existing. Distinguishable interactions, referred to as slit/environmental/observable-slit/environmental/observable interactions, are, in the ideal case, theorized binary, zero-phase difference interactions (designated by a dash, "-") between EM wave increments internal to the observed slit and no observed interaction at the other slits [56] for each emitted source (observed particle characteristics). As an example, the possible binary interactions for four slits ($N = 4$) with complete information (four observers), are: slit1-slit1, slit2-slit2, slit3-slit3, slit4-slit4. For $N = 4$: $P_{4-\text{slits}} = \left(\frac{1}{4}\right)^2 + \frac{(4-1)}{4^2} = \frac{1}{4}$.

Appendix A.5. Multi-Slit Indistinguishable Case:

The indistinguishable case is where information of possible observable slit/environmental interactions in the system is missing (number of states greater than number of observers) so information of all slit-environmental interactions for each source cannot be determined uniquely. This is the quantum mechanical case where superposition between distinguishable states exist resulting in observed wave characteristics. With no path information observers, there is no additional information in the system $\left(y^2 = 0\right)$, i.e., no decrease in the number of states and, therefore, no decrease in the minimum probability of interaction for each state. Since the total number of equally probable states is N^2, the probability of observing each state is $P_{\text{N}-\text{slit}_{\text{Indistinguishable}}} = \frac{1}{N^2}$. The possible indistinguishable binary not observable interactions are referred to as slit/environmental→slit/environmental (designated by an arrow, "→"). In the four-slit example, the possible indistinguishable binary not observable interactions, in addition to those of the distinguishable case are: slit1→slit2, slit1→slit3, slit1→slit4, slit2→slit3, slit2→slit4, slit3→slit4 and the associated symmetric simultaneous reverse interactions. There are 16 total possible interactions: 4 distinguishable interactions and 12 indistinguishable interactions and, therefore, the probability amplitude is $\frac{1}{16}$ for each possible interaction. Indistinguishable interactions are theorized non-zero phase difference interactions between binary EM wave increments exiting different slits (observed interference pattern) [56].

Appendix A.6. Multiple-Slit Combined Distinguishable and Partial Indistinguishable Case

As observers are added, the number of distinguishable states, N, does not change and for R added observers the number of indistinguishable states decrease and is $(N - R)(N - R - 1)$ [56]:

$$\text{Total Number of Possibilities (terms)} = N + (N - R)(N - R - 1) \text{for } R \leq N \quad \text{(A1)}$$

$$\text{Probability for each Possibility} = \frac{1}{N + (N - R)(N - R - 1)} \quad \text{(A2)}$$

The probability for each state in the system equals the minimum probability, $\frac{1}{N^2}$, plus the increase in probability due to available information at other states in the system, y^2. To determine y^2:

$$\frac{1}{N^2} + y^2 = \frac{1}{N + (N - R)(N - R - 1)} \quad \text{(A3)}$$

$$y^2 = \frac{R(2N - R - 1)}{N^2((N - R)^2 + R))} \quad \text{(A4)}$$

For a four-slit system (N=4), the number of states decrease from 16 to 4 as information is added:

R	x^2	y^2	Number of States	Probability for each state: $x^2 + y^2$	Decreased number of states
0	1/16	$1/16 - 1/16 = 0$	16	1/16	0
1	1/16	$1/10 - 1/16 = 6/160$	10	1/10	6
2	1/16	$1/6 - 1/16 = 10/96$	6	1/6	10
3	1/16	$1/4 - 1/16 = 3/16$	4	1/4	12
4	1/16	$1/4 - 1/16 = 3/16$	4	1/4	12

Table A1. State probability and distribution analysis

Since there is always one observer in the system (final detector screen or equivalent), complete information exists for R=4 and R=3.

Appendix A.7. Discussion:

I. Superposition and Symmetry: Superposition can be considered a symmetry (indistinguishability) in quantum relationships [144]. Symmetry change (breaking symmetry) only occurs when indistinguishable states change. In multi-slit systems, symmetry breaking is a change from wave characteristics (indistinguishability with missing information that incorporate imaginary terms) to particle characteristics (distinguishability with complete information with no imaginary terms) with the addition of external observer resets/observations. Thus, with the addition of path information observers, the number of symmetric (indistinguishable) interactions decrease, symmetry is broken. For a N slit multi-slit system, partial symmetry breaking occurs as path information observers are added (decrease number of binary indistinguishable states) up to N observers where symmetry breaking is complete. If the change is reversible (within the limits of uncertainty), the information that is lost in the broken symmetry is retrievable and the broken asymmetry can revert to the symmetric case, reversible symmetry breaking [30]. In multi-slit systems, the symmetry can be restored by reversal of the reset/observation process, i.e., energy addition in the observation/reset process. Post-observation in double-slit systems, the system reverts to the indistinguishable case. This is referred to previously as a reversible irreversible process. If the information is not retrievable, then the asymmetric case cannot revert to the symmetric case, non-reversible symmetry breaking. In entangled spin states, one observation uniquely determines the state of both spins which cannot be reversed for that pair of particle spin states. This is referred to previously as an irreversible irreversible process. The difference in reversibility for these two cases depends on whether the information that breaks symmetry is exclusively a result of reset/observation (double slit) or a combination of observation and known relationships (entangled spin) since known relationship cannot be restored.

II. Macroscopic Superposition: An analogy exists between superposition in macroscopic objects and superposition in quantum mechanics. Superposition in dice will be used as an example where the probability of observing a macroscopic face number in a dice has particle (distinguishable) characteristics. There are six distinguishable states in one dice: 6/1, 1/6, 3/4, 4/3, 2/5, 5/2. Each state has a dual component. That is, analogous to the known relationship between spin (dice faces), observation of one spin state (one dice face) instantaneously determines the other spin state (corresponding dice face). Post-observation for dice dependent environmental relationships between dice faces continue to exist unlike spin where there is no relationship of the previously entangled spin states. The indistinguishable dice states are those cases that incorporate the information of the observation as, for example, one dice face, but still has missing information of the other faces dual component interactions with the environment in the other two dimensions so the system's states cannot be reconstituted. For one observed dual state, the three dimensions consists of one dual component distinguishable state plus the indistinguishable states associated with each of the unobserved dual component relationships.

Comparison of states in dice and multi-slit and spin entangled systems:

1. Physical constraints on dice: Since independent face/environmental interactions do not exist, there are additional constraints so there is more information in the dice system resulting in 24 possible configurations (See Table 1). These are fewer possible configurations than in a six slit systems (36 possible relationships) that do not have these dimensional constraints. A dice system consists of three entangled states (1/6, 6/1; 3/4, 4/3; 2/5, 5/2). There are four states per entangled state. For example, if 6/1 is observed, there are 5/2, 4/3; 2/5, 4/3; 4/3, 2/5; 3/4, 5/2 possible states due to the missing information from the additional dimensions. For an x -dimensional dice system, the total number of states is $\left(2^{x-1}\right)(x!)$. There are $2x$ distinguishable states with $\frac{\left(2^{x-1}\right)(x!)}{2x}$ indistinguishable states per distinguishable states without additional observations (four indistinguishable states per dual distinguishable states for the three dimensions of the dice) .
2. With no observations of the dice face, there are 24 total possible configurations which reduce to 4 total states with one observation. For one observation, the five not observed distinguishable states are eliminated. In the six sided dice example, one bit of information is, for example, if a 6 is observed there is additional information that this is on the top of a three-dimensional dice system. Configurations 1-4 in Table 1 are the indistinguishable states associated with the (6/1) distinguishable state. With a second observer of another dimension without left/right information, two possibilities exist. If the dimensional right/left information in the second observer is available the combined observation results in one possible state (no indistinguishable states).

The observation of environmental interactions of dice is visual. Unlike a wave capable of interacting simultaneously with two slits, i.e., one observation cannot interact with two sides of the dice simultaneously. Rolling the dice is the source, equivalent to the EM wave source in multi-slit systems or the generation of the entangled state, but instead of a sinusoidal wave interacting with the slits or the relationship between entangled states and polarizers, the source is a response to the step energy transfer to the dice which results in no phase difference between dice indistinguishable states. A sinusoidal probability interference pattern is not generated, but changes in the probability of observation will be discrete, i.e., changes in the number of indistinguishable states is discrete.

Configuration #	Top/Bottom	Right/Left	Front/Back
1	6/1	5/2	4/3
2	6/1	2/5	3/4
3	6/1	4/3	2/5
4	6/1	3/4	5/2
5	1/6	5/2	3/4
6	1/6	2/5	4/3
7	1/6	4/3	5/2
8	1/6	3/4	2/5
9	3/4	1/6	5/2
10	3/4	6/1	2/5
11	3/4	2/5	1/6
12	3/4	5/2	6/1
13	4/3	1/6	2/5
14	4/3	6/1	5/2
15	4/3	2/5	6/1
16	4/3	5/2	1/6
17	2/5	4/3	1/6
18	2/5	3/4	6/1
19	2/5	6/1	4/3
20	2/5	1/6	3/4
21	5/2	4/3	6/1
22	5/2	3/4	1/6
23	5/2	6/1	3/4
24	5/2	1/6	4/3

Table A2. Multiplicity configurations (W = 24)

References

1. Young, H.D.; Freedman, R.A.; Sandin, T.; Ford, A.L. *University physics*; Vol. 9, Addison-Wesley Reading, MA, 1996; p. 764.
2. Carnot, S.; Thomson, S.W.; Carnot, H.; Thurston, R.H. *Reflections on the Motive Power of Heat*; John Wiley & Sons: New York, 1897. Progress: Done—All pages of the work proper are validated. Transclusion: Fully transcluded. Validated in: January 2018.
3. Fox, R. Reflexions on the Motive Power of Fire: A Critical Edition with the Surviving Scientific Manuscripts **1986**.
4. Clausius, R. "Uber eine ver"anderte Form des zweiten Hauptsatzes der mechanischen W"armetheorie. *Annalen der Physik* **1854**, *169*, 481–506.
5. Clausius, R. X. On a modified form of the second fundamental theorem in the mechanical theory of heat. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* **1856**, *12*, 81–98.
6. Clausius, R. *The Mechanical Theory of Heat: With Its Applications to the Steam-engine and ...*; J. Van Voorst: London, 1867; p. 401. Memoirs reprinted from the Philosophical Magazine, translated from German originals published in various sources. Book digitized by Google from the library of Harvard University and uploaded to the Internet Archive by user tpb. Possible copyright status: NOT_IN_COPYRIGHT.
7. Faye, J. Copenhagen Interpretation of Quantum Mechanics **2019**. Available online: https://plato.stanford.edu/entries/qm-copenhagen/.
8. Einstein, A.; Podolsky, B.; Rosen, N. Can quantum-mechanical description of physical reality be considered complete? *Physical review* **1935**, *47*, 777.
9. Genovese, M. Research on hidden variable theories: A review of recent progresses. *Physics Reports* **2005**, *413*, 319–396.
10. Shannon, C.E. *The mathematical theory of communication, by CE Shannon (and recent contributions to the mathematical theory of communication), W. Weaver*; University of illinois Press Champaign, IL, USA, 1949.
11. Alpert, M. A Quantum-Based Model for Internal Characterization of Electromagnetic Waves. Manuscript submitted.
12. Ptahhotep.; Hilliard, A.G.; Williams, L.O.; Damali, N. *The teachings of Ptahhotep: The oldest book in the world*; Blackwood Press, 1987.
13. Thompson, R.L. Mysteries of the Sacred Universe. *The Cosmology of the Bhâgavata Purâna. Alachua, Florida: Goverdhan Hill Publishing* **2000**, p. 225.
14. Runes, D.D. *The dictionary of philosophy*; Citadel Press, 2001; p. 318.
15. Rovelli, C. *The order of time*; Penguin, 2019.
16. Augustine, S. *The Confessions of Saint Augustine*; Sacred-texts.com, 1909-1914. Book XI, Chapter 6.
17. Galilei, G. *Discorsi e dimostrazioni matematiche: intorno à due nuoue scienze, attenenti alla mecanica & i movimenti locali... Con una appendice del centro di grauità d#39;alcuni solidi*; Appresso gli Elsevirii, 1966.
18. Hawking, S. *On the shoulders of giants: The great works of physics and astronomy*; 2002.
19. Plato. *Timaeus and Critias*, paperback ed.; Penguin Classics: New York, 2008. Published on November 25, 2008.
20. El-Bizri, N. IN DEFENCE OF THE SOVEREIGNTY OF PHILOSOPHY: AL-BAGHDĀDĪ#39;S CRITIQUE OF IBN AL-HAYTHAM#39;S GEOMETRISATION OF PLACE. *Arabic Sciences and Philosophy* **2007**, *17*, 57–80.
21. Huggett, N. *Space from Zeno to Einstein: classic readings with a contemporary commentary*; MIT Press, 1999.
22. Dainton, B. *Time and space*; Routledge, 2016.
23. Sorell, T. Descartes: A very short introduction **1987**.
24. Vailati, E. *Leibniz and Clarke: A study of their correspondence*; Oxford University Press, 1997; p. 115.
25. Sklar, L. Philosophy of Physics (Boulder, 1992.
26. Newton, I. *The Mathematical Principles of Natural Philosophy*; B. Motte: London, 1729. Public Domain Mark 1.0, Creative Commons License.
27. Clarke, S.; von Leibniz, G.W.F. *The Leibniz-Clarke Correspondence: Together Wiith Extracts from Newton#39;s Principia and Opticks*; Manchester University Press, 1956; pp. 55–96.
28. Immanuel, K.; et al. Critique of pure reason **1855**.
29. Ciufolini, I.; Wheeler, J.A. *Gravitation and inertia*; Princeton university press, 1995.
30. Carnot, S. *R'eflexions sur la puissance motrice du feu*; Number 26, Vrin, 1978; p. 5.
31. Barbour, J. Time#39;s Arrow and Simultaneity: A Critique of Rovelli#39;s Views. *arXiv preprint arXiv:2211.14179* **2022**.
32. Wolchover, N. A Physicist’s Physicist Ponders the Nature of Reality. *Quanta Magazine* **2017**. Senior Editor, Quanta Magazine.
33. Seiberg, N. Emergent Spacetime. In Proceedings of the The Quantum Structure of Space and Time. WORLD SCIENTIFIC, 2007, p. 163–213. https://doi.org/10.1142/9789812706768_0005.
34. Becker, K.; Becker, M.; Schwarz, J.H. *String theory and M-theory: A modern introduction*; Cambridge university press, 2006.
35. Smolin, L. *Three roads to quantum gravity*; Hachette UK, 2008.
36. Rovelli, C. Loop quantum gravity. *Living reviews in relativity* **2008**, *11*, 1–69.
37. Rovelli, C.; Smolin, L. Discreteness of area and volume in quantum gravity [Nucl. Phys. B 442 (1995) 593]. *Nuclear Physics B* **1995**, *456*, 753–754.
38. Rovelli, C. The thermodynamic cost of choosing. *Foundations of Physics* **2024**, *54*, 28.
39. Rovelli, C. How causation is rooted into thermodynamics. *arXiv preprint arXiv:2211.00888* **2022**.
40. Rovelli, C. The relational interpretation of quantum physics. *arXiv preprint arXiv:2109.09170* **2021**.
41. Martin-Dussaud, P.; Rovelli, C.; Zalamea, F. The notion of locality in relational quantum mechanics. *Foundations of Physics* **2019**, *49*, 96–106.

42. Rovelli, C.; Vidotto, F. Pre-big-bang black-hole remnants and past low entropy. *Universe* **2018**, *4*, 129.
43. Rovelli, C. Relative information at the foundation of physics. In *It From Bit or Bit From It? On Physics and Information*; Springer, 2015; pp. 79–86.
44. Ginsparg, P. Applied conformal field theory. *arXiv preprint hep-th/9108028* **1988**.
45. Sokołowski, L.M. The bizarre anti-de Sitter spacetime. *International Journal of Geometric Methods in Modern Physics* **2016**, *13*, 1630016. https://doi.org/10.1142/s0219887816300166.
46. Surya, S. The causal set approach to quantum gravity. *Living Reviews in Relativity* **2019**, *22*, 1–75.
47. Craig, W. The Tenselesss Theory of Time: A Critical Examination, 2000.
48. McTaggart, J.E. The unreality of time. *Mind* **1908**, pp. 457–474.
49. Hawley, K. Temporal parts **2004**.
50. of Weights, I.B.; Measures.; Taylor, B.N.; Thompson, A. *The international system of units (SI)*; US Department of Commerce, Technology Administration, National Institute of ..., 2001.
51. Proceedings of the 17th General Conference on Weights and Measures (CGPM), Resolution 1. In Proceedings of the Proceedings of the 17th CGPM (1983). General Conference on Weights and Measures, 1984, p. 97. https://doi.org/10.59161/CGPM1983RES1E.
52. Young, T. I. The Bakerian Lecture. Experiments and calculations relative to physical optics. *Philosophical transactions of the Royal Society of London* **1804**, pp. 1–16.
53. Frabboni, S.; Frigeri, C.; Gazzadi, G.; Pozzi, G. Four slits interference and diffraction experiments. *Ultramicroscopy* **2010**, *110*, 483–487.
54. Yin, J.; Cao, Y.; Yong, H.L.; Ren, J.G.; Liang, H.; Liao, S.K.; Zhou, F.; Liu, C.; Wu, Y.P.; Pan, G.S.; et al. Bounding the speed ofspooky action at a distance39;. *arXiv preprint arXiv:1303.0614* **2013**.
55. Rovelli, C. *Quantum spacetime*; Springer, 2014.
56. Alpert, M. A new statistical thermodynamic mechanism for quantum mechanics. *Frontiers in Physics* **2022**, *10*, 1014602.
57. Verlinde, E. On the origin of gravity and the laws of Newton. *Journal of High Energy Physics* **2011**, *2011*, 1–27.
58. Shannon, C.E. A mathematical theory of communication. *The Bell system technical journal* **1948**, *27*, 379–423.
59. Newton Potential. *Encyclopedia of Mathematics*. Accessed December 6, 2024.
60. Blandford, R. Astrophysical black holes. *Three hundred years of gravitation* **1989**, p. 277.
61. Dai, D.C.; Stojkovic, D. Superluminal propagation along the brane in space with extra dimensions. *The European Physical Journal C* **2024**, *84*, 1–7.
62. Magueijo, J. New varying speed of light theories. *Reports on Progress in Physics* **2003**, *66*, 2025.
63. Minkowski, H. Die Grundgleichungen f"ur die elektromagnetischen Vorg"ange in bewegten K"orpern. *Nachrichten von der Gesellschaft der Wissenschaften zu G"ottingen, Mathematisch- Physikalische Klasse* **1908**, *1908*, 53–111.
64. Tolman, R.C. *Relativity, thermodynamics, and cosmology*; Courier Corporation, 1987.
65. Kalies, G. A solution of the interpretation problem of Lorentz transformations **2020**.
66. Mach, E. *The science of mechanics: A critical and historical exposition of its principles*; Open court publishing Company, 1893.
67. Oas, G. On the abuse and use of relativistic mass. *arXiv preprint physics/0504110* **2005**.
68. Resnick, R. *Introduction to special relativity*; John Wiley & Sons, 1991.
69. Itano, W.M.; Heinzen, D.J.; Bollinger, J.J.; Wineland, D.J. Quantum zeno effect. *Physical Review A* **1990**, *41*, 2295–2300.
70. Francis, M. Quantum entanglement shows that reality can't be local. *Ars Technica* **2012**, *30*.
71. Wheeler, J.A.; Zurek, W.H. *Quantum theory and measurement*; Vol. 81, Princeton University Press, 2014.
72. Jacques, V.; Wu, E.; Grosshans, F.; Treussart, F.; Grangier, P.; Aspect, A.; Roch, J.F. Experimental realization of Wheeler39;s delayed-choice gedanken experiment. *Science* **2007**, *315*, 966–968.
73. Bell, J. *Quantum (Un) speakables: From Bell to Quantum Information*; Springer Science & Business Media, 2002.
74. Young, H.D.; Freedman, R.A.; Ford, A.L. *University physics with modern physics*; Vol. 191, Pearson San Francisco, 2020; p. 1093.
75. Clauser, J.F.; Horne, M.A.; Shimony, A.; Holt, R.A. Proposed experiment to test local hidden-variable theories. *Physical review letters* **1969**, *23*, 880.
76. Sadiq, M. Counting the Microstates at the Black Hole Horizon and the Immirzi Parameter of Loop Quantum Gravity. *Journal of Applied Mathematics and Physics* **2020**, *8*, 2055–2062.
77. Susskind, L. *The black hole war: My battle with Stephen Hawking to make the world safe for quantum mechanics*; Hachette UK, 2008.
78. Bekenstein, J.D. Black holes and entropy. *Physical Review D* **1973**, *7*, 2333.
79. Pohv, B.; Rith, K.; Scholz, C.; Zetsche, F. Particles and Nuclei, 2002.
80. Lattimer, J.M. Introduction to neutron stars. In Proceedings of the AIP Conference Proceedings. American Institute of Physics, 2015, Vol. 1645, pp. 61–78.
81. Merli, P.G.; Missiroli, G.F.; Pozzi, G. On the statistical aspect of electron interference phenomena. *Am. J. Phys* **1976**, *44*, 306–307.
82. Tonomura, A.; Endo, J.; Matsuda, T.; Kawasaki, T.; Ezawa, H. Demonstration of single-electron buildup of an interference pattern. *Am. J. Phys* **1989**, *57*, 117–120.
83. Kaxiras, E. *Atomic and electronic structure of solids*; 2003; pp. 65–69.
84. Ohanian, H.C. What is spin. *Am. J. Phys* **1986**, *54*, 500–505.
85. Staley, M. Understanding quaternions and the Dirac belt trick. *European journal of physics* **2010**, *31*, 467.
86. Steane, A.M. An introduction to spinors. *arXiv preprint arXiv:1312.3824* **2013**.

87. Feynman, R.P. *Feynman lectures on computation*; CRC Press, 2018.
88. Genz, H. *Nothingness: the science of empty space*; Hachette UK, 2009.
89. Shestakova, T. The Wheeler-DeWitt Quantum Geometrodynamics: its fundamental problems and tendencies of their resolution. *arXiv preprint arXiv:0801.4854* **2008**.
90. Feynman, R.P.; Hibbs, A.R.; Styer, D.F. *Quantum mechanics and path integrals*; Courier Corporation, 2010.
91. Milonni, P.W. *The quantum vacuum: an introduction to quantum electrodynamics*; Academic press, 2013.
92. Griffiths, D. *Introduction to elementary particles*; John Wiley & Sons, 2020.
93. Baccetti, V.; Visser, M. Infinite shannon entropy. *Journal of Statistical Mechanics: Theory and Experiment* **2013**, *2013*, P04010.
94. Schutz, B. *A first course in general relativity*; Cambridge university press, 2022.
95. Parker, L. Particle creation and particle number in an expanding universe. *Journal of Physics A: Mathematical and Theoretical* **2012**, *45*, 374023.
96. Harko, T. Thermodynamic interpretation of the generalized gravity models with geometry-matter coupling. *Physical Review D* **2014**, *90*, 044067.
97. Brandenberger, R.; Delgado, P.C.; Ganz, A.; Lin, C. Graviton to photon conversion via parametric resonance. *Physics of the Dark Universe* **2023**, *40*, 101202.
98. Cardenas, V.H. Dark energy, matter creation and curvature. *The European Physical Journal C* **2012**, *72*, 1–6.
99. Guth, A. Phase transitions in the very early universe, in "The very early universe"(GW Gibbons, SW Hawking, STC Siklos, Eds.) pp. 171–204, 1982.
100. Bridge, M. First Second of the Big Bang. How The Universe Works. Silver Spring, MD. *Science Channel*.
101. Nave, R. Big Bang Models Back to Planck Time. *HyperPhysics, Department of Physics and Astronomy, Georgia State University*, 2020. Accessed April 28, 2020.
102. Davies, C.; McNeile, C.; Wong, K.; Follana, E.; Horgan, R.; Hornbostel, K.; Lepage, G.; Shigemitsu, l.f.J.; Trottier, H.; Collaboration), H. Precise charm to strange mass ratio and light quark masses from full lattice QCD. *Physical review letters* **2010**, *104*, 132003.
103. Ju, A. Researchers Pin Down the Elusive Masses of Up, Down and Strange Quarks. *Cornell Chronicle* **2010**.
104. Fromerth, M.J.; Kuznetsova, I.; Labun, L.; Letessier, J.; Rafelski, J. From quark-gluon universe to neutrino decoupling: 200lt; Tlt; 2MeV. *arXiv preprint arXiv:1211.4297* **2012**, p. 8.
105. Allday, J. *Quarks, leptons and the big bang*; CRC Press, 2016.
106. Freedman, R.; Geller, R.; Kaufmann, W.J. *Universe: The solar system*; Macmillan, 2010.
107. Longair, M.S. Galaxy formation. *Evolution of Galaxies Astronomical Observations: Proceedings of the Astrophysics School I, Organized by the European Astrophysics Doctoral Network at Les Houches, France, 5– 16 September 1988* **2005**, pp. 1–93.
108. Direct neutrino-mass measurement with sub-electronvolt sensitivity. *Nature Physics* **2022**, *18*, 160–166.
109. Castelvecchi, D. How light is a neutrino? The answer is closer than ever. *Nature* **2022**.
110. Beringer, J.; Arguin, J.; Barnett, R.; Copic, K.; Dahl, O.; Groom, D.; Lin, C.; Lys, J.; Murayama, H.; Wohl, C.; et al. Review of particle physics. *Physical Review D* **2012**, *86*.
111. Braibant, S.; Giacomelli, G.; Spurio, M. *Particles and fundamental interactions: an introduction to particle physics*; Springer Science & Business Media, 2011.
112. Safronova, M.; Budker, D.; DeMille, D.; Kimball, D.F.J.; Derevianko, A.; Clark, C.W. Search for new physics with atoms and molecules. *Reviews of Modern Physics* **2018**, *90*, 025008.
113. Bohr, N. I. On the constitution of atoms and molecules. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* **1913**, *26*, 1–25.
114. Frampton, P.H.; Hung, P.Q.; Sher, M. Quarks and leptons beyond the third generation. *Physics Reports* **2000**, *330*, 263–348.
115. Peskin, M.E. New Tests for Quark and Lepton Substructure. *BEYOND THE STANDARD MODEL* **2018**, p. 369.
116. Hentschinski, M.; Kharzeev, D.; Kutak, K.; Tu, Z. QCD evolution of entanglement entropy. *Reports on Progress in Physics* **2024**.
117. Strassler, M. Protons and neutrons: the massive pandemonium in matter. *Of Particular Significance* **2013**.
118. Strassler, M. The Strengths of the Known Forces. *Of Particular Significance: Conversations About Science with Theoretical Physicist Matt Strassler* **2013**.
119. Gell-Mann, M. A Schematic Model of Baryons and Mesons 1. In *The Eightfold Way*; CRC Press, 2018; pp. 168–169.
120. Wilson, F.L. Fermi's theory of beta decay. *American Journal of Physics* **1968**, *36*, 1150–1160.
121. Group, P.D.; Workman, R.; Burkert, V.; Crede, V.; Klempt, E.; Thoma, U.; Tiator, L.; Agashe, K.; Aielli, G.; Allanach, B.; et al. Review of particle physics. *Progress of theoretical and experimental physics* **2022**, *2022*, 083C01.
122. Tanabashi, M.; Grp, P.D.; Hagiwara, K.; Hikasa, K.; Nakamura, K.; Sumino, Y.; Takahashi, F.; Tanaka, J.; Agashe, K.; Aielli, G.; et al. Review of particle physics. *Physical Review D* **2018**, *98*.
123. D'Onofrio, M.; Rummukainen, K. Standard model cross-over on the lattice. *Physical Review D* **2016**, *93*, 025003.
124. Nave, R. Coupling Constants for the Fundamental Forces. *HyperPhysics, Department of Physics and Astronomy, Georgia State University*, 2011. Retrieved March 2, 2011.
125. Christman, J. The Weak Interaction. *Physnet, Michigan State University*, 2001. Archived from the original (PDF) on July 20, 2011.
126. Wood, C. The Quest to Map the Inside of the Proton. *Wired* **2024**.

127. Hobbs, G.; Archibald, A.; Arzoumanian, Z.; Backer, D.; Bailes, M.; Bhat, N.; Burgay, M.; Burke-Spolaor, S.; Champion, D.; Cognard, I.; et al. The international pulsar timing array project: using pulsars as a gravitational wave detector. *Classical and Quantum Gravity* **2010**, *27*, 084013.
128. Abbott, B.P.; Abbott, R.; Abbott, T.D.; Acernese, F.; Ackley, K.; Adams, C.; Adams, T.; Addesso, P.; Adhikari, R.X.; Adya, V.B.; et al. GW170104: observation of a 50-solar-mass binary black hole coalescence at redshift 0.2. *Physical review letters* **2017**, *118*, 221101.
129. McCormick, K. Gravitational Waves Should Permanently Distort Space-Time. *Quanta Magazine* **2021**. Contributing Writer, Quanta Magazine.
130. Ehlers, J. Survey of general relativity theory. In *Relativity, Astrophysics and Cosmology: Proceedings of the Summer School Held, 14–26 August, 1972 at the Banff Centre, Banff, Alberta*; Springer, 1973; pp. 1–125.
131. Weinberg, S. Gravitation and cosmology: principles and applications of the general theory of relativity **1972**.
132. Einstein, A. *The meaning of relativity*; Routledge, 2003.
133. Einstein, A. *Relativity: the special and general theory by Albert Einstein*; Harsimar, 1920.
134. Wald, R.M. General relativity, 2010.
135. Sun, L.L.; Zhou, X.; Tavakoli, A.; Xu, Z.P.; Yu, S. Bounding the amount of entanglement from witness operators. *Physical Review Letters* **2024**, *132*, 110204.
136. Nourian-Avval, A.; Khonsari, M. Rapid prediction of fatigue life based on thermodynamic entropy generation. *International Journal of Fatigue* **2021**, *145*, 106105.
137. Hong, J.M.; Choi, E.S.; Park, S.Y. Selective brain cooling: a new horizon of neuroprotection. *Frontiers in Neurology* **2022**, *13*, 873165.
138. Gocoł, R.; Hudziak, D.; Bis, J.; Mendrala, K.; Morkisz, Ł.; Podsiadło, P.; Kosi&39;nski, S.; Piątek, J.; Darocha, T. The role of deep hypothermia in cardiac surgery. *International journal of environmental research and public health* **2021**, *18*, 7061.
139. Mediano, P.A.; Rosas, F.E.; Luppi, A.I.; Noreika, V.; Seth, A.K.; Carhart-Harris, R.L.; Barnett, L.; Bor, D. Spectrally and temporally resolved estimation of neural signal diversity. *bioRxiv* **2023**, pp. 2023–03.
140. Keshmiri, S. Entropy and the brain: An overview. *Entropy* **2020**, *22*, 917.
141. Morin, D. *Introduction to classical mechanics: with problems and solutions*; Cambridge University Press, 2008.
142. Sinha, U.; Couteau, C.; Jennewein, T.; Laflamme, R.; Weihs, G. Ruling out multi-order interference in quantum mechanics. *Science* **2010**, *329*, 418–421.
143. Machta, J. Entropy, information, and computation. *American Journal of Physics* **1999**, *67*, 1074–1077.
144. Brading, K.; Castellani, E.; Teh, N. Symmetry and symmetry breaking **2003**.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the website and/or the editor(s). The website and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.