Equivalent Time Theory (ETT)

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Abstract

The Feynman-Stueckelberg interpretation equates negative energy with negative time, but since $-E = h(-\nu) = h/(-t)$ it is better to think of this view as a mathematical statement, rather than an interpretation. What is required is to determine what negative time represents, not dismiss its existence as mere mathematics. The immediate implication is that time as it is represented in the equations of motion cannot be time in the fundamental sense. If it were, we would expect anti-matter to travel backwards in time, but we do not observe this. The mathematics of this dimension are startlingly similar to the 3 spatial dimensions, so it is reasonable to assume that this dimension is actually a 4th spatial dimension, and that it has a symmetric relationship with the flow of time. We measure time indirectly with the motion of clocks, and in the same vein, the 4th dimension has become the clock that we use in physics. Using this insight, possible solutions to both the "Arrow of Time" and the "Measurement Problem" become immediately apparent.

Contents

1 Introduction

There is a logical progression from Newton to Einstein, to Dirac. Isaac Newton understood the work of Galileo and the relativity theory he created, but realised that for physics to work, it had to be based on some invariant quantity. Newton postulated two. Time, and space. One second is the same for everyone; one meter is the same for everyone. However, our study of electro magnetism could not be resolved with that view. Einstein realised that there was only one invariant. He took the invariant time interval, and the invariant space interval, and merged them into a single space-time interval. Time and space are now conjugate variables, but the way to interpret this new interval is not entirely clear. Einstein's relativity disproves the existence of universally synchronous time, and this fact resulted in an array of arguments designed to separate time as it is represented in the equations of motion, and time as a fundamental concept. These arguments however, were built around the goal of re-introducing the concept of absolute time and simultaneity, and as such were rightly discarded. This paper re-introduces that separation between time as a variable, and time as a fundamental concept. Going forward, time as it is represented in the equations of motion will be referred to as τ, with the word "time" being reserved for the fundamental concept. This separation is not being pursued out of a desire to disprove the relativity of simultaneity, but because quantum mechanics demands it. The mathematics of the invariant interval are then built on with a simple re-parametrisation of standard quantum mechanics, ultimately resulting in an equation that describes both the quantum non-locality that has been observed, and the circumstances that force a separation between quantum and classical information.

2 Relativity Re-interpreted

Imagine that you exist in 2 dimensions. You have width, and length, but height has no meaning to you. One day, you observe shapes that you cannot explain. Eventually, you deduce that these shapes are projections of a 3rd dimension, and that your 2d world exists within a larger, 3d world. Using 3d mathematics, you can describe this 3d world, but since you only have access to 2d information, determining the full orientation of the shapes you observe is impossible. They may be above, or below; which are concepts you can represent mathematically but have no first-hand experience or understanding of. There are 2 ways to interpret the data, and no clear way to determine which is correct. In that same vein, we have also been working with incomplete information, and we must make a choice as to how to interpret the data.

At its core, ETT is an interpretation of relativity. This interpretation separates the concept of time from τ, but it also separates the mathematical tools with which we use to make predictions from a metaphysical description of the universe. The mathematics are a map, it is not the territory. One logical conclusion ETT arrives at is that the Minkowski metric is inverted, and that it's hyperbolic geometry is not physically real. This should not be surprising, as our inability to determine a preferred reference frame necessarily means that the metric is not a description of one. The central problem discovered by Galileo is that it is impossible to determine a preferred frame, if indeed one exists at all, and out of this fact arises Lorentz symmetry. The laws of physics must be invariant in all reference frames, as any asymmetry would allow us to determine a preferred frame.

We measure the velocity of an observed reference frame relative to our own, using a clock that exists in our own frame. Lorentz symmetry allows us to logically deduce that an observed frame's measurement of our frame's velocity would be equal but opposite to our measurement. We combine what we have deduced as their measurement with our clock value to produce a metric that is symmetric in both frames. It is this symmetry that Minkowski exploits to provide us with an invariant interval, which we can use to make objective statements about the relationship between reference frames, despite having no preferred frame. The predictions this metric provides are objective, but the metric is not a description of any underlying frame, it is a description of the symmetries which deny us the ability to determine a preferred frame, while providing us a reference to make objective statements about relationships.

- An observed frame's motion relative to the observer is $dx^2 + dy^2 + dz^2$
- Logically, a measurement of the motion of the observer's frame from the observed frame's perspective is equal but opposite $-dx^2 - dy^2 - dz^2$
- We combine this with the observer's clock dt to create the Minkowski metric:

$$c^2dt^2 - dx^2 - dy^2 - dz^2 = ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2$$

The Minkowski metric does not represent the complete geometry of spacetime. It represents symmetries which necessarily exist, in a format that allows us to make predictions.

Prior to Minkowski developing his metric, Poincaré demonstrated that the Lorentz transformations could be achieved using the imaginary unit. Today, the Wick rotation is often used to convert the metric into Imaginary Time, which has a range of applications. This metric is sometimes referred to as the "Euclidean Metric", as it is inverted, removing the hyperbolic geometry of Minkowski. What Imaginary Time demonstrates is that there are two mathematically equivalent interpretations of Einstein's relativity. We are working with incomplete information, the metaphysical description of the 4th dimension is inferred, not measured. The gamma term can be easily derived from a 4-vector using euclidean geometry, with only an inversion seeming out of place.

- $ds^2 = dx^2 + dy^2 + dz^2 + c^2 d\tau^2$
- $c^2 = \dfrac{dx^2 + dy^2 + dz^2}{dt^2} + c^2 \dfrac{d\tau^2}{dt^2}$
- $c^2 = v^2 + c^2 \dfrac{d\tau^2}{dt^2}$
- $c^2 - v^2 = c^2 \dfrac{d\tau^2}{dt^2}$
- $\dfrac{c^2 - v^2}{c^2} = \dfrac{d\tau^2}{dt^2}$
- $1 - \dfrac{v^2}{c^2} = \dfrac{d\tau^2}{dt^2}$
- $\sqrt{1 - \dfrac{v^2}{c^2}} = \dfrac{d\tau}{dt}$

$$\boxed{\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{d\tau}{dt} = \gamma} \tag{1}$$

The Imaginary unit is not required for this derivation, but it is necessary to retain the Lorentz co-variance attained with the Minkowski metric. The inversion is easily explained once it is recognised that the metric is not a full description of the geometry of space-time, but rather a description of symmetries. The metaphysical description of the underlying geometry cannot be determined objectively within the confines of Einstein's framework.

The 4th dimension is either a continuous coordinate, or a rotation. Interpreting it as a rotation does have the advantage that infinities are removed, and one could argue infinities represent an unphysical result. However, it is the Dirac equation that confirms that it is the rotation that best represents what is physically real.

3 The Arrow of Time

The "Arrow of Time" is as old as physics itself. The question that arises does not simply concern the apparent direction of time that we observe, but the nature of the relationship between time and the τ-symmetric equations of motion. There is a clear asymmetry in the way we experience time, but this is not even hinted at in the equations of motion. My linguistic choice to separate time as a fundamental concept and the variable of τ may foreshadow that this is partly a category error, and it is the Dirac equation that proves that this must be the case. The Feynman-Stueckelberg interpretation of the Dirac equation resolves the negative energy solutions found by treating antimatter as if it had "negative-time". The concept of "negative-time" is absurd, so while this interpretation is extremely useful, it is not intended to be taken literally, and it is regarded as a mere mathematical convenience. However, this view can be represented as $-E = h(-\nu) = h/(-t)$, so this "interpretation" is actually a clear mathematical statement with wide-ranging ramifications. By separating the concepts of time and τ, and by taking the mathematics seriously, the Arrow of Time disappears. τ has no arrow, the negative energy solutions found with the Dirac equation prove that it goes in both directions. τ is a clock, negative τ is simply the clock running backwards. The rationale for assigning a direction to time also disappears, as this dimensionality apply to τ, not time. Time manifests simply as change, and it's advancement is best understood through entropy, information theory etc. Asking why time always goes "forward" is akin to asking why life-forms grow and evolve. The orientation we have been assigning it is inappropriate.

4 The Synchronicity Constraint

So far, we have several conclusions derived from the existing mathematics and logic alone.

- Time and τ are not equivalent.
- τ is a 4th space-time dimension, and it is best represented as a rotation.
- At the classical scale, space-time should appear 3 dimensional, as the 4th dimension is only a planck-scale rotation.
- In much the same way we utilise a clock, the proper time of a particle can be extrapolated as the analytic continuation of τ's rotation.
- The metric is a representation of symmetries, not complete geometry.
- The space-time interval can be thought of as a budget of motion. All particles travel at c, and motion is divided amongst the space-time dimensions. Acceleration is simply a change in angle between x and τ

The first step is to develop the invariant. Re-arranging the Planck relation this way $E\lambda = hc$ demonstrates that Planck's constant can be thought of as an action interval, with this representing a kind of length-contraction equation. However, describing matter requires the Dirac equation.

- $p_\mu = (E/c, -\mathbf{p})$
- $x^\mu = (ct, \mathbf{x})$
- $p_\mu x^\mu = Et - \mathbf{p} \cdot \mathbf{x}$

$$\boxed{\sigma = \frac{1}{\hbar} \int p_\mu dx^\mu} \tag{2}$$

As the 4th dimension is not time, but rather a 4th space-time dimension, this coordinate must match for there to be an interaction. The synchronicity constraint σ tracks invariant phase for this reason.

5 The Measurement Problem

Quantum theory, while hugely successful, remains a controversial subject. While thoughts about how to interpret the mathematics diverge greatly, the measurement problem represents a practical failure as well as an ontological one, as the question of when the measurement axioms apply prevents us from using the theory to it's fullest potential. The synchronicity constraint σ demonstrates that there will be two distinct interaction types between particles, and this separation constitutes the Heisenberg cut.

5.1 Entanglement

Imagine two clocks existing in the same space, and they are synchronised, and so the hands of each clock are in continuous contact. This is entanglement.

$$\sigma_1 - \sigma_2 = p_\mu(x_1^\mu - x_2^\mu) = E\Delta t - \mathbf{p} \cdot \Delta\mathbf{x} = \Delta\sigma \tag{3}$$

- When the ratio of Δt and $\Delta\mathbf{x}$ remains constant, the quantum state remains coherent.
- Entanglement is not broken by spatial separation alone.
- Decoherence begins when $\Delta\sigma \neq 0$
- Cohesive quantum states have uniform values of proper time.
- An exchange of momentum breaks the constraint, defining the cut.

5.2 Periodic Synchronisation Events

Particles with mismatched σ can still interact periodically. Imagine two clocks existing in the same space, but they are running at different speeds. The faster clock will eventually catch up to the slower clock, and for an instantaneous moment, they will show the same time. At that moment, the measurement axioms apply.

- Wave-particle duality emerges because periodic synchronisation results in point-like interactions and measurements. The delta-function is not a description of a point-like particle, it is a description of a point-like interaction between wave-systems.
- The probability of synchronisation is proportional to phase overlap, resulting in wave-like interference. The Born rule simply differentiates between phase evolution, and phase overlap with the measurement devices or other interacting systems.
- If particles do not synchronise they will tunnel through each other.
- Particles in their ground state and with matching configuration will be unable to synchronise, explaining condensate behaviour.
- The observed flow of time is determined by the relative density of periodic synchronisation events.
- Intermittent periodic synchronisation events that do not alter momentum ratios can result in lightly entangled states.

6 Final Thoughts

The description of non-locality given by σ could be dismissed as a coincidence. As ETT is suggesting that the probabilities are the result of hidden variables, this is not just a simple interpretation, but a description of new physics, and as such experimentation is required to verify these claims. One possible avenue for pursuing verification is through the Aharonov-Bohm effect. A direct comparison can be made between σ and a Wilson line, and as such the QED description of the AB effect naturally follows. Since the AB effect alters phase without a force gradient, it allows the alteration of a cohesive quantum state without collapse. This may provide a mechanism to alter probability distributions in a way that would indicate that the underlying mechanism described in this paper are correct.

In general, the fact that ETT is so closely aligned with the existing mathematics is both a blessing and a curse, as it may be as difficult to disprove as it is to discover new physics.

7 Conclusion

Time is a concept that is deeply connected to the human experience. We feel the passage of time, and its inevitable effects. This makes understanding its true nature extremely difficult, as it requires us to separate ourselves from a concept that affects everything that we perceive.

Albert Einstein's description of time does not match our experiences. We do not experience time as a line, or dimension that we are moving through. We experience the present as an instantaneous moment. The past has changed into the present, and the future is what the present will change into. We remember the past, and can imagine the future.

The speed of light is constant to the observer, and this resulted in Albert Einstein creating a theory where time and space bend to accommodate this fact. However, this curvature was only observed in an abstract way. We observe gravitational lensing, not photons following a straight line through curved space-time. We observe gravitational acceleration, not the curvature which describes that acceleration.

Albert Einstein's interpretation requires a complete suspension of disbelief, as it contradicts all of our perceptions of time and space.

General Relativity disproves the concept of universally synchronous time. Every world-line has it's own continuity of time, implying that time is an independent property of each world-line, not a universal property. ETT takes this literally. τ is a material property of each particle, and what follows from this insight is an interpretation of relativistic quantum mechanics that matches our everyday observations.

Time is a product of many interacting phenomena, and due to the symmetry of these relationships, we have misunderstood the hierarchy on which it is built. Time does not create rhythm, rhythm creates time.