Images of Reality and Relativity Theory

C. Kingston

Abstract

This paper initially explores the image of reality associated with Relativity Theory. Although the two basic assumptions (speed of light and principle of relativity) that form the basis of Special Relativity Theory appear to be reasonable, they are interpreted and extended by additional assumptions in such a way that the end results are no longer reasonable. Some conclusions arising from these additional assumptions about physical behavior appear to be inconsistent with some physical experiments. This exploration leads to a different image of reality that is based on the movement of energy (in the form of free energy or matter) in terms of energy velocity components. This image does not require dilation or contraction of either time or space and provides a basis for explanations of ‘relativistic’ physical behavior that differ from those of Relativity Theory without being inconsistent with the data from related experiments and observations.

Introduction

Special Relativity Theory (SRT) is essentially based on two fundamental assumptions and the Lorentz transformation (LT) equations. The LT equations are used as a basic set of transformation equations in SRT. They have been accepted as valid by many because the equations, or at least part of the equations, seem to be consistent with the experimental data pertaining to certain types of physical behavior. The concern in this paper is the logical basis for the interpretation of those equations and the variables therein, and the associated chain of assumptions and reasoning that is required to support the image of reality that is developed in SRT. Although SRT itself did not lead directly to a theory of gravity, concepts from SRT were used in the development of General Relativity Theory (GRT). Therefore some problems with basic concepts in SRT are carried over to GRT.

The image associated with SRT presents some unreasonable conclusions about the nature of the physical world. This alone would not be sufficient to reject the theory (reasonableness is a subjective evaluation), although it has been sufficient for considerations by others of alternate approaches that result in less unreasonable conclusions. However, some of the basic conclusions of the theory are not consistent with some experimental results concerning the behavior of light. The behavior of light and the associated assumptions are explored in the initial sections of this paper. This exploration results in an alternate way of looking at some of the basic assumptions that are intrinsic to SRT about the nature of light and the relationship of relative velocity to the behavior of light and
objects. This leads to an image of reality that corresponds to the physical behavior that is now associated with SRT but that eliminates the unreasonable conclusions of SRT.

**Inertial systems**

SRT is based on behavior in what are called inertial systems. However, inertial systems (systems with no acceleration) do not actually exist in the physical world. This would appear to be recognized by many, if not most, of those who accept relativity theory. The hypothetical environment of an inertial system must be a true vacuum that contains no matter or any other form of energy (otherwise gravity and thus acceleration within the system would be present). As a counterpoint it is claimed that an inertial system can be approximated by a system in outer space. An online encyclopedia states that

> “An inertial reference frame is a space-time coordinate system that neither rotates nor accelerates. In real life, such frames of reference are purely theoretical, because gravitational force (and thus acceleration) exists everywhere in the known universe. However, they may be approximated very well in intergalactic space, or to a lesser extent within the confines of a coasting spacecraft.”

In his book on relativity, Bergmann\(^2\) says:

> “The action of a gravitational field on a body is indistinguishable from “inertial accelerations.” Both gravitational and inertial accelerations are independent of the characteristics of the test body. Therefore, we are unable to separate the gravitational from the inertial acceleration and to find an inertial system.”

Such imaginary systems may be useful for examining relationships in a reasonably simple setting. Inertial systems are imaginary and must exist only in a true vacuum which would not contain any form of energy. Even free energy appears to have a gravitational effect. In the real world there may be relatively little matter in space but there is a large amount of energy moving about. This includes radiation (light, heat, etc.) from stars, including our own sun, the cosmic microwave background, and particles such as neutrinos. Energy such as the above that is familiar to us is apparently only present as a small percentage (under five percent?) of the total energy in our environment according to current cosmological theory. It seems that the tendency is to think of all of that energy as being ‘out there’; but some of it is also ‘right here’ as well\(^a\). The absence of matter in an area may constitute a ‘matter vacuum’ but it does not constitute a true vacuum. Deep space may offer an approximate material vacuum but not an approximate true vacuum. Inertial systems might best be viewed as imaginary coordinate systems that move with constant linear velocity in a true vacuum. The closest that we can come to that in the real world are systems described in the above encyclopedia reference that are situated in deep space and therefore exist in approximate material vacuums having relatively weak gravitational fields; they would have a uniform velocity as their only motion. Such systems might be referred to as ‘practical inertial systems’; it would still be necessary to take into

---

\(^a\) The term ‘right here’ refers to any location an observer might be, including locations in deep space.
account the presence of energy that can have an influence on the motion of light and matter within the system.

**Galilean transformation**

A transformation of coordinate values from one coordinate system to another when the two systems have a uniform relative motion can be accomplished by using the Galilean transformation (GT). The GT equations can be written as:

\[ x' = x - vt, \quad y' = y, \quad z' = z, \quad t' = t \]  \hspace{1cm} (1)

In RT, the GT is replaced by the Lorentz transformation (LT).

**Lorentz transformation**

The Lorentz transformation equations were developed prior to the development of SRT by Lorentz in 1904 presumably as a means of explaining the Michelson-Morley\(^3\) experiment through contraction of lengths. In SRT these equations replace the Galilean transformation equations. The GT and the LT are equivalent if the relative velocity is 0. The LT equations can be written as

\[ x' = \gamma (x - vt), \quad y' = y, \quad z' = z, \quad t' = \gamma \left( t - \frac{vx}{c^2} \right) \]  \hspace{1cm} (2)

The factor \( \gamma \) is defined as

\[ \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \]  \hspace{1cm} (3)

The variable \( v \) is the constant velocity of the system under consideration relative to another system or an observer. The variables \( x, y, z, \) and \( t \) are considered to be coordinate values for a given coordinate system, with the primed values referring to an equivalent coordinate system that is moving with some constant velocity \( v \) along the \( x \) axis relative to the non-primed coordinate system. There is apparently no distinction made between two different systems or a single system at two different velocities. The value of \( c \) is considered to be a constant that is equal to the speed of light in a vacuum.

The equation that is used to relate a time interval (T) with respect to the two set of coordinate values is

\[ T' = \frac{T}{\sqrt{1 - \frac{v^2}{c^2}}} = T \gamma \]  \hspace{1cm} (4)
It is primarily $\gamma$ that is used to compare theoretical and experimental results using SRT. The experimental evidence is persuasive that a factor such as $\gamma$ has some physical significance. Einstein used the LT equations along with two fundamental assumptions\(^b\) to form a theory characterizing the relationship of the LT to the physical world. This theory, SRT, brought attention to the gamma factor, which could be used to show relationships between the mathematics of SRT and certain experimental results.

The two main assumptions for the development of SRT and the derivation of the LT within SRT are

1. *The speed of light in a vacuum is constant.*

2. *The laws of physics are the same in a uniformly moving room as they are in a room at rest*

Both assumptions are often expressed in ways that are different than stated above. The second assumption is considered to be an expression of the ‘principle of relativity’.

**Speed of light**

The speed of light is the subject of the first assumption of SRT: *The speed of light in a vacuum is a constant.* This assumption sets the path that is followed by SRT and seems quite simple and direct. On further reflection, it is not so clear exactly what is meant by the term ‘speed of light’, nor is the nature of the vacuum referred to in the assumption clear. Also, the ‘in a vacuum’ part of the assumption appears to be routinely ignored when applying the assumption to actual physical behavior.

The equation \( x = ct \) (or \( x^2 + y^2 + z^2 = c^2 t^2 \)) is used in discussions of SRT to represent the mathematical relationship between location, time, and the speed of light. The mathematical logic applied to develop SRT is based upon \( c \) being a constant equal to the speed of light in a vacuum. However, after Einstein, using some of the ideas of time and space from SRT, developed GRT, he apparently modified his view on the speed of light. He said\(^4\):

“…our result shows that, according to the general theory of relativity, the law of the constancy of the velocity of light *in vacuo*, which constitutes one of the two fundamental assumptions in the special theory of relativity and to which we have already frequently referred, cannot claim any unlimited validity. A curvature of rays of light can only take place when the velocity of propagation of light varies with position. Now we might think that as a consequence of this, the special theory of relativity and with it the whole theory of relativity would be laid in the dust. But in reality this is not the case. We can only conclude that the special theory of relativity cannot claim an unlimited domain of validity; its results hold

\(^b\) Actually more than two since other assumptions are slipped into the development of SRT. Making additional assumptions can be necessary, but if such assumptions lead to unreasonable or illogical conclusions they need to be carefully re-evaluated.
only so long as we are able to disregard the influences of gravitational fields on the phenomena (e.g. of light).”

Experimental evidence also shows that the speed of light as defined by \( c = \frac{x}{t} \) does not always have the same value if the environment through which the light travels is varied. The refractive index of a material is defined as the ratio of the speed of light in a vacuum divided by the speed of light in the material. The speed of light through the earth’s atmosphere is less than it is through a vacuum. The speed of light also presumably varies depending upon its position in a gravitational field as noted by Einstein. Although the speed of light might be considered to be a given constant value in any imaginary inertial system with a vacuum environment, the speed of light is not a given constant value in the real physical world where environments can vary.

It has been pointed out that in spite of the experimental results showing that the speed of light in water and other material media is slower than it is in a vacuum, the speed of light is always the same and that it just seems slower because it is delayed in its travel by interaction with the atoms of the environment. That is presumably meant to support the RT viewpoint of the speed of light, but is similar to the analysis presented later in this section. It is also claimed that the Maxwell equations show that the speed of light always has the same constant value. But what about the experimental evidence that shows that its speed is not always the same when traveling through different environments? The logical explanation is that the term ‘speed of light’ does not always mean the same thing. In other words, it is being implicitly defined in different ways.

Fig. 1 shows a possible path of a photon in a real environment as it travels from A to B. The effective linear path of the photon is shown as a combination of free travel (Direct paths) and interaction with obstacles (Interaction paths). The interactions within a gravitational field will cause the overall path to be curvilinear rather than strictly linear. Some photons may never reach B if they are absorbed or are diverted along a different path (such as occurs in scattering). The time or extent that a photon interacts with obstacles is time during which the photon’s energy is not fully involved in moving toward B, at least not with the same speed as when freely moving along a direct path. The more the photon interacts along its path, the longer it will take it to travel the distance \( x \) from A to B. The speed of light determined by the time it takes to travel a given distance can be called the linear speed of light.

![Photon path components](image)

*Figure 1: Photon path in a real environment*
The speed of light (considering all velocity components) at any single point along its actual travel path and at a given instant of time, either direct or during an interaction, can be referred to as the total instantaneous speed of light (or just instantaneous speed of light which will be understood to be the sum of all velocity components unless otherwise specified). This probably represents a constant linear speed in a true vacuum\(^c\). In the real world, however, a photon will travel in a given direction, or the charges associated with the photon will move in a given way, until some interaction modifies this in some manner. The value of \(c\) as used in the LT equations is the length or distance, \(x\), divided by the time interval it took for the light to travel that distance (in this case, between A and B). Thus the value of \(c\) in a particular environment, which can be referred to as the local linear speed of light, can be variable since it depends upon how the light is affected by interactions along its path. The term ‘linear’ as applied to light paths will be understood to include possible curvilinear paths such as would occur in a gravitational field.

This gives us at least two definitions of the speed of light. There is the instantaneous speed of light at any given instant of time. Then there is the local linear speed of light, which represents the average of the velocity component in a specified direction, which is determined by how long it takes the light to travel a given distance. That the local linear speed of light varies as a function of the material environment is an experimentally demonstrated fact. With the view that the linear speed of light is moderated by interactions with any appropriate obstacle in its path, it is reasonable to say that the linear speed will vary in general as a function of the energy density along its path. The term ‘energy density’ encompasses the existence and behavior of any form of energy, whether it is in the form of matter (air, water, etc.) or in the form of free energy (photons or any energy that is not in the form of matter). Since gravity is associated with energy density\(^d\) it would follow that a gravitational field presents an energy density gradient that presents a varying obstacle to the movement of light, and thus the local linear (or curvilinear) speed of light would also vary under different gravitational conditions even in the absence of any material environment. This is reflected in the earlier quoted statement by Einstein.

Maxwell’s equations are sometimes used to support the consideration of \(c\) as a constant. However, the Maxwell equations do not show that the speed of light is always the same. The speed of electromagnetic waves through space in the Maxwell equations can be shown to be\(^5\) \(c^i = c / \sqrt{\mu \varepsilon}\), where \(c\) is the presumed speed of light in a vacuum. This indicates that the speed of light along a given path can be moderated by the permeability and dielectric properties of the environment through which it is traveling. In this form the denominator is assumed to be equal to 1 when the equations are applied with respect to

---

\(^c\) Since a true vacuum cannot be achieved within our current scientific capabilities, the general use of the word ‘vacuum’ as it applies to the real world implies a ‘material vacuum’. Since a material vacuum contains potential obstacles (in the form of free energy) with which light can interact, the linear speed of light in a material vacuum would be less than the linear speed of light in a true vacuum. Furthermore, the energy density in a material vacuum can vary depending upon the location. Thus the linear speed of light in a material vacuum may also vary even though the instantaneous speed may not.

\(^d\) The stress-energy tensor in Einstein’s gravitational field equations characterizes the distribution of the matter and energy content (i.e. energy density) of a local area.
free space (which is considered by some to approach a true vacuum). Sometimes a
distinction is apparently made between a material medium and a free energy medium,
with the above equation applying only to the former. The behavior of light in a gravita-
tional field indicates that the equation should apply to both. The values represented by
\( \mu \) and \( \varepsilon \) are defined (not measured) constants for free space, as is the value \( c \) for the
speed of light in free space. The actual values for \( \mu \) and \( \varepsilon \), as well as \( c \), in a material
vacuum (or free space) will presumably vary from the defined values depending upon the
energy density in the area and environment in which the values are considered or
measured.

We are now in a position to consider the specific use of the term \( c \) in SRT and the LT. It
seems clear that the equations of the LT use \( c \) in the sense of the linear speed of light.
There should be no ambiguity about the relationship \( c = x / t \) or its extension to the four
dimensions of space-time in SRT as indicating that the speed of light is measured by
dividing the distance between two locations by the time interval that is required for the
light to travel between them. From the above discussion it follows that the value of \( c \) in
the LT depends upon the environment through which the light travels. The value of \( c \) will
vary and will generally not be equal to any fixed value although it may remain essentially
the same throughout a given practical inertial system. Thus the value of \( c \) cannot be con-
sidered to be a constant in the true sense of the term. If the speed of light in the first
assumption of SRT is interpreted as the instantaneous speed of light in a material vacu-
num, then it is not properly used as such in the LT. If it is interpreted as the linear speed of
light, then it is not a constant that always has the same value in other than a true vacuum
environment contrary to the general interpretation in SRT. In either case, the logical basis
of the LT as the primary equation of SRT is flawed with respect to the interpretation of
the speed of light in the RT image of reality.

**Principle of relativity**

The second assumption of SRT is that of the principle of relativity: *The laws of physics are the same in a uniformly moving room as they are in a room at rest.* A motivation for
the development of SRT was the conclusion that the laws of motion for light did not
appear to be the same as the laws of motion for material objects. In other words, the GT
did not seem to transform the motion of light in the same way that it transformed the
motion of objects in inertial systems. A major factor in SRT is the assumption that the
linear speed of light is always the same for all observers, which is presumably based at
least in part on the first assumption of SRT. There is experimental evidence that contra-
dicts that assumption, although it is not interpreted in this manner by those who believe
that the SRT image represents reality.

A couple of example situations may help provide a focus for examining this. Initial con-
ideration here will be given to practical inertial systems since SRT is only concerned
with inertial systems. The environment to be considered is some region of outer space
that is reasonably devoid of any matter form of energy. The term system will signify
small areas associated with imaginary coordinate axes. The energy density throughout the
region will be assumed to be uniform. The linear speed of light throughout the region will
be essentially the same anywhere in the region to an observer at rest relative to the region, and any minor variations within this region in speed due to minor variations in energy density will be considered negligible.

For this first example the entire region is considered as a practical inertial system. Assume that two photons are emitted at the same time and in the same direction from a minimally sized area A somewhere within the region. Both photons travel toward some minimally sized area B in the region. When both photons reach B it should not be controversial to claim that both traveled essentially equal distances in essentially equal time intervals. Now let’s repeat this and designate one of the photons as an official observer. This does not alter the photon or its behavior in any way and only means that the motion of one photon is going to be considered relative to the other ‘observer’ photon. There is no reason that these two photons will not also travel essentially equal distances in essentially equal time intervals. Thus the relative speed of the ‘observed’ photon to the ‘observer’ photon would be essentially zero; otherwise they would not travel the same distance in the same time interval. If the two photons were going in opposite directions then the relative speed would be $2c$ where $c$ is the speed of photons relative to the environment. This is contrary to the assumption in SRT that the speed of light is the same relative to all observers in an inertial system.

Now consider two systems within the region that consist of imaginary coordinate axes and the small areas in which they are assumed to be located at any given time. The imaginary movement of these imaginary systems cannot have any effect on the environment of the region or on the areas considered at any given time as part of the systems. As a system moves, the associated area will be that part of the region where the axes are located at any given time; the environment does not move (in reality or effectively) with the systems. The speed of light in the region’s environment relative to the environment is the same throughout the region and in any direction in the region. Call that speed $c$.

Assume that the two systems (essentially the two imaginary coordinate axes $S_1$ and $S_2$) have uniform velocities (say $u_1$ and $u_2$) with a relative velocity of $v = u_2 - u_1$ between them. Since the movement of the systems (which is actually only the movement of the imaginary coordinate axes) can have no effect on the speed of light relative to the environment, and since the speed of light is considered to be the same throughout the region, $u_1$ and $u_2$ can be considered as being relative to whatever basis the speed of light in the region is considered relative to.

Assume that two imaginary observers, $O_1$ and $O_2$, are in $S_1$ and $S_2$ respectively. It should be clear that, in this example, the speed of light in $S_1$ will have different speeds relative to $O_1$ depending upon the direction the light travels through $S_1$. For instance if the light is traveling in the same direction as $S_1$, then its speed relative to $O_1$ would be $c-u_1$; if light is traveling in the opposite direction as $S_1$, then its speed relative to $O_1$ would be $c+u_1$. The same can be said for $O_2$ and $S_2$. A similar situation exists for $O_1$ and $O_2$ with light traveling in $S_2$ and $S_1$ respectively, in which case the relative speeds would have to include $v$. This again is contrary to the assumption in SRT that the speed of light is the same relative to all observers in an inertial system. Keep in mind that the linear speed of light is the same anywhere in the described environment to an observer (say $O_0$) at rest with respect
to the environment and that the motion of the imaginary systems or imaginary observers
cannot have any effect on this speed.

The use of the term ‘observer’ can be somewhat problematic for discussions involving
relative velocities and light. A real observer cannot physically observe objects or light
unless some sort of signal is transmitted between the observer and whatever is being
‘observed’. This signal is usually considered to be light or some form of electro-magnetic
radiation. Since light, or any form of signal currently known, has a finite speed, the
appearance of what is physically occurring can be distorted during the observation pro-
cess. For situations in which an observer could not physically observe an event, an
observer will be considered to have the ability to instantly perceive physical events as
they are occurring. A real observer in such situations, who might not receive any signals
from the ‘observed’ event or system, might have to calculate the nature of the event using
the laws of physics applied directly to the event and/or system.

Real systems involve real objects and environments associated with these objects. When
objects are present in a region their gravitational behavior suggests that they are sur-
rounded by an area that has an energy density that becomes less as the distance from the
object increases. The behavior also suggests that this energy density gradient behaves as
though it were traveling with an object that has a uniform velocity. Light will encounter
more obstacles (or obstacles that are more interactive) with which it can interact as its
path gets closer to an object, and its linear speed will decrease accordingly. When this is
the case, the analysis outlined in the examples above has to be modified to take into
account the properties of the environmental energy density associated with an object.

Consider an area such as in Fig. 1 that is associated with some object which is in motion
along the line marked x in the direction from A to B with some velocity $v$. The property
of the energy within the area is assumed to behave as though the energy density were
moving along with the area and object. Light entering at A that travels to B will have
further to travel (with respect to the light and an external observer) than light traveling
from B to A. Since the energy density in the area is effectively moving with the area, the
number and nature of obstacles encountered by the light from the two directions in the
area between A and B will essentially be the same. However the rate at which light
encounters the obstacles will be different for different directions. The propulsion of the
light presumably does not depend upon the environment associated with an object, but its
linear speed does depend upon the number and nature of obstacles it encounters in the
area. The time interval that is required for light to travel a given local distance would
presumably generally be the same if it encounters the same number of similar obstacles
regardless of the rate at which it encounters those obstacles, at least for low energy
density environments. In that case light would travel at the same local linear speed in a

---

$^a$ This may seem similar to an earlier hypothesis that the speed of light was relative to a single transmitting
medium, or ether, and that the ether local to an object was carried along (completely or partially) with the
object, or the earth. The aberration of starlight is considered to contradict that assumption. However, it is
assumed here that the local environment affects the linear speed of light but does not carry the light along
with it except possibly to the extent to which the light is interacting with a material environment. Thus
starlight aberration does not contradict the image presented in this paper.

$^b$ But not necessarily physically – see footnote on page 24.
given area regardless of its direction. That this conclusion applies with at least insignificant error in general in air on the earth is supported by observations and experimental results.

This was not the case for the above example using imaginary coordinate systems since the energy density (obstacles) did not effectively move with the systems (i.e. the imaginary coordinate axes). Therefore the light encountered a uniform moderation rather than a moderation that depended upon direction. In that case the speed of light relative to a moving imaginary coordinate system did vary for light traveling in different directions. In Fig. 1 the moderation is illustrated using periods of free flight and periods of interaction. Moderation might also be continuous; it would seem to make little difference to the overall effect but might affect a detailed theoretical consideration. Moderation might also be considered as energy drag. An object’s velocity can be moderated by air drag; energy drag would moderate the velocity of light and possibly that of objects as they achieve very high velocities. A well known related experiment will be considered next.

The experiment referred to was done by Fizeau where the speed of light traveling in two directions was compared as it traveled through water that was considered to be in uniform motion through the pipes of the experimental apparatus. The linear speed of light in water is expressed as \( c/n \), where \( c \) is the linear speed of light in the local environment and \( n \) is the refractive index (RI) of water at rest relative to the environment under the existing conditions. The RI of water for a given wavelength of light will vary as a function of temperature and pressure. An increase in pressure will generally increase the density of water, which in turn will increase its RI. In order to move water at a given velocity through tubing it must be put under an appropriate pressure at the input location. This will increase the average density, and thus the average RI, of the water. Although the increase is small, it is probably sufficient to affect the speed of light in the water. Let the RI of water at rest in the Fizeau apparatus be \( n \), and let \( n_d \) be the average RI of the water when it has an average density of \( d \) due to the pressure necessary to move the water at some velocity \( v \) through the pipes. The linear speed of light relative to the water through water at rest is \( c/n \). The average linear speed of light in and relative to water with velocity \( v \) in the experimental apparatus is \( c/n_d \). Since the light would presumably have the same linear velocity in either direction relative to the water, its velocity relative to an external observer would then be expected to be \( (c/n_d) \pm v \), depending upon its direction of travel parallel to the velocity of the water. The reported results of the experiment varied from this at least partly because the altered RI for the moving water was not taken into account. A major significance of the experiment regardless of any explanation of the exact numerical results is that the speed of light through the moving water is not the same in all directions relative to external observers.

The Fresnel and Einstein equations are used to explain the reported results of the experiment. These equations are examples where the math seems to work (in a limited sense) but the associated theory does not appear to be relevant to the experimental conditions and results. Neither the water nor the energy in the environment would likely provide a supporting medium for the travel of light (except possibly to the extent of the interaction of the light with the water). Thus the Fresnel equation does not seem applicable.
Einstein’s equation is derived from the LT which itself is flawed as noted earlier, and thus its use to explain the experiment’s results is questionable.

Another experiment that demonstrates the relative variable speed of light as a function of the velocity of the environment was done by Michelson and Gale\(^7\). The environment in that experiment was a partial vacuum inside pipes laid out on the surface of the earth. Two sides of a rectangle (2010 X 1113 feet) were parallel to the velocity due to rotation of the earth’s surface where they were located. These two sides were traveling at different actual velocities due to the curvature of the earth. Light traveling around the rectangle of pipes in one direction traveled at a different average speed than light going in the opposite direction; this was observed using an interferometer arrangement. This experiment extends the evidence that the speed of light is not the same for all observers to an essentially non-material environment. It also provides for an interesting discussion of the precise meaning of terms such as ‘local and external observers’, ‘system’, and ‘relative velocity’.

A point needs to be made with respect to the principle of relativity. Saying that the laws of physics are the same in all inertial systems is not the same as saying that all entities behave exactly the same in such systems under otherwise equivalent conditions. Velocity, like temperature, can change the nature and behavior of a situation or event. Also, different entities may show different behavior because of their particular physical properties. For instance, consider a photon and a rock. The velocity of both a photon and a rock (or other material object) can be thought of as being influenced by both the environment through which they are traveling and the source from which the motion is initiated. The behavior of both shows that both have the velocity of the source imparted to them and the motion of both can be moderated by the environment. A photon can interact with both the free energy and matter in an environment as discussed in the previous section. A rock will interact primarily with the matter in an environment (e.g. air drag), although it can also interact with free energy when that free energy plays its role in the gravitational process. A photon presumably always travels at a given linear speed relative to a uniform environment, and this speed can vary depending upon the nature of its environment. The velocity of the source of a photon becomes a component of that photon’s velocity and may affect the direction that the photon travels but cannot affect the photon’s local linear speed relative to the environment. The velocity of the source of a thrown rock becomes a component of that rock’s velocity and the local relative speed would generally depend upon the force used to throw the rock. The photon and rock behave somewhat differently in this respect but follow the same physical laws. If the environment was dense enough to limit the rock’s linear velocity when tossed with a given or greater force, then both the rock and light could behave in a similar manner with respect to the velocity of their ‘sources’.

It follows from the above that the motion of both light and objects in a real system moving uniformly relative to an external observer would be viewed by that external observer as behaving in a similar manner other than as noted above. Both objects and light could travel at different speeds when going in different directions within the observed system relative to an external observer. This is consistent with the earlier
analysis of systems associated with objects, the results of the water experiment by Fizeau, and the results of the Michelson-Gale experiment.

Other observations and experimental results are consistent with the above image of reality. If the observer, environment, and system are effectively moving together at the same velocity, and if the environment is uniform, then light produced from a source at rest relative to the system will travel at the same speed relative to that environment in any direction. This is consistent with the results of the Michelson-Morley experiment in which light was observed to travel at the same linear speed (within achievable error limits) in each perpendicular arm of an interferometer. The experimenters were local observers at rest relative to the interferometer and its light source which were essentially at rest relative to the earth’s environment with everything (other than the light) traveling at essentially the same overall velocity. The effect of gravity was apparently not significant since the horizontal orientation of the interferometer kept the light paths in a nearly constant gravitational environment as well as a relatively constant atmospheric pressure and density.

The light from double stars travels through uniform areas of deep space at the same speed in any given direction regardless of the direction and orbital speed of the star emitting the light. This is consistent with the linear speed of light always being the same (for any given frequency) when traveling through the same environment with the linear speed determined by the environment. Two rocks thrown in the same direction by two orbiting platforms can travel at different speeds unless the environment is dense enough so that it can limit the maximum velocity of the rocks just as the energy in an environment can limit the maximum velocity of light.

Aberration of starlight is consistent with the linear speed of light being moderated by the environment without the light being carried along by the environment except possibly for periods of time when the light is interacting with a material environment. This interaction time for light would be a small fraction of the total travel time of the light traveling through the earth’s atmosphere. Light emitted from a source at rest relative to the telescope and the local environment would share the environment’s velocity as a result of the velocity of the source being imparted to it (altering its path but not its linear velocity) and would therefore not show aberration.

That the source of light imparts its velocity to the emitted light as one of the light’s velocity components would seem to be consistent with the laws of physics. Would not the laws of physics apply equally to all forms of energy? Both material objects and light are just different forms of energy. The claim or implication that they react in completely different manners to a force does not seem to be sustainable. The effect of the imparted velocity on the speed of light must be viewed in terms of the effect of the local environment on the linear speed of light as well as the physical nature of light, which essentially has its own propulsion system. Light presumably does not depend upon an external force

---

8 This is presumably the case only when the environment effectively travels with the system or object. This would not necessarily be true for all combinations of environment velocity and energy density or behavior. It would also depend upon the moderation factor discussed in the next section.
to achieve its linear velocity. The effect of a force on the light as imparted through means of the emitter needs to be considered separately from the linear speed of light. This is generally not the case for an object.

It was partly the assumption that the linear speed of light always had to be the same for all observers that led to the conclusion that the principle of relativity as represented by the GT did not apply to both objects and light. The GT indicated that the transformed velocity of both light and objects varies with relative direction and velocity within a remotely observed system. This is consistent with the previous discussion. The assumption by some that this was not the case led to the development of SRT in an attempt to resolve this assumed violation of the principle of relativity in this regard.

**Time**

It will be useful to start this section by considering how time, or a time interval, is generally measured. At a basic level a time interval is measured by counting consistent repetitive events. The number of orbits of the earth around the sun is associated with the number of years in a time interval. The number of rotations of the earth around its axis is associated with the number of days in a time interval. The number of oscillations of a given resonant frequency associated with a specific type of atom divided by an appropriate conversion factor can provide the number of seconds in a time interval. In the latter case the conversion factor can be chosen so that the interval is consistent with that determined from the orbit or rotation of the earth. The frequency of the repetitive behavior can be influenced by an associated velocity. For instance, a change in the average velocity of the earth’s orbit around the sun would result in a change in the yearly time interval, and so on. This change affects the method of measuring time and implies no change in the actual passage of time.

The twin paradox can be interpreted as being based on a way of measuring the effects of the local passage of time – by lifespan. The nominal lifespan of a fruit fly is about 30 to 40 days; the nominal lifespan of a giant tortoise is about 170 years. This difference is a result of differing internal processes that occur within the different species; presumably nobody would claim that this is because the local time runs at a different rate for different species. The twin paradox presents the argument that a twin who takes a voyage on a space ship which is moving rapidly relative to the other twin’s location would have a longer expected lifespan than the twin who remained at the original location. This can be interpreted as a difference in the local passage of time for each twin or as a difference in the internal processes for each twin resulting from the differences in velocity. Experiments show that rapidly moving muons have a longer expected lifespan than relatively slow moving muons. This too can be interpreted as a difference in local time or as a difference in the rate of internal processes. A rationale for the view that velocity can affect the rate of internal processes is discussed later.

Discussions of time in relativity often mention the light clock, which will be considered shortly. It will be useful to first consider one aspect of photon motion in some detail by examining the effect of relative velocity between two different velocity states of a system.
on the measurement of the speed of light. The two states are illustrated in Fig. 2. The discussion will be cast in terms of two systems that are equivalent except for velocity.

![Figure 2](image)

**Figure 2**

Movement of light relative to two systems.

System S’ is moving with velocity \( v \) relative to system S. A photon aimed at a (red) target which is in S’ is emitted from O’ when point O’ is coincident with point O. The photon (p’) will remain directly over O’ since it will have the velocity \( v \) imparted to it. Thus the photon will travel along the path D with respect to S and along path D’ with respect to S’.

Assume also that a photon (p) within S is emitted from O at the (grey) target in S at the same time. This photon will travel in the \( y \) direction as seen within S. Assume that the speed of p in S is \( c \), and the speed of p’ in S’ is \( c’ \) with the condition that \( c = c’ \) when \( v = 0 \). The velocity of a photon can be considered in terms of velocity components relative to the coordinate system. When S’ is moving with velocity \( v \) relative to S, the velocity of p’ relative to O will have an \( x \) velocity component (\( V_x \)) and a \( y \) velocity component (\( V_y \)). Relative to O’ it will appear to only have a \( y \) velocity component (\( V_y’ \)), which has the magnitude \( c’ \) when \( v = 0 \). \( V_x \) is a real velocity component even though it may not be recognized as such from within S’.

As p’ moves through S’ the process of moderation is varying as a function of direction and velocity. The photon p’ will essentially move faster through S’ when it is traveling in the same general direction as S’, and slower through S’ when traveling in the opposite general direction as S’. Moderation is tentatively assumed to behave such that the speed of a photon in S’ as measured in S’ is the same in any direction. If this is a valid assumption, then \( V_y \) would remain the same for both S and S’ regardless of their relative velocity since the moderation of a photon in the \( y \) direction would be the same for either system. That would mean that \( c = c’ \) as long as the energy density in one system does not change. The photon p’ can be thought of as traveling in the direction D as viewed by an external observer since the velocity \( v \) has been imparted to it. It must actually travel this path to reach the target in S’ from its origin at O’ when O’ was coincident with O even though only \( V_y \) is recognized in S’. It has to actually travel the distance \( D + D_{ext} \) in the indicated direction in order to reach the target in S’. If \( c’ \) does not change, then p’ must travel faster in the D direction than in the D’ direction so that the time interval to reach the target remains the same as it was when \( v = 0 \). This is only possible if the moderation behaves as
was assumed above. There are some indications that moderation does not always behave in such a manner, particularly in high energy density environments.

This suggests that using a moderation factor $k$ that modifies $v$ to represent the amount of moderation that occurs in addition to the interaction between a photon and a stationary environment. If $k = 0$, the value of $c'$, which is the velocity of $p'$ as measured in $S'$, would not change as a function of $v$. If $k > 0$ the value of $c'$ would not remain the same for all directions. Relative to $S$ or a remote observer in $S$ the velocity of $p'$ would be $c' = c + (1 - k)v \cos \theta$. The value of $c$ in this equation is the linear speed of $p'$ in $S'$ when $v = 0$. Within and relative to $S'$ or a local observer in $S'$ the equation for the velocity of $p'$ as measured in $S'$ would be $c' = c - kv \cos \theta$, where $c$ is the speed of light in $S'$ when $v=0$.

The general nature of the results as reported for the experiment with moving media as done by Fizeau and others would be consistent with $k > 0$ (around $1/n^2$ for the original Fizeau experiment, where $n$ is the refractive index in water for the light used) for a material environment, such as water or glass if the experimental results are valid. If $k=0$ for all velocities of $S'$, then the velocity of light relative to $S$ would approach $2c'$ as the velocity of $S'$ approaches $c'$. The implication of this is that the speed of light in a true vacuum would be about twice that as currently measured on the Earth. This may be possible and represents an interesting possibility; if $k$ does vary it would probably generally vary as a function of the particular type of environment, its energy density and its velocity. Another factor would likely be the tenacity of the interaction between light and the environmental obstacles, including any variation as a function of the environmental velocity. Since the theoretical explanations of the results of the Fizeau type experiments which might apply to determining the behavior or functional value of $k$ are highly questionable, the issue seems resolvable only by additional appropriate physical experiments with a wide range of conditions or the development of a reasonable theoretical basis for determining the moderation factor.

SRT views the relationships in Fig. 2 equally from either system. This is necessary since the equations of SRT do not have any provision for including information on how the actual velocities of the two systems differ. The ‘relative velocity’ in SRT is essentially the ‘relative speed’ which does not provide information of the actual speed of either system. The implicit assumption in the above discussion was that $S'$ was moving faster than $S$ and thus had a greater velocity magnitude than $S$. It is necessary to know which system in such an analysis is moving faster in order to know what is happening in each system with respect to the moderation of the photon. If the actual velocities, or at least their actual relationship, are not known then it is not possible to determine what is actually happening in either of the systems on the basis of the relative speed. One way this is circumvented is to claim that it is the acceleration that is responsible for any ‘relativistic’ differences – this is just an indirect way of recognizing that it is necessary to know the actual relationship of the velocities of the two systems. There are other situations which essentially utilize relative speed rather than velocity which do give the same observational result regardless of which way they are viewed, and it is informative to
consider them in both directions; this will be apparent in the following discussion of the light clock.

A way of hypothetically measuring time that is often used in discussions of SRT is the light clock, which is illustrated in Figure 3. The light clock consists of two parallel mirrors at some given distance apart. A photon is assumed to be traveling back and forth between the mirrors, and time intervals can be measured by counting the number of trips the photon makes between the mirrors during an interval. The diagrams on the left (3a) represent the clock as viewed by a local observer. The light is traveling perpendicular to the mirrors to an observer local to and at rest relative to the clock. A local observer at rest relative to the clock would observe the same path behavior regardless of the velocity of the local system within which the clock is at rest. This would not be possible unless the photon had a velocity component equal to the velocity of the clock. This velocity would be imparted to the photon by its source, which would presumably be a primary source at rest relative to the mirrors. The diagrams on the right (3b) represent the moving clock and the photon path as viewed by an external observer.

Figure 3: The light clock
(a): local view, (b): remote view

In Fig. 3a the local linear speed of light for the light clock’s environment is shown as \( c \). This local linear speed can vary as a function of the energy density in the environment and the value of the moderation factor \( k \). It may vary as a function of velocity if that velocity affects the energy density and/or the value of \( k \). Thus similar light clocks in two different environments or systems may have different tick rates since the local linear speed of light could be different. This would have an effect on measured time intervals if local time is measured as a function of the local linear speed of light as it is in the light clock. The possibility that clocks in different systems or different states of one system might not tick at the same rate does not mean that the general flow of time is different; it is only the clocks that Behaves differently. The concern here is only the local tick rate, not

---

\[ ^b \text{The speed of a photon, and thus the tick rate of a light clock, can change as a function of the local environment and the interaction of light with that environment. Relativity theory claims that the speed of light always remains the same, and that time, along with space, changes independently of the speed of light. The image of reality in SRT seems to be that the space around the light clock changes thus changing the length of the light clock in the direction of travel which is presumed to be related to, or coincident with, a change in the ‘tick’ frequency, or time interval, as measured by the light clock.} \]
whether clocks in different systems, or very far apart in the same system, are synchronized to the same time.

Relative speed can have an effect on the relationship of the observed local time interval to a remote observer’s local time. Consider clocks in two systems that have some relative speed between them, and that each light clock sends a flash of light out in all directions each time the photon hits a mirror. If a system \( S_1 \) has a relative speed \( u \) with respect to another system \( S_0 \), then the time it takes information carried by light from \( S_1 \) to reach \( S_0 \) will vary for each flash depending upon the value of \( u \). If \( S_1 \) is traveling directly away from \( S_0 \), then the interval between equally spaced repetitive events on \( S_1 \) will seem longer to an observer on \( S_0 \) than they would to an observer on \( S_1 \). Let \( T_l \) be the local time interval on \( S_1 \) and \( T_0 \) the apparent time interval as seen from \( S_0 \). The relationship between \( T_0 \) and \( T_l \) as a result of the finite speed for the transmission of light if \( S_1 \) is moving directly away from \( S_0 \) is

\[
T_0 = T_l / \left(1 - u / c_s \right).
\]

The average linear speed of light in the space between \( S_0 \) and \( S_1 \) is represented by \( c_s \). If \( S_1 \) is not moving directly away from \( S_0 \), the equation would have to be modified accordingly. This relationship is symmetrical between the two systems – an observer on one system sees the photon travel time between mirrors on the other system as being greater than it is to a local observer in the other system, or less if the systems are approaching each other. This does not represent a real physical change in the behavior of the light clock; it is only how the photon travel time in a system would appear to an outside observer who is not moving with the system and is measuring time intervals based on the time between successive flashes of light according to a clock local to the observer.

This represents two different aspects in determining time intervals as measured by a specific type of clock. One is the time as measured by counting ticks of a clock in a system for an event in that same system. The other is the observed time in terms of the apparent time interval of a tick as it appears relative to a clock local to an external observer. If a practical inertial system, say \( S \), is moving relative to other systems, the local time in \( S \) as determined by tick counts remains the same for all observing systems regardless of the velocity of \( S \) relative to those systems. The time in \( S \) as determined by the interval between the start and end of one or more ticks may appear different to other observers because of their relative speeds and the finite speed of signals between the systems. This is observational distortion. If one of the observing systems, say \( S_x \), alters its velocity relative to \( S \), the locally measurable time in \( S \) does not change\(^1\) even though the observed tick interval may change relative to clocks in \( S_x \).

If only the velocity of \( S \) changes, which would change its speed relative to all observers, then both the tick interval and tick count for a given event could change. Whether or not this change of velocity would actually result in a change in the local tick count for a specified event in \( S \) would depend upon the nature of the event. How observers view the

---

\(^1\) This assumes that any effect of gravity because of the change has no significant effect on \( S \).
new tick interval depends in part upon the new relative speeds. A real physical change of tick count and the remote observation of the tick interval have different mathematical characterizations. After the change in relative speed, all observers would again observe a common tick count for the event in S regardless of their speed relative to S whereas the observed tick interval would be a function of each observer’s velocity. An equation such as the LT cannot represent or transform both aspects of such situations.

The hypothetical light clock depends upon the linear speed of a photon within the light clock. This speed can change as a function of the environment within the light clock and possibly the velocity of the light clock. If the material environment of a light clock is changed, such as filling it with water in place of air or a material vacuum, time intervals measured by that clock would also change. This is essentially a change in the physical means for measuring time and is not likely to be considered as an actual change in time flow such as time dilation (even in RT). Is it any different in effect if the speed of light in the light clock changes because of a change in the environment or velocity? This raises the question as to whether the flow of time actually changes as a function of environment or velocity, or are any changes simply a matter of variations in physical behavior of a clock (of light velocity relative to the clock in the case of the light clock). Once the means of physically measuring time is specified, does a change in the characteristics of the means also imply a change in the flow of time? Time would seem to be a subjective concept that is only made objective when a physical means of measuring time intervals is specified1. Such measurements would logically be based on some presumably stable periodic physical behavior. Given a specified means of measuring time intervals, it would seem to be a matter of personal preference whether changes in the periodic behavior used as a basis for the measurements is considered as such or as ‘time dilation or contraction’. The latter seems somewhat similar to saying that time is dilating because your watch is running slow.

Space

According to SRT, the physical space between two defined points can change (or appear to change?) as a function of the relative motion of the system within which that space, or distance, is measured. SRT views space-time in terms of four coordinate points such as (x, y, z, t), which is dependent on a specific set of coordinate axes, but views distance in terms of four measurements, three of which are based on the normal concept of length and the fourth is length in terms of the product of a time interval and the speed of light. The relationship is often expressed in an equation such as \( X^2 + Y^2 + Z^2 = c^2T^2 \), or more generally as \((x - x')^2 + (y - y')^2 + (z - z')^2 = c^2(t - t')^2\), which is essentially a normal space equation that is not necessarily dependent on any specific set of coordinate axes. This distance equation indicates that the two methods of measuring normal (3D) distance \( \sqrt{X^2 + Y^2 + Z^2} \) and \( cT \) should give the same results. According to SRT, the \( cT \) method of measurement can vary depending upon where it is measured since \( c \) is const-

1 Time in SRT appears to be defined in terms of a variable \( (t) \) in the LT and related equations. This is sometimes associated with the dial of a clock apparently without any physical relationship between the two being specified. The relationship of time to physical behavior (in terms of distance and velocity) then depends upon how the LT is interpreted and applied.
considered to always have the same absolute linear velocity whereas time intervals are considered variable. In order to establish the invariance of the distance between two points in a transformation from one system to another if the actual passage of time is considered to change (as is done in SRT) it is necessary to assume that at least one of the normal lengths can vary (in SRT it is the one parallel to the direction of motion). The variability of the \( cT \) measurement, however, depends upon the assumption that the speed of light always has the same absolute value, but that time (or a time interval) can independently vary.

The image of reality presented in this paper indicates that the measurable linear speed of light does not always have the same actual value even in practical inertial systems, and that the most logical view of local time as measured by a light clock is that it is a function of the local linear speed of light. A decrease or increase in the speed of light in this case is balanced by an increase or decrease in an associated time interval, which keeps the numerical value of \( cT \) for equivalent measurements the same in different states of a system. Thus the distance between two points can remain the same in transformations between different system states without the need to assume that a transformation must show that at least one of the normal lengths changes in order to keep that distance invariant.

The size of an object may appear to vary as a function of position and relative velocity to external observers due to the finite speed of light. This is a perceived variation in size, not a real physical variation of either the object or the space around it. An object may physically vary in size due to conditions such as temperature and possibly velocity. Such physical variations in size depend upon the composition and structure of the object and do not represent a change in the space containing it.

The perception of the distance an object travels when comparing two different velocity states of a system, or two systems with some relative velocity, can be interesting. The following illustration provides a means of focusing on one situation.

Fig. 4 shows two balls tossed toward a platform moving with velocity \( v \) in a practical inertial system. The two balls are tossed so that they have the same vertical velocity. Observer \( O_1 \) is moving with the platform; observer \( O_2 \) is not. The blue ball was moving with the platform when tossed and therefore has the velocity \( v \) imparted to it, while the red ball was at rest relative to \( O_2 \) when tossed at the same time. The lower blue horizontal line is the platform position when both balls were tossed. The upper line is the platform position when the balls reach it. The blue dotted arrows represent the paths of the balls as seen by \( O_1 \), and the red dotted arrows represent the paths as seen by \( O_2 \). The balls reach the platform at the same time according to both observers since they have the same vertical velocity. The velocity \( v \) is slow enough so that neither signal speed nor ‘relativistic’ effects are significant. \( O_1 \) observes that \( B_2 \) (the red ball) has traveled further than \( B_1 \) (the blue ball). \( O_2 \) observes just the opposite: that \( B_1 \) has traveled further than \( B_2 \). So \( O_1 \) and \( O_2 \) may disagree on their conclusions about the distance the balls traveled, and the extent of their disagreement on the distances depends upon the velocity of the platform.
This situation is a matter of symmetric observations by observers having some relative velocity between them. Their conclusions based on their observations depends upon how they use any knowledge they have of the actual conditions and how well they are able to establish the involved velocity components. At a minimum it would be necessary to know the velocity (not just the speed) difference between the two observers. There may be situations similar to the above where it may not be clear to either observer exactly what the relative velocity is (although they may agree on the relative speed). This would make it difficult for them to agree on exactly what is happening. In that case the observations present nothing more than the perception of distance that is symmetrically different for two observers in two different reference frames when viewing events in each other’s frame of reference. In this example such differences are not due to a physical contraction of space, and it makes little difference if the moving entities are balls or photons. This does not change if the velocity of the platform is increased, although the ability of the remote observer to make an accurate observation of the events relative to the platform could change.

According to GRT the presence of matter and energy curves space and the curvature of space determines how matter and energy move. A simple form of the equations that express this relationship is known as the Einstein Field Equation:

\[ G_{\mu\nu} = 8\pi T_{\mu\nu} \]  \hspace{1cm} (6)

The right side of Eq. (6) is portrayed as being concerned with the location, density and some aspects of the motion of matter and energy in a given region of space. The left side is portrayed in GRT as being concerned with how space curves. The actual measurements that can be made to test the equations, and indeed to specify the parameters or coefficients of the equations, are those of the motion of matter (or energy) in terms of the paths that are followed by moving objects (or energy) in the presence of other matter and energy. These paths are then considered to be a result of the curvature of space, and this image of reality has been accepted by those who accept GRT. The concept of curved space apparently arose and is supported in SRT by the interpretation of space in accordance with the LT.
A different image of reality that can be associated with the paths taken by moving objects (and energy) is that it is the active interaction of the moving entities with the local energy environment that determines the paths taken. Paths in an environment with a uniform energy density (which implies the lack of a gravitational field) would not change, while paths in a non-uniform energy density (such as associated with gravity) would change. These paths of motion can be modeled in some mathematical space that consists of points that satisfy a set of postulates, and it may be reasonable to consider such a space as a mathematically curved one; but the space in which we live is a real one and not a mathematical one. Showing that the paths of objects can be modeled in a mathematically curved space does not imply that real space is curved. The tensor structure of the field equations can equally be considered to model curved paths or curved space. Einstein’s field equations would seem to provide a successful description of these paths of motion in so far as they have been tested, but they do not tell us that physical space is curved or support that viewpoint as the only explanation.

**Absolute Motion**

The discussion so far points to the necessity for considering motion with respect to some absolute basis in situations where physical behavior may be a function of velocity. SRT considers only relative speed and position. It was previously shown that the instantaneous speed of light might be considered as an absolute value but that the linear speed of light cannot be considered as such. One difficulty that arises when trying to measure the absolute (or actual) velocity of any object is that of finding some absolute frame of reference for the measurement. It may be possible to establish an object as being at absolute rest without using a coordinate system (as discussed later), thus forming a basis for determining absolute velocity. The term ‘actual velocity’ will be used to indicate a velocity that is measured relative to some object at absolute rest. Or perhaps it could be considered relative to the instantaneous speed of light which is probably an absolute value. Since such measurements do not seem possible at this time, the numerical determination of actual velocity must be estimated and there will be some uncertainty associated with actual velocities.

Returning to the discussion of Fig. 2, both S and S’ will have some actual velocity. The actual velocity of S will be called $u$; the actual velocity of S’ as described would then be $u+v$. The relative velocity $v$ is the difference between their actual velocities in the direction of the x axis. The actual velocities have to be known, or assumed, in order to determine, or assume, the velocity $v$. If $u>0$ the paths of p and p’ as shown in Fig. 2 only represent their velocity components relative to S and S’. The actual paths of p and p’ cannot be determined unless the actual values of $u$ and $v$ are known. The magnitude (speed) of $v$ could probably be determined from within either S or S’. But it would probably be difficult to determine the actual velocity $u$. That represents one problem when using actual velocities. It does not, however, mean that a situation should not be analyzed in terms of actual velocities even though the actual values may not all be readily measurable.
If the relative velocity between two systems or objects is considered as a relative speed rather than as an actual velocity, which is implicitly done in SRT, the information necessary to evaluate what is physically happening within each system or object as a result of their velocities is not available. In SRT it is presumably considered that the actual velocity could be in either direction between systems or objects which leads to the awkward conclusion that the same physical behavior must be considered to occur in both as a result of their relative velocity. As noted in the section on time, only the symmetrical results of observation can be determined using only the relative speed.

Considering location in absolute terms also poses difficulties since we do not seem to be able to find a fixed absolute coordinate system to serve as a basis of measurement. However, unlike using relative motion, using relative location does not appear to pose significant problems for understanding physical behavior. Therefore, considering space in absolute terms does not appear to be necessary, whereas considering velocity in absolute terms does appear to be necessary in some situations.

Energy

This section explores the relationship between the motion of entities and the energy associated with those entities.

Energy and motion are intimately related; energy implies motion and motion implies energy. Energy can be expressed in terms of the kinetic energy of an entity. The component of this energy due to its overall velocity $v$ can be written as $KE = (1/2)mv^2$. The instantaneous energy of an entity due to its velocity as a unit, or its momentum, can be expressed as $mv$. If the linear velocity of an entity with mass $m$ changes from $v_1$ to $v_2$ the sum of the instantaneous energy involved in the change is equal to the overall change in the kinetic energy:

$$\int_{v_1}^{v_2} mdu = mv_2^2/2 - mv_1^2/2.$$

It should be noted that the velocity difference (or relative velocity) between the two states is not sufficient to determine the actual numerical value of the change in kinetic energy – the actual velocities are required for that.

For purposes of this discussion a photon is considered as a particle that is associated with wave behavior much in the same way that an electron (or other particle) is considered as a particle that is associated with wave behavior. A prevailing point of view in the context of RT is that a photon has no mass$^k$. The problem with this is that those who claim this decline to define mass. That a photon has no mass cannot be substantiated unless mass is defined in physical terms so that we can know what it is that a photon does not have. A different point of view is that matter, which is said to have mass, is a form of energy. This implies that energy must have mass unless mass is defined as something that exists only when energy takes the form of matter. Mass has not been so defined, and a photon is

$^k$ Some would say that light has no rest (or invariant) mass. All energy, even that in the form of matter, is always in motion in one way or another. Thus it might be said that nothing has any rest mass.
a form of energy, so it would follow that a photon has mass\(^1\). There is no logical reason to consider photons and matter as different kinds of entities; they are both forms of the same kind of energy. That is the view taken for the following discussion.

The kinetic energy of a photon emitted within a given environment can be written as

\[
KE = \frac{1}{2}mc^2 + \frac{1}{2}m\varepsilon^2 = \frac{1}{2}m(c^2 + \varepsilon^2). 
\]

The variable \(c\) can be viewed as the average linear speed of a photon and \(\varepsilon\) as the average interaction speed of the photon within a given environment. If changes in the environment change the probability or degree of interaction, the actual linear speed of the photon would change accordingly. Assuming that the photon retains the same total kinetic energy\(^m\), this relationship can be expressed as

\[
\frac{1}{2}m(c^2 + \varepsilon^2) = \frac{1}{2}m(c_1^2 + \varepsilon_1^2).
\]

If \((1/2)m\) is cancelled out this becomes

\[
c^2 + \varepsilon^2 = c_1^2 + \varepsilon_1^2. 
\]

The velocity variables in the above equations are actual velocities and can be thought of as being related to the probabilities that the photon’s energy is devoted to linear (or curvilinear) travel and/or to interaction. The value of \(\varepsilon\) can also be thought of as a function of the rate at which the photon encounters obstacles with which it can interact as well as of the degree to which the obstacles interact with photons. It is not clear whether a photon’s travel is one of ‘free flight’ with intermittent interactions or whether the interaction is a continuous but possibly variable process. Thus it seems best to view the variables in terms of averages or probabilities. In a uniform and stationary environment (in an absolute sense) the average value of \(\varepsilon\) would remain the same regardless of the direction in which a photon is traveling. In a moving environment the average value of \(\varepsilon\) would vary as a function of the direction in which the photon is traveling relative to the motion of the environment. This means that a photon would appear to travel at different actual speeds in different directions in that environment to an external observer that is not at rest relative to the environment while its speed through a uniform environment would generally remain the same (provided the moderation factor \(k=0\)) for a local observer who is moving with the environment.

---

\(^1\) Another view is that nothing that has mass can travel at the speed of light. This view may arise from the relativistic view that (relativistic) mass increases with velocity and presumably becomes infinite at the speed of light. It should be clear later that this is not the case, and that variations in velocity alone cannot result in variations in mass. This precludes the necessity of not using mass in equations for the energy or momentum of a photon. It may also be the case that the speed of light would be much greater if it did not have mass.

\(^m\) Some interactions which result in scattering or absorption can result in a transfer of a photon’s energy to another entity. Such interactions are not included in the subsequent equations.
The presumption here is that a photon does not travel with an environment – it generally travels through an environment and does not depend upon the environment for its propulsion\(^n\). If it is traveling in the same direction as a uniform environment, the frequency with which it encounters obstacles will be less than if it is traveling in the opposite direction. In that case the value of \(\varepsilon\) will be different in the two directions. However, the light will on average encounter the same number of obstacles over a given local path length in a given uniform environment regardless of the direction in which it is traveling. Assuming a stable average time of interaction with obstacles, a photon in a stable uniform environment (which may be moving with a uniform velocity) would take the same local time to travel a given distance regardless of its direction. Thus the actual linear speed of a photon in a given environment can vary but its linear speed relative to a uniform environment moving at a uniform velocity generally will not (if \(k=0\)). This may not be the case for all combinations of environment, velocity, and energy density that are associated with objects. As discussed earlier, it is not the case for an imaginary system since there is no environment that ‘moves’ with the system.

At this point it would be useful to look at a system related to an object with its environment and ask if, or how, the velocity of that system affects the above equations. There are two basic aspects to be considered. 1) Any change in motion of an environment can change its speed relative to light passing through it. This can change the rate that light encounters obstacles with which it can interact, which depends upon the relative directions that the light and environment are moving. This has been discussed above. 2) The question as to whether or not the energy density of an environment undergoes any change other than that noted in the first aspect. One way of considering the difference between the two aspects is that the first involves a change in the rate at which light encounters obstacles with which it can interact, while the second involves a change in the nature of the environment and/or its mode or intensity of interaction with light.

Since there appears to be no experimental or observational data relative to this, it will not be considered further here. Most tests of RT have been related to the effect of velocity on objects (e.g. atomic clocks on airplanes) or particles (e.g. muons). Thus there are experimental results that relate to the effect of velocity on an object (but not necessarily on the associated environment), which is considered next.

The kinetic energy of an object can be represented by the following equation:

\[
KE = \frac{1}{2} m \varepsilon^2 + \frac{1}{2} m v^2 = \frac{1}{2} m (\varepsilon^2 + v^2).
\]  

\(^a\) It is not known whether or not light will travel through a true vacuum or requires some medium to be present. The energy density present throughout space would probably serve as that medium. The movement of an object through this energy would not necessarily drag the energy with it. But it would affect the local behavior of that energy, and that behavior would accompany the object in the sense that it is constantly renewed. The environment around an object can be considered as consisting of any local energy and its behavior as well as any local persistent material atmosphere. Thus the energy environment associated with an object can be considered as ‘moving’ with the object without considering that the energy itself physically moves with the object as well.
The variable \( v \) in this case can be thought of as either the actual common linear or curvilinear velocity of the energy quanta forming the object, or as the velocity of the object as a unit. The variable \( \varepsilon \) can be thought of as the actual velocity associated with the interactions of the energy quanta within the object. It is assumed that each energy quantum has the same interaction velocity magnitude; otherwise \( \varepsilon \) would have to be viewed as an average value. Only the velocity magnitude is used in these equations. The variable \( m \) is the total mass of the object. If the object is now considered to have a different velocity of \( v_1 \), then \( \varepsilon \) would change to \( \varepsilon_1 \) if the object is to retain the same energy. The relationship can be written as

\[
\frac{1}{2} m (v^2 + \varepsilon^2) = \frac{1}{2} m (\varepsilon_1^2 + v_1^2).
\]

By cancelling out \( \frac{1}{2} m \) we get

\[
(\varepsilon^2 + v^2) = (\varepsilon_1^2 + v_1^2).
\]

This can be rewritten as

\[
\varepsilon^2 - \varepsilon_1^2 = v_1^2 - v^2.
\]

Let \( \Delta v = v_1^2 - v^2 \) be the difference of the squared velocities. After substituting and rearranging, we can write

\[
\varepsilon_1^2 = \varepsilon^2 - \Delta v.
\]

If we divide both sides by \( \varepsilon^2 \) and take the square root of each side we have

\[
\frac{\varepsilon_1}{\varepsilon} = \sqrt{1 - \frac{\Delta v}{\varepsilon^2}}, \quad \text{or} \quad \frac{\varepsilon}{\varepsilon_1} = \frac{1}{\sqrt{1 - \frac{\Delta v}{\varepsilon^2}}} = \gamma.
\]

Keep in mind that the variable \( \varepsilon \) represents the interaction velocity of energy quanta within the object. Energy quanta that form the object have no linear velocity except that represented by \( v \) which is the actual velocity of the object. When considering objects, the variable \( \varepsilon \) is related to \( c \) as used in \( mc^2 \), which refers to material objects, but can also refer to free energy if free energy is considered to have mass. The values of \( \varepsilon \) and \( \varepsilon_1 \) are those at two different states of an object, and can range between zero and the maximum velocity of energy quanta. The value of \( \varepsilon \) for an object cannot be zero since that would mean that there would be no interaction energy and an object would probably not exist as

\[^{\text{0}}\text{The } c \text{ in } mc^2 \text{ might be interpreted as the overall instantaneous speed of light. The value of } \varepsilon \text{ refers only to the interaction speed of energy quanta, which would presumably represent the internal velocity magnitude of most of the energy of a stationary object on the earth.}\]
an object if that were the case. The value of $\varepsilon$ for a stationary object on Earth would probably be close to the value for $c$ used in $\gamma$. For that situation, which would apply to an object’s initial state in most earthbound experiments, there is a close relationship between $\gamma^*$ and $\gamma$. If the initial velocity $(v)$ is considered to be 0 and $\varepsilon$ remains at an initial value equal to $c$, then the two factors can provide equivalent results. Since actual velocities are used in $\gamma^*$ the results from the two factors will have a small percentage difference, and $\gamma^*$ will depend on the sign of the difference of the squared velocity magnitudes.

When using a light clock, time is theoretically measured in terms of the local linear speed of light (or of the distance within the clock that the light travels according to SRT). That is a hypothetical line of reasoning since the light clock is a hypothetical device that is not available for experimentation. When using an atomic clock time can be measured by means of a particular resonant frequency within the atoms. It seems reasonable, based on actual behavior of atomic clocks, to assume that this frequency is dependent on $\varepsilon$. The interaction speed of energy quanta within an atomic clock is presumably related to the periodicity, or frequency, of clock ticks and thus of the measurement of time by the clock. The relationship of $\varepsilon$ to a time interval $(T)$ in two systems is such that $\varepsilon T = \varepsilon_1 T_1$ (or $cT = c_1 T_1$ with $c$ interpreted as the interaction speed of energy quanta within an object). Thus time intervals for an atomic clock in two different states of the same system are related by the equation $T_1 = T \gamma^*$. This does not signify a difference in the passage of time; it only signifies a difference in the behavior of the clock.

The variables $v$ and $c$ in the above equations represent readily observable motion. The value of $\varepsilon$ as used in Eq. 7 represents motion that can be thought of as being confined to a very small region, and which will not generally be directly observable. This suggests that an additional variable, $\alpha$, should be added that applies to the molecules and atoms which are a part of an object. The local movement within an object of the atoms and molecules is to a large extent a function of temperature. The effect of variations in temperature or other conditions that might influence $\alpha$ is not represented explicitly in the equations in order to keep the focus on the main ideas of the image. For this discussion of the image, the velocities attributable to $\alpha$ and $v$ are considered as being combined in the variable $v$ unless otherwise noted. In this case the variable $v$ may have multiple velocity components with linear velocity being one of these. In some cases, such as when the environment is within a sun, $\alpha$ can be a major factor and should probably be considered as a separate component.

Energy involving $v$ or $c$ can be referred to in terms of kinetic energy. Energy involving $\alpha$ or $\varepsilon$ is sometimes referred to as heat energy or potential energy although it can still be represented in terms of kinetic energy. Eq. 8 implies that any change in motion results in an internal change in the distribution of energy velocity components. An object should presumably have the same actual overall energy content in any system or state unless it absorbs or emits energy quanta in some form. Other than that the change in the observed motion of an object represents a redistribution of the velocity components as shown in Eq. 8, not a change in overall energy. This change in motion can be transferred between $v$ and $\varepsilon$ or $\alpha$ depending upon the situation. If the object collided with another object, the
energy (except for possible loss as radiated heat, etc.) in the other object could internally transfer between ε or α and v depending upon the nature of the collision. This process is consistent with the conservation of energy (instantaneous as in momentum or summed as in kinetic energy); it also implies the conservation of velocity (instantaneous velocity and its sum over a change in velocity) for a given entity. Some collisions may result in an actual transfer of energy as a result of absorption or other inelastic interaction.

Visualizing transfers between interaction energy and linear velocity is easier when viewing velocity as absolute rather than as a relative measure. For instance consider an orbital interaction such as an electron orbiting an atomic nucleus. This should be easier to visualize than considering similar interactions between energy quanta in groups that form particles or other forms of matter. Many are familiar with the picture of an orbiting electron. This picture will generally remain the same even if the atom is moving with some velocity if the orbit of the electron is considered relative to the nucleus. Rather than looking at the progression of events as the velocity increases, let’s consider that the object that contains the atom has reached its maximum possible velocity as the linear velocity v. Thus the electron and the nucleus have also reached their maximum velocity. Consider that the electron is at the moment moving along side of the nucleus. In order for the electron to orbit the nucleus in any manner it would have to at times achieve a velocity greater than v, which is not possible. Thus the energy that was once involved in the orbiting interaction (ε) is now devoted primarily to linear velocity (v). This transfer of velocity occurs gradually as v increases – not all at once when the maximum velocity is reached.

The above equations provide a means for at least a tentative characterization of an object that can be considered to be at absolute rest. If v = 0 for the center of mass of an object, then that object can be considered to be at absolute rest. Saying that an object is at absolute rest by this definition does not mean that the object has no motion. A spinning object can be at absolute rest even though the individual atoms or molecules may be in motion and the energy quanta that form an object will always be in motion under foreseeable circumstances. Since acceleration for a given force varies as a function of v with the greatest sensitivity around the actual value v=0 (see Fig. 5), it seems theoretically possible to be able to determine whether or not an object is at absolute rest by this definition using sufficiently sensitive and accurate instruments and methods. In that case there would be no need to find an absolute coordinate system in order to determine if an object is at absolute rest.

Some Implications

At one time the GT was considered applicable to the analysis of motion in inertial systems. After Maxwell formalized the equations relating to electromagnetism and electromagnetic radiation (EMR), it was noted that the GT did not seem to transform the motion of light as generally interpreted at the time and the Maxwell equations in the same way that it transformed the motion of objects. There were two problems: a) The equations were interpreted to mean that the speed of light (actual or observed) was independent of the inertial reference frame, which would not be the case with the GT, and b) the Max-
well equations were not invariant when transformed by the GT. Thus it was concluded that the GT did not apply equally to objects and EMR. Einstein sought to remedy this by replacing the GT with the LT, for which the equations have been shown to be invariant under the conditions assumed in SRT. This led to the conclusion that time and space had to vary as a function of velocity in order for the equations to be correct.

The above two problems were based on a particular image of reality associated with RT. This image portrayed the speed of light (with the ‘in a vacuum’ part stated but otherwise ignored) as having an absolute value that would be the same for all observers in all systems and thus completely independent of any inertial reference frame. Previous sections have shown that this is not a valid assumption or conclusion based both on logical thinking and experimental data. The GT was deemed to be inappropriate for EMR since it led to the conclusion that the speed of light relative to the system in which it is traveling would depend upon its direction relative to that system according to a remote observer. That was contrary to the assumptions with respect to light that were made at the time. The discussion associated with Fig. 2 demonstrated that the speed of light in S’ and relative to S’ did depend upon its direction of travel according to an observer in S. Since the GT does result in a variation in speed depending upon the direction of light travel, it should not be rejected on that basis alone. It should be noted, however, that the GT does not agree with the discussion in this paper with respect to the details of the variation.

One of the main factors involved in analyzing viewpoints relating to differing velocities is how different observers view the velocity components of the motion in different frames of reference. Another factor is the nature of any assumptions made. This is true for the motion of both light and objects. Although the LT is oriented largely to the motion of light, the discussions so far have raised serious questions about its applicability to that motion. Conclusions based on the LT are also formed with respect to objects. The following discussion, which involves velocity components of motion, will be directed to that issue.

Figure 5, which is based on Eq. (9), shows the relationship of \( \varepsilon \) and \( \nu \) to each other for equal energy increment transfers (equal to 0.01 of the total object energy) between an object’s interactive energy (\( \varepsilon \)) and linear velocity (\( \nu \)). The change in the linear velocity of the object for equal energy increment transfers, which is a function of the object’s actual velocity, is shown by the curve labeled \( \text{dv} \) (which depends upon the size of the energy increment used). The object’s velocity decreases rapidly at first and then less rapidly as the linear velocity increases. The last energy increment in the chart results in the interaction energy within the object going to zero along with a smaller increase in velocity –
after that the linear velocity of the object as a complete entity, if it manages to reach that velocity as a complete entity, cannot increase$^p$.

![Figure 5: Relationship of energy velocity and object velocity for equal energy increment transfers between ε and v.](image)

If a constant force is applied to accelerate an object, the acceleration of the object will gradually decrease. If the object is viewed in terms of having different system states at different times when it has different speeds, then the resulting acceleration for a specified amount of force being applied would not be the same for each system state. This difference in behavior in different system states is not a violation of the principle of relativity since the same physical laws are applicable.

Some implications of the relationship between an object’s energy distribution and its velocity as described above will be briefly discussed in the following paragraphs.

The total energy of an accelerating body does not increase in general and thus its mass does not increase in general as a result of acceleration. Some methods of acceleration may incidentally increase mass and thus energy, such as bombardment with light or particles. As shown in Eq. (8) the increase in the magnitude of the moving linear velocity of an object (and thus the increase in its moving linear kinetic energy) is balanced by a decrease in its internal interaction energy; the mass must be the same on both sides of the equation. Any increase in total energy or mass would be a result of an actual absorption of energy quanta (such as photons or larger particles) by the object, which cannot occur from the acceleration itself. To say that the assumed increase is in ‘relativistic mass’ rather than real (or rest) mass is simply a play on words. Relativistic modifications of the equations for momentum and kinetic energy would have the energy of an object increase

$^p$ As the interaction energy of an object transfers to its overall velocity the energy involved in internal interaction decreases. If this internal interaction energy is involved in maintaining the energy in the form of matter (the object) then it would seem that a speed might be reached where it would be insufficient to do so. At that point the object might either revert to smaller particles that would hold their form with less overall interaction energy or to free energy. To experience the latter would probably require speeds close to the instantaneous speed of light which would not be likely except possibly in a true vacuum. This behavior would appear to be consistent with the theoretical consideration of running coupling constants and some observed behavior of protons and the quarks therein at very high speeds in particle accelerators.
with its linear velocity. This can only happen if the actual mass is increased. The energy required to accelerate an object will generally go into creating the conditions which cause the acceleration, not into the object being accelerated. The overall energy of an object does not increase with its linear velocity, but its ability to cause a greater change of velocity through redistribution of internal energy within the involved objects as a result of a collision does increase with increasing velocity. This can create the perception that the overall energy or mass of an object increases with its velocity.

The change in energy distribution represented by Eq. (8) depends upon the speed but not on the mass of the object; the mass must remain the same during any acceleration for the equation to be valid. Thus this change in acceleration as a function of the redistribution of velocity components for a given amount of applied force would not appear to be related to inertia. The amount of energy necessary to accelerate an object in a given state does depend upon the mass of the object, which is indicated by Newton’s second law ($F=ma$). This presumably is related to inertia. The view in modern physics is that the mass (or relativistic mass) increases as a function of velocity, and the factor $\gamma$ is introduced to modify Newton’s equation to $F = m\gamma a$ to indicate this. In the image of reality presented in this paper the mass does not increase as a function of velocity, and thus $\gamma$ does not modify $m$ as it does in relativistic equations.

The fact that the applied force must be increased as a function of speed to maintain a reasonable increase in speed is easily shown using Newton’s original equation and does not involve any increase in mass. The equation expressed in terms of work is $Fd = mad = \frac{1}{2}m(v_f^2 - v_i^2)$, where $v_i$ is the starting velocity and $v_f$ is the ending velocity for the distance $d$. If $m$ is considered to have a value of 1.0, then the relative amount of energy required for an increase in the velocity of an object by 1 m/s would be proportional to $(v_f^2 - v_i^2)/2$, which equals $v_i + 0.5$. Thus the required energy to keep increasing the velocity by 1 m/s (or any other given velocity increase or mass) for each $d$ increment is proportional to the velocity of the object – it is not necessary to assume an increase in mass to explain it.

Assuming that $\gamma$ does modify Newton’s second law so that it shows a better fit to actual accelerator data (which seems to be the case), the question is what is the physical basis for this. In the image here $\gamma^*$ would replace $\gamma$. The main consideration is that accelerator data is reported to show that a given force has a decreasing effect in accelerating a charged particle as its velocity approaches that of light, and that an applied force beyond that shown by Newton’s law is necessary as the speed of a particle increases to maintain a reasonable increase in velocity. One possibility is the following. As a particle’s speed is increased there is a decrease in the interaction energy within the particle. This could result in a decrease in the effective charge of the particle as a function of its velocity$^q$.

$q$ This is suggested by the theoretical behavior of running coupling constants and the reported behavior of quarks at high speeds in accelerators. Quarks have fractional charges that generally add up to an integer charge on a particle under normal conditions. It seems possible that a decrease in interaction energy at high speeds could affect the way that the quarks contribute to the overall charge on a particle leading to an effective decrease in that charge.
This may be due to a different configuration of the charge as the particle’s interactive energy decreases, or it may be due to an unrecognized relationship between the charge of a particle and the permittivity of an environment with respect to a particle as a function of the speed of a particle therein. Since the acceleration in an accelerator is a function of the reaction of the charge to an electric field, this would affect the expected acceleration of a particle with respect to a given field strength. There does not appear to be any evidence that the same situation would occur with methods of acceleration not based on charge. If the effect is specific to charge based acceleration, then the inclusion of $\gamma$ or $\gamma^*$ in Newton’s equation may not be valid in general.

This same situation would occur with the determination of momentum (and thus mass) that is based on charge. The momentum of rapidly moving charged particles is generally measured in terms of the radius of curvature of a charged particle moving in a magnetic field. If the effective charge of the particle decreases with increasing speed, the radius of curvature will increase. This would result in the appearance of an increase in momentum, and thus mass, as a function of speed, and would be characterized by the same factor ($\gamma$ or $\gamma^*$) as that for accelerators as discussed above. The apparent increase in ‘relativistic’ momentum, or ‘relativistic’ mass, with increasing velocity in this case might actually be due to the decreased effect of the magnetic field on the charged particle. The ‘relativistic’ increase in mass as postulated in SRT presents the highly unlikely situation that the value of the mass or kinetic energy of an entity approaches infinity as the entity’s velocity approaches its maximum possible value.

The possibility that the effective charge on a charged particle decreases as a function of the particle’s speed in a given environment is consistent with the behavior of groups of rapidly moving electrons. It has been noted that groups of electrons moving at high velocities do not scatter apart to the degree that would be expected on the basis of their common negative charge. This is discussed by Einstein who suggests that “The general theory of relativity renders it likely that the electrical masses of an electron are held together by gravitational forces.” A second and perhaps concomitant possibility is that the effective charges on the electrons become less as their velocity increases. There appears to be no experimental evidence that denies this possibility; in fact, it is actually supported by the experimental data from accelerators and the motion of particles through magnetic fields. This of course depends upon how one wants to interpret the data. Without further supporting evidence, the choice is between believing that mass (and energy) can become infinitely large or that there is an alternate explanation such as the effective charge decreasing with velocity. The mathematical characterization of the behavior of charges (with emphasis on the strength of a charge) is based on experiment rather than theory. The charge based experiments involving high velocities (such as with accelerators and particle path visualization) can be considered as providing additional experimental data relating to the behavior or strength of charges as a function of velocity.

The decrease in internal interaction energy also appears to have other effects on the physical behavior of moving objects. For instance consider an atomic clock. An increase in the linear speed of the entire clock ($v$) would result in a decrease in the speed related to the interaction energy ($\varepsilon$). This would presumably affect the rate or frequency (relative to
a stationary external clock) at which natural internal processes occur within the clock, the
effect of which could be observed, for example, with respect to energy emitted by the
clock (as associated with photon frequency or time measurement) and the longevity of an
object in general. An object would presumably not ‘age’ as fast if its internal processes
are proceeding at a slower rate.

The so called ‘transversal Doppler Effect’ is likely due to the variation in frequency of a
 photon emitted by a particular energy level transition as a function of the atom’s internal
interaction energy $\varepsilon'$. The frequency of the emission would be $f = f_0/\gamma^*$, where $f$ is the
 emitted frequency and $f_0$ is the emitted frequency on the Earth when $\varepsilon_1 = \varepsilon$ (see Eq. 11),
which is essentially the result (allowing for differences between $\gamma$ and $\gamma^*$) found by Ives
and Stilwell$^{11}$ and Hasselcamp$^{12}$. The observed ‘gravitational red shift’ of a photon
emitted by a specific transition in a particular atom associated with a sun is also most
likely due to the effect of gravity on $\varepsilon$ and the shift of energy velocity from $\varepsilon$ to $v$ and/or $\alpha$
as a result of the high temperature of the sun. In such cases there is no change in the
energy of the photon after it is emitted except for certain kinds of scattering and absorp-
tion with fluorescent re-emission; it is originally emitted with a lower energy than it
would have been under earthlike conditions. These are examples of different behavior in
different systems with the same physical laws being followed.

This section concludes with some comments on transformation equations. Physical laws
are generally expressed as mathematical equations, and transformations are applied to
these equations. The assumption that physical laws are the same in all ‘inertial’ systems
is generally interpreted as requiring that the equations for physical laws remain the same
when transformed between ‘inertial’ systems; in other words that the equations are invar-
iant under the transformation. Suppose that a transformation is applied between two
systems, one of which contains a gaseous environment similar to the earth’s atmosphere
and the other contains a liquid environment similar to water. These different environ-
ments will have different effects on both light and matter. Differences in different
gaseous or energy environments will also have different effects on light and matter. How
should these differences be incorporated into the transformation? In a transformation
between systems that have different temperatures, how is the effect of the systems on the
energy component related to temperature ($\alpha$) incorporated into a transformation? Even
though the actual physical laws may be invariant, the mathematical equations represent-
ing those laws may not be unless they include the effects of the different properties found
in different systems, even if the involved systems are all ‘inertial’.

The effect of different physical conditions can be eliminated by considering only a single
system (S) which remains in a given physical state. Assume that S is moving with some
actual velocity $u$. An observer (O) in S has amassed considerable information on the be-
havior of light and objects within S. O will now go outside of S and maintain a velocity
of $v$ relative to S (with the actual velocity of O being less than that of S), and then will

---

1 The Doppler Effect with respect to the emitter in other directions would be related to the transversal fre-
quency and the direction of the emitter velocity. This would presumably be related to the exact nature of
the transition of an electron from one energy level to another and the influence on this of the overall velo-
city of the emitter at the moment of the transition.
determine how selected events that have occurred in S with respect to a coordinate system centered on S would appear in a coordinate system centered on O. It is assumed that distances remain the same in both coordinate systems. The axes for the coordinate systems are aligned and the positive x-axis for both coordinate systems is in the same direction as \( \mathbf{v} \). O now wants to determine the position in O’s coordinate system \((x', y', z')\) of some point \( p \) in S that is located at \((x, y, z)\) in S after some time interval \( T \). If \( T \) is considered to be 0 when the coordinate centers of O and S would have been aligned, then the following modification of the GT should provide that information:

\[
x' = x + vT\gamma^*, \quad y' = y, \quad z' = z, \quad t' = T\gamma^*.
\]

It is assumed that equivalent atomic clocks are used by O and within S; the factor \( \gamma^* \) provides the relationship between the clock’s physical time intervals based on their actual velocities. Any equivalent clocks in S should provide the same time interval (for any observer not having any motion relative to the clock) regardless of their position in S, even though it may not be possible to set all the clocks to indicate the same exact time at any given moment due to the finite speed of signals. This modified GT provides a starting point for determining the coordinates in O’s coordinate system of the events for which O already has information about the behavior of entities and the associated coordinates in S. This would be true for both light and objects. The equations would probably not be adequate when considering behavior in different systems having different physical properties.

The velocity relative to S of a moving entity of any kind within S would have to be added to \( \mathbf{v} \) to obtain the coordinates within S of the moving entity, with appropriate modifications for the equations if the uniform velocity of the entity was not in the same direction as \( \mathbf{v} \). The coordinate data relative to S for photons, particles, and other objects, have already been determined and simply need to be transformed into O’s coordinate system. The transformations should be the same for equivalent events that occur in S at any later time except that the starting distance in O’s coordinate system would not be zero. If \( \mathbf{v} \) changes, the transformation equation values would have to be modified to conform to the different value of \( \mathbf{v} \), but the pattern of the final transformed values should match regardless of the value or direction of \( \mathbf{v} \). The way in which an event in S occurs does not necessarily depend on \( \mathbf{v} \), but the event may depend on \( \mathbf{u} \). The sign in the first equation would depend upon the orientation of the x axes and the direction of \( \mathbf{v} \).

The above is just an initial exploration of what might be required to transform data from one coordinate system to another under the stated conditions. Whether the modified GT would satisfy the basic requirements for a valid general set of transformation equations has not been explored. Neither the classical GT nor the LT are valid for the image presented in this paper. The classical GT does not account for different properties or time interval relationships between systems and is thus not a suitable transformation for this image. The LT does not account for different system properties, but does contain a factor that is supposed to account for differences in measuring time intervals; there are other problems with accepting the LT as an appropriate transformation even though it may have some desirable mathematical properties. The value of \( c \) in the LT could be inter-
interpreted as the linear speed of light as measured in the observing system, or as the reported speed of light in the observed system. In that case, it might be appropriately used in the $\gamma$ factor. However, $\gamma$ does not use actual velocity and is applied to a space coordinate as well as velocity and time. An event should behave the same physically regardless of where it occurs within a practical inertial system that has uniform properties. This does not appear to be the case with the LT (depending upon how one is interpreting it for a given situation; signal based observations might vary as a function of distance). On the other hand, an event could behave differently at different locations in a system if a significant gravitational field were present in the system. In that case the major difference could be considered to occur along a given direction from the center of gravity, which could be assigned as the x axis. Thus the general structure of the LT (but not necessarily the LT itself) would seem to be more suitable in terms of physical behavior when a gravitational field is present rather than in an inertial system as specified in SRT.

**Summary and Conclusions**

The discussion in this paper has considered several aspects of RT, including the basic and extended assumptions which form a basis for SRT, and the general effect of these assumptions on conclusions about the nature of the speed of light, relative motion, time and space. It is reasonable to assume that the instantaneous speed of light remains the same in a vacuum or in any other environment. However, the linear speed of light (the distance the light travels divided by the time interval to travel that distance) varies depending upon the environment through which it is traveling. RT uses the linear speed of light; thus that speed is not a universal constant value as claimed in RT. The refractive index of light, the action of gravity on light, and the results of related experiments support this in both material and free energy environments. The additional assumption in SRT that the speed of light is always the same for all observers or in all directions is contradicted by the Fizeau and the Michelson-Gale experiments. This, together with the consideration of the hypothetical light clock, leads to the conclusion that the interval shown by a clock for an event in the same system may show a different interval when both are in a different systems without implying either time or space dilation or contraction.

The image of reality developed in this discussion (which can be called the Energy Velocity Component Image or EVCI) involves the internal distribution of energy velocity components associated with free energy or objects. The basic concept is simple but can serve to explain some apparently complicated behavior in the physical world. Linear velocity, like temperature, is a physical parameter that needs to be specified when evaluating physical conditions and behavior. A major concern in both EVCI and SRT is the effect of velocity on the behavior of objects (whereas GRT seems more oriented toward the effect of objects on velocity or acceleration). Changes in both linear velocity and temperature can result in a redistribution of the energy velocity components within objects. Changes in linear velocity can result in a shift between $\varepsilon$ and $v$; changes in temperature can result in a shift between $\varepsilon$ and $\alpha$. Energy shifts between $\varepsilon$ or $v$ and $\alpha$ are associated with thermodynamic behavior. The distribution of energy velocity components between $\varepsilon$ and $v$ provides a basis for explaining what might be called ‘relativistic’
behavior. The EVCI appears to be consistent with observed ‘relativistic’ behavior of energy and objects.

This results in some concepts and interpretations that are different than those that have arisen in modern physics since the introduction of RT. For instance, RT introduces the concept of relativistic mass that is a function of velocity, whereas the EVCI considers that changes in velocity cannot directly have any effect on mass, but might result in altering the effective charge of, or the effect of external electric and magnetic fields on, charged particles. The $\gamma$ factor that is found in the LT has a prominent role in mathematically relating SRT to many experimental results. The $\gamma$ factor is replaced by a similar factor in the EVCI called $\gamma^*$, which can be expressed as the ratio of the interaction energy ($\varepsilon$) at two different states of an object. This factor requires the use of actual velocity – the use of relative velocity does not provide sufficient information in general to make appropriate assessments of physical behavior that involves energy velocity components. Both $\gamma$ and $\gamma^*$ provide similar mathematical results with many situations, but $\gamma^*$ better reflects the actual physical relationship between velocity and the behavior and properties of objects. The EVCI makes a distinction between the laws of physics being the same in different systems and the results of equivalent experiments in different systems, which do not necessarily remain the same. This leads to differences between RT and the EVCI in the interpretation of the nature of, for instance, the gravitational red shift and the nature of the velocity associated ‘Doppler shift’ of light at its source.

The primary reason for the continued acceptance of SRT and GRT would seem to be that the mathematical calculations associated with the theories seem to match experimental results within currently achievable experimental error limits. The correspondence of mathematical calculations and experimental data does not, however, show that any particular theory forms anything more than a possible image of reality, which may not actually describe reality. If a theory predicts results that are experimentally verified, the claim that the theory actually represents reality is an invalid form of deductive inference (sometimes referred to as “affirming the consequent”). There is nothing wrong with using calculations that provide useful results regardless of the theory (if any) that is associated with them. It is prudent, however, to remain flexible regarding the theory.

As long as the math associated with a theory corresponds with experimental results, why should anyone be concerned whether or not the theoretical and speculative aspects of the theory are flawed? Perhaps those pursuing research in quantum (or a related) theory should be concerned. It has been noted in writings on quantum theory that ‘quantum theory is not compatible with relativity theory’ and that ‘quantum theory cannot violate relativity theory’, or equivalent statements. It seems that quantum theorists should be very concerned with the logical basis of SRT and GRT. RT might serve as a barrier to research in certain directions in quantum theory as long as it is forced to conform (in one way or another) to the former. Furthermore, when RT is eventually replaced by a more successful one which would provide a different image of reality, directions of research in quantum theory that were taken to avoid conflict with RT may have problems because of being forced away from a more logical direction of inquiry. One such direction of re-
search is that of ‘quantum loop theory’, which is an attempt to form a string type theory that is compatible with RT, but which still seems to run into problems with RT$^{13}$. 

The discussion of the EVCI in this paper is a broad overview that presents the major ideas and some associated equations in a simple manner. The EVCI may or may not reflect reality. All that can be said at this time is that it seems to be consistent with reality. That is all that can be claimed for any image that is consistent with experience and the results of experiments. The EVCI provides an explanation of much of the behavior associated with SRT. On the other hand, they differ significantly on the interpretation of what is sometimes referred to as ‘relativistic’ behavior; interpretations in the EVCI do not require the unreasonable conclusions that are demanded by the assumptions and subsequent mathematics upon which RT is based. Of course what is unreasonable is a matter of personal opinion; those who are conditioned to think in terms of the RT image of reality will likely maintain that the RT image and its implications are reasonable. Others who are less conditioned in that direction may find some aspects of the discussion in this paper that will be useful in their own explorations.
References

6 Fizeau, M. H. “On the Effect of the Motion of a Body upon the Velocity with which it is traversed by Light”, Phil. Mag. S. 4, Vol. 19, No. 127, April 1860. (English translation from the original article).
8 http://archive.ncsa.uiuc.edu/Cyberia/NumRel/EinsteinEquations.html#symbolic.