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A Model of Time based on the Expansion of Space

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ABSTRACT

We present a model relating the expansion of space to time. We previously hypothesized the universe is the surface volume of a four dimensional, hollow hyperverse. Here, we claim that hyperverse 2c radial expansion is the basis of time, giving us quantized time, and the one-way arrow of time. We hypothesize that the surface of the hyperverse consists of a matrix of vortices, self-similar to the hyperverse, and that these vortices, which have the same energy, tangential velocity, and frequency, are the building blocks of both space and matter. We show that there is an energy connected to time, derived from the centripetal velocity of the vortices. Relative motion decreases centripetal velocity and consequently, perceived frequency. The time dilation function of special relativity is derived from the ratio of the centripetal velocities of the observer and the observed. Time is created by hyperverse radial expansion and the energy and spin characteristics of the quanta of space.

Subject headings: centripetal velocity; hyperverse; radial expansion of space; theory of time time physics

Contents

1. Introduction

"What is time?" is one of the most fundamental questions we have about existence, something nearly everyone must wonder about at some point in their lives. Time is so integral to existence that we cannot imagine life without it. The word 'time" is the most commonly used noun in the English language [1], while the second is 'year' and the fifth is 'day'. Despite our moment to moment living with time, no reasonable theory for time appears to exist, helping to explain a trend in physics claiming time in not real [2]. Time appears related to the expansion of space, as many cosmologists believe both space and time started with the Big Bang [3], and, additionally, the cosmological arrow of time is said to be the "direction towards which the universe becomes bigger" [4], a definition leaving open the question as to which direction that is. Relativity says time can appear to pass more slowly for objects moving relative to an observer, who can claim to be at rest. To solve the mystery of time, or to understand it better, would be a significant advancement in human thought.

The goal of this paper is to explain time.

Our model of time will:

- show that the direction of the expansion of the universe is the direction of the arrow of time, and explain why time goes one-way, to the future.
- explain why time occurs everywhere in the universe.
- show that events in the past are not just distant in memory, but distant physically.
- give an explanation of how the expansion of space quantizes time.
- reveal an energy, and a velocity, associated with time.
- use this 'energy of time' to create relativity and atomic time.
- produce a simple explanation for time dilation.
- And we will see that time consist of two parts: hyperverse time, related to the 2c radial expansion of space, and atomic time, the consequence of the energy aspects of the quanta of space comprising space and matter itself.

2. The 2c Radial Expansion of Space

In Tassano [5] we found that if the universe were the surface volume of a four dimensional sphere, a 'hyperverse', then the radius of the hyperverse is radially expanding at twice the speed of light, and its circumference is expanding at a rate equal to Hubble constant.

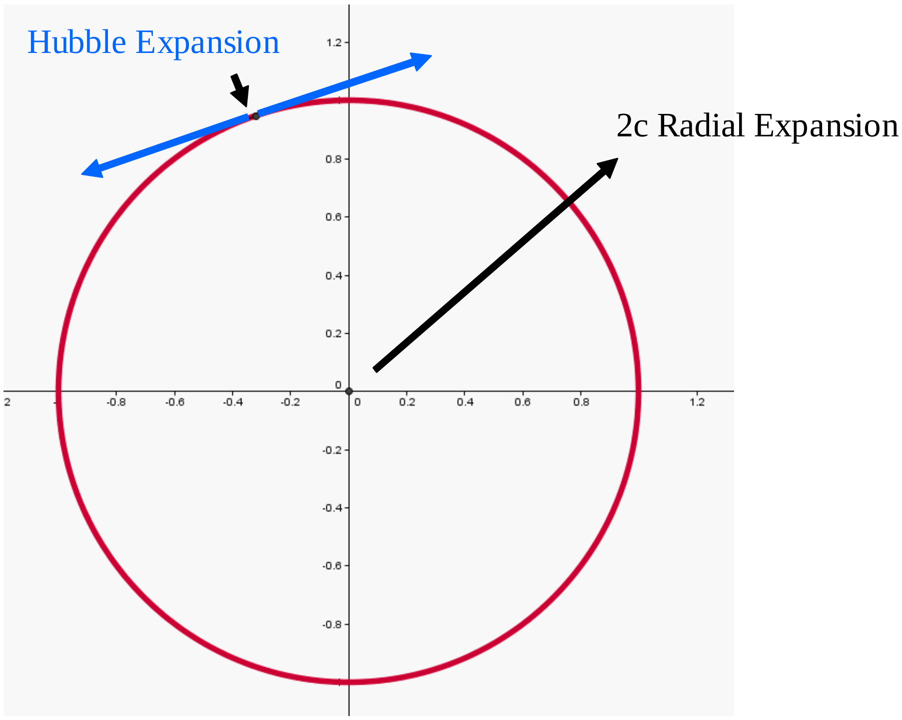


Figure 1. Radial and Circumferential Expansion. In this 2D representation of the 4D hyperverse, the circumference is the 3D surface volume of the hyperverse. The hyperverse is expanding radially at twice the speed of light, and the circumference is expanding at a rate equal to the Hubble expansion.

Every point on the surface of a 4D sphere is at the same distance from the center of the 4D sphere, meaning every point on the surface is moving radially at twice the speed of light. The 2c radial expansion might seem to be a violation of relativity, so let us address this concern. Consider a tire rolling along a road, at the speed of light. The translational, place to place, velocity is the speed of light, but recall the tire is rolling. The top of a rolling tire moves at twice the speed of the tire, so the top of a tire traveling at the speed of light has an instantaneous velocity of twice the speed of light. It is just a point that moves a very short distance before coming to an instantaneous stop (See Figure 3). A note, carrying information, attached to a point on the tire, does not get to the destination any faster than the tire does. So although the maximum velocity of information is the speed of light, the fastest instantaneous velocity is twice the speed of light. Nothing can move faster than the universe radially expands; radial expansion sets the speed limit in the universe.

3. Hyperverse Time

The 2c radial expansion is the foundation of what we will call 'hyperverse' time, the aspect of time associated with the radial expansion of space. We can visualize better how every point in 3D space can move at the same speed into a fourth dimension, if we recall that every point on the 2D surface of a balloon is at the same distance from the center of the balloon; the balloon's surface is flat in relation to the 3D volume of the balloon. Analogously, the 3D surface volume of the hyperverse is flat in relation to the 4D hypervolume of the hyperverse.

Looking again at Figure 1, in the circle representing the expanding hyperverse, by allowing the circumference of the circle to represent the 3D surface volume, which is also the 3D volume of the observable universe, we can, by analogy, follow our radial expansion. In one second of time, every point on the hyperverse surface will have moved two light seconds into the fourth dimension, or about 600,000 kilometers.

As we have said, we are flat to the fourth dimension, but not totally flat. We will make the claim now, and support and elaborate on it, in this and the other papers in related to the hyperverse model, that the surface of the hyperverse is composed of four dimensional vortices, or something that acts like vortices, and the source of the energy of the universe is the spin of these vortices. At this early stage, let us just use the value we will derive in Tassano [6] for the radius of these 'atoms of space': about 3.98×10^{-96}meters.

The universe is expanding radially at twice the speed of light, and the radius of the atom of space, which we are claiming is the building block of space and matter, has a radius of about 3.98×10^{-96}meters. This gives us about 1.51×10^{104} radial advances per second:

$$\frac{2\,(2.99792458 \times 10^{8}\,\mathrm{m\,s^{-1}})}{3.981\,166\,633\,261\,840\,704\,9 \times 10^{-96}\,\mathrm{m}} = \frac{1.506\,053\,303\,548\,235\,063\,6 \times 10^{104}}{\mathrm{s}} \tag{1}$$

The amount of time it takes for an atom of space to make a radial advance is the inverse of equation (1):

$$6.639\,871\,229\,285\,295\,604\,4 \times 10^{-105}\text{seconds} \tag{2}$$

Here is where we are at. The hyperverse, expanding at twice the speed of light, has a surface composed of a matrix of vortices, each with a radius of 3.98×10^{-96}meters. Thus every vortice makes 1.51×10^{104} radial steps per second. The time to make one radial advance is about 6.6×10^{-105} seconds.

- We have radial expansion going one way, radially outwards, into the fourth dimension; expansion is one-way only. The cosmological arrow of time points to the direction of expansion, and that direction is the direction of the radial expansion. The past is in the hypervolume of the hyperverse, the present is where the hyperverse surface is located at any particular moment, and the future is beyond the hyperverse surface volume.

- Expansion occurs everywhere in the universe, as all points in space are on the surface of the expanding hyperverse. Hyperverse time, or radial expansion, is everywhere.

- The past is behind us, literally. The further in the past an event occurred, the farther away it actually is. Time and distance are related, except it is not distance in the universe, it is distance within the hypervolume of the hyperverse.

- A 2c radial expansion implies a discrete, one-to-one, relation between radial expansion and light speed. There are two radial steps for every 'step' that light can travel within the universe. Light travels one step 'over' (along the circumference of the hyperverse) for every two steps 'out' (radially). This suggests a quantized aspect to expansion. With a surface consisting of four dimensional vortices, we can relate a radial step to time. That is, the vortex is thought to advance one radial step, one vortex radius, at a time. The time to make one radial step is 6.6×10^{-105} seconds. We will consider this to the be the smallest unit, or moment, of time.

Hyperverse time is not all there is to the story. Hyperverse time is not relativisitic, as all points in space experience the same number of radial advances. We will now generate relativity from the atoms, or vortices, of space.

4. Some Energy Aspects of the Surface Vortices

We also saw in [6] that we can express the Hubble constant as an energy equation, $\frac{\Delta E_o}{E_o}$, where ΔE_o is the change in the energy of the universe, and E_o is the energy of the universe. The Hubble constant is a measure of the fractional, or at every point, increase in the energy of the universe. The surface of an expanding hyperverse must be different from the nothingness into which it is expanding, and it is our claim that the universe is composed of energy, and that this energy is in the form of vortices.

The surface of the hyperverse is hypothesized to consist of atoms of space, or vortices, which are all at the same distance from the hyperverse center, and like the hyperverse itself, are considered to be hollow, four dimensional, spinning vortices. These vortices will be shown to be quanta in [6].

The 2c radial expansion is viewed as occurring in steps, called frame advances. In this model, no motion is allowed between frame advances. The frame advance is the radial advance of a cell.

We will claim that energy is derived from spin, and that every cell has the same energy. As supported below, the sum of the potential energy (PE) and linear kinetic energy (KE_{Linear}) of a cell equals mc^2:

$$KE_{Linear} + PE = mc^2 \tag{3}$$

Linear kinetic energy is given as:

$$KE_{Linear} = \frac{1}{2}mv_L^2 \tag{4}$$

We will use the convention that lineal velocity, v_L, and tangential velocity, v_T, are given as a percentage of the speed of light. For example, $v_L = 0.5c$.

Since vortices, or cells, all spin, they possess rotational kinetic energy:

$$KE_{rotational} = \frac{1}{2}I\omega^2 \tag{5}$$

Rotational kinetic energy is defined as the potential energy:

$$PE = KE_{rotational} = \frac{1}{2}I\omega^2 \tag{6}$$

5. The Square Root of the Net Potential Energy Equals the Special Relativity Time Function

The Lorentz factor, $\frac{1}{\sqrt{(1-v_L^2)}}$, is the time dilation factor used in special relativity equations. Its inverse is $\sqrt{(1-v_L^2)}$, which we will refer to as the special relativity time function.

Rearranging (1) and substituting (2) for KE_{Linear}, potential energy can be stated as the difference between the total energy and linear kinetic energy:

$$PE = Total\ Energy - KE_{Linear} \Rightarrow PE = mc^2 - \frac{1}{2}mv_L^2 \tag{7}$$

We will define 'net potential energy' as what is left of the potential energy after subtracting the linear kinetic energy from it:

$$PE_{net} = PE - KE_{Linear} \tag{8}$$

Substituting (5) into (6) gives net potential energy:

$$PE_{net} = \left(mc^2 - \frac{1}{2}mv_L^2\right) - \frac{1}{2}mv_L^2 \tag{9}$$

which reduces to:

$$PE_{net} = \left(mc^2 - mv_L^2\right) \tag{10}$$

Taking the square root of the net potential energy gives us the special relativity time function, which reveals the energy nature of the time dilation equation:

$$\sqrt{PE_{net}} = \sqrt{(mc^2 - mv_L^2)} \tag{11}$$

If we define $c = 1$ and $m = 1$, we get the standard function, which, unlike the above equation, is devoid of a clear connection to energy:

$$\sqrt{(mc^2 - mv_L^2)} \Rightarrow \sqrt{(1 - v_L^2)} \tag{12}$$

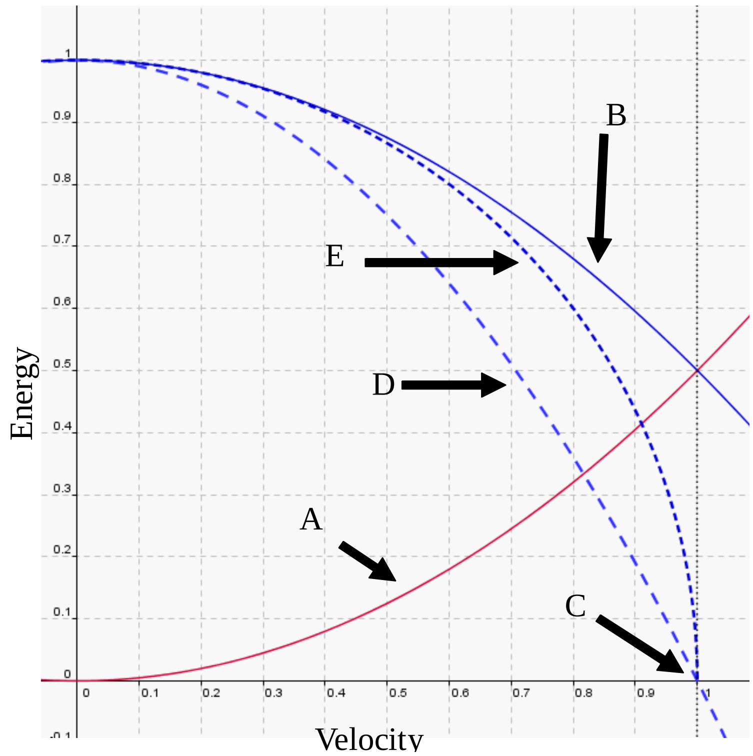


Figure 2. The relationship between linear kinetic energy (A), potential energy (B), net potential energy (D), and the square root of the net potential energy (E). Position (C) marks the location where velocity is equal to the speed of light.

6. Tangential Velocity

In equation (3), the rotational kinetic energy of the cell was given as $KE_{rotational} = \frac{1}{2}I\omega^2$. The moment of inertia, I, is defined as for a point particle:

$$I = mr^2 \tag{13}$$

We can define $I = mr^2$ because, although we define the hyperverse has having spin, the spin is restricted to the component vortices; there is no axis of rotation and all points are equidistant from the center.

Omega, ω, the angular velocity, squared, is defined as:

$$\omega^2 = \frac{v_T^2}{r^2} \tag{14}$$

Rotational kinetic energy can thus be presented as:

$$KE_{rotational} = \frac{1}{2}I\omega^2 = \frac{1}{2}\left(mr^2\right)\frac{v_T^2}{r^2} = \frac{1}{2}mv_T^2 \tag{15}$$

Additionally, we can express the total energy of a unit of space as the sum of the linear and potential energies:

$$mc^2 = \frac{1}{2}mv_L^2 + \frac{1}{2}mv_T^2 \tag{16}$$

If the unit has no linear velocity, then all energy, mc^2, is expressed as rotational kinetic energy, or spin:

$$mc^2 = \frac{1}{2}mv_T^2 \tag{17}$$

By solving equation (15) for v_T, we find that the tangential velocity of a vortex, one without any apparent linear kinetic energy, is the square root of two multiplied by the speed of light:

$$v_T = \sqrt{2}c \tag{18}$$

To determine the general equation for tangential velocity, we rearrange (14), substitute $\sqrt{2}c$ for v_T, cancel the mass, and solve:

$$v_T = \sqrt{2c^2 - v_L^2} \tag{19}$$

If the linear velocity is zero, the tangential velocity is equal to $\sqrt{2}c$. If the linear velocity equaled the speed of light, the tangential velocity would also be the speed of light. Thus the tangential velocity will vary from a maximum of $\sqrt{2}c$ to c as the object's linear velocity varies from rest to the speed of light.

A tangential velocity greater than the speed of light is not a violation of relativity. As discussed earlier in this paper, picture an automobile traveling by you at the speed limit. The top of the tires, however, are moving at twice the speed of the automobile, thus surpassing the speed limit.

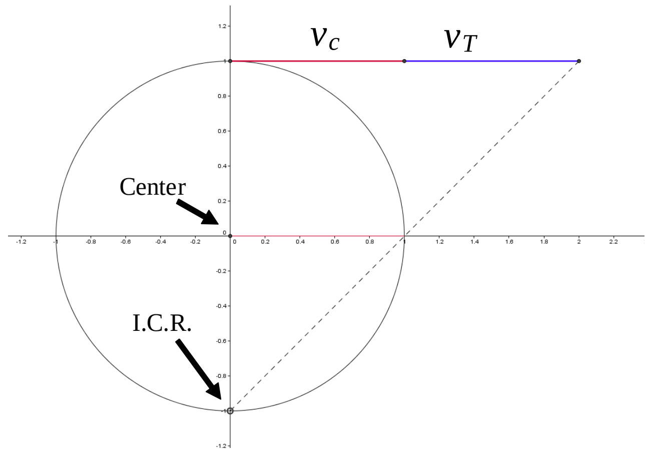


Figure 3. The top of a rolling circle has a combined tangential and linear velocity of two times the linear velocity. The bottom of the circle, where the I.C.R., (the instant center of rotation) lies, has an instantaneous velocity of zero.

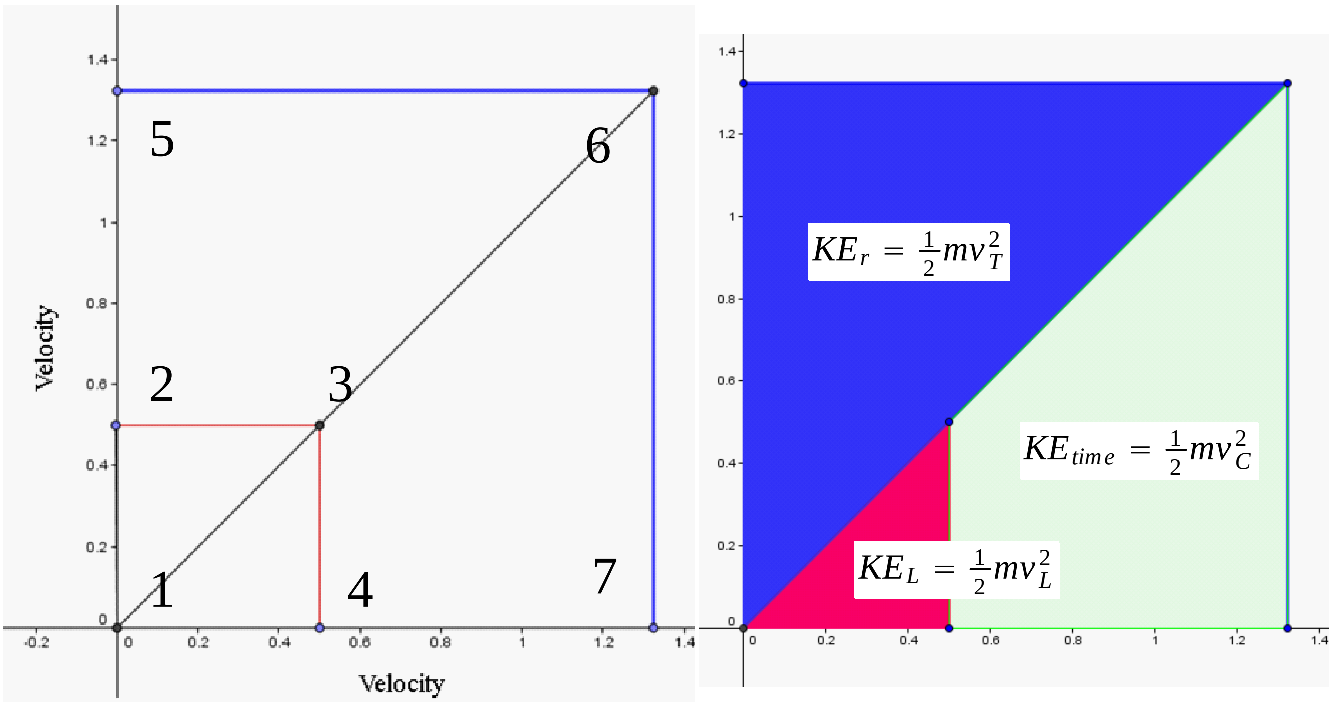
Figure 3 shows the 'top' of a spinning object moving translationally at the speed of light moves at twice the speed of light. Although the maximum translational velocity is the speed of light, the fastest that information can be transferred, the maximum velocity for any point in space is actually $2c$. This value is the true maximum velocity within the universe, and it is noteworthy that the $2c$ combined translational and tangential velocity matches the $2c$ rate of radial expansion. It appears that the rate of radial expansion sets the speed limit within the universe.

maximum translational velocity	c
maximum rotational velocity	$\sqrt{2}\,c$
maximum combined velocity	$2c$

Table 1. The maximum velocities

7. The Energy of Time

The special relativity time function equals the square root of the difference between the rotational kinetic energy and the linear kinetic energy. To explore this more, we created a 'velocity square' to better visualize the energies. The next images show a velocity square for an object traveling at 0.5c relative to the observer. In Figure 4A, the 1-2-3-4 square represents the square of v_L for a linear velocity of 0.5c. The corresponding tangential velocity square has the corners 1-5-6-7.



Figures 4A and 4B. Velocity squares. Figure 3A, left, shows the square created for the linear kinetic energy, with a velocity of 0.5c. The square is defined as 1-2-3-4. The square created by the rotational kinetic energy is defined as 1-5-6-7. In Figure 3B, right, since energy is one-half the velocity squared, we can define the red area the linear kinetic energy, and the blue area as the rotational kinetic energy. The remaining area, in green, represents the energy associated with time.

Figure 4B displays the associated energies. Since energy is one-half of the velocity squared, only one half of each velocity square, a triangle, is shown. The red triangle represents the linear kinetic energy of the moving object, $\frac{1}{2}mv_L^2$. The large blue triangle represents the rotational kinetic energy, $\frac{1}{2}mv_T^2$. The tangential velocity, v_T, is $\sqrt{2c^2 - v_L^2}$, and for an object with a linear velocity of 0.5c, the tangential velocity equals $\sqrt{1.75}c$. The net potential energy is the difference between the rotational and linear kinetic energies, the green area.

The green area is equal to the square of the special relativistic time function, and in the example of Figure 4, has a value of 0.75c. The structure of Figure 4B suggests there is a third energy value, one associated with time.

8. The Third Velocity

Let us solve for this implied velocity and energy. We will call this new energy KE_{time}. and the associated velocity v_C. The kinetic energy of time would have the following form:

$$KE_{time} = \frac{1}{2}mv_C^2 \tag{20}$$

We see from our equations and Figure 4, that the kinetic energy of time is equal to the difference between the rotational and linear kinetic energies:

$$\frac{1}{2}mv_C^2 = \frac{1}{2}mv_T^2 - \frac{1}{2}mv_L^2 \tag{21}$$

Substituting $\sqrt{2c^2 - v_L^2}$ for v_T and solving for v_C we get:

$$v_C = \sqrt{2c^2 - 2v_L^2} \tag{22}$$

In this example, where v_L is 0.5c, the value of v_C is $\sqrt{1.50}c$.

We now have three velocities: a linear, tangential and this new velocity. In our example, where the linear velocity is $0.5c$, the tangential velocity is $\sqrt{1.75}c$, and the new velocity is $\sqrt{1.50}c$. These three velocities form a right triangle, as shown in Figure 5.

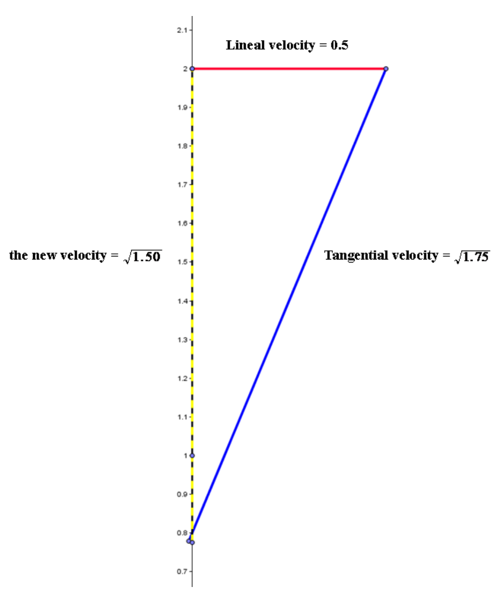


Figure 5. The three velocities form a right triangle.

The three velocities always form a right triangle, as they are related by the Pythagorean theorem:

$$v_L^2 + v_c^2 = v_L^2 + \left(2c^2 - 2v_L^2\right) = 2c^2 - v_L^2 \tag{23}$$

From (17), $2c^2 - v_L^2 = v_T^2$, we find:

$$v_L^2 + v_c^2 = v_T^2 \tag{24}$$

Let us look at a couple more examples of energy squares and velocity triangles. If the linear velocity was 0.1c, the tangential velocity would be $\sqrt{2c^2 - (0.1c)^2} = \sqrt{1.99}c \approx 1.411c$. Figure 6 shows the energy square and the associated velocity vectors. The lineal kinetic energy is small, and the kinetic energy of time is almost as large as the rotational kinetic energy.

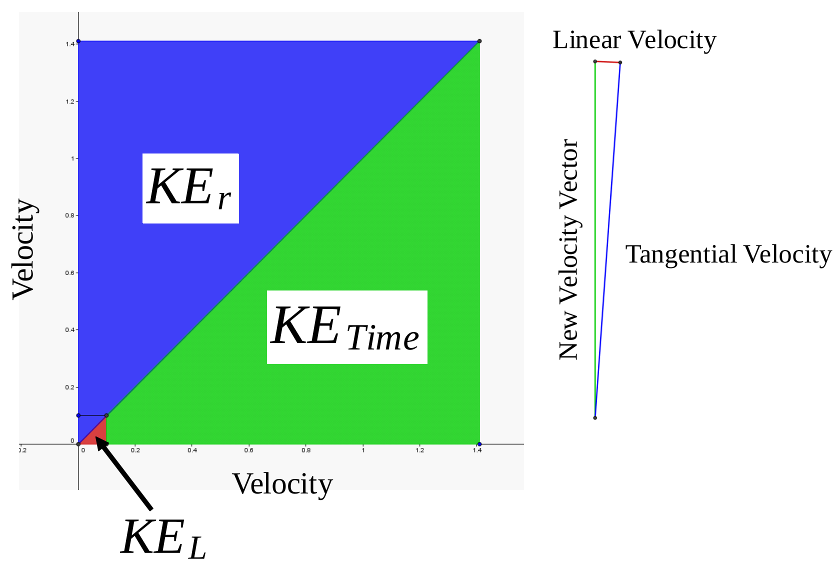


Figure 6. The velocity square and vector triangle for a vortex moving at 0.1c.

The situation at the other extreme, with lineal velocity equal to 0.9c, Figure 7. The tangential velocity would be $\sqrt{2c^2 - (0.9c)^2} = \sqrt{1.19}c$. Figure 7 shows the velocity square and vector triangle for an object moving at 0.9c. The energy related to time is shrinking, as is the related velocity vector. We see that as the linear velocity approaches the speed of light, the new vector shrinks to zero, and the linear and tangential vectors converge to become equal.

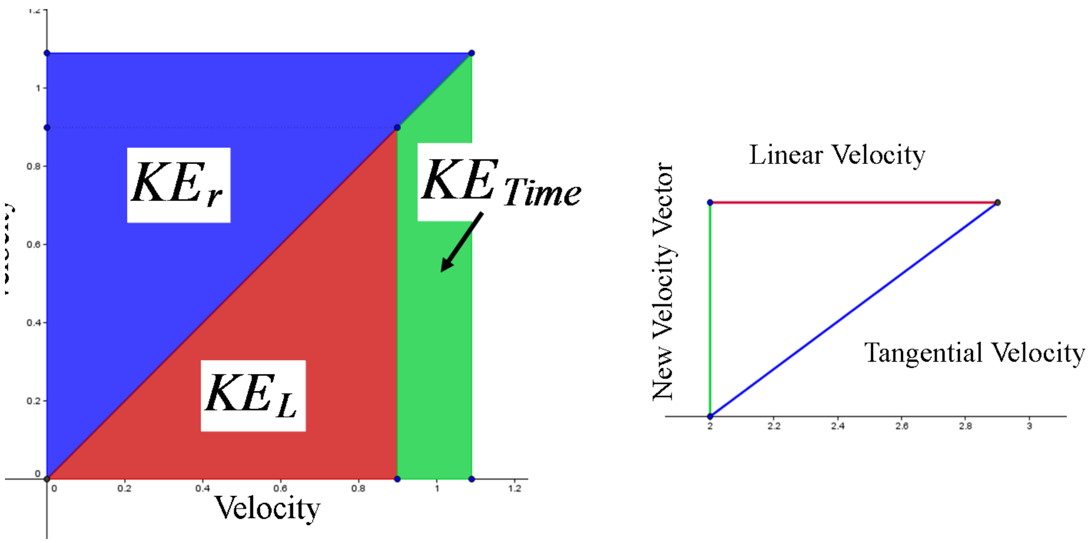


Figure 7. The velocity square and vector triangle for a vortex moving at 0.9c.

This new energy is not a fundamental energy, but an emergent energy, and the new velocity vector is not a fundamental velocity, but an emergent velocity. For example, if you were to throw a ball north while a strong wind was blowing to the east, the path of the ball would be northeast, the net direction of the two velocities. In the case of the spinning and linearly moving object, the tangential and linear velocity vectors combine to a form a new vector, sometimes called a 'resultant' vector.

9. Centripetal Velocity

The word "centripetal" means center-seeking, and a centripetal force is what makes an object follow a curved path, pushing it towards the center of rotation. Our new velocity vector is the centripetal velocity of the vortex. It points to the center of rotation and is derived from the linear and tangential velocity vectors. Surprisingly, physics tesxts to not suitably discuss centripetal velocity, necessitating a short description here.

When a spinning circle is at rest, relative to the observer, the centripetal velocity vector points to the true center of a circle. With motion relative to the observer, the centripetal velocity vector points to the instant center of rotation, a location that shifts from the true center to the very bottom of the circle (the circle is defined as moving to the right) as the circle is seen to move from rest to a roll. In Figure 8, we see that the location of the instant center of rotation can be found at point F, the intersection of the circle's vertical midline, $\overline{AH}$, and the diagonal line connecting the summed tangential and linear velocity vectors for the top and bottom, $\overline{CG}$.

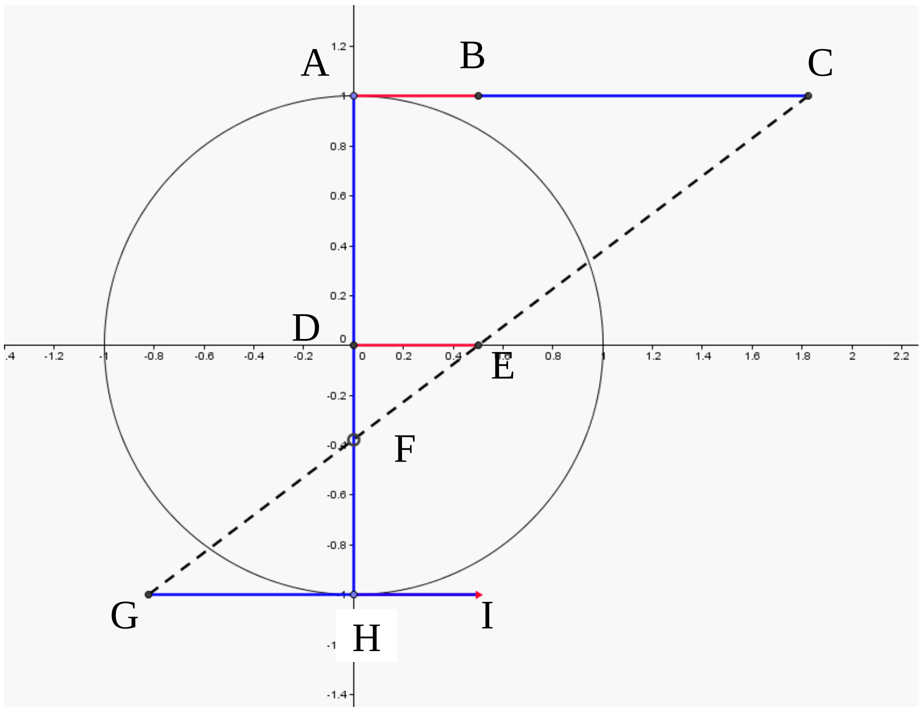


Figure 8. The line $\overline{AB}$ is perpendicular to the line connecting the center of the circle to a point on the circumference, point A. Line $\overline{AC}$ is perpendicular to the line connecting the instant center of rotation to point A. Line $\overline{BC}$ represents the lineal velocity vector, $\overline{AB}$ is the tangential velocity vector, and $\overline{AC}$ is the centripetal velocity vector. This example represents a spinning object moving at 0.5c to the right.

When we look at the velocity vector arrangements for our 0.5c example, Figure 9, we find the tangential velocity vector, $\overline{AB}$, is tangent to the circle and is perpendicular to the true center. The centripetal velocity vector, $\overline{AC}$, is perpendicular to the line connecting point A and the instant circle of rotation, ICR.

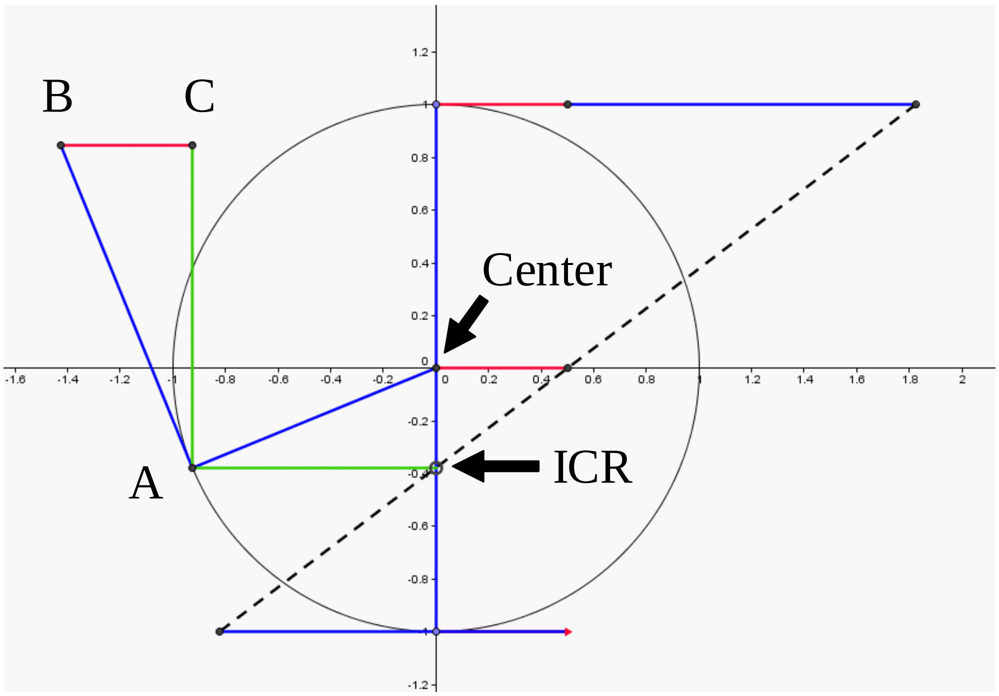


Figure 9. The line $\overline{AB}$ is perpendicular to the line connecting the center of the circle to a point on the circumference, point A. Line $\overline{AC}$ is perpendicular to the line connecting the instant center of rotation to point A. Line $\overline{BC}$ represents the lineal velocity vector, $\overline{AB}$ is the tangential velocity vector, and $\overline{AC}$ is the centripetal velocity vector. This example represents a spinning object moving at 0.5c to the right.

If the linear kinetic energy is zero, then the centripetal velocity is $\sqrt{2}c$, matching the tangential velocity:

$$\text{if } v_L = 0, \text{ then } v_C = \sqrt{2c^2 - 2v_L^2} = \sqrt{2c^2 - 2\,(0c)} = \sqrt{2}c \tag{25}$$

In the case where the linear velocity is 0.5c, the centripetal velocity is $\sqrt{1.5}c$:

$$\text{if } v_L = 0.5c, \text{ then } v_C = \sqrt{2c^2 - 2v_L^2} = \sqrt{2c^2 - 2\,(0.5c)^2} = \sqrt{1.5}c \tag{26}$$

When the linear kinetic energy is the speed of light, and the object would appear to roll, the centripetal velocity is zero:

$$\text{if } v_L = 0, \text{ then } v_C = \sqrt{2c^2 - 2v_L^2} = \sqrt{2c^2 - 2\,(c)^2} = 0 \tag{27}$$

Centripetal velocity is distinct from tangential velocity if there is any motion relative to the observer. Let us compare the equations of tangential and centripetal velocity side by side:

$$v_T = \sqrt{2c^2 - v_L^2} \qquad v_C = \sqrt{2c^2 - 2v_L^2} \tag{28}$$

When these equations are graphed, we can see the different behavior the equations display as linear velocity approaches the speed of light:

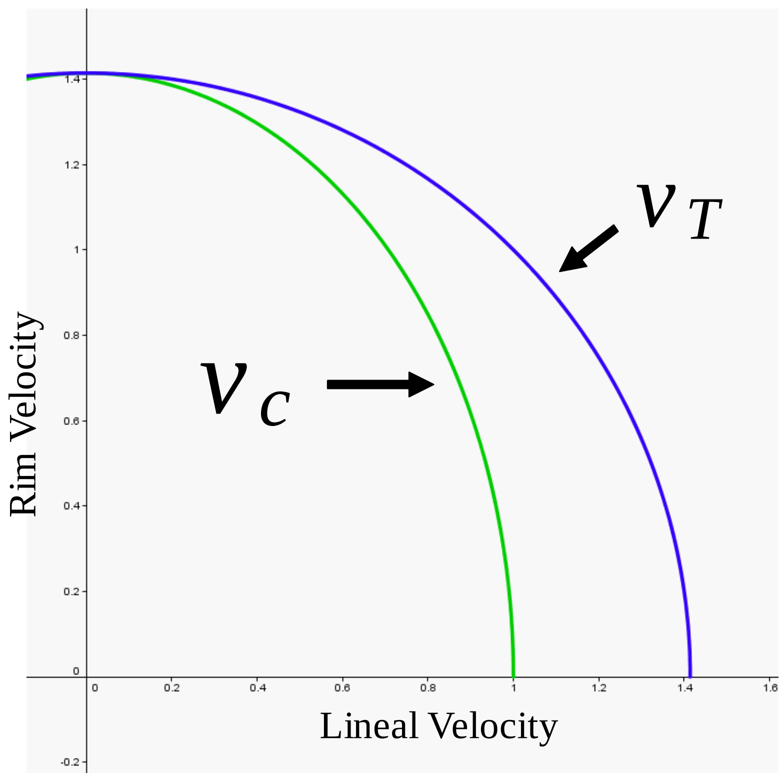


Figure 10. A comparison of tangential velocity and centripetal velocity. They are identical when the object is at rest, but diverge as the object's speed increases relative to the observer. V sub T represents the tangential velocity; V sub c is the centripetal velocity.

In physics texts, centripetal velocity and tangential velocity are considered equivalent and interchangeable, as the tangential velocity equation used in textbooks describes objects in the observer's frame of reference, without discussion of what relative motion does to centripetal velocity. Translational motion changes the nature of the centripetal velocity vector, causing the tangential and centripetal velocity vectors to diverge or split from one another. The equations of tangential and centripetal velocity are identical when the spinning object is at rest relative to an observer, when the linear velocity is zero, but we must use the proper centripetal velocity equation when working with an object that is translationally moving relative to the observer.

10. The Frequency of Rotation is determined by the Centripetal Velocity

Centripetal velocity is related to the period of time a spinning object takes to complete a revolution:

$$v_C = \frac{2\pi r}{period} \tag{29}$$

A decrease in the centripetal velocity increases the period, or time, to complete a revolution. A long period of rotation implies a low frequency, as period and frequency are reciprocals:

$$frequency = \frac{v_C}{2\pi r} \tag{30}$$

Substituting in the value of v_C, and factoring out c, gives:

$$frequency = \frac{\sqrt{2c^2 - 2v_L^2}}{2\pi r} = \frac{\sqrt{c^2 - v_L^2}}{\sqrt{2}\pi r} = \frac{c\sqrt{1 - \frac{v_L^2}{c^2}}}{\sqrt{2}\pi r} \tag{31}$$

11. The Base Frequency

The observer has an inherent frequency, and will see himself at rest, since his linear velocity is zero: $v_L = 0$. The observer's frequency is thus:

$$\text{base frequency} = \frac{c}{\sqrt{2}\pi r} \tag{32}$$

12. The Ratio of Observed to Base Frequency

To measure the frequency of an object moving relative to him, the observer will compare the frequency of the observed to his own base frequency:

$$\frac{\text{frequency of observed}}{\text{base (observer) frequency}} = \frac{\left(\frac{c\sqrt{1-\frac{v_L^2}{c^2}}}{\sqrt{2}\pi r}\right)}{\left(\frac{c}{\sqrt{2}\pi r}\right)} = \sqrt{\left(1 - \frac{v_L^2}{c^2}\right)} \tag{33}$$

which can be expressed as:

$$\text{base (observer) frequency} = \frac{\text{frequency of observed}}{\sqrt{\left(1 - \frac{v_L^2}{c^2}\right)}} \tag{34}$$

Alternatively we can use our centripetal velocity equation. Since the observer has no perceived linear kinetic energy, his centripetal velocity would be $\sqrt{2}c$.

$$\frac{\text{centripetal velocity of observed}}{\text{centripetal velocity of observer}} = \frac{\left(\sqrt{2c^2 - 2v_L^2}\right)}{\left(\sqrt{2c^2 - 2v_L^2}\right)} = \frac{\left(\sqrt{2}c\sqrt{c^2 - \frac{v_L^2}{c^2}}\right)}{\sqrt{2}c} = \sqrt{c^2 - \frac{v_L^2}{c^2}} \tag{35}$$

Let c equal one:

$$\sqrt{c^2 - \frac{v_L^2}{c^2}} \Rightarrow \sqrt{1 - v_L^2} \tag{36}$$

Rearranging, we find the same relation as in equation (32):

$$\text{centripetal velocity of observer} = \frac{\text{centripetal velocity of observed}}{\sqrt{1 - v_L^2}} \tag{37}$$

Ratios of both frequency and centripetal velocity produce relativity.

13. Two Steps to Time

Due to a constant tangential velocity of $\sqrt{2}c$, every vortex has the same energy, mc^2. All observers, regardless of their state of motion would agree that 'their' quanta have this total quantity of energy. Self-observers in uniform, non-accelerated motion, see their own energy as fully allocated to spin. They see themselves as being at rest, with no linear movement, and no linear kinetic energy; all of the energy is rotational, and their spin rate is seen as the maximum allowed. Because the total quantity of energy of spinning atoms of space is everywhere identical, and all observers can claim that they themselves are at rest, their vortices all have identical spin rates, and thus, identical clock rates.

If two observers are moving at constant, but different, velocities relative to each other, each can claim they are at rest and it is the other who is moving. Each observer deduces that the other has a decreased centripetal velocity, and therefore a lower frequency and clock rate.

Since the total energy per atom of space is the same for each actor, if one observer perceives the other is moving, the mover must have linear kinetic energy, which could only have been at the expense of rotational kinetic energy. The faster the other appears to move, the more linear kinetic energy they would appear to possess. This decreases the energy that is seen to be allocated to spin, lowering perceived rotational kinetic energy and frequency of rotation, translating to lower perceived clock rates.

Atomic clocks depend on frequency to measure time. We time events using our clocks, in our reference frame, and our base frequency. A moving object will display a lower frequency and thus a lower clock rate to us, and we, to them. This is why we observe that a moving clock runs more slowly than ours, easily explaining special relativity.

Understanding centripetal velocity is a key to this concept. The vortices of both actors have the same energy and spin rates, and each self-observes the same frequency and inherent clock rate, but they would see the other actor's vortices, moving relative to them, as having a lower spin rate, or frequency, and thus a lower clock rate. We see the consequence of apparent energy allocation as relativity. Matter is shown to be composed of the vortices, or quanta, of space [7],[8], and the description of time is applicable to particles of matter as well.

We have seen that hyperverse time, a direct consequence of the radial expansion, carries us into the fourth dimension at twice the speed of light, giving us the one way arrow of time, the sense of the short nature of a moment, the relentless passage of time, why time exists everywhere, and giving us quantized time when viewed in combination with the concept that space and matter consist of vortices of space. The vortices of the hyperverse surface, comprising space and matter, give us relativity. Time is real, and it is a consequence of the expansion of space.

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