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Exploring Entropy and Time: Reversibility in the 4th Dimension

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Abstract: ***This paper explores the intricate relationship between entropy, the arrow of time, observable randomness in quantum mechanics, and the concept of the 4th dimension in quantum intervals. Building on previous theories, it introduces the concept of "almost simultaneity," highlighting the emergence of quantum probabilities and randomness as essential to this understanding. The reversibility of the 4th dimension denoted as Cτ, is explored through the lens of Planck's quantum time. This critical physical value, representing the energy wavelength Lambda, provides a crucial link between the 4th dimension and the realms of space, time, and mass, as proposed by Lorentz and Einstein.***

Keywords: 4th dimension, entropy, arrow of time, quantum intervals, simultaneity, block universe, theory of space

1. Introduction to time

Time is one of the physical parameters that is difficult to explain and often categorized as an illusion. In the 2nd millennium BCE, Indian philosophy conceived time as a cyclic characteristic, a "wheel of time" or Kalachakra, seen notably in religions such as Hinduism, Jainism, Sikhism, and Buddhism with reincarnation thoughts. A linear concept of time was embraced by the Greek philosopher Aristotle in the 4th century BCE, providing a systematic explanation of time as a measure of changes between the past and future, an infinite physical parameter with no beginning and no end. The great physicist Isaac Newton developed the concept of absolute space and time in 1686. Later, Lorentz's gamma factor revealed the non-universality of the value of time. Einstein, in 1905 with his Special Theory of Relativity (STR), interpreted relative-proper time as a physical dilation in nature due to movement. His professor Hermann Minkowski presented time in 1906 [1] as a longitudinal 4th dimension (Ct) and the spacetime concept of events. Finally, Einstein in 1915 presented his General Theory of Relativity (GTR), linking spacetime to the energetic presence, leading to the modern understanding of the gravitational effect. A proper time is dependent not only on its kinetic energy but also on the presence of energetic objects.

Despite significant advances, the concept of time remains misunderstood in certain aspects. The first one is that physical occurrences are independent of the frame of reference. In other words, "Now" happens in the universal passage of time, i.e., a common "now" with an absolute passage of time. **When something happens, it happens for all observers.** On the other hand, its proper clock value is conditioned to its historic location and energetic presence. This universal "now" goes together with the axiom that physical laws are preserved independent of the frame of reference.

The delay in some physical effects doesn't contradict the previous paragraph. For example, delays in particle communication or gravitational effect is embraced by the "now" time.

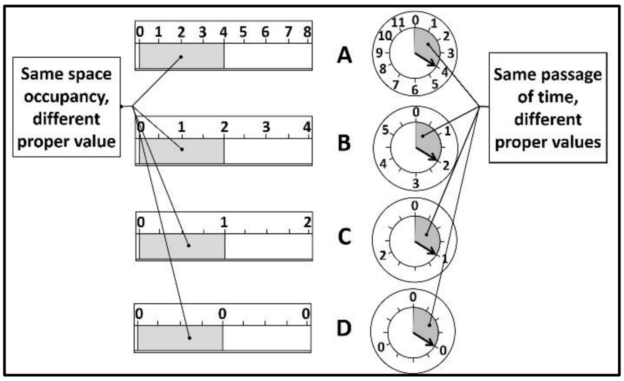

Figure 1: Figure 1 of reference [2]

In a previous paper [2], the author presented a simple way to imagine clocks, not slowing their handle movement but changing their dial as seen in Figure 1. The handle of all possible clock points to the same "now," while each one has on its dial a proper value that depends on its "historic" position and energetic presence. Note that in Figure 1, the A drawing represents time values without energetic presence. The B, C, and D drawings represent respectively a clock going at 86.6%, 96.8%, and 100% of the speed of light (C). By this, a photon sees the universe in the same passage of time as objects at rest despite having its Δt equal to zero. Photons aren't at any time; they are at the same "now" as the rest of the physical world. From a frame of reference at Earth's surface, light can be located in space and time and can be measurable even with its length contraction also equal to zero.

2. Introduction to the arrow of time and entropy

Time's evolution (time of events) has a unique direction also known as an asymmetric physical parameter. In the 19th century, it was recognized in gases and other substances as a discrepancy between macrostates and microstates. Microstates seem to behave symmetrically in time, but some macroscopic observations evidence that time is irreversible or asymmetric. In 1927, Arthur Eddington introduced the concept of the arrow of time, helping to popularize this behavior which is still analyzed to this day. It should be noted that many opinions relate this directionality of time to the directionality of entropy.

The first concept of entropy was given by Rudolf Clausius in 1854 presenting the 2^{nd} law of thermodynamics (energies flow tendency). Thermal energy is described through the macro physical parameters of temperature and entropy; an average value combined with its distribution (unidirectionality of diffusion or tendency to get dispersed). In 1877, Ludwig Boltzmann connected macroscopic observations with microscopic behaviors [3]. An important contribution that involves the presence of atoms with statistical parameters, providing a central role in thermodynamics. Along with the law of large numbers, he presented entropy in closed systems; a value that during its evolution over time can only remain constant or increase. He defined entropy as the parameter that is proportional to the logarithm of the number of indistinguishable states. His equation follows as $S=Kb \ln\Omega$; where S is the entropy, Kb is Boltzmann's constant and Omega Ω is the number of microstates whose energy equals the system's energy.

Later, in 1902 J. Willard Gibbs [4] gave a different way to understand entropy, his approach involves the probabilistic distribution of microstates.

3. Some Natural Units

In a recent paper [5], the new constant ζ was presented with relativistic and quantum considerations replacing Newton´s G constant and obtaining the following natural units:

$$\zeta = 2Gh/C^4 = 1.09499\ 10^{-77}\ [m\ s] \quad (1)$$

From this constant, the natural units can be expressed as follows:

Tq = SQRT [ζ / C] = 1.9111 10^-43 s for time (2)
Lq = SQRT [ζ C] = 5.7295 10^-35 m for length (3)
Mq = SQRT [h^2 / (ζ C^3)] = 3.8576 10^-8 kg for mass (4)
TTq = SQRT($h^2C/\zeta Kb^2$) = 2.51118 10^ 32 ºK for temperature (5)
Eq = SQRT(h^2C/ζ) = 3.46706 10^9 J for energy (6)
Sq = Kb = 1.38065 10^-23 J/ºK for entropy (7)

Note that Mq contains Planck´s constant and not its reduced value [4], this is modified because Lq/Mq must have the value of 2G/C^2 = 1.48523 10^-27 m/kg. For reference, Lq/Tq must give the speed of light.

Also, note that the natural unit of entropy in equation (7) is equal to Eq/TTq which is exactly Boltzmann´s constant.

4. Simultaneity and the block universe

A simultaneous event is seen as an occurrence in the same "now," regardless of the selected frame of reference. The STR and GTR provide tools to correlate each proper time to a unique passage of time. Thus, the passage of time is not relative to the observer; only its proper time value shows a relative magnitude.

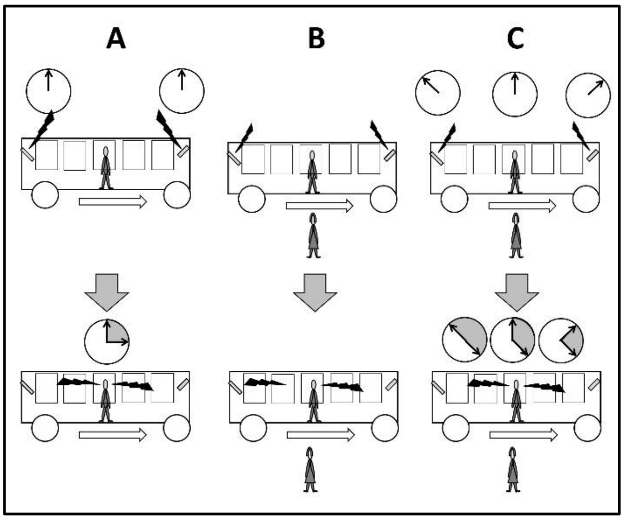

Figure 2: Figure 2 of reference [2]

For example, Figure 2 contains a drawing similar to Einstein's thought experiment, a train traveling at relativistic speed with two observers, Alice outside on the embankment and Bob in the middle of the wagon. A lightning storm illuminates "simultaneously" the two mirrors located at the beginning and end of the wagon; at the same instant that Bob is passing in front of Alice. Figure 2 shows cases A, B, and C with upper and lower drawings revealing two instances of the trajectory of both rays. Figure 2A is Bob's view; he sees both rays reaching him simultaneously. Figure 2B is Alice's misconceived point of view; seeing Bob moving with the wagon to the right, she would apparently deduce that the ray on the right side would reach Bob first. Figure 2C clarifies Alice's point of view; the top drawing shows that Alice "sees" three different local times (the observed time of moving inertial frames depends on their position), one of the mirrors on the right side, another, a little later where Bob is, and the third time, the latest, is from the mirror on the left side. With this consideration, Alice "sees" both rays reaching the mirror simultaneously (same passage of time, not the same time value) and a moment later, both rays reaching Bob also simultaneously, that is, at the same instant. Note the three clocks drawn at the top of the wagon, the ray on the left side has more time to travel to reach Bob, while the ray on the right side has less time; this time difference makes it possible for both rays to reach Bob together (where all three clocks have the same time value). The physical phenomenon of both rays reaching the mirrors and Bob together is the same in Alice's and Bob's views.

As an extension of the previous example, suppose Bob includes a mechanism that activates only when both rays arrive together (simultaneously) from the left and right sides. It is expected that the mechanism activates from Bob's view and must also activate from Alice's point of view (a physical reality independent of the observer).

In addition to simultaneity, the well-known block universe disorients the concept of time. First, event time "t" and its corresponding Ct are not suitable for analyzing physical phenomena with diverse proper times. Events must be related to the common passage of time, that is, consecutive "nows" and not to a particular proper time. The only physical existence is "now," and past events were a reality, and future events that are yet to come will occur probabilistically (read the next section). Perhaps from a historical point of view, the block universe of past and current nows can be conceived, but not future events that contain randomness.

For reference, see what happens if proper clocks and Ct are considered the basis of the block universe. In electromagnetic (EM) waves, their clock dial contains the same value, so in the case of detecting the cosmic microwave background, this has at least a difference of 4.5 billion years compared to the oldest clock on the Earth's surface (the age of our Earth). In other words, the entire distance traveled has passed zero times. Another comparison of proper clocks is between one on the Earth's surface and the other on the Sun's surface. The Sun's clock is 9.4 thousand years younger than the clock on the Earth's surface. Meanwhile, our current existence survives thanks to the Sun despite this large difference in time values. Now it is evident that comparing proper clock values is not the best way to analyze time. Other examples would be the case of a clock on the event horizon of black holes where its radiation is observed, as well as the case of clocks on GPS satellites that are in perfect agreement with time dilation due to kinetic velocity, as well as due to the energetic presence of our massive Earth.

5. Irreversibility of Time and the Arrow of Entropy

In a previous paper [6], the author proposes that the diversity of solutions in a quantum system (superposition of eigenstates) is a consecutive development of them with a one-by-one presence in 3D. This presence-eigenvalue changes randomly (memoryless) at the rate of its energetic frequency. An almost simultaneity of solutions that is, unfortunately, somewhat far from current experimental capabilities of attoseconds. This “quasi” superposition of solutions is the key to understanding the arrow of time, as well as the arrow of entropy.

A random presence of eigenvalues makes its reversibility impossible. **That is, a sequence of eigenstates cannot be randomly reproduced backward; i.e., randomness in nature, forward and backward in time, is the central impediment**. Note that an instantaneous superposition of solutions is capable of reversibility; that is, there is no difference between an existence forward in superposition from a backward superposition. Thus, the physical observation of the arrow of time indirectly confirms the author’s proposition of a “quasi superposition.”

With the same reasoning, when a new condition or interaction is assumed by the quantum system, each of the eigenstates will randomly develop over time, that is, from the first eigenstate to the entire variety of eigenstates. It is understood over time that the presence of each eigenstate will contain its probabilistic weight given by Schrödinger’s wavefunction and the average values of these eigenstates will be the expectation value (law of large numbers). This condition of one-by-one presence of solutions makes nature go from a single state to a congregation of states. In other words, from less entropy to greater entropy due to the progressive existence of solutions. The aleatory presence of the one-by-one eigenstates with its probabilistic weight of quantum mechanics embraces the principle of unity but not Laplace’s principle of indifference. This probabilistic presence coincides with the probabilistic behavior treated in thermodynamics. Therefore, entropy is more than a thermal characteristic; it is at the core of nature.

From Gibbs´s perspective of probabilistic distribution of microstates, the information of a quantum system with various eigenstates in quasi-superposition has less specific “knowledge” than a single eigenstate; therefore, a greater entropy. Meanwhile, a packaged superposition is similar to the case of a single eigenstate. When a quantum system acquires information, it will go to a condition of lower entropy. For example, when tunneling has been produced, when an EM wave passes through a polarizer grid, on interactions, etc. Idem, when some measurement is done to the system, it changes from its polydeterministic characteristic to a defined mono-deterministic scenario with a reduction in its entropy.

From an atomic view, in the formation of a hydrogen atom, the electron is first in one of its orbital solutions and immediately evolves to the diversity of solutions, shielding the electric field of its nucleus. An essential electric shield in atoms avoids the repulsion between the nucleus of neighboring atoms and makes possible the formation of molecules and cellular organisms that share the electrons of their outer orbital. This electric shield is achieved thanks to the higher entropy it contains compared to a particular orbit. Diversity or complexity is part of nature, and the word "disorder" to which it is normally referred does not appropriately reflect its grandeur.

From a macro view, the uniformity of the cosmic microwave background (with just EM radiation without the presence of masses) makes it reasonable to think that the beginning of the universe (Big Bang) contained all the energy in an undistinguishable state with Δr and Δt equal to zero, without extra space or changing time values. This induces the thought that the entire universe was a single state of pure energy; i.e., the lowest possible entropy. When it began to release energy, the space values and time values emerged (Δr and Δt different from zero) and the complexity of states also emerged; that is, the arrow of entropy. The initial space acquiring space values can explain the period of inflation or the hypergrowth of space values; it´s reasonable that the space did not start from a point, it started from the initial space (see left side of case D of Figure 1) where its relativistic value Δ corresponded to zero.

The initial condition and its evolution are quite different from the later black holes where their entropy is enormous; they contain the accumulation of cosmic dust, massive entities, EM waves, etc.; a cluster of microstates and macrostates surrounded by the outer space.

In contrast to this proposal, classical mechanics cannot explain these behaviors because it only manages a single state-solution; that is, a mono-deterministic scenario. Under this consideration, classical time can be reversible (symmetric), relegating the arrow of time to a mystery. With the same reasoning, “simultaneous superposition of states” can neither explain nature’s peculiar evolution of nature either. Similar to classical mechanics, a packaged superposition can be reversible, mono-deterministic and the

2nd law of thermodynamics will remain circumscribed to the average of kinetic-thermal effects.

Therefore, the irreversibility of time-events, the arrow of entropy, the polydeterminism, and the measurement-observation of one eigenvalue (never in superposition) give consistency and robustness to this proposal; that is, a quasi-superposition of random states.

6. C*Time, the reversibility of the 4th longitudinal dimension.

The evolution of time or time-events is understood as irreversible; a value that always increments. But what about Planck's periodicity time? Is the 4th dimension also irreversible? How will it be mathematically handled?

From the perspective of STR and Minkowski, an extra 4th dimension Ct was added to the three observable longitudinal dimensions. This inclusion made new equations possible for a relativistic scenario. In 2021, the author presented this 4th dimension as Cτ [7], where τ is the periodicity of Planck time ($E = h/\tau$). A novel presentation that unites relativity with quantum concepts; is quite different from Minkowski's Ct where "t" is the irreversible time of events. Note that the time of events is not associated with energy; it is linked only with space without involving mass as Lorentz´s gamma factor and Einstein´s GTR does. Likewise, event times are proper and correspond to the proper historical accumulation of intervals and not to something common where interactions can be easily analyzed.

This 4th dimension as Cτ, is sustained by the fact that τ is a crucial time of nature; it reveals the presence of energy in quanta. It also coincides with quaternions, where the imaginary scalar Lambda (iCτ energy wavelength) goes along with the 3D vectorial. When energy increases, Lambda becomes smaller and space undergoes length contraction. Remember that Lorentz presented his "gamma factor" due to relative movement between inertial frames of reference; a kinetic effect over space, time, and mass. Einstein reinforced this kinetic-energetic concept with the energetic presence of massive objects, concluding in his GTR. **Therefore, nature behaves with a link between energy and space, time, and mass, not with a single link between space and time.**

The magnitude of this Cτ as the 4th longitudinal dimension of energy can be incremented or reduced depending on the corresponding interactions; that is, delivering or acquiring energy respectively. As proposed in 2021 by the author, Planck's mathematical artifice is interpreted as the quantum system entering and leaving 3D. A fluctuation of its presence explains why energy in 3D appears in chunks. It also explains how nature changes from one eigenstate to another, and why only one eigenstate can be observed. Additionally, the creation and destruction of particles can be understood. This revolutionary proposal considers that the longitudinal dimensions do not exist together but in an oscillation between them (3D versus 4D). With this in mind, a need to handle complex numbers in mathematics to include a presence phase in the equations.

Note that from the law of energy conservation, in an interaction, the sum of the inverse of previous Lambdas equals the sum of the inverse of subsequent Lambdas.

A reversible time-τ is expected in the interval of one fluctuation. This quantum interval will follow Poincare's invariance; more precisely, the value of the addition of (Δr) ^2 + (iΔCt) ^2 being invariant; linking space with energy. Note that Richard Feynman assumed that in this quantum interval, the time of anti-charge particles can be negative or go backward from the end of the fluctuation to the beginning of it.

The accumulation of these quantum intervals corresponds to the evolution of time and gets registered in each proper time clock. Where the random diversity of eigenstates, the irreversibility of time-events and the arrow of entropy become understandable.

7. Conclusions

This paper challenges established quantum interpretation by proposing the concept of "quasi superposition" where its randomness can now explain time´s irreversibility and entropy´s nature. It also solves the measurement problem because the presence in 3D of the eigenstates is in a one-by-one form, changing randomly at the rate of its energetic frequency. These solutions give consistency and robustness to the author´s theory of space and unveil some of the mysteries of modern physics [8] [9].

By redefining the 4th dimension as Cτ (Planck's periodic time τ) a link is evidence between energy and space, time and mass, this research paves the way to future explorations into the interconnections of quantum and relativistic phenomena. In these quantum intervals, Planck's periodic time τ can increase, keep constant, or decrease; moreover, with Feynman's perspective of a negative value. The accumulation of quantum intervals corresponds to the evolution of its proper time.

This proposal embraces Schrödinger's wavefunction, not as "a packaged superposition of eigenstates, but as a statistical solution of the variety of presence of the quantum world in 3D.

This study reinforces time as a universal "now" that evolves, while its space contraction and time dilation behave with proper values depending on its position and energetic content. It simplifies the relation between the diversity of proper clocks by considering a universal "now." At the speed of light, it clarifies that zero Δr still occupies space and zero Δt still follows the passage of time. It changes the concept of a block universe (past, present and future) to a partial one (now and its history); challenging the deterministic future due to the intrinsic randomness of nature.

Declarations

The author declares no conflicts of interest regarding the publication of this paper.

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