Special Relativity: A Reexamination of the Second Postulate and of Space Contraction and Time Dilation

Paul A. Klevgard, Ph.D.
Sandia National Laboratory, Ret.

Abstract

Pure entities consist of mass or energy without the presence of the other: the inertial rest mass is all mass and no kinetic energy (no velocity); the photon is all kinetic energy and no (rest) mass. Pure entities may be compared at the ontological level (for form, progression in a dimension, extension in a dimension and storage). From this analysis it is shown that Einstein's second postulate of special relativity (constant speed of light) is actually derivative from a more fundamental attribute of all pure entities. Part two of this essay focuses on the space contraction and time dilation of moving physical objects. Arguments against attributing these changes to space and time itself (Minkowski) are offered. Instead, the roles of kinetic energy and of de Broglie wave effects are presented as a better explanation. The famous twin's paradox is discussed in an appendix.

Special relativity has been with us for over a century and its predictions have been confirmed by countless experiments. Nevertheless, its conceptual and ontological foundations are not completely satisfactory. This essay will offer a critical review of two main aspects of special relativity: 1) the desirability/validity of erecting a postulate for a single phenomenon, namely the constant speed of light, and 2) the challenge of explaining why different inertial observers measure space and time differently (space contraction, time dilation). But one cannot analyze special relativity without considering the photon and the nature of radiant energy. Hence this essay will also look at how radiation energy went from quantity to entity.

Part I - The Constant Speed of Light

1.0 Introduction

The Scientific Revolution of the seventeenth century was mostly about mechanics and the laws of motion of material entities. Hence when scientists began to explain energy processes they naturally invoked material entities as causal agents. Three examples may be cited. The energy of combustion was at first regarded as due to the release of a material substance (philogiston). Heat itself was another assumed material substance (the caloric) that self-repelled so it would migrate from a hot object to a cold object. And, of course, in the nineteenth century radiation was regarded as a wave disturbance of the all-pervasive material aether.

In the last half of the nineteenth century theories of energy became dependent upon experiments (e.g., Joules) and perhaps less speculative. Great progress was made in thermodynamics and in the kinetic theory of gasses. By 1900 all of the preceding energy theories that involved material entities were dead or on death's door (the aether). Energy had become simply a quantitative measure in contrast with mass which was an entity with properties plus a quantitative measure. **For physics in 1900, mass was an entity and energy was a quantity**. But change was in the air.

In December of 1900 Max Planck announced that radiation energy was quantized. That took some years to be accepted but other theoretical or experimental confirmations followed in 1905 (Einstein's paper on the photoelectric effect), 1917 (Einstein's assertion that radiation quanta have momentum) and 1923 (Arthur Holly Compton's experiment of X-rays losing energy when bouncing off electrons). By the mid-1920s the quantized nature of radiation could not be denied and a quantum of light was given the name "photon." But giving a name to quantized radiation was more of a

linguistic convenience than it was a conceptual change. Physicists clung to the traditional idea of energy as a quantity (not an entity) even though quantized radiation as pure energy retained its identity while traversing space just as quantized matter as pure mass retained its identity while traversing time. The outstanding physicists of the 1920s were inclined to keep as much as possible of the old ideas (energy as quantity) while still accommodating new findings. A century later we are under no similar constraints and we can explore the idea of the photon as an entity that occurs, has properties and traverses a dimension.

1.1 Looking Ahead

The mathematics of special relativity has long been settled and it will not be recounted here. Our concern instead is with the nature of those entities whose properties physicists have not always examined closely.

The photon and the material entity ("particle") have obvious differences. The material entity exists, extends in space, progresses ("persists") in time and has mass as a quantitative measure whereas the photon occurs, extends (oscillates) in time, progresses in space and has energy as a quantitative measure. But in terms of ontology they are both entities and may be compared as such. Although he didn't characterize them as entities, Einstein compared the photon and the material particle in many of his papers with great effect.[1]

In the following sections we shall see that mass and (photon) energy are closely related as $E = mc^2$ implies. Both of them extend in, and can be compressed in, one dimension only: space for mass and time (oscillation) for the photon. That is, the material entity can be squeezed in space by applying a force to it while the photon may be squeezed in time by the observer moving toward the photon source.

Because extension (entity volume or duration) is confined to one dimension, we shall see that entity progression in the alternate dimension is unaffected by entity compression. Compressing inertial mass in space will not change its time progression; compressing the photon in time will not change its space progression. This insight permits a redefinition of Einstein 2nd postulate.

But before this analysis can begin we must clarify our terminology.

1.2 Nomenclature

The concept of quantity is straightforward. It may involve the counting of discrete units such as atoms or molecules, or it may involve measurement relative to some standard yielding a definite amount of kilograms, volts, meters or seconds. Quantitative measures may be factual but they are not physically real. Something is physically real if it has a dimensional presence (space or time) and can be said to exist or occur. For physics we may assume that only mass and energy have a dimensional presence and either exist or occur.

"Field" became a protean word in twentieth century physics. It is used here in the primitive sense of something that exists and extends in space. Thus a material particle is a field (with a density measure) and so is the potential energy that surrounds a charged particle or an ion. A field is the ontological opposite of a wave: the former exists, the latter occurs. Also, the word "kinetic" means or implies patent, open or obvious; hence for physics it means "unstored." On the other hand, the word "potential" equates to latent or hidden and hence means "stored" (e.g., potential energy is stored energy). The precise term for matter (rest mass) is "kinetic mass" since it is mass that is unstored, unhidden. In what follows the term "inertial" is shorthand for an object or system that is force-free and regarded as space-stationary for a local observer.

"Entity" is also a protean word (e.g., legal entity, public entity). In the realm of physics entities must be composed of either mass or energy. Keeping a material entity in mind as a template, we can set out entity requirements. **Entities must: 1) have a form which implies a dimensional presence; 2) have a quantitative measure; and 3) store their opposite.** For the material entity the form is that of field, the dimensional presence (extension) is space, mass is the quantitative measure and energy is what is stored.

---

[1] In his 1905 "Heuristic" paper (on the photo-electric effect), Einstein compared the thermodynamics of the blackbody radiation gas (photons) with the enclosed molecular gas (particles) to argue for quantized radiation. He made similar comparisons between the aggregate behavior of photons and molecules in subsequent papers in 1909 and 1916/17. And while Bose applied his statistics to photons (1924), Einstein quickly saw the parallels and went on to apply these same statistics to atoms. See Martin J. Klein, "Einstein and the Wave-Particle Duality," in *Natural Philosopher*, v.3, 1964.

Since the 1920s physicists have treated the photon as an entity: an object of study and experimentation to ascertain its properties. The photon also meets the requirements we have set out for an entity. Photons oscillate and therefore extend in the dimension of time. They have the waveform, their quantitative measure is energy (joules) and they store their opposite, namely (relativistic) mass.

1.3 Pure Entities

The photon is pure kinetic energy and is devoid of kinetic (rest) mass. The inertial massy particle or object is pure kinetic mass and is devoid of kinetic energy for a local observer. Accordingly, the photon and the inertial mass are **pure entities** since they do not mix mass and energy in their kinetic forms.

Obviously both pure entities are quantized and they extend in a dimension. The inertial mass extends over a space interval and the photon, because of its oscillation, necessarily extends over a time interval. Both entities are also at rest and therefore located in their extension dimension.[2] The inertial mass is at rest in space by its own measure and the photon is at rest in time by its own measure, time standing still at the speed of light.

Both entities also progress at the maximum rate in that dimension where they do not extend. The photon extends in time where it is stationary but progresses (advances) at the speed of light in space. The inertial mass extends in space where it is stationary but progresses in time at the maximum possible rate (were the inertial mass to acquire any relative velocity in space its clocks would slow down). Both entities follow Aristotle in having a form, but of course the forms differ: a field is suited to existing inertial mass progression in time whereas a wave is suited to occurring photon progression in space.

Storage is the last formal parallel we need to mention here. The inertial mass stores energy: thermal energy stored within the mass plus the energy the mass represents via $E = mc^2$. The photon stores mass, namely, the relativistic mass released upon photon impact/termination. The two pure entities exchange mass-energy in their interactions. The photon gives up stored mass (and its momentum) when terminating upon a material target (absorption). The material object/atom gives up stored energy when releasing a photon (emission).

Because pure entities store their opposite this gives them two identities. They have an unstored, kinetic identity which is mass for the inertial mass and energy for the photon. They also have a stored, potential identity which is potential energy for the inertial mass and potential (relativistic) mass for the photon. To summarize our two pure entities:

Inertial Mass	Photon
Quantized	Quantized
Pure mass (conserved)	Pure energy (conserved)
Stationary in space	Stationary in time
Located in space	Located in time
Extends in space	Extends in time
Max. progression in time	Max. progression in space
Field form	Waveform
Stores energy	Stores mass

[2] To be stationary in a dimension means to be located there, even if an object is its own reference.

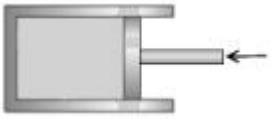
We are now ready for a definition of a pure entity.

- **A pure entity is composed of field form mass or waveform energy that stores its opposite which gives it a kinetic identity and a potential identity.**
- **It extends in one dimension wherein it is stationary, located and discrete.**
- **It progresses continuously over paths in the opposite dimension.**

The significance of entities and the parallel nature of pure entities have been quite ignored by both physicists and philosophers of science. But it is not our task here to remedy that. Our present concern is narrowly focused upon certain issues of special relativity first of which is the constant speed of light for all observers. This topic is best approached indirectly by looking at how it is possible to stress an entity.

1.4 Stressing pure entities

Entities can be stressed (compressed or rarefied) in their extension dimension. They cannot be stressed in their progression dimension. A material entity extends in space and that is where it may be stressed. Suppose we have a space-stationary (inertial) material object we wish to stress, say the air within a cylinder with a piston at one end. Pushing on this piston constitutes work the energy of which is transferred to, and stored by, the trapped air. This air is now warmer, denser and higher in pressure. As a material entity the air's extension in space and its stored energy have been changed by stressing.



Now consider a single photon emitted from a source and progressing toward an observer. To stress this pure entity the observer must compress it in its extension dimension which for the photon is time. This is to say that photon oscillation spans a certain time interval and compressing this interval raises photon frequency. If the observer increases her speed toward the photon's source, work is done which results in two changes. First, the observer has increased her kinetic energy relative to the photon source. Second, the observer has Doppler-stressed the approaching photon raising its frequency. A compressed (higher frequency) photon stores more releasable mass due to $E = mc^2$ where E in this case equals Planck's constant times the photon frequency. The photon's extension in time (wave period) and its stored mass have been changed by stressing.

Compressing pure entities constitutes positive work done. The entity compressed has a greater stored quantity and it quanta become closer in space or in time. The opposite case is a diminution of what is stored and this constitutes negative work. A gas that expands gets colder and has less stored energy per mole. A photon heading toward an observer who is moving away from the light source has lower frequency and stores less mass.

1.5 Conclusions

Stressing pure entities affects them in their extension dimension, space for inertial mass and time for the photon. Stresses applied by an observer have no affect whatsoever on pure entity progression. The photon will always progress in space at a constant rate regardless of observer velocity stress. The inertial mass will always progress in time at a constant rate regardless of observer pressure stress. Since the photon is massless and progresses in only one dimension (thereby lacking a trajectory) it cannot be a projectile and Galilean velocity addition does not apply to it.

When Einstein had his splendid insight regarding what we know as special relativity he made the constant velocity of the photon into a postulate. This is understandable, even admirable, in the context of 1905 but it is misguided. There are a number of problems with Einstein's second postulate.

- First of all, it is ad hoc. It addresses but does not solve a specific problem. It becomes a substitute for an explanation.
- Second, it is a postulate at the physics level and postulates should reside at a more foundational level.
- Third, it is derivative from a foundational point of view and hence it is unnecessary.

1.5.1 Replacement

The second postulate of special relativity should be replaced by a more fundamental (ontological) assertion from which the constant velocity of light may be derived.

Stressing any pure entity changes its extension dimension but has no effect on entity progression.

Replacing the second postulate of special relativity in this way avoids the dilemma posed by the velocity addition requirement of Galilean relativity. Unfortunately we still have no satisfactory explanation for the space contraction and time dilation of material objects. For that we have to extend our analysis of the nature of entities.

Part II - Space Contraction and Time Dilation

2.0 Background

Theories that address the failure of different inertial observers to agree on space and time dimensions tend to fall into two categories. Kinematic (descriptive) theories point out the inevitable dimensional disagreement of observers forced to measure remote and moving objects via light signals. Formulas for translating points (or intervals) from one inertial coordinate system to another are offered (the Lorentz transforms). Dynamic (explanatory) theories go beyond this and suggest what physical changes in matter might account for rods that shrink and clocks that run slow for a moving system. Dynamic accounts tend to view physical change as real while kinematic accounts tend to view such change as apparent.

Einstein takes the kinematic approach in his 1905 paper[3]. In this paper Einstein views space contraction as an apparent effect for the observer rather than a real effect.[4]

In contrast, H.A. Lorentz regarded the space contraction of material objects as physically real since it was a consequence of the effect the aether had on the electrostatic forces holding atoms together. Hence Lorentz has a causal explanation for dimensional transformation and he also retains a Newtonian world where time is separate from space. For this reason his theory has drawn some recent admiration and even adherents.[5]

Hermann Minkowski took the space and time (Lorentz) transforms that Einstein used and showed they could be represented geometrically where time was merely an additional dimension. Minkowski took his four-dimensional space-time as both real and fundamental; the four dimensions as a unity were "…real and observer-independent."[6] For Minkowski relative velocity merely reveals different spacetime views of a hidden reality.

All of these interpretations have both their adherents and their defects. Einstein's 1905 version does not explain any of the material transformations. Lorentz requires us to accept an aether we can neither measure nor detect. And Minkowski denies the reality of our familiar world which other branches of science (quantum mechanics, astronomy, geology, biology, etc.) take for granted. Is there any hope for an explanation of dimensional transformations between

---

[3] Albert Einstein, "On the Electrodynamics of Moving Bodies," translation by George Barker Jeffery and Wilfrid Perrett in *The Principle of Relativity* (London: Methuen and Company, Ltd. 1923). Also available at: https://www.fourmilab.ch/etexts/einstein/specrel/www/ (accessed March 2014).

[4] Jaykov Foukzon, "Generalized Principle of Limiting 4-Dimensional Symmetry. Solution of the 'Two-Spaceship Paradox'," http://arxiv.org/ftp/arxiv/papers/0805/0805.2820.pdf, 4-5, (accessed March 2014).

[5] See Harvey R. Brown, *Physical Relativity: Space-time structure from a dynamical perspective* (Oxford: Clarendon Press. 2005). Also J. S. Bell, "How to teach special relativity," in *Speakable and Unspeakable in Quantum Mechanics* (Cambridge: Cambridge University Press, 1987), 67-80.

[6] Olivia Levrini, "The substantivalist view of spacetime proposed by Minkowski and its educational implications," http://www.fisica.uniud.it/URDF/laurea/idifo1/materiali/g5/2_Levrini_Minkowski2.pdf, 7 (accessed March 2014).

inertial observers that conforms to our familiar world where mass and energy interact in three dimensions of space plus a separate one in time?

2.1 Looking Ahead

Space contraction and time dilation characterize material objects (projectiles) that travel at any relative velocity, although the changes are significant only close to the speed of light relative to some observer. De Broglie wave effects obtain regardless of an object's size or relative velocity; both spaceships and electrons are affected to the same degree (the mathematics is the same). At high velocity relative to an observer, material objects become a mixture of forms: the field form of the kinetic mass (rest mass) and the (de Broglie) waveform of the kinetic energy. The result is a hybrid entity (projectile) whose presence in space is now divided between the extension of rest mass as field versus the progression of kinetic energy as a wave. Regarding projectiles as hybrid entities is the key to understanding space contraction and time dilation.

- **The traditional assumption that kinetic energy is a mere quantity, the addition of which leaves a material object unchanged, is NOT true.**

2.2 High Velocity and High Energy

Dimensional warpage (space contraction and time dilation) and relativistic mass increase are all consequences of high relative velocity. These changes are objective and are not a simple consequence of signaling problems. For example, unstable particles at high velocities have a retarded disintegration time interval (half life). What is it about high relative velocity, and the high kinetic energy it creates for an observer, that results in these objective changes for the observer?

We know that small particles such as electrons with high energy and high velocity relative to some observer exhibit wave behavior. This was first suggested by Louis de Broglie and later confirmed in the laboratory. So what is the difference between such particles and a meter stick when both are traveling at nine-tenths of the speed of light? They both are space contracted by the factor τ and both are time dilated by the inverse factor $1/\tau$ where $\tau = \sqrt{1 - v^2/c^2}$. Of course the meter stick is vastly more massive than the electron, but velocity affects the increase of relativistic mass for both by the same factor: $m_{rel} = m_{rest}/\tau$. Since any rest mass, however small, will generate infinite relativistic mass at the velocity of light, no rest mass can achieve that velocity relative to any observer.

Just as the effective mass (rest mass plus relativistic mass) of any material object increases without limit the closer you get to the velocity of light, so does the momentum of an object. And momentum is inversely proportional to the wavelength λ of an object: $\lambda = h/mv$. As a result of the latter, a meter stick and an electron at the same velocity relative to an observer have, for that observer, vastly different wavelengths. The electron's wavelength is large enough to generate diffraction effects in the laboratory, but the meter stick's wavelength is so infinitesimal that diffraction effects are precluded. But diffraction effects are irrelevant when it comes to the fundamental nature of the waveform; waves are waves whatever their wavelength or frequency. At the same high velocity relative to an observer the meter stick and the electron both possess the de Broglie waveform in addition to the rest mass field form. So how does the waveform relate to the effects we see in special relativity, namely space contraction and time dilation?

2.3 The Projectile As Hybrid Entity

We have seen (Part I) that pure entities extend in one dimension and progress in the opposite dimension. Kinetic mass (inertial particle) by itself as a field extends in space and races along in time. Kinetic energy by itself as a photon wave extends in time and races along in space. Any material object (technically speaking, a field-form kinetic mass) at high relative velocity acquires the de Broglie waveform because of its kinetic energy. Such projectiles therefore have a hybrid nature: part field due to rest mass and part wave due to de Broglie effects. Fast moving projectiles are hybrid because they have material mass field form acquiring de Broglie waveform. When you combine the two forms, wave and field, then extension and progression in both space and time get merged and altered. A unified, hybrid entity no longer has progression (or extension) confined to a single dimension.

2.4 Progression versus Extension

In Part I progression and extension were defined in terms of pure entities. Space progression was confined to the kinetic energy pure entity (the photon) since the kinetic mass pure entity (inertial matter) was space stationary by its own measure. Space progression was seen in Part I as a consequence of the expansion of a wave in space. Now that we are considering projectile motion we need to retain the original connection between space progression and wave motion while still recognizing that projectiles themselves change location in space relative to some observer.

Assume we have an inertial observer and an inertial spaceship in relative motion. If the observer is remotely guiding the spaceship toward a distant planet then the observer is very much concerned with spaceship velocity. But if the observer is a special relativity theorist (our case), then the velocity of the spaceship is of no concern at all. It does not matter to our observer whether the relative velocity of the spaceship is 5 kilometers per hour or 50,000 kilometers per hour. Our observer is only interested in measuring spaceship length (in the direction of motion) at any one time instant. Despite the difficulties that arise (getting simultaneous signals from opposite ends of the spaceship), our observer is attempting to get a snapshot, a measurement, of the spaceship frozen in time. This means that the observer is trying to "see" (measure) the spaceship as if it were standing still; as if the spaceship as matter constituted a pure mass of Part I (space-stationary matter). The "complication" of projectile motion is really not a complication for the special relativity theorist; he or she is attempting a measurement on a remote and moving object just as if that object was space-stationary and at-hand.

The space progression of immaterial waves (photon waves, de Broglie waves) is very different from the translation of material objects in space. Translation motion (location change) is reversible; given some energy one can retrace one's steps. Wave space progression is irreversible and retracing is never possible. Translation motion has a trajectory and is a consequence of some energy difference (work, i.e. force over distance) between observer and projectile. Space progression has no trajectory and instead is a fundamental (ontological) part of what waves do: energy waves must progress in space just as mass fields (matter) must progress in time.[7]

What translation motion does, for a distant observer, is to add kinetic energy to a material object which the observer attempts to regard as fixed (stationary) in space at some instant in time. A material object (spaceship, projectile) as a pure mass field entity thus acquires a pure energy wave entity (de Broglie radiation). The object/spaceship is now a hybrid entity combining the characteristics of field and wave, of kinetic mass (matter) and kinetic energy (radiation). Space is where an existing field (particle) extends but it is also where an occurring (de Broglie) wave progresses. A mixed wave/field projectile will therefore have its space extension compromised by the presence of a wave component that space progresses. The hybrid entity must reflect the space preferences of its two constituents. Adding wave progression in space detracts from field extension in space.

Of course, time is where an existing field (particle) progresses but it is also where an occurring (de Broglie) wave oscillation extends (occupies cycle time). Because of this, the mixed wave/field projectile will have its time progression retarded by the presence of a wave component that extends in time rather than progressing there. Adding wave extension in time detracts from field (particle) progression in time. The result is time dilation for the hybrid entity as seen by a stationary observer.

Extension and progression vary inversely for moving objects. A meter stick at rest has a certain space extension (one meter) while it progresses rapidly in time. But that meter stick at .866 times the velocity of light relative to some observer has expanded (dilated) its time progression by a factor of 2 while it has contracted its space extension by the same factor. It is as if object extension and progression in a single dimension are conserved: when one is enhanced the other must be diminished. What an object loses in its space extension (length) it gains in its space progression.

We think a meter stick moving at .866 times the velocity of light is the same existing object that it was when it was stationary next to us. But that is not the case. Because of its large (relative) kinetic energy, the moving meter stick has now transitioned into a hybrid "object" that occurs as well as exists and objects that gain occurrence (and the waveform) relinquish some of their space extension (and time progression) since they are now different "objects." The ultimate occurring object (the photon) is all wave, all space progression and no space extension. The ultimate existing object (the inertial, space-stationary particle) is all field, all time progression and no time extension. Projectiles

---

[7] Conflating wave progression for the photon with space translation (trajectory) for material projectiles is most unfortunate. Those who support this idea cite the space point termination of photon (relativistic) mass upon matter. But any entity stores its opposite and releases what is stored (quantized mass for the photon, quantized energy for the atom) at a point in space or in time (emission, absorption). But that argument cannot be pursued here.

(spaceships) occupy the middle ground and combine waveform and field form. They extend (or progress) in in a dimension according to their proportional balance of field form (existence) versus waveform (occurrence).

At velocities approaching the speed of light for some observer, kinetic energy and its de Broglie waveform will dominate whatever object is moving: an electron, a meter stick or a planet. With that in mind let's look at two observers who disagree about muon lifetime and the space over which it travels.

2.5 Muon Case Study

Muons are short-lived particles of small mass created by cosmic rays interacting with the earth's upper atmosphere. These projectile particles (hybrid entities) have a half-life of less than 2 microseconds and travel very close to the speed of light. Even with their great speed they require over 100 half-lives to reach the surface of the earth which suggests that none of them do. Yet that is not the case because time has apparently slowed down for them. However, an observer accompanying a muon does not experience any change in the progression of time.

For an observer on the earth the muon is mostly kinetic energy waveform plus quantitative relativistic mass due to its extreme relative velocity. As we have seen, pure waves (the photon) that are exclusively kinetic energy have time only as extension, not as progression (time is stationary). Accordingly, the muon as near-wave and mostly energy for the earth observer has a small amount of time as progression (due to its rest mass), but much more of time as (static) extension (due to its wave nature). The earth observer measures a drastic slow down of time for the muon as wave-dominated hybrid entity (projectile). Of course, an observer accompanying the muon is only presented with the muon's kinetic (rest) mass and measures "proper" (fast) time for the muon's disintegration.

The observer within the muon's inertial system finds the earth approaching at close to the speed of light. The muon observer must have reciprocity with the earth observer; if the earth observer finds the muon to be mostly wave then the muon observer will find the earth to be mostly wave. The disparity of mass in the two cases is irrelevant. Of course the observer in the muon's inertial system will find that the wavelength of the approaching earth is exceedingly short.

Since the earth is now much more wave (and occurrence) than field (and existence) for the muon, the earth's extension in space as kinetic (field) mass is now diminished by the earth's progression in space as kinetic (wave) energy. The earth's spatial extension, including the thickness of its atmosphere, has contracted. The observer aboard the muon finds the muon's lifetime to be normal but decides that the surface of the earth can be reached because the distance the muon must travel after birth is much less than the earth observer claims.

For the earth observer space travelled is local (within its inertial system); for the muon observer time lapsed is local (it has the disintegration "clock"). Each of them finds the non-local dimension "warped" because they are confronted with a near-wave hybrid entity approaching them that objectively either has its space mostly progressing rather than extending (space contraction) or its time mostly extending rather than progressing (time dilation). So what has been transformed, the hybrid entity itself or space and time itself?

2.6 Theories of Dimensional Change

The assumption of physicists, Einstein included, has been that adding energy to material objects via relative velocity does not change these objects. Somehow energy of motion is a benign and observer-relative quantity that can be added and subtracted without effect. So if objects change (contract in space, slow down in time) and their relative velocity (and energy) is not the cause, then it must be space and time itself that changes the objects. This view of space and time as actors has been quite popular over the years and we may cite a few of its supporters here. According to John Norton (my italics):

> "Special relativity, as *a theory of space and time*, cannot make pronouncements by itself on energy, mass and matter. It can only constrain the ways that they can manifest in space and time…."[8]

---

[8] John D. Norton, "Einstein's Special Theory of Relativity and the Problems in the Electrodynamics of Moving Bodies that Led him to it." (2004): 34, http://www.pitt.edu/~jdnorton/papers/companion.pdf. See also his "realist conception of Minkowski spacetime," in "Why Constructive Relativity Fails." (2007): 3-4, http://philsci-archive.pitt.edu/3655/1/Constructive_Relativity.pdf. Both accessed March 2014.

Michael Friedman agrees that special relativity is all about space and time; he embraces the "physicalization of [Minkowskian] geometry."[9] Vesselin Petkov argues that it is spacetime that determines how objects appear.[10] True reality for Petkov resides with the four-dimensional worldtubes of Minkowski spacetime; our world of three space dimensions is illusory.

Unfortunately these arguments are based upon a false premise, namely that relative velocity and the kinetic energy it creates cannot affect material objects. One side result of this misconception is that the subject of kinetic energy and relativistic mass due to velocity is absent from discussions on special relativity.

It is very revealing that when special relativity theorists discuss meter sticks moving at very high relative velocity they ignore relativistic mass and wavelength measures and only discuss space contraction of the meter stick. In contrast, when quantum mechanics theorists discuss electrons moving at very high relative velocity they discuss relativistic mass increase plus the wave properties of the electron. But except for (irrelevant) wavelength measures, both cases are identical! When you add enough relative velocity to a material object so that kinetic energy dominates kinetic mass, then waveform dominates field form and you get the following situation: space contracts, time dilates, relativistic mass dominates rest mass and wave effects appear (diffraction being measurable only if the rest mass is very small). By equating wave behavior with diffraction effects, special relativity theorists have overlooked the fact that their large material objects (meter sticks, planets) at extreme relative velocities are in fact subject to wave effects other than diffraction, namely: space as progression not as extension and time as extension not as progression.

2.7 What Is Relative?

To assert that the space and time of an inertial system are warped because of the relative velocity of an external observer is unsupported by the facts of special relativity. Space contraction and time dilation were in need of an explanation after 1905 when opinion turned against the idea of the aether. Making space and time into an agent of change for material objects was an easy leap to make, but it was a mistake.

The reality is that inertial observers with different velocities relative to a common material object (projectile) are each encountering a different blend of kinetic mass and kinetic energy, of field form and waveform, and therefore a different (hybrid) entity. Since these different observers measure different entities, of course they find different splits between wave and field, between time and space and between rest mass and relativistic mass. Each hybrid entity is unique for a specific observer because that observer alone determines the singular kinetic energy filling out the hybrid entity's identity.

That which is fundamentally relative for different observers with different velocities is the reality of the hybrid entity; experiencing space, time and mass measures differently follows from that. It is not the case that the velocity of an inertial system (relative to some observer) changes/warps the space or time metric for that inertial system. It is the material meter sticks and material clocks as hybrid entities that undergo the change. This change is objective for the observer yet it is also subjective in the sense that it is only true for that observer at that (relative) velocity.

Physics is the study of matter and energy and special relativity is a branch of physics. As Darryl Hoving[11] has pointed out, subordinating relativity to geometry is to make an effect into a cause.

2.8 Conclusion

Two mistakes have bedeviled relativity discussions for well over a century and they probably still have legs. The first mistake is that light is some kind of projectile progressing in two dimensions (space and time) and its violation of Galilean relativity can be resolved by a postulate. The second mistake is the idea that projectiles are simple so adding

---

[9] Michael Friedman, *Foundation of Space-Time Theories: Relativistic Physics and Philosophy of Science* (Princeton University Press, Princeton, New Jersey, 1983), chap. IV.

[10] Petkov, "The muon experiment...demonstrated that space itself contracts relativistically." From Vesselin Petkov, "Accelerating spaceships paradox and physical meaning of length contraction." (2009): 4, http://arxiv.org/pdf/0903.5128v1.pdf, (accessed March 2014).

[11] Darryl Hoving, "Matter or geometry as fundamental in relativity theory." (2013): 27, http://philsci-archive.pitt.edu/9737/1/matterandgeometry.pdf, (accessed March 2014).

kinetic energy (relative velocity) to kinetic mass does not change the nature or identity of that mass: this wrong idea ("conventional wisdom") that two observers in relative motion are measuring the same object which should have the same space and time measurements.

The correction for both of these mistakes is a proper (ontological) understanding of entities in physics. Pure entities of kinetic mass or kinetic energy have a pure form (wave or field) and progress uniformly in only one dimension; hence the kinetic pure energy entity (the photon) is not subject to Galilean relativity. And when de Broglie waveform and rest mass field form combine as projectile they create a hybrid entity whose mass, space and time measures are unique for each inertial observer.

Unfortunately, correcting these mistakes faces considerable obstacles, namely the intellectual inertia of generations of physicists and philosophers who continue to view kinetic energy as a mere quantity rather than as an entity. Continuing to view kinetic wave energy (photon waves, de Broglie waves) as mere quantities simplifies the world view for physicists and philosophers, but it leads to the many paradoxes and puzzles of modern physics.

Seeing quantized energy as the entity equivalent of quantized matter was a change of viewpoint that the quantum revolution of the early 20th century never achieved. A century later it is time for reconsideration despite the angst that will involve.

Appendix A – The Twin's Paradox

One of the most famous paradoxes of special relativity involves the thought experiment of Bob and his twin sister Alice. Bob stays on earth while Alice travels to and back from a distant star at eight-tenths of the speed of light. While in flight Alice is space contracted and time dilated. When Alice finally returns to earth she has only aged 8 years while Bob has aged 10 years. But Alice is the same size as when she left; space contraction has been reversed, but not time dilation.

Actual experiments have been conducted with identical, synchronized atomic clocks, one "at rest" on the earth and one subjected to repeated flights on jet planes. When the flights are over and the clocks are finally compared side-by-side, the travelling clock has lost time but its size in space is identical to its twin.

This lack of symmetry is a consequence of how dimensional warpage affects progression differently than extension. Alice extends in (occupies) space and her space contraction in flight gets reversed when her flight is over. Extension is like a quantity: that which is taken away during flight gets restored when the flight concludes.

But things are different for the dimension wherein Alice progresses, namely time. Her progression rate in time slows during flight and her rate will speed back up to Bob's rate when her flight is over. But the aging interval that Alice lost due to her temporal slowdown is permanent. There is no way Alice can recover the time interval lost when her aging (progressing) rate fell behind that of Bob.

While field-form material entities such as Alice progress in time, waveform energy entities (the photon) progress in space. Hence a photon can have a "lost space" interval just as Alice experiences a "lost time" interval. There are two ways a photon can have a lost space interval, one more practical than the other.

The obvious/practical way is for the photon to travel in a vacuum, enter a medium such as glass or water, and then emerge back into vacuum. Although the emerging photon resumes its vacuum speed, it has incurred a lost space interval due to its reduced velocity in the transparent medium.

The less practical way for the photon to have a lost space interval is to duplicate Alice's experience but in reverse. The scenario for Alice is as follows. She is kinetic mass that acquires kinetic energy (relative velocity) and has a lost time interval after giving up her kinetic energy (her velocity) and returning to the inertial system of her twin brother. The scenario for the photon must involve the adding and subtracting of kinetic mass (matter) rather than kinetic energy. Somehow the kinetic energy photon acquires a small amount of kinetic mass (matter) and thereby slows its rate of space progression. After this "heavy" photon sheds its kinetic mass and resumes regular photon velocity it has a lost space interval it can never make up. While photons in practice may not behave this way, that is NOT the point. The point is that lost intervals always belong to the progression dimension. For kinetic mass (matter, namely Alice) the interval lost is in time; for kinetic energy (the photon) the interval lost is in space.

A lost time interval in special relativity is sometimes attributed to the "arrow of time." That is, Alice cannot regain her lost time interval because movement in time is constrained in one direction ("advancement") at a set rate whereas space movement is possible at any rate in any direction. According to this argument Alice is movement-free in space but not in time. But as pointed out in section 2.4 above, that is to confuse translational movement (and rate of movement) in space with extensional change. Translational movement (change of space location) is unrelated to extensional change (length contraction) except for the fact that velocity determines projectile kinetic energy which in turn governs how the hybrid projectile apportions its space presence between extension versus progression.

As seen by Bob, Alice has no freedom to influence either her space warpage or her time warpage. Alice's lost time interval is a consequence of time being her constant progression dimension; it is not a consequence of the "arrow of time."

References:

Bell, J.S. "How to teach special relativity" In *Speakable and Unspeakable in Quantum Mechanics*, 67-80, Cambridge University Press, 1987.

Brown, H.R. *Physical Relativity: Space-time structure from a dynamical perspective*, Oxford: Clarendon Press, 2005.

Einstein, A. "On the Electrodynamics of Moving Bodies." (1905) Translated by G. B. Jeffery & W. Perrett, in *The Principle of Relativity.* London: Methuen and Company, Ltd. 1923.

Foukzon, J. "Generalized Principle of Limiting 4-Dimensional Symmetry. Solution of the 'Two-Spaceship Paradox.'" 2008, http://arxiv.org/ftp/arxiv/papers/0805/0805.2820.pdf (accessed March 2014).

Friedman, M. *Foundation of Space-Time Theories: Relativistic Physics and Philosophy of Science*. Princeton, New Jersey: Princeton University Press, 1983.

Hoving, Darryl "Matter or geometry as fundamental in relativity theory." 2013, http://philsci-archive.pitt.edu/9737/1/matterandgeometry.pdf, (accessed March 2014).

Klein, Martin J. "Einstein and the Wave-Particle Duality," in *Natural Philosopher*, v.3, 1964

Levrini, Olivia "The substantivalist view of spacetime proposed by Minkowski and its educational implications." *Science & Education*, 2002, 11, No.6, 601-617. Also at: https://www.researchgate.net/publication/226346703_The_Substantivalist_View_of_Spacetime_Proposed_by_Minkowski_and_Its_Educational_Implications?ev=pub_cit_inc. (accessed March 2014).

Norton. J.D. "Einstein's Special Theory of Relativity and the Problems in the Electrodynamics of Moving Bodies that Led him to it." 2004, http://www.pitt.edu/~jdnorton/papers/companion.pdf, (accessed March 2014).

Petkov, V. "Accelerating spaceships paradox and physical meaning of length contraction." 2009, http://arxiv.org/pdf/0903.5128v1.pdf, (accessed March 2014).