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A Simple Model Unifies Space, Matter and Light

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Abstract

An alternative model is proposed to derive several of Einstein's basic relativity equations, which would make relativity theory easier to comprehend and more intuitive. Despite the radical nature of the hypothesis, the findings are consistent with many predictions of relativity theory and shed light on the fundamental aspects of various relativity concepts. The model unifies Space, Matter, and Light, all of which are of the same nature. The building block is a mass-unit composed of size and motion. The invariant space-time interval and the corresponding space-mass interval are derived and explained. Only when there is "external force", the Einstein's energy-momentum equation becomes applicable. The "no external force" scenario leads to the generation of a new energy-momentum equation that explains the nature of gravity and perhaps even dark matter. Modified Minkowski space-time and space-mass diagrams clearly depict time dilation, length contraction, the mass-momentum-energy relationship, and other relativity phenomena.

Keywords

Relativity, Time Dilation, Length Contraction, Gravity, Black Hole, Dark Matter

1. Introduction

Einstein's theory of relativity is one of the most successful theories in centuries. It is well-known for providing a series of predictions on phenomena, such as time dilation, length contraction, mass increase in moving objects, and curved space-time in gravity. However, several concepts and paradoxes are difficult to understand and some topics are still under debate even in the scientific community. The fact that the relativity theory cannot be compatible with quantum mechanics is another drawback. Despite the successes and advances in the field of modern physics, there is a lack of clarity even at the most fundamental levels. Numerous simple issues are still unresolved. Consider the following questions:

What is the nature of space, why does length contraction occur, how does mass relate to speed, and where does gravity come from.

A unified theory of physics is a theoretical framework in physics that aims to explain all fundamental aspects of the universe. It seeks to provide a complete understanding of the universe, including all of the fundamental particles and their interactions, as well as the nature of space and time. The ultimate goal of a unified theory is to unify all of the fundamental forces of nature, including the strong nuclear force, the weak nuclear force, the electromagnetic force, and gravity.

The idea of a unified theory has been a long-standing goal in physics, and many theoretical models have been proposed over the years. One of the most well-known attempts to develop a unified theory is string theory, which suggests that the fundamental building blocks of the universe are tiny, one-dimensional strings of energy. These strings vibrate at different frequencies, producing all of the different particles in the universe [1].

Another approach to developing a unified theory is through the study of quantum field theory, which describes the behaviour of particles at the subatomic level. This approach seeks to unify the fundamental forces by treating them all as different aspects of a single, underlying force [2].

Despite the many theoretical models proposed, no conclusive evidence for a unified theory has been found yet. However, there have been many promising developments in the field, such as the discovery of the Higgs boson, which provides insight into the mechanism by which particles acquire mass.

The search for a unified theory continues to be an active area of research in physics, with ongoing efforts to refine existing theories and develop new ones. The ultimate discovery of a unified theory would be a monumental achievement in physics, bringing us closer to a complete understanding of the universe and its fundamental nature.

This study proposes a straightforward model that unifies Space, Matter and Light, explains a number of basic concepts on theory of relativity, and provides a link between relativity and quantum theory.

2. Space, Matter, and Light

Special relativity (SR) predicts length contraction, time dilation, and derives relativistic mass-energy equations. Einstein found it was difficult to accommodate gravity in SR and invented general relativity. Let us revisit this issue and see whether the nature of space-time and gravity can be formulated within SR framework and establish a connection to quantum mechanics. **Figure 1** poses a simple question, the answers to which could provide a fundamental insight into the nature of gravity and its link to quantum theory.

Are the length contractions, time dilations and relativistic kinetic energies the same for a matter (c) that experiences constant acceleration by a force and a matter (b) that free falls in gravity? Is there a deeper physical reason for length

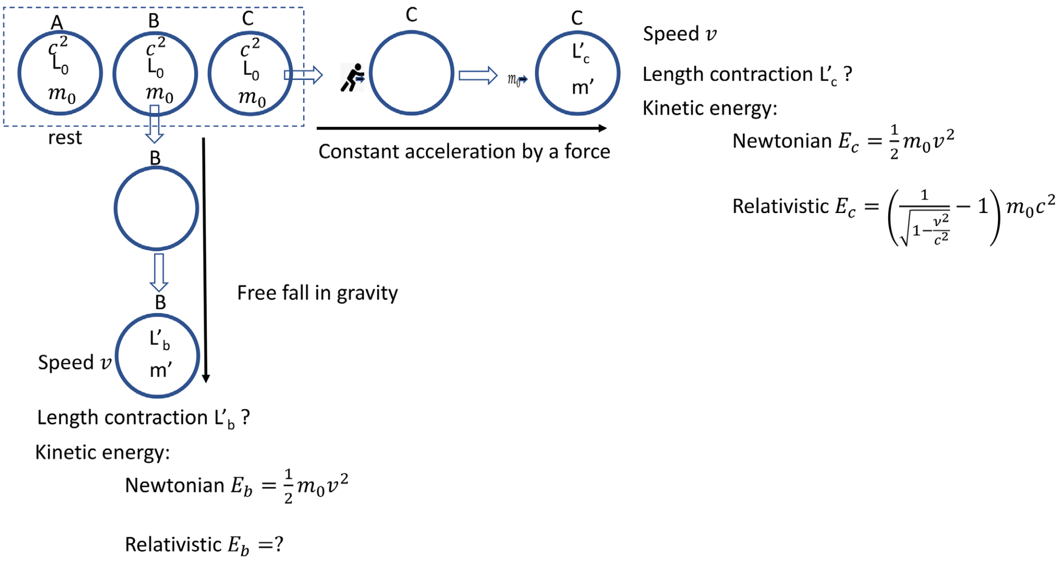

Figure 1. Three identical matters (light clocks): (A) is at rest, (B) is free falling in gravity, and (C) is experiencing constant acceleration due to an external force push. (B) and (C) reach the same speed *v*.

contraction, and what are the consequences? Newton treated the two scenarios identically because he believed that gravity was a force that did not differ from other mechanical forces. For the scenario of matter (c) being pushed by a force, Einstein's SR theory provided more accurate predictions and correct equations on mass-energy-momentum. However, within the SR framework, there were no corresponding and equivalent mass-energy-momentum equations for the free fall object in gravity. This research fills the gap by answering these simple questions without resorting to general relativity or complex mathematics.

Let us take a look at the early versions of energy-momentum equations. The classical energy equation,

$$E = \frac{p^2}{2m} + V$$

The relativistic energy-momentum relation was first established by Paul Dirac in 1928 under the form [3],

$$E = \sqrt{m_0^2c^4 + p^2c^2} + V$$

where V is the amount of potential energy.

The Schrödinger wave equation in its time-dependent form for a particle of energy E moving in a potential V in one dimension is

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x,t)\Psi$$

The potential energy V is related to position/size and is generally regarded as system energy. However, in special relativity the final relativistic equation for a particle's total energy did not take into account the potential energy V, and the equation is

$$E = \sqrt{m_0^2c^4 + p^2c^2} \quad (1)$$

As a result, the kinetic energy of the particle is what is represented by the total energy E in Equation (1). In this study, we reintroduce potential energy as an intrinsic part of a mass-unit and discover that the Equation (1) does not always apply to all situations. In physics, the term "point mass" is frequently used, with no regard for size or shape. Understanding the nature of the size, on the other hand, may reveal surprising results. We argue that a mass-unit, the fundamental building block, is not a size-less point, but a system consisting of both intrinsic kinetic energy (relating to motion) and intrinsic potential energy (relating to size). By connecting the size of the mass-unit with length contraction, we propose a model that unifies Space, Matter, and Light and explains the origin of gravity, speed, and dark matter.

If we admit that the smallest time period (time-unit "T") exists, because an observer cannot discern motion within the time-unit, a moving point mass with speed c (**Figure 2(a)**) appears to be a line which is its size s (**Figure 2(b)**). Size "s" has the same value as speed "c", which can be expressed as a value per mass-unit or time-unit.

From the perspective of energy, the moving mass-unit simultaneously possesses both size and motion with size energy "s^2" and motion energy "c^2" (**Figure 2(c)**). The terms "intrinsic potential energy" (E_s) and "intrinsic kinetic energy" (E_k) are used to describe the size energy and motion energy, respectively.

This rationale can be expanded to every basic component of the Universe. It is proposed that Space, Matter, and Light (Photon) are all of the same nature and origin and are composed of the same basic building block—the mass-unit. Therefore, a mass-unit consists of two energy elements: E_s and E_k. The total energy E, which is a constant, is given by:

$$E = E_s + E_k = constant$$

The following diagram demonstrates how Space, Matter, and Light are distinct from one another (**Figure 3**).

Space has the maximum E_s. If Space is stationary, then c^2 is assigned to both E_s and E_k; that is, $E_s = E_k = c^2$ while the total energy is constant as $E = 2c^2$

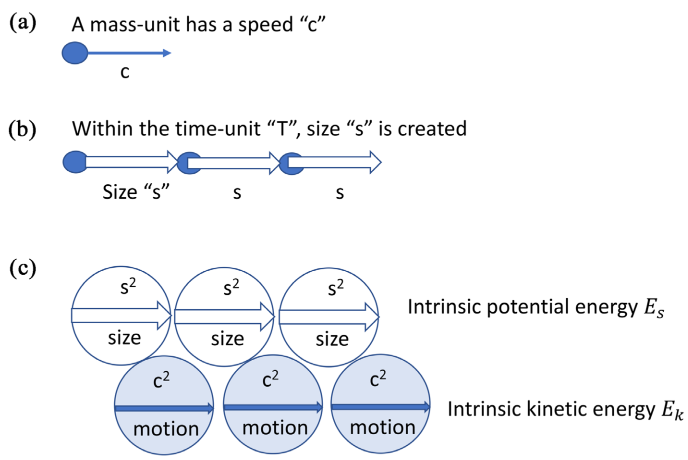

Figure 2. Formation of size from motion and time-unit.

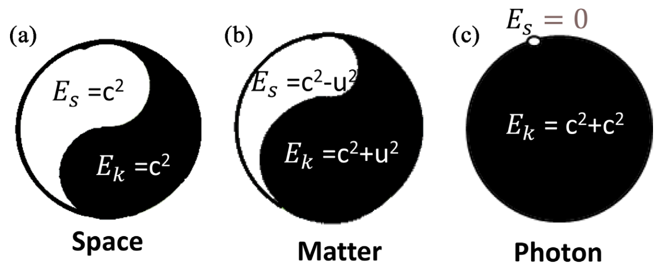

Figure 3. While the sizes of the mass units of Space, Matter, and Light differ, the overall energy remains constant.

(Figure 3(a)).

Matter is condensed Space where its mass-unit's $E_s < E_k$ (Figure 3(b)). It appears as though the Matter has increased in speed by u^2 and shrunk in size by u^2 relative to the stationary Space. As a result, the mass-unit of Matter has the following properties: $E_s = c^2 - u^2$ and $E_k = c^2 + u^2$, but the total energy is constant as $E = 2c^2$. However, this intrinsic speed u^2 is normally hidden and there is probably no mechanism to determine it.

If we assume that the Matter is at rest and disregard the intrinsic speed u^2, then c^2 is assigned to both E_s and E_k; that is, $E_s = E_k = c^2$. If a Matter gains a speed v from a known source such as described in Figure 1, the mass-unit of the Matter has energies $E_s = c^2 - v^2$ and $E_k = c^2 + v^2$. The net (extra) kinetic energy ΔE_k is calculated by deducting the kinetic energy of the mass-unit at rest from the kinetic energy of the mass-unit in motion ($\Delta E_k = E_{k-motion} - E_{k-rest}$).

Photon is an extreme form of mass-units where $E_s = 0$ and $E_k = c^2 + v^2 = 2c^2$ (Figure 3(c)). Since photon has no size and travels in the size (medium) of Space, its net kinetic energy ΔE_k is calculated by deducting the medium's (local Space) kinetic energy from the total kinetic energy of the photon ($\Delta E_k = E_{k-photon} - E_{k-space}$).

As shown in the following sections, this assumption generates the same equations as Einstein, as well as a new mass-energy equation under the "no external force" scenario. A concept of space-size gradient explains the nature of acceleration and gravity.

3. Lorentz factor and Invariant Interval

To better understand the nature of the Universe's fundamental elements, let us first look at the Lorentz factor and time in greater detail. The literature contains many derivations of the Lorentz transformation. We present a simple alternative derivation that uses the mass-unit as a light clock due to the mass-unit's size of Matter and Space in which light can travel.

Assuming that the light-clock is a round disc, a clock tick is produced by shining lights from the centre to the round edge in half the time-unit T_1, which then bounces back in another half of the time-unit T_2 (Figure 4).

Two identical light-clocks A and B are at rest in the beginning. Then, clock A remains at rest while clock B gains a speed v. Using clock A as reference, clock

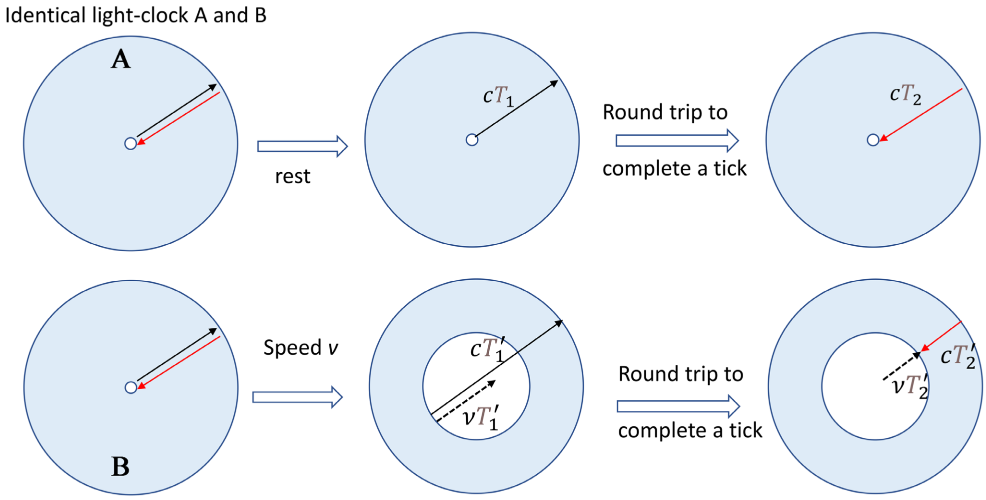

Figure 4. Mass-unit with a size is a light clock. When clock A is at rest, clock B gains a speed. The properties of clock B are calculated using the properties of clock A as reference.

B's size s', speed of light c', and time unit period T' are calculated and their relationship ratios based on clock A's size s, speed of light c, and time-unit period T are derived (**Table 1**).

The time period of one round of clock tick, which is also known as the time-unit, is divided into two sub-intervals T_1 and T_2. In clock A, light travels from the centre to the edge for one direction, and the travel length is $L_1 = cT_1$. In clock B, the length is $L_1' = cT_1' - vT_1'$ (**Figure 4**). The transformation factor γ relates the lengths L_1 and L_1', which is given by:

$$L_1 = \gamma L_1'$$

$$cT_1 = \gamma\left(cT_1' - vT_1'\right) \tag{2}$$

For the reverse direction, light bounces back from the edge to the centre, and the travel length $L_2 = cT_2$ in clock A is related to length $L_2' = cT_2' + vT_2'$ in clock B, likewise by the same transformation factor γ, and the results are shown in the following equations.

$$L_2 = \gamma L_2'$$

$$cT_2 = \gamma\left(cT_2' + vT_2'\right) \tag{3}$$

Multiplying the Equations (2) and (3),

$$c^2 T_1 T_2 = \gamma^2 T_1' T_2' \left(c^2 - v^2\right) \tag{4}$$

If we assume $T_1 T_2 = T_1' T_2'$ and remove them from Equation (4), the equation becomes:

$$c^2 = \gamma^2\left(c^2 - v^2\right) \tag{5}$$

The Lorentz factor is derived as:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{6}$$

In this paper, the terms length "L" and size "s" are both used. While "length" is used to describe Matter (a collection of mass-units) or space-time interval, "size" refers specifically to a mass-unit. The relationship of length and size is $L = sm$ (shown in section 4) or $L = st$, where m is the number of mass-units in a matter, t is the number of time ticks on a mass-unit clock. For the mass-unit clock and one time tick, where $m = 1$ and $t = 1$, the length and size are the same, and the average length (size) ratio between two clocks is:

$$\frac{s'^2}{s^2} = \frac{L_b^2}{L_a^2} = \frac{L_1' L_2'}{L_1 L_2} = \frac{1}{\gamma^2} = \frac{c^2 - v^2}{c^2} \tag{7}$$

The square of size is related to energy. From Equation (7), we can see that the stationary clock A has an intrinsic potential energy $E_s = c^2$, while the moving clock B has a reduced $E_s' = c^2 - v^2$, which matches the assumption in section 2. In terms of size, the size of clock A is $s = c$ while the moving clock B has a reduced size as

$$s' = \sqrt{c^2 - v^2} \tag{8}$$

The assumption $T_1 T_2 = T_1' T_2'$ has important indications. Since the geometric mean time-unit is invariant, the Equations (4) and (5) indicate that the transformation factor λ applies to both length and the speed of light. The light speed of the moving clock is c'. Therefore,

$$c^2 = \gamma^2 c'^2 \tag{9}$$

$$c' = \frac{c}{\gamma} = c\sqrt{1 - \frac{v^2}{c^2}} = \sqrt{c^2 - v^2} \tag{10}$$

Equation (10) shows in the clock B medium the speed of light is slowed down. The slower speed of light in clock B, however, does not violate the theory of relativity. For any observer who perceives itself to be at rest, the speed of light remains constant since the stationary observer attributes the characteristics of Space to itself. However, the stationary clock A or "a far away observer" will see that the speed of light is flowing across the medium of the moving clock B at a slower rate as $\sqrt{c^2 - v^2}$. In other words, the moving clock as measured by an observer in their frame sees the light moves as c, whereas a stationary clock or the "the far away observer" sees light travelling inside (the medium of) the moving clock at reduced speed c'.

For a round trip of light, the arithmetic mean of the time-unit is T. For clock A, $T = (T_1 + T_2)/2$ and for clock B $T' = (T_1' + T_2')/2$. Using Equations (2) and (3), the relationship of T and T' is derived as:

$$T' = \frac{T_1' + T_2'}{2} = \gamma \frac{T_1 + T_2}{2} = \gamma T$$

$$\frac{T'}{T} = \gamma \tag{11}$$

This is known as time dilation.

The ticking time t ("clock reading" or simply "time" which is as commonly referred to as proper time or coordinate time) is calculated from the time-unit and is equal to the inverse reciprocal of time unit T.

$$t' = \frac{1}{T'} = \frac{1}{\gamma T} = \frac{t}{\gamma}$$

$$\frac{t'}{t} = \frac{1}{\gamma} \quad (12)$$

According to the preceding arguments, apart from the conventional understanding of the Lorentz factor, which is the ratio of length contraction or the ratio of time dilation, the meanings of the Lorentz factor as proposed herein are the ratio of the sizes of mass-units or the ratio of light speeds between stationary mass-unit and moving mass-unit. **Table 1** summarises the properties of a moving mass-unit in relation to the properties of a mass-unit at rest.

Another implication of the invariant geometric mean time is that time-unit may be two-dimensional. In the mass-unit clock, light travels in one direction taking half time-unit T_1 and travels back in reverse direction taking another half time-unit T_2 to complete a round tick, the product T_1T_2 is constant for mass-units at any state. This is illustrated in the diagram (**Figure 5**) below. On the other hand, the product of ticking time t and time-unit T is also constant $T' * t' = T * t$ (**Table 1**). If time is viewed as a wave, ticking time t is equivalent to frequency, and time-unit T is equivalent to wavelength.

Caution is needed when discussing about "time". If by ticking rate you mean the reading on a clock, it varies significantly because different mass-units give different readings, such as when photons, or space/matter at event horizon are clock, the ticking completely stops. If "time" refers to the result of the ticking time t and the time unit T, then everything has the same time value $T * t$ which

Table 1. Summary of the properties of two mass-unit light clocks with one at rest and another in motion.

	Mass-unit clock at rest	Mass-unit clock in motion
Length	L	$L' = \frac{L}{\gamma}$
Light speed in the clock	c	$c' = \sqrt{c^2 - v^2}$
Size of a clock per time-unit	$s = c$	$s' = \sqrt{c^2 - v^2}$
Ticking time (reading)	t	$t' = \frac{t}{\gamma}$
Length of clocks in ticking time t (space-time interval)	ct or st	$ct' = c't = t\sqrt{c^2 - v^2}$
Geometric average of time-unit	T_1T_2	$T_1'T_2' = T_1T_2$
Arithmetic average of time-unit	$T = \frac{T_1 + T_2}{2}$	$T' = \frac{T_1' + T_2'}{2} = \gamma T$
Constant universal time value	$T * t$	$T' * t' = T * t$

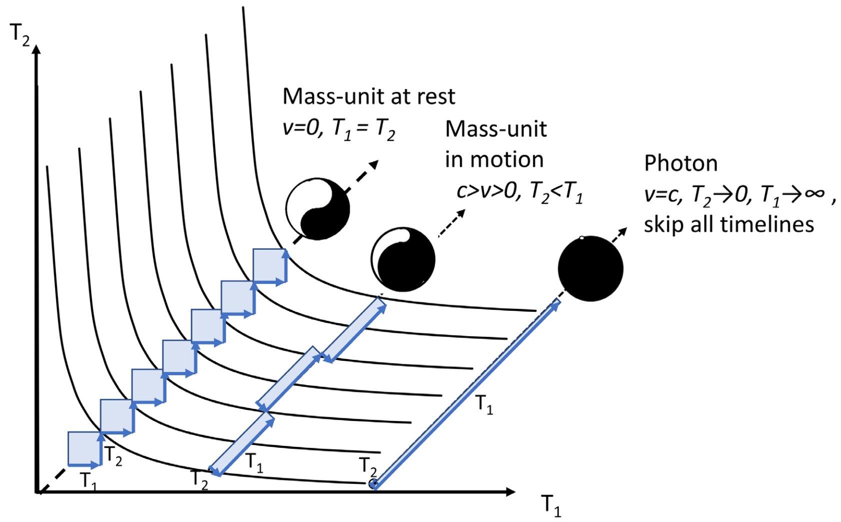

Figure 5. Two-dimensional time-unit where $T_1 T_2$ is invariant.

flows through the Universe at the same speed.

3.1. Invariant Space-Time Interval

By combining Equations (12) and (5), the following is obtained:

$$c^2 t'^2 = \left(c^2 - v^2\right) t^2 \tag{13}$$

It can also be written as:

$$c^2 t'^2 = c^2 t^2 - x^2 \tag{14}$$

where t' is the ticking time on the moving clock, which is the proper time; t is the ticking time on the clock at rest, which is the coordinate time. $c^2 t'^2$ in Equation (14) is the invariant space-time interval S^2 in Minkowski four-dimensional space-time. Then, the space-time interval S^2 between the two events that are separated by a distance x in space and ct in the t coordinate is:

$$S^2 = c^2 t^2 - x^2 \tag{15}$$

Equation (15) is a simplified form of four vector equation given by:

$$S^2 = -c^2 t^2 + x^2 + y^2 + z^2 \tag{16}$$

The space-time interval $S^2 = \left(ct'\right)^2$ is frame independent and all reference frames agree on the value of this interval. The proper time t' on the moving clock is a physical reality in which all observers see the same time reading.

The physical meaning of invariant space-time interval is that "S" is the length (sum of sizes) of multiple moving clocks, each of which correspond to a time tick. "S" (=ct') is calculated as the product of the ticking time t' on the clock in motion and speed of light c (or the size) of the clock at rest. ct' equals $c't$, which is the product of the ticking time t on the clock at rest and speed of light c' (or the size) of the clock in motion. Speed of light c is constant and is attributed to all observers at rest and stationary Space, whereas $c' = \sqrt{c^2 - v^2}$ is the speed of light travelling in the medium of the moving clock. c' is also the size of the mass-unit of the moving clock $s' = c'$. This notion is clearly demonstrated in the modified Minkowski space-time diagram (Figure 6).

Figure 6 depicts an intuitive and simple diagram describing Minkowski space-time, in which the basic principles of relativity can be easily understood. In this diagram, the moving clock's time axis t' is perpendicular to the stationary clock's space axis x, while the stationary clock's time axis t is perpendicular to the moving clock's space axis x'. Both the clocks agree that the moving clock gains a speed v from an energy exchange. Figure 6 shows that the stationary clock ticks five times ($t = 5$), which is equivalent to five clocks at rest as represented by five circles with size c. The moving clock t' axis has a slope c/v in reference to $t \sim x$ frame and slope of $\sqrt{c^2 - v^2}/v$ in relation to $t \sim x'$ frame. Because of speed v, the moving clock has a size of $s' = \sqrt{c^2 - v^2}$ and ticks twice ($t' = 2$). Despite the slowed ticking time, the distance is still filled by five clocks of the smaller size of $\sqrt{c^2 - v^2}$. The Pythagorean theorem of Euclidean geometry can be used to calculate the distance ct', which is the invariant space-time interval:

$$(ct')^2 = (ct)^2 - (vt)^2 \tag{17}$$

It is equivalent to compressing five clocks (at rest) on the t axis into the space of two stationary clocks, resulting in the five clocks with small size appearing on the t' axis. The consequence is that the size of the clock is reduced and distance (vt) of stationary frame is also reduced (to vt') in the moving clock frame.

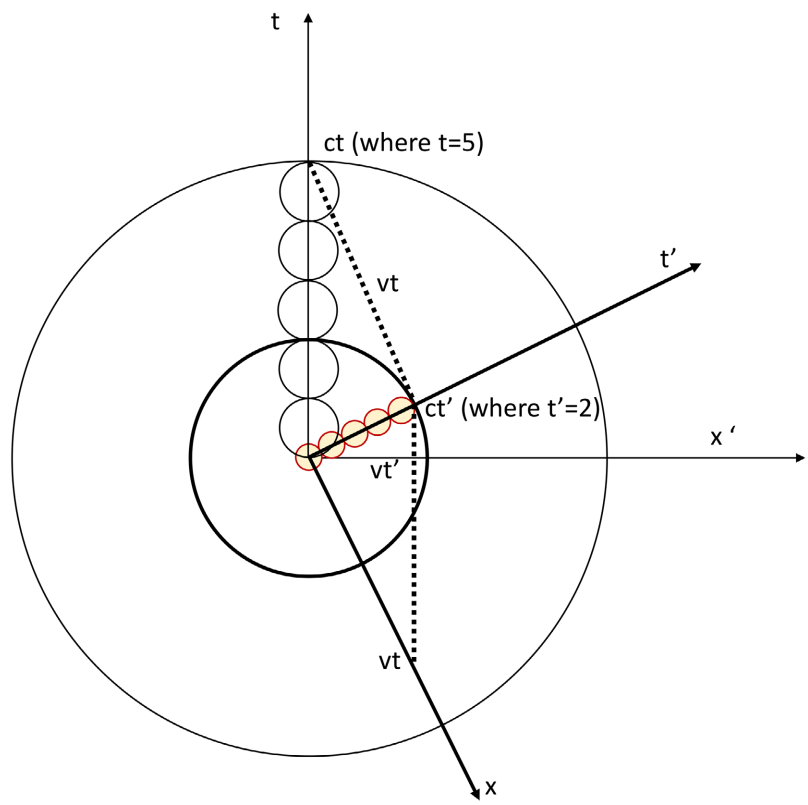

Figure 6. Modified Minkowski space-time.

3.2. Invariant Hyperbola

Figure 7 shows the worldlines of the moving clocks in space-time coordinates. A black-line circle above the x' axis represents a curve crossing with worldlines that share the same coordinate time t of the clock at rest. The circle is equivalent to the Minkowski invariant hyperbola. Worldlines of clocks with different speeds and proper times are displayed. Varying t' axis have different speeds and different ticking times ($t' = 4,3,2,1$) that correspond to the same coordinate time $t = 5$ in t axis.

When speed v approaches the speed of light, the t' axis overlaps with the x' axis, resulting in the moving clock being converted to photon. Photon's clock stops ticking as $t' = 0$, and size of the photon is zero. For photon, the distance vt' is also zero. This phenomenon indicates that when any particle becomes or contains a size-less quantum, the distance is zero; that is, $vt' = 0$. This means that distance does not exist in the realm of size-less quantum. This explains the reason for quantum entanglement across long distances because the concept of distance does not exist for a quantum.

Light cones and two invariant zones of space-time are also shown in Figure 7. When speed $v = c$, the t' axis and x' axis are merged. The future light cone is represented by the region above x' axis, while the past light cone is represented by the region below the x' axis.

3.3. Acceleration

When a clock has a constant acceleration, the clock size (mass-unit's size) decreases

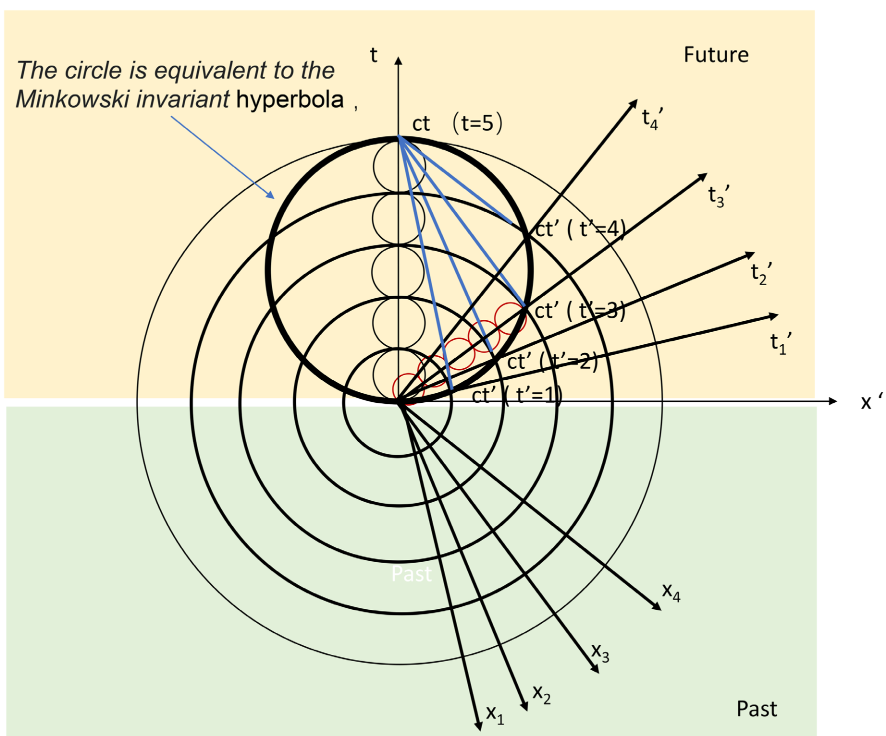

Figure 7. Various worldlines of moving clocks in space-time $t' \sim x'$ coordinates.

constantly as shown in the diagram by the yellow circles in the series t' axis (Figure 8). If the speed keeps increasing, the clock's size will eventually reach zero and the clock will become a size-less photon. The size gradient is created due to acceleration.

3.4. Invariant Space-Mass Interval

Because the mass-unit is light clock, mass and time are inextricably linked. A clock's ticking frequency is equal to its mass in terms of the number of times. For example, if a clock ticks five times, the equivalent mass is five clocks ($m_0 = 5$) at rest (Figure 7 and Figure 9). This is reflected in the photon's energy equations as well. When the mass-units (a matter) pick up speed and eventually becomes a photon, the mass-units ($m_0 = 5$) are compressed into zero size ($m' = 0$) and becomes a size-less photon (Figure 10). The net kinetic energy of a photon can be expressed in terms of mass as $\Delta E = mc^2$ and in terms of frequency as $\Delta E = hf$, where h is the Planck constant and f is frequency. The frequency f is equivalent to the ticking time t of a stationary clock. Then, $mc^2 = hf = ht$ is obtained, and the mass and time ratio is constant $\frac{m}{t} = h/c^2$. In terms of Planck time (time-unit) $T_p = \sqrt{hG/c^5}$ and Planck mass $m = \sqrt{hc/G}$, we have $mT_p = h/c^2$. Because time and mass have an equivalent relationship, we can replace the time axis t with the mass axis m in the space-time diagram of Figure 7, resulting in space-mass diagram Figure 9.

A space-mass diagram, which is equivalent to a space-time diagram, can be

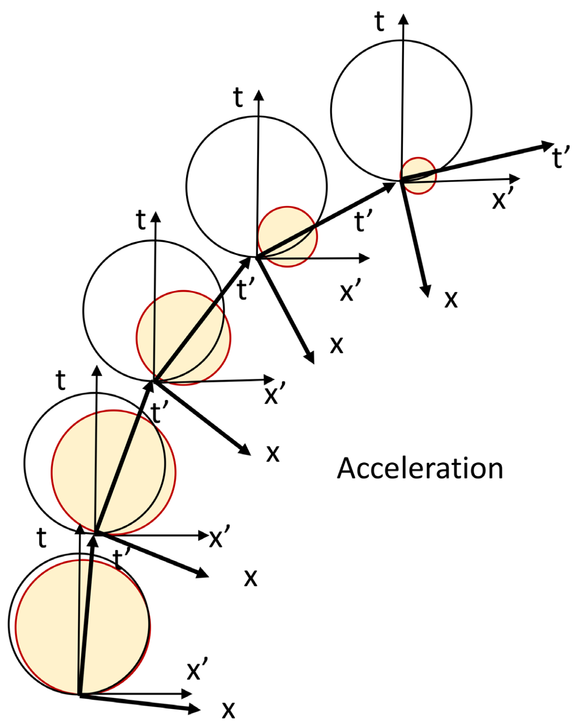

Figure 8. When a light clock experiences steady acceleration, its t' axis tilts towards the x' axis and the clock shrinks in size.

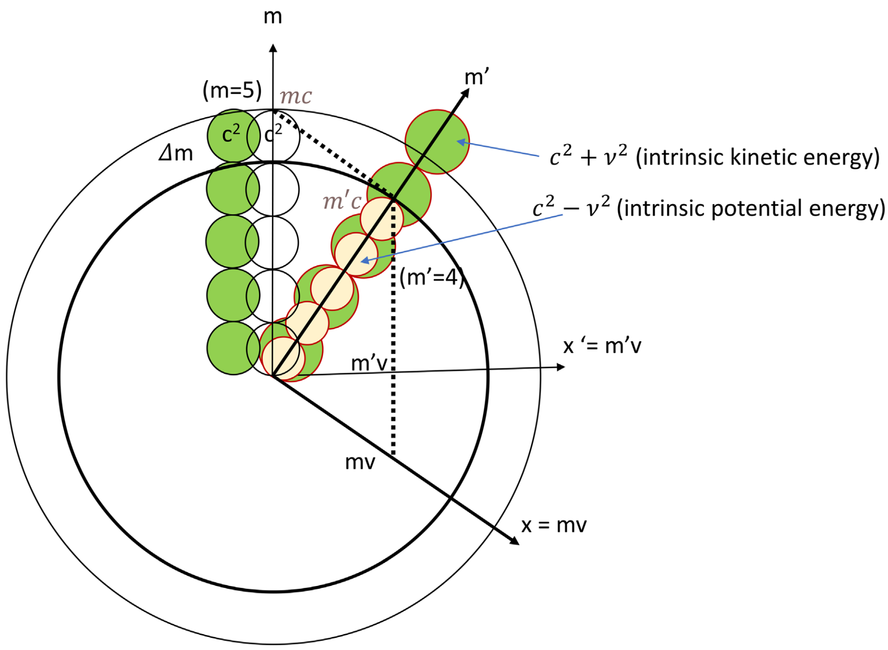

Figure 9. Space-mass invariant interval.

drawn as shown in **Figure 9**. The mass-unit is composed of intrinsic potential energy (size energy E_s) and intrinsic kinetic energy (motion energy E_k, which are represented by open and solid circles, respectively. When the stationary five mass-units (m = 5) gain speed v, they are compressed into four mass-unit size (m' = 4) as shown in the m' axis. This process is also equivalent to squeezing the size of an allocated mass Δm into the space of the other four masses. As a result, E_s decreases while E_k increases (the size of the solid circle increases as shown in **Figure 9**). The reduction in size is the sole cause of speed v.

The space-mass relationship is also obtained using Pythagorean theorem (**Figure 9**).

$$(m'c)^2 = (mc)^2 - (mv)^2 \tag{18}$$

Like the invariant space-time interval $(ct')^2$, the matter's length (multiple mass-unit's size) $m'c$ and mc (length in m' and m axis, respectively) are space-mass intervals, where mc (length in m axis) is invariant. Depending on the source of motion, Equation (18) has different versions, as shown in the following section. Since mc and mv are usually expressed as momentum, according to Equation (18) we can see that the intrinsic momentum is invariant. This Equation (18) is derived from the mass-unit's size that corresponds to potential energy.

By multiplying Equation (18) by c^2 and applying momentum $p = mv$, the energy form is

$$m'^2c^4 = m^2c^4 - p^2c^2 \tag{19}$$

And the Lorentz Invariant

$$m^2c^4 = m'^2c^4 + p^2c^2$$

differs from the conventional energy momentum equation, which is further discussed in the following section and Table 2.

Equation (19) shows that after gaining a speed v, the original potential energy m^2c^4 (length in m axis) is reduced to the new potential energy $E_s'^2 = m'^2c^4$ (length in m'axis)

$$E_s'^2 = m^2c^4 - (mv)^2 c^2 \tag{20}$$

The potential energy E_s'

$$E_s' = mc\sqrt{c^2 - v^2} \tag{21}$$

When $v = c$, the original mass m becomes photon, where $E_0 = pc$, $m' = 0$ and $E_s'^2 = 0$, which means all potential energy is converted to kinetic energy. We know that the total energy of any matter is $E = 2mc^2$ and total intrinsic kinetic energy $E_k = E - E_s'$. Then,

$$E_k = 2mc^2 - mc\sqrt{c^2 - v^2} \tag{22}$$

To calculate the net (extra) kinetic energy ΔE_k, the kinetic energy of the matter at rest mc^2 is subtracted from E_k, we have

$$\Delta E_k = mc^2 - mc\sqrt{c^2 - v^2} \tag{23}$$

In an extreme case, when $v = c$ (Figure 10), the intrinsic potential energy m'^2c^4 is zero as indicated by Equation (19). This means that the size vanishes and $m' = 0$, and the original mass-units m becomes a photon. The photon's frequency and the original mass amount are related as $m/f = h/c^2$. The photon's mass $m'$is zero. In terms of photon's predecessor, the Matter/Space, they

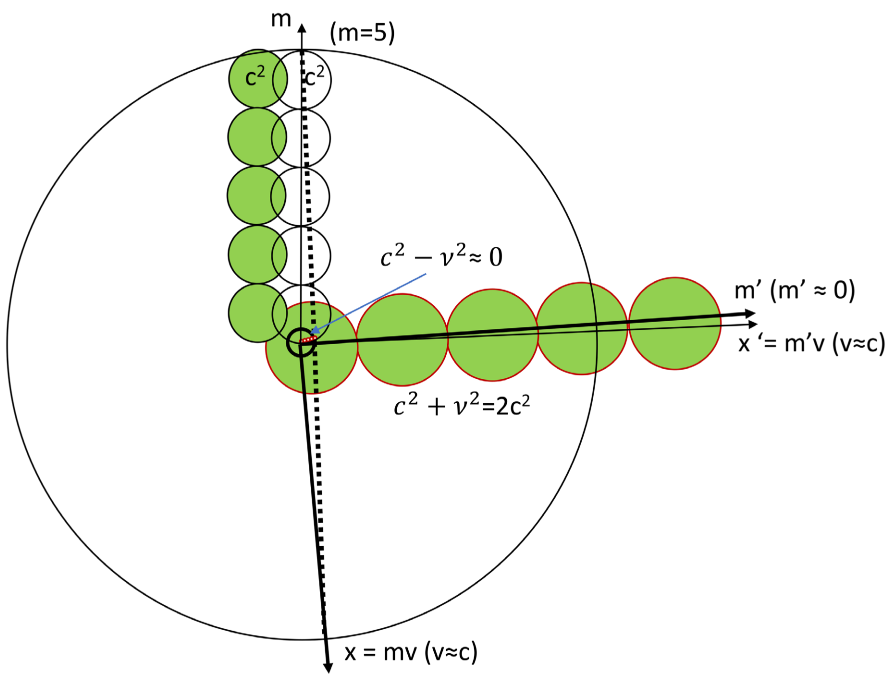

Figure 10. When speed approaches light speed, its m' axis tilts towards the x' axis and eventually merge, the mass-units become a photon.

obviously have the mass m_0. In other words, a stationary mass-unit (Matter or Space) with mass m_0 can be converted to photon with mass $m' = 0$. In reverse, photon can be converted to a stationary mass-unit and its rest mass m_0 is restored. When we say a photon has no mass, it means that it has no size and its size equivalent mass m' is zero.

4. Mass and Energy

Newton's Laws describe the behaviour of point masses, which are intentionally simplified objects with no size or volume since size is not expected to change in Newtonian equations. Newton's first law states that unless acted upon by a force, a body will remain stationary or move at a constant velocity. This section demonstrates that Newton's first law holds true only when the size remains constant. Newton's first law cannot be applied if a mass's size can fluctuate.

For moving objects, Einstein's special relativity predicts length contraction. However, the nature and consequence of the length contraction are unknown in the existing theory of relativity.

In Newtonian dynamics, the kinetic energy E_k of a point mass is given by:

$$E_k(v) - E_k(0) = m\int_0^v v\mathrm{d}v = \frac{1}{2}m\left(v^2 - 0\right) = \frac{1}{2}mv^2 \tag{24}$$

Kinetic energy as a function of speed is given by:

$$E_k(v) = \frac{1}{2}mv^2 \tag{25}$$

In Einstein's theory of relativity, mass increases as a function of speed (but does not explain why), and the momentum of a point mass changes from $p = m_0 v$ to $p = m_v v$. Its kinetic energy is given by:

$$E_k(v) - E_k(0) = c^2\int_{m_0}^{m_v} \mathrm{d}m_v = m_v c^2 - m_0 c^2 \tag{26}$$

Therefore, kinetic energy in the relativity form is:

$$E_k(v) = m_v c^2 - m_0 c^2 = \Delta m c^2 \tag{27}$$

Since $m_v = \dfrac{m_0}{\sqrt{1 - \dfrac{v^2}{c^2}}}$

$$E_k(v) = m_0 c^2\left(\frac{1}{\sqrt{1 - \dfrac{v^2}{c^2}}} - 1\right) \tag{28}$$

The extra mass in Einstein's theory of relativity is given by:

$$\Delta m = \left(\frac{1}{\sqrt{1 - \dfrac{v^2}{c^2}}} - 1\right)m_0 \tag{29}$$

Remarkably, none of the equations above involve length contraction. Moreover, Einstein's theory of relativity does not explain why mass increases and how speed and extra mass are related to length contraction. The preceding equations are also erroneous in the case of "no external force", as stated below, and only apply to a certain type of motion brought on by an outside force.

This study proposes a simple method to derive more general mass-energy equations and explain the nature of motion, length contraction, and mass-energy relationship using the space-mass invariant interval described in the previous section.

A Matter is a set of mass-units and its behaviour is governed by the rule of invariant space-mass interval given in Equation (18).

According to Equation (18), the invariant space-mass interval is

$$m'c = m_0\sqrt{c^2 - v^2} \tag{30}$$

This equation can be interpreted as follows: m_0 is the number of mass-units in a Matter at rest and its mass-unit's size is $s = c$. When the Matter gains a speed v, the size of the mass-unit in motion decreases as $s' = \sqrt{c^2 - v^2}$. For example, when the stationary four mass-units gain speed v, they are compressed into the three mass-unit size as shown in **Figure 11(a)**. This is equivalent to that mass m_0 is divided into two parts: Δm and m', and the allocated Δm is squeezed into the size of three mass-units m'. The space-mass interval $m's$ ($m'c$) is equal to the product of the original mass number m_0 and reduced size of mass-unit s', which is $m_0 s'\left(m_0\sqrt{c^2 - v^2}\right)$. This scenario (A) is depicted in **Figure 11(a)**, which corresponds to the diagram in **Figure 9**.

As $m's = m_0 s'$, where $s = c$ and $s' = \sqrt{c^2 - v^2}$, then we have Equation (30) as $m'c = m_0\sqrt{c^2 - v^2}$.

Since $m' = m_0 - \Delta m$, substitute m' in Equation (30) to obtain

$$\left(m_0 - \Delta m\right)c = m_0\sqrt{c^2 - v^2}.$$

Then,

$$\Delta m = \left(1 - \sqrt{1 - \frac{v^2}{c^2}}\right)m_0 \tag{31}$$

Since the net kinetic energy is $\Delta E_k = \Delta mc^2$, ΔE_k is obtained for the scenario A as:

$$\Delta E_k = \left(1 - \sqrt{1 - \frac{v^2}{c^2}}\right)m_0 c^2 \tag{32}$$

It was observed that Equation (32) is the same as Equation (23).

These equations differ from Einstein's kinetic energy equation in that scenario (A) of "No external force" describes a spontaneous motion without a push from an outside force, which is not supported by Einstein's theory. The derived Lorentz Invariant in the energy momentum equation $m_0^2c^4 = m'^2c^4 + p^2c^2$ is also different, which indicates that when $v = c$, we have $m' = 0$ and $E_0 = pc$. However, the scenario (A) does occur spontaneously without the involvement of

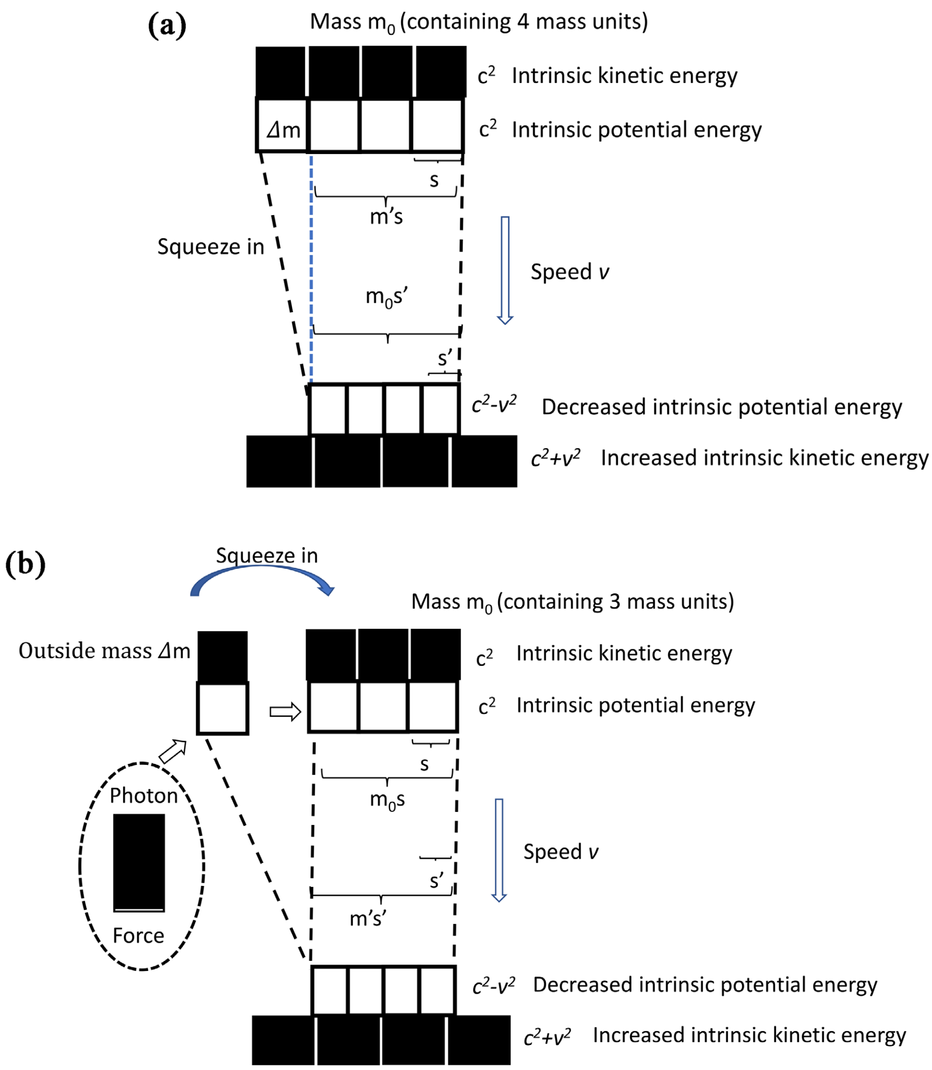

Figure 11. Based on the invariant space-mass interval, two distinct mass-energy relationships are derived under two conditions (a) "No external force" and (b) "With external force".

any external force. It is simply an energy conversion between size and motion with no change in total energy.

Motion is the result of size reduction of mass-units. If you want to increase the speed of a mass-unit or maintain a constant acceleration, you don't need an external force (or energy) to push. Motion can happen even in the closed system of the Matter where there is no energy exchange with outside source, just by reduction of the mass-unit size while the total energy of the Matter remains constant. When the speed approaches that of light, the size is reduced to zero and the original Matter is converted to photons.

This scenario can be experienced by anything that spontaneously exchanges intrinsic energy between E_s and E_k such as quantum fluctuation observed in quantum mechanics. This occurs in our daily lives as well; for example, Matter in gravity, which is a typical scenario (A) involving intrinsic energy oscillation without change in total energy. This actually answered part of the first section's question.

Figure 11(b) depicts space-mass interval invariance of scenario (B) "with external force". In its original state, a Matter at rest has a space-mass interval $m_0 c$, where $m_0 = 3$. Newton's law states that "force" is required to set the Matter in motion. This external Newton's force can be thought of as a photon, which is equivalent to extra external mass Δm. When the Matter transitions from being at rest to being in motion, a force Δm is applied. The external Δm is squeezed into the size of m_0, resulting in reduced size of the mass-unit to $\sqrt{c^2 - v^2}$, and that the Matter gains a speed v. According to the invariance of space-mass interval principle, $m_0 c$ is invariant and is equal to the product of new mass m'(=4) and new size s', which is given by:

$$m_0 c = m' \sqrt{c^2 - v^2} \tag{33}$$

Since $m' = m_0 + \Delta m$,

$$m_0 c = (m_0 + \Delta m)\sqrt{c^2 - v^2} \tag{34}$$

Then Δm is derived as:

$$\Delta m = \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) m_0 \tag{35}$$

The net kinetic energy ΔE_k is given by:

$$\Delta E_k = \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) m_0 c^2 \tag{36}$$

These equations are the same as those derived by Einstein's theory of relativity for Δm and ΔE_k. If the speed of Matter increases in scenario B, extra mass Δm must be added from external source. The size of resulting total mass ($m_0 + \Delta m$) shrinks to the size of original m_0, due to a invariant space-mass interval. When the speed approaches the speed of light c, an infinite amount of external mass must be added.

If scenario B is described in the space-mass diagram, it can be drawn as shown in Figure 12. Original matter with five mass-units ($m_0 = 5$) at rest gains speed v_1 or v_2, where v_1 corresponds to six mass-units ($m_1' = 6$), and v_2 corresponds to seven mass-units ($m_2' = 7$). The space-mass intervals (length of the Matter) are

$$m_0 c = m_1' \sqrt{c^2 - v_1^2}$$

$$m_0 c = m_2' \sqrt{c^2 - v_2^2}$$

We can see that the length $m_0 c$ of the matter is invariant, so its energy form $m_0 c^2$ which is the E_s or E_k of the matter at rest is also invariant. Based on (33), energy-momentum equations $m'^2 c^4 = m_0^2 c^4 + p^2 c^2$ or $E'^2 = E_0^2 + p^2 c^2$ is derived, which is the same as Einstein's energy-momentum Equation (1), but with a slightly different meaning. In our equations, E_0^2 (or m_0c) represents the intrinsic potential energy of the original matter m_0 at rest, which is the same as the intrinsic kinetic energy of the matter m_0 at rest. E'^2 represents the intrinsic potential energy of original matter m_0 plus the potential energy of the extra mass Δm. Interestingly, E'^2 is the same as the total kinetic energy of the matter in motion. The potential energy of the extra mass Δm is the same as the net kinetic energy of the extra mass Δm. E'^2 can be viewed as the total intrinsic kinetic energy of the original matter m_0 plus the extra mass Δm ($m_0 + \Delta m$). When $v = 0$, we have $E'^2 = E_0^2$; and when $v = c$, E' is infinity ($E' = \infty$). This differs from the traditional interpretation of Equation (1). The traditional view states that as v increases, the energy E' increases because m_0c^2 is invariant; however, when $v = c$, the energy E' is photon's energy $E' = pc$ and m_0 is zero, but because m_0c is invariant in this scenario involving extra mass, m_0 cannot be zero. Actually, the equations (1) and (33) (**Figure 12**) can only apply in the scenario with external force and indicate that when v approaches c, m' approaches infinity. In fact, in the scenario A where there is no extra mass involved, according to Equation (19), when v approaches to c, we have $E_0 = pc$, $m' = 0$, and original m_0 becomes size-less photon. In terms of photon's energy $E_0 = pc$, the Equation (19) of the scenario (A) matches the traditional view, in the situation of $E' = \infty$, the Equation (33) of scenario (B) matches the traditional view.

The derivation of Δm using space-mass interval invariance principle for the two scenarios indicates the properties of mass and energy shown in **Table 2**.

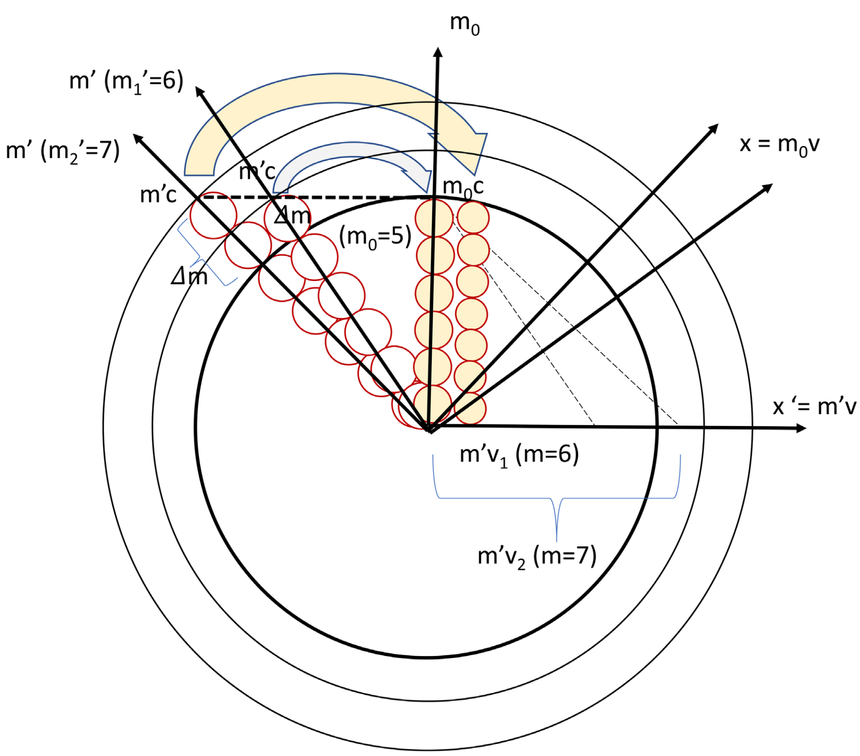

Figure 12. The space-mass diagram shows scenario (B) with external force.

Table 2. Mass and energy under two scenarios "No external force" and "With external force".

	No external force of scenario A	With external force of scenario B
Δm	$\left(1-\sqrt{1-\frac{v^2}{c^2}}\right)m_0$	$\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}-1\right)m_0$
Origin of Δm	internal	external
Net kinetic energy ΔE_k	$\left(1-\sqrt{1-\frac{v^2}{c^2}}\right)m_0c^2$	$\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}-1\right)m_0c^2$
Intrinsic kinetic energy $E_k=\Delta E_k+E_{k-rest}$	$\left(2-\sqrt{1-\frac{v^2}{c^2}}\right)m_0c^2$	$\frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}}$
Intrinsic potential energy $E_s=E_0-E_k$	$\left(\sqrt{1-\frac{v^2}{c^2}}\right)m_0c^2$	m_0c^2
Δm when $v=c$	$\Delta m=m_0$	$\Delta m=\infty$
Mass m' when $v<c$	$m'=m_0\sqrt{1-\frac{v^2}{c^2}}$	$m'=\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$
Lorentz Invariant $m_0^2c^4$	$m_0^2c^4=m'^2c^4+(m_0v)^2c^2$	$m_0^2c^4=m'^2c^4-p^2c^2$
Mass m' changes when v increases	decrease	increase
Example	Gravity	External force with applying work

Equation (31) indicates that when speed v is equal to speed of light, that is, $v=c$ in scenario (A), the allocated extra mass equals the original mass $\Delta m=m_0$, which means that all m_0 become photons. The mass of a photon in terms of m' is zero. Equation (35) indicates that when $v=c$ in scenario (B), $\Delta m=\infty$, which means that no matter how much force (photons) is applied, the matter's speed cannot reach the speed of light.

Under scenario (A) a matter can move even in the absence of an external force, which was considered impossible. It seems scenario (A) violates Newton's first law. In classical and modern physics, a matter is conveniently regarded as a point mass, in which the size is ignored. SR, on the other hand, did predict length contraction but did not understand why, and did not introduce scenario (A). The scenario (A) equations (Table 2) fill a critical gap in SR theory.

To answer the questions in the first section, Figure 13 depicts the outcome.

The phenomena of reduced mass-unit size and time dilation are the same in both scenarios. The matter (b) that free falls in gravity is a typical example of scenario (A). The length contraction for matter (b) occurs as the length from original m_0c is reduced to $m_0\sqrt{c^2-v^2}$. The matter (c) that experiences constant acceleration by a force has a constant length m_0c (t_0c), so the length contraction is invisible for matter (c). However, in matter (c)'s frame anything else is shorter because $m_0v < m'v$ (**Figure 12**). The relativistic kinetic energies and relativistic mass m' differ between two scenarios, as illustrated in **Figure 13** and **Table 2**.

5. Acceleration

When a mass-unit with E_s (hollow circle) and E_k (solid circle) is accelerated, its size decreases and speed increases as shown in **Figure 14**. A size gradient is

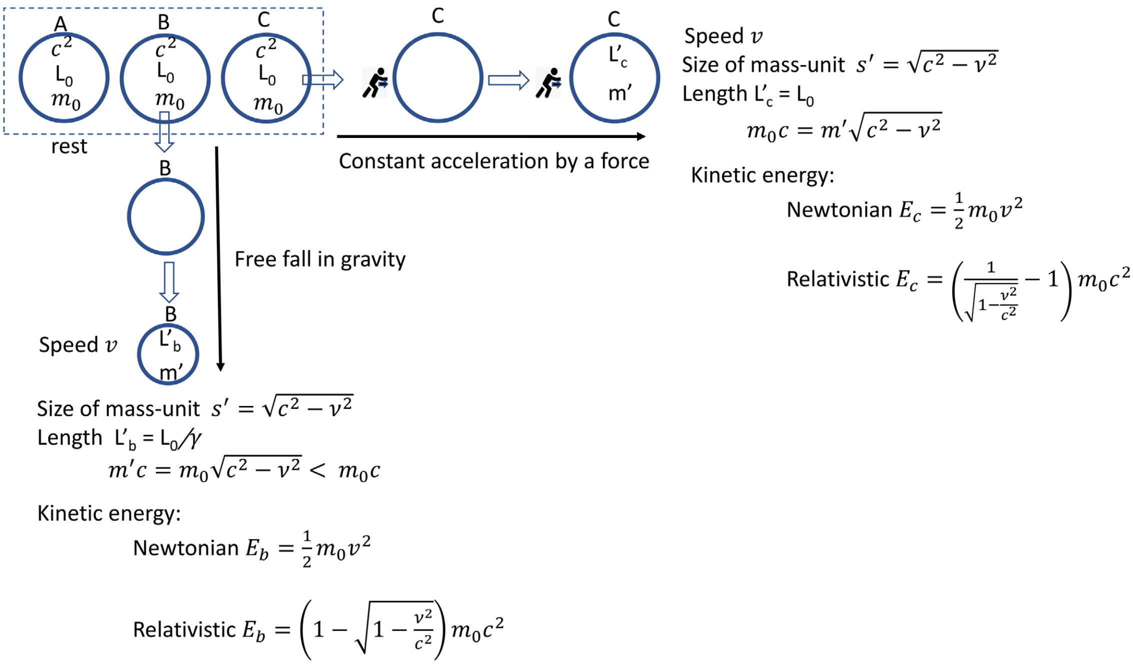

Figure 13. The answers to questions in **Figure 1**.

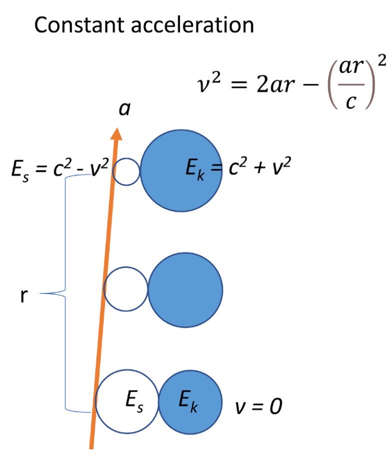

Figure 14. A mass-unit experiencing constant acceleration.

formed by a series of decreasing sizes over a time period or distance *r*.

Assuming a constant acceleration *a* in the scenario (A) of "No external force", the mass *m* is constant and the work *W* done by internal size contraction over the distance *r* is given by:

$$W = mar \tag{37}$$

The increased kinetic energy is equal to the work *W*. As previously stated, the increased kinetic energy ΔE_k is derived from size reduction of existing mass, which is equivalent to a fraction of mass Δm turning into a size-less photon as $\Delta E_k = \Delta mc^2$.

$$mar = \Delta mc^2 \tag{38}$$

Applying Equations (32) to (38),

$$mar = \left(1 - \sqrt{1 - \frac{v^2}{c^2}}\right) mc^2 \tag{39}$$

Then,

$$v^2 = 2ar - \left(\frac{ar}{c}\right)^2 \tag{40}$$

The size of the mass unit at distance *r* is given by:

$$s = \sqrt{c^2 - v^2} = c - \frac{ar}{c} \tag{41}$$

The size gradient is the Lorentz factor represented as:

$$\gamma = \frac{s_0}{s} = \frac{c}{\sqrt{c^2 - v^2}} = \frac{1}{1 - \frac{ar}{c^2}} \tag{42}$$

In the scenario (B), extra mass Δm is constantly added to the existing mass *m* and the work done *W* by external "force" over the distance *r* is calculated.

$$W = \gamma mar \tag{43}$$

With mass addition, the increased kinetic energy ΔE_k is the same as extra Δm kinetic energy given as:

$$\gamma mar = \Delta mc^2 \tag{44}$$

Apply Equation (36)

$$\gamma mar = m\left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1\right)c^2 \tag{45}$$

Then, the same value of v^2 as in scenario (A) is obtained $v^2 = 2ar - \left(\frac{ar}{c}\right)^2$.

Matter at rest is assigned the attributes of stationary Space. The accelerated Matter creates a size gradient to itself over a time period or distance as illustrated in Figure 14 and Figure 15 (left). This size gradient of the accelerated matter is seen from the Space observer or from a far-away observer. If the accelerated Matter is merely an observer, then the Matter thinks it is at rest and its size is uniform. Then the background Space appears to have a size gradient, but in the opposite direction, as shown in Figure 15 (right).

A Matter in a Space background has a tendency to overcome the Space's size gradient by creating the same size gradient of its own. As a result, an observer (even inside the accelerated matter) who sees the Space size gradient (Figure 15 right side) feels a downward pull like gravity. If allowing the observer to free fall, the observer will have the same size gradient as the Space background, thus giving the observer the impression that the Space is flat and uniform. This phenomenon explains size gradient-related pseudo-forces, also known as inertial forces and gravity; consequently, pseudo-force and gravity are of the same nature.

6. Gravity

According to general relativity, gravity is curved space-time. In this study, a simplified model of gravity is proposed, which is a size gradient of Space.

Matter and Space are both mass-units with size; however, the mass-unit size of the former is smaller than that of the latter. Therefore, Matter is condensed Space. Space is the continuation of Matter, which causes a Space size gradient in the medium of Space. Consider the following illustration: Matter is analogous to a fast-spinning whirlpool in the seawater background of an ocean, and Space is analogous to the seawater. The seawater circulates around the whirlpool. The surrounding seawater moves faster when it is closer to the whirlpool.

Therefore, gravity is a Space size gradient that corresponds to curved space-time rather than a force. Any object having size in Space that sees a space size gradient has a tendency to overcome the size gradient by creating the same size gradient through acceleration. The photon is a special mass-unit because it has no physical size, perceives the gradient of space differently from matter, and travels through the gravity space at a speed equal to the size of the space, as was

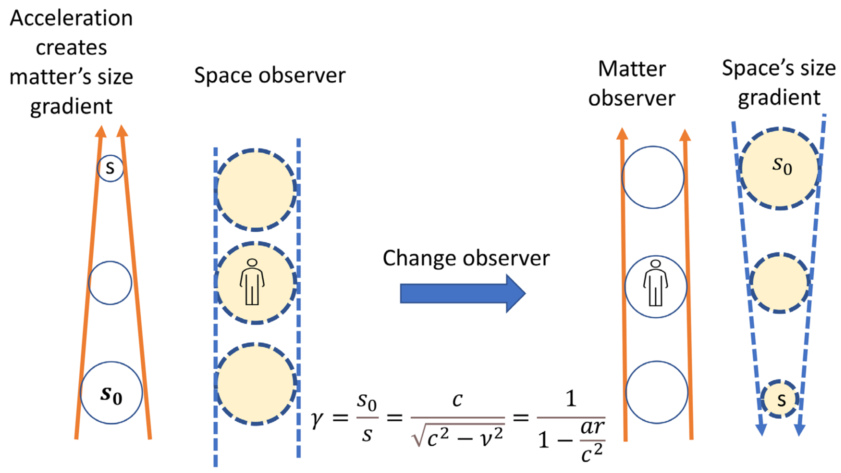

Figure 15. Size gradient created by acceleration.

previously stated. As a result, gravity slows down the speed of light. The light travels slower and slower until it eventually comes to a stop at the event horizon as the size of the space gets smaller and smaller as it approaches a massive star or a black hole.

A free fall object's acceleration is the cancellation of the size gradient of Space. The cancelation causes the object to feel stationary in a uniform Space background.

Newton's gravity is not relativistic because the speed in Newton's equation is allowed to exceed the speed of light. To derive a relativistic Newton's gravity, a relativistic mass-energy rule should be used. Since there is no external force acting on an object in gravity, the free fall object does not gain external mass Δm. Therefore, the gravity kinetics should follow the rule of scenario (A) described in the Mass and Energy section.

Newton's equation of gravity is given by:

$$F = \frac{GMm}{r^2} \quad (46)$$

According to Newton's second law $F = ma$, we have

$$\frac{m\mathrm{d}v}{\mathrm{d}t} = \frac{GMm}{r^2} \quad (47)$$

where F is the force, M is the large mass causing gravity, m is mass of the object interacting, r is the distance between the centres of the masses, G is the gravitational constant and v is the speed of the object. The energy conservation formula in Newton's gravitation field is given by:

$$\frac{1}{2}mv^2 + m\varphi = 0 \quad (48)$$

or

$$\varphi = -\frac{1}{2}v^2 \quad (49)$$

In Newtonian gravitational field φ satisfies:

$$\varphi = -\frac{GM}{r} \quad (50)$$

The Equation (47) is valid only when the gravitational field is weak. According to (47), in a strong gravitational field, the speed of a free-falling object can exceed the speed of light, which contradicts Einstein's theory of relativity. In other words, (47) is a non-relativistic equation that is not valid in the strong field, so in the strong field $\varphi \neq -\frac{GM}{r}$. The mass-energy equation of "no external force" criterion can be used to adapt Newtonian gravity to relativistic gravity. We will calculate a relativistic potential that applies to the strong gravitational field.

In gravity, the gravitational potential energy E_s and kinetic energy E_k have the formula $E_s + E_k = 0$. Since the non-relativistic Newtonian kinetic energy

$E_k = \frac{1}{2}mv^2$ and gravitational potential energy $E_s = -\frac{GMm}{r}$, we have

$$\frac{1}{2}mv^2 - \frac{GMm}{r} = 0 \quad (51)$$

To convert it to relativistic gravity, Newtonian kinetic energy in (51) is replaced with relativistic kinetic energy $\Delta E_k = \Delta mc^2$ of the "No external force" Equation (32)

$$\left(1-\sqrt{1-\frac{v^2}{c^2}}\right)mc^2 = \frac{GMm}{r} \quad (52)$$

The speed squared at location *r* can be calculated from above

$$v^2 = \frac{2GM}{r} - \left(\frac{GM}{rc}\right)^2 \quad (53)$$

This is different to the conventional gravitational speed $v^2 = \frac{2GM}{r}$, which can exceed the speed of light. The new speed $v^2 = \frac{2GM}{r} - \left(\frac{GM}{rc}\right)^2$ in (53) is a relativistic speed in which the speed of light is the upper limit. The comparison of two speeds is shown in **Figure 17**.

If we keep formula (48) and (49), the gravity field potential is revised, and the relativistic gravitation field is:

$$\varphi = \frac{GM}{r} - \frac{1}{2}\left(\frac{GM}{rc}\right)^2 \quad (54)$$

Then the relativistic gravity law is given by

$$F = \frac{m\varphi}{r} = \frac{GMm}{r^2}\left(1-\frac{GM}{2rc^2}\right) \quad (55)$$

Equations (54) and (55) could apply to strong gravity fields like black holes, which is used to calculate the event horizon radius in the Black hole section.

In terms of the size of the Space's mass-unit in gravity, $s = \sqrt{c^2 - v^2}$, we can use Equation (53) to calculate the size at each distance *r* and Space size gradient $\gamma = \frac{s_0}{s}$.

As shown in the diagram (**Figure 16**), at a distance *r*, which is the distance from centre of *M* to an observer's location, the observer perceives that the entire mass *M* is filled in the distance *r*. Because the mass of *M* is constant (ignoring dark matter which is described in dark matter section), as the distance *r* increases, so does the size of the Space's mass-units.

When the location is a far away where $r = \infty, v = 0$, the Space size is $s = c$. When the location is at distance *r*, based on Equation (53) and $s = \sqrt{c^2 - v^2}$, the Space size is given by:

$$s' = c - \frac{GM}{cr} \quad (56)$$

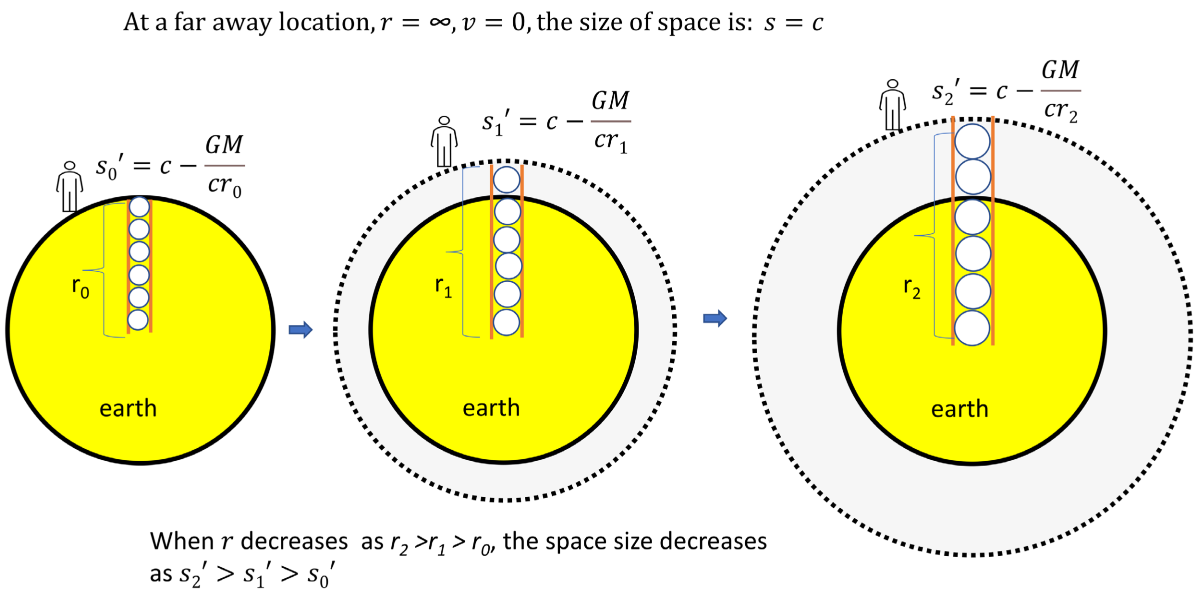

Figure 16. Space sizes at various locations *r* relative to the centre of earth.

The Space size ratio between a far away and location *r*, also known as the Lorentz factor is given by:

$$\gamma = \frac{s}{s'} = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{1 - \frac{GM}{rc^2}} \tag{57}$$

Therefore, the length contraction ratio (where *l* is length at a far away location, where *l'* is length at location *r*) is:

$$\frac{l'}{l} = \frac{1}{\gamma} = 1 - \frac{GM}{rc^2} \tag{58}$$

The Gravitational time dilation ratio (where *T* is the time -unit at a far away, *T'* is the time -unit at location *r*) is:

$$\frac{T'}{T} = \frac{1}{1 - \frac{GM}{rc^2}} \tag{59}$$

This time dilation factor was frequently used in the literature as an approximation to the general relativity time dilation factor $\frac{1}{\sqrt{1 - \frac{2GM}{rc^2}}}$. In fact, Equation (59) is the correct relativistic gravitational time dilation factor that can be applied to strong fields like black holes.

As previously stated, light travelling in the Space background has a speed equal to the Space's size; in the gravity, Space size and light speed are equal.

$$c' = s' = \sqrt{c^2 - v^2} = c - \frac{GM}{cr} \tag{60}$$

As a result, light moves slower in gravity. At event horizon, the Space's size is zero, so light's speed is also reduced to zero, and Photons and Space become the same thing. The light speed ratio between location r and the far away location is:

$$\frac{c'}{c}=\frac{1}{\gamma}=1-\frac{GM}{rc^2} \tag{61}$$

Einstein also derived a similar reduced light speed formula [4], which was regarded as an approximation of the transformation factor $\sqrt{1-\frac{2GM}{rc^2}}$ of general relativity. In fact, formula (61) is the correct relativistic light speed formula, whereas the transformation factor $\sqrt{1-\frac{2GM}{rc^2}}$ is a non-relativistic and weak field approximation.

7. Black Hole

Black holes can form in both Newtonian theory and general relativity. A Newtonian argument by Michell and Laplace predicting the existence of "dark bodies" can provide an exact general-relativistic result namely the exact formula for the Schwarzschild radius $R=\frac{2GM}{c^2}$ [5] [6]. It has been argued that the convergence of the event horizons and Newtonian horizons is a coincidence. However, no plausible explanation for this coincidence has ever been provided. One such research work by Preti [7] provides an explanation using Einstein's mass-energy equation $E=\frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}}$. As discussed in the previous section, this equation is only valid in scenario B where the external Δm keeps adding to the existing mass. Because there is no external force in gravity, Einstein's mass-energy equation cannot be applied.

This study proposes that the deeper cause of the coincidence is that general relativity derives the g_{00} from the Newtonian limit. Newtonian gravitation potential is a non-relativistic weak field approximation. When dealing with a strong gravitational field, such as a black hole, the traditional Newtonian gravitational potential should be replaced by the relativistic gravitational potential described earlier.

The following equations show how the conventional g_{00} is derived. The geodesic equation [8] is used in general relativity to describe particle motion.

$$\frac{\mathrm{d}^2x^\mu}{\mathrm{d}\tau^2}+\Gamma^\mu_{\gamma\lambda}\frac{\mathrm{d}x^\gamma}{\mathrm{d}\tau}\frac{\mathrm{d}x^\lambda}{\mathrm{d}\tau}=0 \tag{62}$$

Using the weak field assumptions and using only first order terms in h, the simplified geodesic equation is given by:

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2}=\frac{1}{2}c^2\nabla h_{00} \tag{63}$$

In Newtonian mechanics the force on an object due to a gravitational potential ϕ is given by:

$$\frac{\mathrm{d}^2 x}{\mathrm{d}t^2} = -\nabla\varphi \tag{64}$$

Comparing the two Equations (63) and (64), we obtain the following

$$h_{00} = -\frac{2\varphi}{c^2} \tag{65}$$

Therefore, the metric can be written in terms of a potential energy function ϕ as:

$$g_{00} = \eta_{00} + h_{00} = -1 - \frac{2\varphi}{c^2} = -\left(1 + \frac{2\varphi}{c^2}\right) \tag{66}$$

This is the Newtonian limit, which implies that gravity and geometry of nature are the same. The Newtonian potential function φ is given by:

$$\varphi = -\frac{GM}{r} \tag{67}$$

Therefore, the conventional g_{00} is

$$g_{00} = -\left(1 - \frac{2GM}{c^2 r}\right) \tag{68}$$

This metrics g_{00} has been used in the Schwarzschild solution as:

$$\mathrm{d}s^2 = -\left(1 - \frac{2GM}{c^2 r}\right)c^2\mathrm{d}t^2 + \left(1 - \frac{2GM}{c^2 r}\right)^{-1}\mathrm{d}r^2 + r^2\left(\mathrm{d}\theta^2 + \sin^2\theta\mathrm{d}\varphi^2\right) \tag{69}$$

When $1 - \frac{2GM}{c^2 r} = 0$, the Schwarzschild radius of black hole $R = \frac{2GM}{c^2}$ is derived. The Newtonian second law and gravitational potential function $\frac{\mathrm{d}^2 x}{\mathrm{d}t^2} = -\nabla\varphi$ and $\varphi = -\frac{GM}{r}$ are used here, thus indicating that the Newtonian kinetic energy and potential energy function $\frac{u^2}{2} = \frac{GM}{r}$ is also applied. This is why the radius of a "Newtonian black hole" is the same as the radius of a Schwarzschild black hole in general relativity.

However, the previous section highlights that the Newtonian functions $\frac{\mathrm{d}^2 x}{\mathrm{d}t^2} = -\nabla\varphi$ where $\varphi = -\frac{GM}{r}$ is not a relativistic form; *i.e.*, $\varphi \neq -\frac{GM}{r}$. In the strong field, the Newtonian potential function should be replaced using $\varphi = -\left(\frac{GM}{r} - \frac{1}{2}\left(\frac{GM}{rc}\right)^2\right)$. In fact, Einstein used the Newtonian limit to derive the constants k that appear in Einstein's field equations, which may also need to be revised.

By using the relativistic gravitational potential function (54) and combining with Equation (66), the correct g_{00} is derived as:

$$g_{00} = -\left(1 - \frac{GM}{c^2 r}\right)^2 \tag{70}$$

The modified Schwarzschild solution should be written as:

$$ds^2 = -\left(1-\frac{GM}{c^2r}\right)^2 c^2dt^2 + \left(1-\frac{GM}{c^2r}\right)^{-2} dr^2 + r^2\left(d\theta^2 + \sin^2\theta d\varphi^2\right) \quad (71)$$

We can see that the traditional formula $g_{00} = -\left(1-\frac{2GM}{c^2r}\right)$ is an approximation of the modified formula $g_{00} = -\left(1-\frac{GM}{c^2r}\right)^2 = -\left(1-\frac{2GM}{c^2r}+\frac{G^2M^2}{c^4r^2}\right)$, where $\frac{G^2M^2}{c^4r^2}$ part is small and can be neglected for the weak field.

Since $\left(1-\frac{GM}{c^2r}\right)^{-1}$ is the Lorenz factor γ given in Equation (57), the modified Schwarzschild solution in Equation (71) can be simply rewritten as:

$$ds^2 = -\gamma^{-2}c^2dt^2 + \gamma^2dr^2 + r^2\left(d\theta^2 + \sin^2\theta d\varphi^2\right)$$

The modified Schwarzschild radius R should be derived from the Equation (71) when $v^2 = c^2$, $1-\frac{v^2}{c^2} = \left(1-\frac{GM}{c^2r}\right)^2 = 0$. Then,

$$R = \frac{GM}{c^2} \quad (72)$$

This new radius is twice as small as the traditional Schwarzschild radius $\frac{2GM}{c^2}$, because in strong fields such as black holes, $\frac{G^2M^2}{c^4r^2}$ part cannot be neglected. The radius in Equation (72) is consistent with the notion of Planck mass. The standard Compton wavelength λ of a particle is given by $\lambda = \frac{h}{mc}$. The Planck mass is defined by $m = \sqrt{hc/G}$. The Planck mass is supposed to be the mass of the smallest possible black hole for which the Compton wavelength and Schwarzschild radius are the same. If we use the Schwarzschild radius $R = \frac{2GM}{c^2}$, then $\frac{h}{mc} = \frac{2GM}{c^2}$ and $m = \sqrt{hc/2G}$, which differs from the Plank mass. If we use the new radius $R = \frac{GM}{c^2}$, then $\frac{h}{mc} = \frac{GM}{c^2}$ and $m = \sqrt{hc/G}$, which agrees with the Plank mass.

The square of speed of the modified kinetic energy in gravitational Space gradient is $v^2 = \frac{2GM}{r} - \left(\frac{GM}{rc^2}\right)^2$. Then, we get the relativistic speed in gravity as:

$$v = \sqrt{\frac{2GM}{r} - \left(\frac{GM}{cr}\right)^2} \quad (73)$$

In Newtonian gravitation and energy conservation, we have $v^2 = \frac{2GM}{r}$. The Newtonian speed is given by:

$$v = \sqrt{\frac{2GM}{r}} \quad (74)$$

which is an approximation of the Equation (73).

A plot of the two functions mentioned above is shown in **Figure 17**.

We can see from this plot that the speed v in Newton's formula can exceed the speed of light after the event horizon at Schwarzschild radius $R = \frac{2GM}{c^2}$. However, the corrected formula prohibits speed v from exceeding the speed of light because speed c is the upper limit at new radius $R = \frac{GM}{c^2}$. After crossing the event horizon at radius $R = \frac{GM}{2c^2}$, the speed slows to zero (an "Infinity"-like region). Two infinity points can be derived from Equation (73); that is, one far away where $R = \infty$ and another when $R = \frac{GM}{2c^2}$. There is no singularity because Equation (73) does not allow $R = 0$.

Assume a massive object such as a star that shrinks to the size of a blackhole (**Figure 18(a)**). A free fall particle at infinity ($r = \infty$) has $v^2 = 0$. When it enters the star's gravitational field, the speed squared $v^2 = \frac{2GM}{r} - \left(\frac{GM}{cr}\right)^2$ is increasing and its size ($s = \sqrt{c^2 - v^2} = c - \frac{GM}{cr}$) is decreasing. The free fall particle becomes photon as the star continues to shrink into a black hole at the event horizon $R = \frac{GM}{c^2}$; then, $v^2 = c^2$. The free fall particle continues to fall to "another infinity" inside the black hole at $R = \frac{GM}{2c^2}$ and $v^2 = 0$.

In fact, the free fall particle is not needed to describe the properties of Space in gravity. Because the free fall particle has the same size gradient as local Space, it

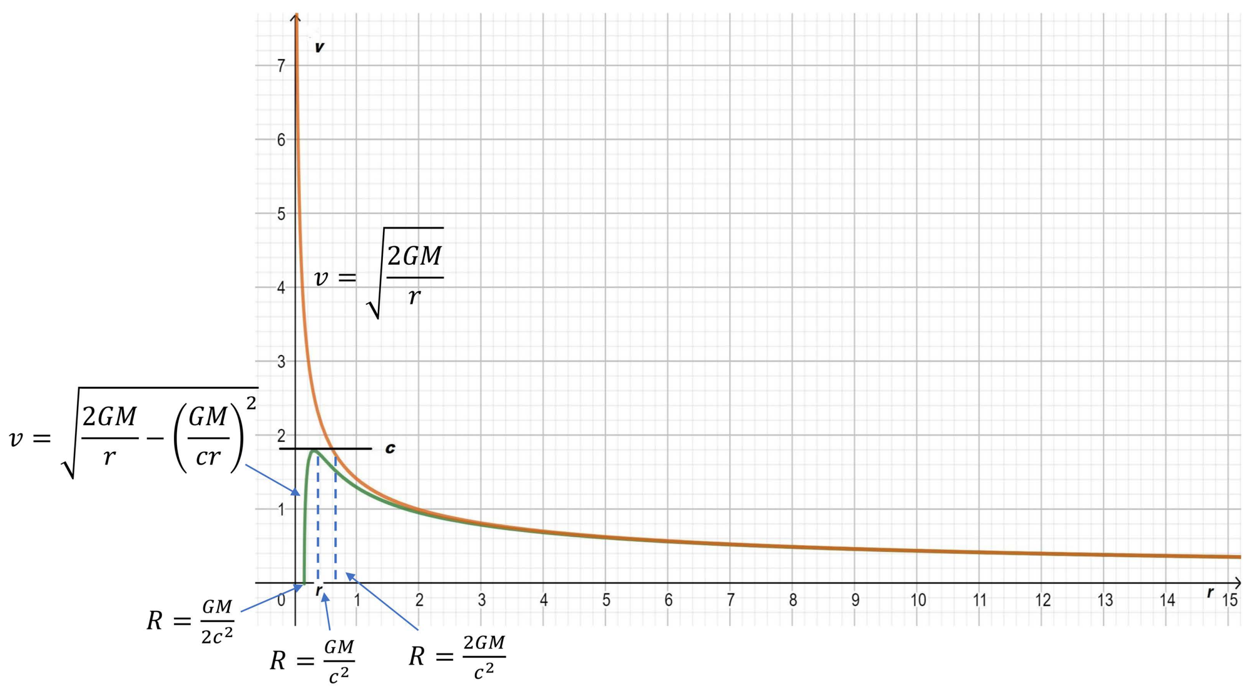

Figure 17. Plot showing curves of two functions of Newtonian speed and relativistic speed in gravity.

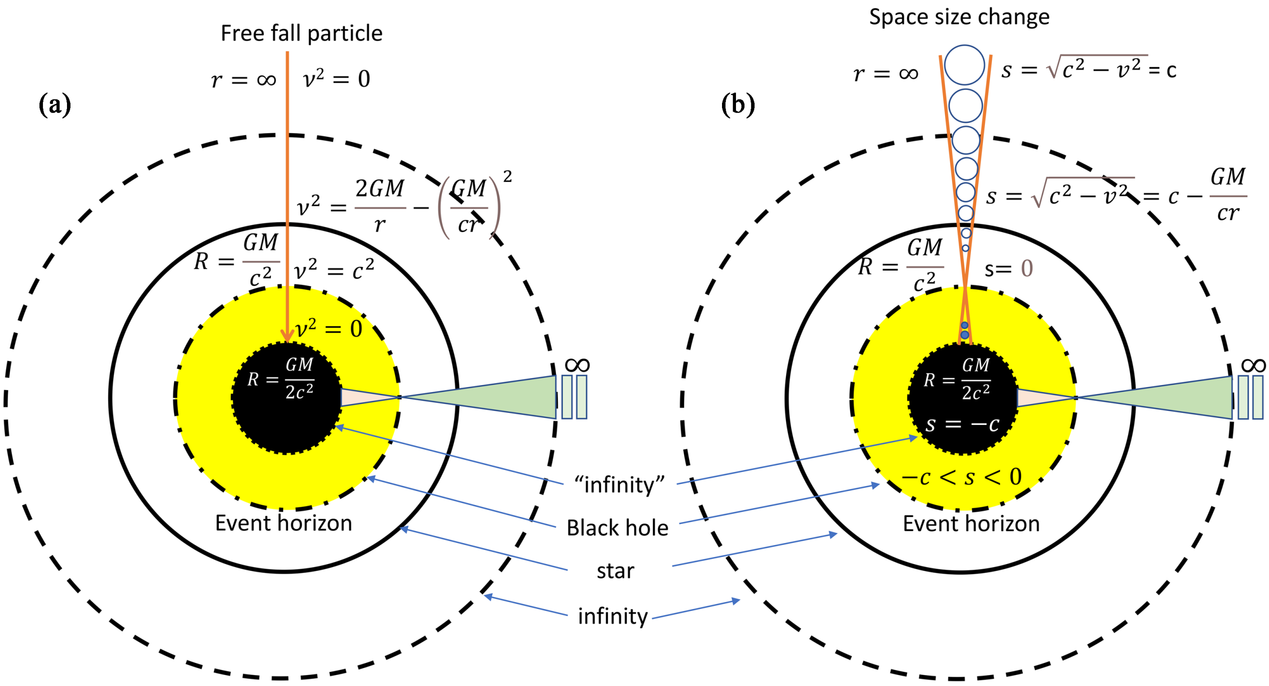

Figure 18. Diagrams showing a massive star shrinking to the size of a blackhole.

feels stationary and uniform against the local Space background. **Figure 18(b)** depicts the changes in Space size, as $s = \sqrt{c^2 - v^2} = c - \frac{GM}{cr}$, which is also the speed of light in the gravitational field. When a star collapses into a black hole, the Space size $s = 0$ at the event horizon, thus implying that the Space itself at the event horizon becomes a photon or has photon-like properties. The light stops travelling at the event horizon because the speed of light is also zero. The clock stops ticking as the ticking time $t' = 0$ and time unit $T' = \infty$. In fact, at the event horizon, Space, Matter and Photon become the same thing, *i.e.* the size-less mass-units with the maximum kinetic energy and zero potential energy. Inside the event horizon where $R < \frac{GM}{c^2}$, the Space size becomes negative $s < 0$. When the radius reaches $R = \frac{GM}{2c^2}$, the Space size becomes minus light speed $s = -c$, the Space at this location is another "infinity".

8. Dark Matter

Dark matter proposed in this study is the Space surrounding massive visible objects that is more condensed than far away Space. Space and Matter share the same building block—the mass-unit—but have different densities. The Space has a size gradient and is not uniform because, as it gets closer to the massive star, it gets denser. "Denser" means that the mass-unit of Space is smaller in size. Therefore, the Space close to a star is more like Matter. Dark matter can be thought of as a spatial extension of visible Matter.

To simplify the calculation, the mass-unit's size inside the massive star with mass m_0 is assumed to be uniform from the surface position r_0 to the centre of the star and has a size $s' = \sqrt{c^2 - v^2} = c - \frac{Gm_0}{cr_0}$. (Figure 19(a), circles are laid across radius r_0 where a circle represents the size of a mass-unit).

In addition, the star's outer Space, *i.e.*, the dark matter m_d is assumed to have a uniform Space size, which is the same as the far away Space size where $v = 0$ and $s = c$ (In Figure 19(a), circles are drawn between locations r and r_0 where $r' = r - r_0$).

To calculate the amount of dark matter, we allow the mass of the outside Space shrinking to the same density as the star (Figure 19(b)); therefore, the outside Space (*i.e.*, dark matter) has the same properties as visible Matter.

The mass-unit size ratio between the surface at r_0 and far away location is:

$$\frac{s'}{s} = \frac{1}{\gamma} = \frac{\sqrt{c^2 - v^2}}{c} = 1 - \frac{Gm_0}{c^2 r_0} \tag{75}$$

To bring the dark matter between the surface and location r to have the same density as the visible Matter, the distance r' must be reduced by $\frac{1}{\gamma}$; therefore, the effective radius is $\frac{r'}{\gamma}$ (Figure 19(b)). The mass densities ρ of visible stars and dark matter are the same after shrinking.

$$\rho = \frac{m_0}{r_0} = \frac{\gamma m_d}{r'} \tag{76}$$

The dark matter's mass is given by:

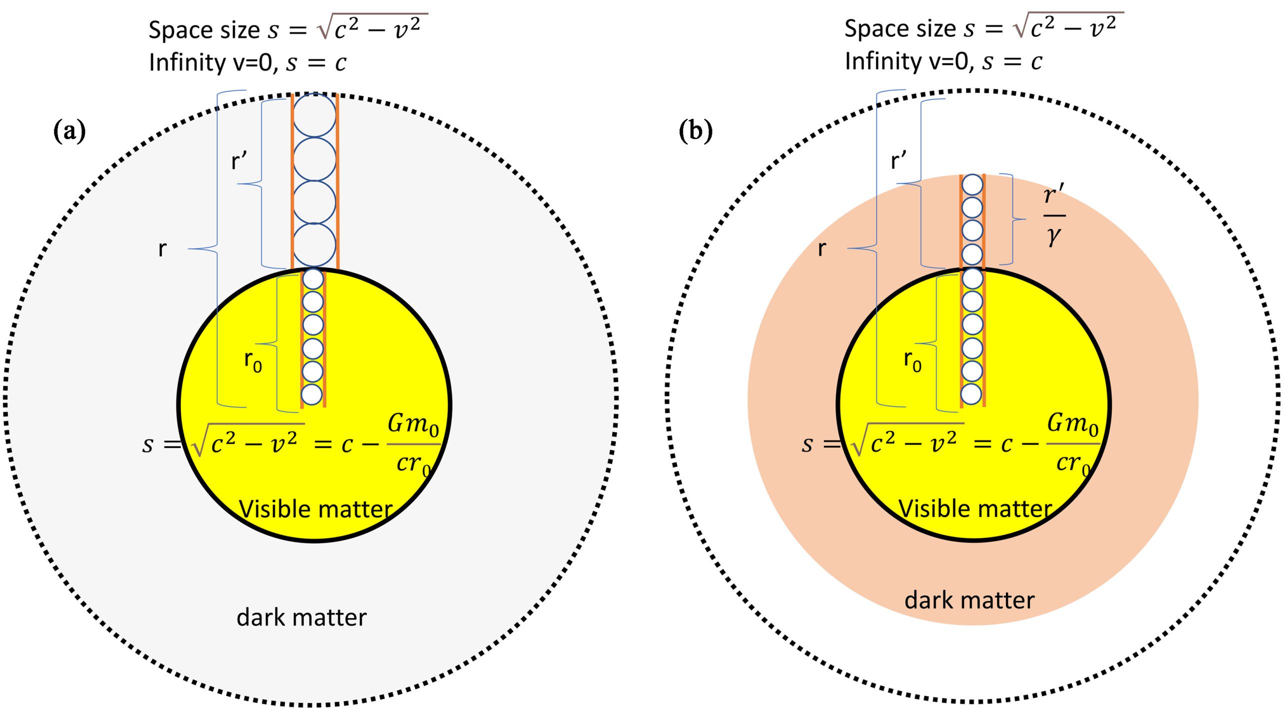

Figure 19. Space is brought to the same density as visible Matter and the dark matter is revealed.

$$m_d = \frac{m_0}{\gamma}\frac{r'}{r_0} = \frac{m_0}{\gamma}\left(\frac{r-r_0}{r_0}\right) \quad (77)$$

The total mass is given by:

$$M = m_d + m_0 = \frac{m_0}{\gamma}\left(\frac{r-r_0}{r_0}\right) + m_0 \quad (78)$$

γ factor in (75) $\frac{1}{\gamma} = 1 - \frac{Gm_0}{rc^2}$ is applied to (78) to get the following

$$M = \left(1 - \frac{Gm_0}{c^2 r_0}\right)\left(\frac{r-r_0}{r_0}\right)m_0 + m_0 = \frac{rm_0}{r_0}\left(1 - \frac{Gm_0}{c^2 r_0}\right) + \frac{Gm_0^2}{c^2 r_0} \quad (79)$$

We can incorporate (79) into Newton's gravity equation and use the orbiting speed in the simple circular orbit $u^2 = \frac{GM}{r}$.

$$u^2 = \frac{Gm_0}{r_0}\left(1 - \frac{Gm_0}{c^2 r_0}\right) + \frac{G^2 m_0^2}{c^2 r_0 r} = \frac{Gm_0}{r_0}\left(1 - \frac{Gm_0}{c^2 r_0} + \frac{Gm_0}{c^2 r}\right) \quad (80)$$

Then, the rotating speed with dark matter is obtained as:

$$u = \sqrt{\frac{Gm_0}{r_0}\left(1 - \frac{Gm_0}{c^2 r_0} + \frac{Gm_0}{c^2 r}\right)} \quad (81)$$

When $r = \infty$,

$$u = \sqrt{\frac{Gm_0}{r_0}\left(1 - \frac{Gm_0}{c^2 r_0}\right)} \quad (82)$$

The two functions, namely Equation (81) and Newtonian rotating speed $u = \sqrt{\frac{Gm_0}{r}}$ are plotted for comparison; the curves are shown in Figure 20.

Equation (81) and Figure 20 indicate that the speed of an orbiting object is primarily determined by the radius of visible stars r_0. When $r = r_0$, there is no dark matter, and the rotating speed is the same as predicted by Newtonian theory. When r increases, the speed does not decrease much. The rotating speed is constant when $r = \infty$ as indicated in (82). The observed star rotating trajectory matches well with the speed curve predicted by Equation (81). It should be noted that Equation (81) is only a rough calculation because it does not take into account that the Space surrounding a massive object is not uniform but has a size gradient and that inside of the star is also not uniform. In addition, the new relativistic gravitation potential is similarly not included in the calculation because its impact on the weak field of gravity is minor.

9. Conclusion and Discussion

This study highlights that Space, Matter, and Photon are all of the same nature and are composed of the same mass-units but have different sizes. A mass unit has interchangeable intrinsic potential energy E_s which is connected to size, and intrinsic kinetic energy E_k which is related to motion. It is comparable to the old

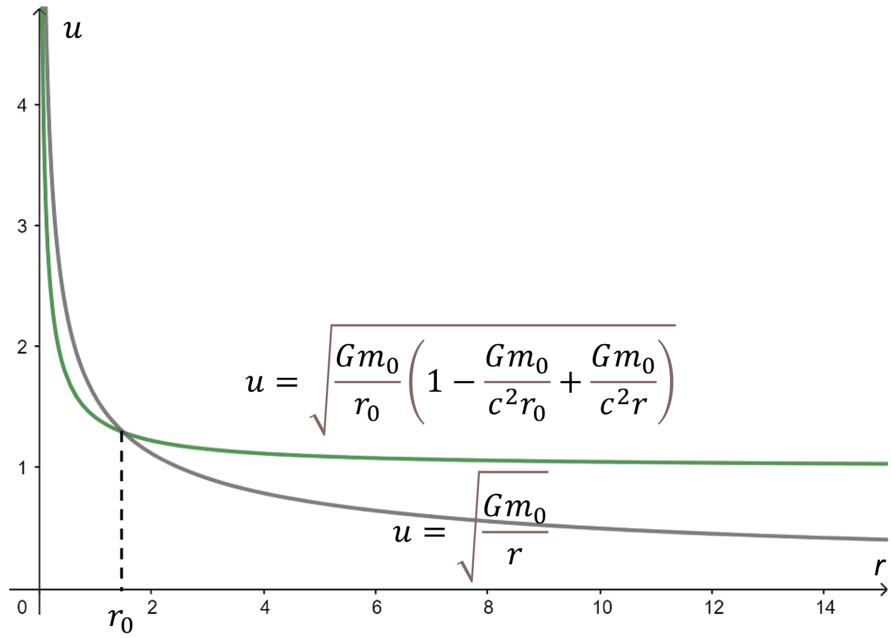

Figure 20. Plot curves of the two functions: speed including dark maker and Newtonian speed.

Yin-Yang theory, which holds that the universe is governed by two opposing but interdependent energies. Similar to Ying and Yang, E_s and E_k are converted into one another but the total energy stays the same.

Space has the largest E_s. The speed of light squared c^2 is assigned to both its E_s and E_k provided Space is assumed to be stationery and uniform, and $E_s = E_k = c^2$. Similarly, for Matter, which is a condensed Space, its $E_s < E_k$. When a Matter is assumed at rest, c^2 is also assigned to both its E_s and E_k, and $E_s = E_k = c^2$. Matter gains a true speed v when its size is reduced, which results in its $E_s = c^2 - v^2$, $E_k = c^2 + v^2$. The net kinetic energy ΔE_k is calculated as Δmc^2 for a matter, which is equals to the result of subtracting mass-unit' resting kinetic energy E_{k-rest} from $E_{k-motion}$ of the mass-units at motion, yielding $\Delta E_k = E_{k-motion} - E_{k-rest}$. Photon is an extreme form of mass-unit whose E_s is zero and $E_k = 2c^2$. The net kinetic energy ΔE_k of a photon is calculated by subtracting the Space's $E_{k-space}$ from the intrinsic kinetic energy $E_{k-photon}$ of the photon, thus yielding $\Delta E_k = E_{k-photon} - E_{k-space}$, which depends on which location of space you are talking to. At the far away location since $E_{k-space} = c^2$, photon's $\Delta E_k = c^2$, whereas at even horizon space's kinetic energy $E_{k-space} = 2c^2$, photon's $\Delta E_k = 0$.

The internal energy conversion was accomplished by shrinking in size while increasing motion and vice versa. In this study, the case where from energy's point of view the speed v is a scalar value with a known origin (exchange energy between E_s and E_k) is considered. The definition of "speed v" herein differs from the traditional definition for relative speed in SR. If we assume that the ticking time t is a physical characteristic independent of an observer, then the speed v should be comparable and relative to light speed c, which is absolute and has no direction. Because the distinction between those who have speed v (size reduction, time dilation) and those who are at rest in this situation is absolute rather than relative, the twin paradox is avoided. It appears that size reduction is the only source of speed v, and size s was formulated as $s = \sqrt{c^2 - v^2}$.

The mass-unit, the fundamental unit of the universe, is viewed as a light clock that ticks at different rates depending on its size and motion. At event horizon, Space, Matter and photon merge into the same thing as the sizeless mass-units in which the clock stops ticking and the mass m' is zero. It appears that time (rate) and mass m' are linked, with more time implying more mass m'. The constant universal time $T * t$, on the other hand, is always there, as is mass m_0; but the ticking time t and mass m' that are perceivable by far away observers vanish at even horizon. Time may be the most fundamental aspect of the Universe. Everything, including mass and information, is time-dependent or derived from time.

The mass-unit clock theory allowed us to derive invariant space-time and space-mass intervals. A modified version of the Minkowski space-time diagram was used to simply explain time dilation, length contraction, and other Einstein's relativity equations. The significant consequence of space-mass interval invariance was the prediction of a new equation of mass-energy relationship and an explanation for the increase in mass with speed. Thus, it was concluded that one type of speeding was caused by a decrease in kinetic mass m' rather than its increase. Although the speed appears universally as a result of size reduction, the kinetic energy equations for the two scenarios were not the same. Gravity was associated with "no external force" spontaneous size reduction.

Gravity is a space-size gradient. Because acceleration also causes a space-size gradient, acceleration and gravity are of the same nature. Newtonian gravity theory was slightly modified using the "no external force" equation so that the relativistic Newtonian potential could be applied to general relativity for the strong field.

A revised black hole was also predicted by the modified Newtonian gravity. It was observed that the new Schwarzschild radius was two times smaller than the traditional one when the relativistic Newtonian potential was used, and there was no singularity. The Space inside the black hole is negative and another infinity was identified. Dark matter was also predicted by the theory. The condensed Space surrounding a massive object is probably the source of dark matter. Space may be much heavier than we think.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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