

The Heuristic Significance of the Principle of General Relativity on the Nature of Time

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Abstract

The principle of relativity is a basis of the laws of physics. As such it is not only explicitly at work in the kinematics of physical systems, it must also be explicitly at work in the dynamics, framing our ontological differentiation of the fundamental dimensions of physics - space, time and mass.

It is therefore not enough for theory to uphold the laws with respect to the constancy of the velocity of light via formulas of relativistic transformations of kinematics. The laws of physics must emerge from a relativistic framework such that the dynamics of the fundamental dimensions result in the constancy of the velocity of light.

"This is the reason why all attempts to obtain a deeper knowledge of the foundations of physics seem doomed to me unless the basic concepts are in accordance with general relativity from the beginning. ... The comparative smallness of what we know today as gravitational effects is not a conclusive reason for ignoring the principle of general relativity in theoretical investigations of a fundamental character. In other words, I do not believe that it is justifiable to ask: What would physics look like without gravitation?" - Albert Einstein[1]

In 1905 Einstein introduced a relativistic framework for the laws of physics based on the continuum space-time and in the same year defined the ontological concept quantum (photon). It soon became apparent these two ideas - "continuous" and "discrete," would present one of the greatest philosophical conflicts at the foundation of physics. The goal of physics is to discover the fundamental principles that determine the physical structure of nature to the degree that all such conflicts are resolved. Each major success in the pursuit of this goal confirms a crucial epistemological principle of physics, that all such conflicts are indications of epistemological errors shaping flawed models of nature as apposed to indications of an incomprehensible structure of nature. It will be shown that the physical structure of nature is both discrete and continuous without conflict as this conflict only arises as a result of an incomplete model of the nature of time. The model of time presented here not only removes the conflict of discrete and continuous, but in doing so removes the incomprehensible structure of nature or, the "strangeness" of quantum behavior.

Introduction

It has been suggested that time is symmetrical whereas the order of events "in" time are not.[2] Separating time from the order of events so as to sustain the symmetry of time and uphold the laws of physics that permit time symmetry not only requires introducing a dynamic responsible for the order of events giving rise to the second law of thermodynamics, it also raises a new problem: if time is not the order of events then neither is the

rate of time the rate of events. Such a suggestion removes time from the considerations of physics completely and turns our attention to discovering a dynamic responsible for the order and rate of events giving rise to the second law. Of course, we will have to give such a dynamic a label and there is no reason not to call it "time". This line of reasoning serves to clarify our present notion of time as the "kinematical" evidence of both the order and rate of physical events.

The Principle of Unification

Emmi Noether discovered continuous symmetries express laws of conservation. A continuous symmetry refers to the extent to which one type of transformation leaves the subject of the transformation unchanged with respect to the laws of physics and/or mathematics. This draws our attention to the notion that between symmetry and conservation lies a principle of unification. A principle of unification by which a continuous symmetry of dynamics expresses a law of conservation of dimension, similar to the conservation of the dimensions space and time discovered by Einstein expressed in the continuum space-time.

As kinematics arise from dynamics, the present "kinematic" description of time is in need of a dynamic definition that binds or is itself the unification of the dynamics responsible for the order and rate of events. This dynamic is not presently accounted for in the laws of physics, thus the time symmetry of the laws are in conflict with the evidence of the second law of thermodynamics. It is widely accepted in physics today that the second law of thermodynamics does not "forbid" events from exhibiting the time symmetry of the laws, but the probability is so infinitesimally small that for all intents and purposes such events will "never" be observed. This defines a very important departure from the fundamental principles of physics. It is the first and only case of physics "accepting" the symmetry of the equations of the laws hold authority over the contrary empirical evidence of the laws.

The Special Principle of Relativity

In his paper "On the Electrodynamics of Moving Bodies," Einstein proposes raising the following conjecture to the status of a postulate, referred to as the principle of relativity. "the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good." With this the property rest is reduced from absolute, to a property of the coordinates of a frame of reference, which in turn designates an observer with respect to the validity of the equations of mechanics, at rest with the frame. This sets a "relative" quantitative change of dimension between frames which is also a qualitative change of dimension. The laws of physics are valid in each frame because the equations of mechanics hold. That they do hold requires the translatory change in one dimension must be accompanied by a translatory change in the others sustaining the laws of conservation and expressing a continuous symmetry of dimension through the transformation of motion and proximity to mass. The laws then are not absolute with respect to the quantitative value of measurement between frames, but they remain valid by expressing a relative qualitative change of dimension that is reflected in quantitative measures of dimension.

When time is marked by comparison of quantitative kinematics of systems, a change in kinematics from frame to frame must be attributed to a change in dynamics from frame to frame. This dynamical change giving rise to the kinematical change that is the evidence of time, will be shown to be the physical dynamics of time.

The Principle of General Relativity

Einstein incorporated the principle of general relativity into the laws of mechanics by realizing *“the general laws of nature are to be expressed by equations which hold good for all systems of co-ordinates, that is, are covariant with respect to any substitutions whatever.”* He goes on to clarify such a requirement as being an inherent aspect of the laws of nature as apposed to a mathematical framework of the laws. *“We do not ask “What are the laws of nature which are covariant in face of all substitutions for which the determinant is unity?” but our question is “What are the generally covariant laws of nature?”*[3] Historically this statement of qualification is not considered to express any fundamentally new concept of relativity. For many years it has been seen as an unnecessary qualification attributed to Einstein’s relatively new exposure to tensor equations which are expressions of covariance. But a more detailed examination of this statement in context of the line of reasoning he followed in his foundations of the general theory of relativity reveals what Einstein may have originally seen in this concept.

When this statement is taken to mean the laws of nature must express a “quantitative” covariance of measure that is a relativistic effect of motion and proximity to mass, it refers to the “quantitative” covariant transformations of dimension defined by special and general relativity.

But when it is taken to mean the laws of nature must express a “qualitative” covariance of measure is a relativistic effect of motion and proximity to mass that defines ontological identity, it refers to the fundamental relativistic nature of the laws themselves. Thus the laws of nature are not of strick magnitudinal formula, but rather laws that define the relative nature of physical events and measurement as covariant quantities and “qualities” of the dimensions that comprise both.

Einstein left us with the task of defining the magnitude of dimensions as our measures of each is transformed by our motion and proximity to mass. We must now look beyond the magnitude of these transformations and recognize a quantitative change in dimension defines a qualitative change in the dimensions themselves. Space is a relativistic qualification of time, time is a relativistic qualification of space, space-time is a relativistic qualification of mass and mass is relativistic qualification of space-time.

Time

Time is one of three fundamental dimensions of physics - space, time and mass, which is to say it is not defined more fundamentally than as a measure of the other two. The model of time held by physics posits the periodic motion of a physical system(clock) as the period of motion against which we define by comparative measure, all motion as a duration of time. This leads to a circular logic, but suffices to define our measure (relative and/or constant) of the other two dimensions - space and mass, which in modern physics is all that is required of a definition of time to develop an internally consistent theory of kinematics.

As space, time and mass are the most fundamental concepts of physical dimension, any new definition of time must be based wholly on space and mass. Such a requirement suggests nothing less than a principle of unification will define all three dimensions as different aspects of a continuum. General relativity is one of the most successful models unifying the fundamental dimensions as aspects of a continuum. But it fails to account for quantum behavior because its continuum is modeled on a definition of time as nothing more than the kinematical evidence by which it is quantified, which is not a definition but as mentioned above, a circular, self-referential "description" of time.

A solution to the conflict of discrete and continuous is found in the model of a continuum described below that expresses time as a transformation of space and mass, not only in the quantitative kinematical transformations of general relativity, but also in the qualitative ontological transformations of dynamics as expressed by $E=mc^2$.

The Continuum Space-Time-Mass.

The kinematics of a two body system in motion express a physical change we attribute to our measure of the dimension space between the two bodies. This is not a dynamical change of the space measured, it is a change in the "magnitude" of our measure of space between the two bodies. Newtonian mechanics considers space a fixed, absolute structure with respect to which the two bodies are in motion or at rest. But with the introduction of Einstein's Special Theory of Relativity we realize the only meaningful measure of space (changing or not) is a measure of the time of light signals between the two bodies. There is no longer any absolute, fixed nature to space. Space has no intrinsic structure to which we can attribute a change, thus the change in the magnitude of our measure of spatial dimension we call motion, is defined only in terms of a measure of the time of light signals between the two bodies.

With the introduction of Einstein's General Theory of Relativity (GR) however, it is discovered we "must" attribute some intrinsic property to the dimension space with the confirmation of the change in the rate of time marked by clocks at different distances (altitude) from mass. But the idea that a property (the rate of time) can be attributed to something that cannot itself be detected except as a measure of the property we attribute to it, is nonsensical. This circular reasoning becomes more evident when one considers the constancy of the speed of light affords physics a ruler marked in units of time by which a quantity of space is measured, yet as each unit of this ruler is itself a measure of the change of space in a system we call a clock, it appears physics is reduced to the study of space as nothing more than a measure of time and time as nothing more than a measure of space. The General Theory of Relativity does not resolve this problem, it provides us with a relational model of space, time and mass, but it leaves time as the evidence of the kinematics (clocks) by which it is quantified and it leaves space as a measure determined by the same. GR is the most accurate and robust theory of the relative geometrics of space, time and mass supporting the evidence of mechanics at large scales. But our understanding of the dynamics that drive its geometric model must wait for and be reconcilable with a working model of matter.

GR is a field theory that defines the curvature of space-time surrounding mass. This does not mean

space curves but the geometry of space as a measure of time is curved. As this phenomena only occurs in the presence of mass and always occurs in the presence of mass, it is mass that changes the rate of time as the geometry of space, hence space-time is an extension of mass.

The relationship of space to time can be understood as a localized characterization of energy, presently referred to as gravitational potential. This relationship is determined by the energy of mass whereby the relative rate of time decreases or the relative measure of space increases as one approaches mass. If we could make a clock sufficiently small such that we could place it an infinitesimally short distance from a massive particle, we would find the rate of time almost ceases. In contrast to this and by way of the rate of time slowing, we would also find a measure of space at such distances approaches infinity. This seems a nonsensical, contradiction of our everyday experience. How can we set a clock at an infinitesimal distance from a massive particle if our measure of distance approaches infinity? One must remember that we are talking about the geometry of space-time as a localized characterization of energy. This localization is a relativistic expression, relative to our everyday experience of space-time at macro scales. In the thought experiment above, a local observer at such micro scales would not notice time slowing. Of course this is physically impossible as an observer is made of the massive particles they are trying to place the clock next to. But what this thought experiment allows us to see is the notion of a continuous space-time field that continues all the way down to the micro scale of particles. It is the conjecture of the author that massive particles are indeed nothing more or less than the relative concentration of space-time. A massive particle is a region of relatively condensed space-time, a region where time literally ceases to exist giving rise to a quantifiable entity, a stable particle of enormous potential energy in its relation of space to time at macro scales.

This model is too mechanically naive and contrary to many known properties of space, time and mass. Without a dynamic definition of time, this model fails to stand up to basic physical evidence. It was not until the discovery of a physical dynamic of time that defines the constancy of the speed of light as a natural "physical dynamic", a physically real consequence of the principle of general relativity that this model could be considered as a falsifiable framework of mechanics.

"If at first, the idea is not absurd, there is no hope for it."

--Albert Einstein.

"Problems cannot be solved by thinking within the framework in which the problems were created"

--Albert Einstein.

Einstein's words are offered as a caution, for what follows will most certainly seem absurd to many, but with careful consideration, the fundamental geometry of a continuous symmetry that redefines our present notions of the conjugate nature of space, time and mass will emerge.

We must afford space the physical properties necessary to condense as a measure of time, in order to understand this model of time. Once the model is understood as a fully relational model of space, time and mass, this physical property attributed to space vanishes.

Let a spherically symmetrical measure of space condense to its center from infinity. By condense it is understood that the radial coordinates extending from the center of the sphere accelerate toward the center as a measure of the increased rate of time toward the center with respect to an observer at a fixed distance from the center. An observer accelerating with any coordinate will observe their own clock to mark time at a constant rate - this is self evident in their relative measure of space and time as their proximity to the center decreases. An observer at a fixed distance or radial coordinate from the center of condensing space will also observe their local clock to mark time at a constant rate. To remain at this fixed distance from the center of condensing space, this observer must be under and therefore capable of measuring, a constant force directed away from the center of condensing space. This constant force is measured via the equations of mechanics as a test of the motion of masses with respect to the property rest this observer attributes to the coordinates of their frame of reference. To uphold the equations of mechanics, this observer must conclude they are accelerating away from the center of condensing space. But this is in conflict with their measure of the unchanging distance between their frame and the center of condensing space. It is in conflict when they consider via any local measure of time that the density of space is constant between their frame and the center of condensing space. Yet as a measure of time we know space must be attributed with a relative, physical change of measure with proximity to mass. If the observer considers the density of space to increase as a measure of time with proximity to mass, they will reconcile this conflict between rest and acceleration as does GR by concluding their inertial (un-accelerating) path of motion is a geodesic that moves them toward the center of condensing space and any force holding them against this geodesic will be measured as local acceleration. This is the GR solution to the conflicting measures of rest and acceleration and is of course very successful in cosmological events. But as mentioned earlier, its success comes at the cost of the complete elimination of time from physics as anything more than the kinematical evidence by which it is quantified. This in turn leads to the time symmetry of the equations of mechanics taking authority over the empirical evidence of the second law of thermodynamics and finally it leads to the catastrophic philosophical dilemma of discrete and continuous at the core of the irreconcilable nature of GR and QT.

The solution is a model of time that begins with the notion that space condenses in a spherically symmetrical geometry as a measure of the "rate" of time to a focus at its center where the relative rate of condensation of space, or the rate of acceleration of its radial coordinates approaches the speed of light and the relative rate of time approaches zero. The condensation of space "is" time. The rate of condensation is the rate of local time, a differential which by definition (i.e. a measure of space is a relative measure of time) is minimal at macro scales and relatively significant approaching micro scales. The speed of light is the rate at which the condensation is measured as the energy of mass.

This is not the complete structure of the model, it is a necessary conceptual structure that must be realized before the complete dynamic of this model can be understood. It is clear such a model predicts the attraction of mass as well as the manifestation of matter, but in this incomplete form it also predicts mechanics contrary to observation not the least of which is the requirement that all mass should have long since condensed to a black whole.

For this model to express a fully relational framework of the laws of mechanics that upholds all existing evidence of physics as well as offer solutions to the conflicts mentioned earlier requires its structure “predicts” electrodynamics. It does this in a simple but fascinating manner as a result of its definition of mass upholding the principle of least action. Recall mass is the area of the field at which the rate of condensation approaches c and the rate of time approaches zero. Mass then is a relative concentration of energy that is the condensation of space-time at a scale of dimension where time ceases. Keep in mind this is a relative measure of both space and time as the continuum space-time with respect to macro domain measures. When time stops at the threshold of dimension we measure as the energy we label mass, mass is the region of the field where the strength is greatest and gravitation is the region of the field where the strength is less. If for any reason the gradient of this field is not smooth, a detectable interference would exist as a measurable change in space-time. Such a change would be detected as imparting momentum on a mass as it passes through it. Any such change in the smooth gradient of this field could not by the definition of the condensing nature of the field, remain static but must either itself condense with the field, or propagate out in the field. If such an interference were to condense with the field, it would acquire a relative increase in the dimension space and decrease in the dimension time. The inverse would be true if the interference were to propagate out in the field. A measure of such an interference would then be quantified as increased energy (length over time) as it moved toward the center of the field, the region that becomes mass, and a decreased energy as it moved outward in the field. Of course this proportionality is defined by Planck’s Constant, which becomes a relative measure of the energy characterized by the ratio of space and time.

In this very rudimentary form we can see a definition of electrodynamics beginning to emerge. We have in this model a wave structure of light that possesses, in fact is itself “momentum” yet is not mass. When this interference is understood to propagate out from the region of the field we call mass, it is in fact the antithesis of mass. As the definition of mass is the region of the field at which the relative rate of condensation approaches the speed of light, there is no mechanical means by which an interference could propagate outward unless it did so at the speed of light. As the field is changing density of space-time such a propagating change will always be measured to have the speed of light, or will “be” the constant known as c . Such an interference, by the definition of time being the condensation of space, would necessarily be a propagating cessation of time. Now we begin to see the nature of light is not only without mass yet capable of imparting momentum on mass, but is also without time as it is a propagating cessation of time. This begins to add a certain deterministic nature to our otherwise “strange” definition of light.

How does such a model of space, time and mass produce the evidence of both GR and QT without the apparent conflict perceived today? It is probably already obvious to some that a definition of photons as a propagating cessation of time, makes the timeless mechanics of QT perfectly understandable. The notion of quantization itself is no longer in conflict with classical mechanics. Quanta are “discrete” and “finite” because they quite literally are propagating “cessations” of the continuous condensation of space-time the process of which is perceived as, and the kinematics of which are defined as, the passage of time. Quanta have no option but to be “discrete” as their measure is a conjugate aspect of our definition of space and time. Quanta are a “discrete” cessation

of a “continuous” process - the fundamental philosophical conflict vanishes.

This model leads to very interesting interpretations of classic quantum behavior. How can a propagating “wave” be measured as a “particle”; or what is the wave-particle duality of light? This is the most difficult notion of this model that requires considerable focus on the nature of light as a propagating cessation of the condensation of space as a measure of time.

Photon detection is accomplished by detecting a change in the state of energy of the detector during collision. That this change is isolated to a small region of the surface of the detector is interpreted as evidence of the incident photon also being isolated to a small region of space-time upon colliding and not spread out as a wave-front affecting the entire surface of the detector. When a photon is understood to be a propagating, discrete and finite cessation of the processes we perceive as time, the entire wave front will strike the entire surface of the detector over a very short period of time as any spherical wave front must. But the detection of this collision can only be measured at the first, small region of contact with the detector. As the detection of a photon is in both the time of collision and position of collision, once this initial criteria is determined to “be” the event the remaining area of the detector cannot be isolated from the event.

Unless the wave fronts of two interference waves strike the detector within the same “time” that is their wavelength, only one will be detected. Over time all collisions thus average out to the familiar interference pattern of waves.

The Principle of Uncertainty

The properties of a photon are measured and determined by the physical construct or design of the experiment. We may measure a relative change in space-time as a statement of position or momentum of a photon, but as these are conjugate properties of the continuum space-time-mass and a photon is a propagating cessation of the condensation of the field space-time, the inversely proportional accuracy of their measures are a result of their physically real construct. Thus the principle of uncertainty is a statement of the impossibility of measuring the cessation of time - a photon - as both a simultaneous measure of Length and Time.

The Principle of Equivalence of Condensing Space and Time.

We hold a physical ruler to space and measure a quantity of what? Is our ruler the measure of space? No, our ruler is a tangible, material rod, but we have no evidence that the space we hold it to is unchanging. As the ruler resides in the space-time being measured, we cannot say with any certainty that the ruler has not changed with space-time. Such a change would be imperceptible when our ruler is our gauge of change.

Light that traverses source to detector is the only measure of space as a quantity of time that has any relevance to our concepts of a measure of space. So how can we even begin to conceive space condenses to mass? Our only option is to hold to the notion that the separation of source and detector is a measure of space ruled by and quantified as the time of light signals.

If a force is applied to the source or detector between any two emissions of light signals, the time of the signal between source and detector will change. This can only be interpreted as an change in the separation of source

and detector which is our quantification of space.

A measure of space is then the time of light signals between frames of reference. When such frames are massive, the change in the rate of signals is a measure of the condensation of space referred to as free fall. When such frames are under force against free fall the force is a measure of the condensation of space referred to as acceleration.

The Second Law of Thermodynamics

This model of a continuum of space-time-mass that is a dynamical process of space-time condensing to mass, predicts the evidence of the second law of thermodynamics. The second law is no longer a statistical probability of mechanics but describes a physical dynamic that is the direction of time in the direction of condensation of space-time toward mass. The time symmetry of the equations of the mechanics define the conservation of all dynamics through the transformation of time-reversal as the expansion of mass to space-time. ($m=E/c^2$)

Conclusions

This continuum of space-time-mass offers a path to the solution of many questions in physics today including but not limited to:

Inertia - the condensation of space-time to mass requires effecting a change in the state of motion of mass must change the rate of condensation, i.e. is proportional to mass.

Dark Energy/Matter - is the condensation of space-time as a relative measure of mass set by c at cosmological scales.

Entanglement - is the instantaneous relativity of a measure of Time and Space in the uncertainty of a measurement of a wave-front regardless of the separation or diameter of the propagating wave.

Cosmological Constant - is an expression of the difference between the rate of expansion of the universe and the rate of condensing space-time at inter-galactic scales.

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