A Novel View of Spacetime Permitting Faster-Than-Light Travel

Article · February 2004
DOI: 10.1063/1.1649686

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Abstract. Recent discoveries across many disciplines of physics have supported a driving need for a "new" science to explain the apparent relationship between phenomenon at cosmological scales and those at the quantum, subatomic level while still supporting the classical mechanics of motion, electromagnetism and relativity. A novel view of both the spacetime continuum and the universe is postulated that not only connects these fields of interest, but proposes a method to travel at superluminal speeds by examining the underlying equations of special relativity. The governing mathematics of special relativity describe a symmetrical continuum that supports not just one, but three, independent spacetimes each with a unique set of physical laws founded on the speed of light, *c*. These spacetimes are the subluminal (where $v/c < 1$), the luminal (where $v/c = 1$), and the superluminal (where $v/c > 1$) comprising a 'tri-space' universe. Relativistic symmetry illustrates that there can be up to three velocities (one for each spacetime) for a given absolute energy state. The similar characteristics of mass and energy in each spacetime may permit faster-than-light (FTL) travel through a quantum transformation/exchange of energy and mass (at the quark level or beyond) between the subluminal and superluminal realms. Based on the suggested characteristics of superluminal spacetime, the 'trans-space' method of FTL travel would allow a particle to traverse sublight space by traveling through the superlight continuum without incurring the penalties of special relativity or causal relations. In addition, the spacetime construct and superluminal realm of the 'tri-space' universe may offer a different perspective than the current ideologies that could better represent physical phenomena including universal expansion, the zero-point field, dark matter, and the source of inertia.

INTRODUCTION

There are three categories which classify all observed particle motions: slower-than-light (subluminal), light speed (luminal), and faster-than-light (superluminal). Subluminal particles, called tardyons, consist of everything made from the most elementary states of matter and can be quantified through analytical tools such as Newtonian physics and classical mechanics. Faster particles such as photons (luxons) and the propagation of electromagnetic (EM) waves are unique in that they can not be made to go slower or faster when in a vacuum. This characteristic defines the speed of light, *c*, and has been declared an absolute velocity limit for photons and non-photons alike. Particles that travel faster than light, called tachyons, are also unique in that such entities have yet to be discovered in nature. Despite their apparent absence, the tools developed to evaluate particles at superluminal speeds are derivatives of those used to describe tardyons and luxons. In this way, superluminal motion has been defined with respect to subluminal conditions leading to complex equations of motion and coordinate transformations (Puscher, 1980; Murad, 1997; Jones, 1982) Although correct, these adaptations may not be entirely representative of how the superluminal realm, or spacetime in general, should be perceived.

From the present understanding of the cosmos and observed natural phenomena, our perception of the universe includes all subluminal and luminal events (including the behavior of light itself), while the hypothetical superluminal realm exists only in a mathematical sense lacking the experimental proof for its existence. The mathematical representations predicting the behavior of normally sublight particles traveling faster than light (FTL) introduce relativistic effects and causality from the sublight point of view, which yield insurmountable issues for most FTL travel concepts. This paper, however, will discuss a novel relationship between the speed of light, matter, energy, and time that identifies three separate continua within the universe such that FTL travel without relativistic or causal effects could be made possible.

CP699, *Space Technology and Applications International Forum–STAIF 2004,* edited by M.S. El-Genk

RELATIVISTIC SYMMETRY AND THE TRI-SPACE UNIVERSE

The formulation by A. Einstein on special relativity in conjunction with Lorentz transformations has become the established criteria for evaluating motion at sublight and near light speeds. In summary, these principles state that as a particle approaches c, its relativistic mass, m, appears to increase, its relativistic length, l, appears to shorten, while time, t, begins to slow down, all with respect to an observer in a different reference frame. These processes are known as relativistic mass increase, length contraction, and time dilation, respectively, and are represented by first three equations of (1). Once a particle reaches c, an observer would see that its mass would become infinitely large, its length would become immeasurably small, and time would appear to stand still. Since Einstein's mass-energy relationship (1) shows that infinite energy, E, is required to move a particle to light speed due to the infinite increase in relativistic mass, achieving light speed through pure acceleration is considered impossible. The subscript "o" denotes the "proper" or "rest state" quantities measured when the velocity of the particle, v, equals zero with respect to the observer's reference frame.

$$m = \frac{m_o}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \quad , \quad L = L_o\sqrt{1-\left(\frac{v}{c}\right)^2} \quad , \quad t = t_o\sqrt{1-\left(\frac{v}{c}\right)^2} \quad , \quad E = m\,c^2 \tag{1}$$

Sublight and superlight relativity stems from the contribution of the square root terms in (1) in that it contains the ratio of particle velocity to light speed, v/c. For particles that exist and travel at only sublight velocities where $v/c < 1$, the relativistic quantities m, l, and t are positive, real values. For particles like photons that are created and exist only at light speed ($v/c = 1$), the square root term equals zero. In this case, t and l become zero, but m becomes undefined. To make the relativistic mass a real value, the proper mass, m_o, must be zero (which has been verified by experiment for such particles [Herbert, 1989]). For particles that are created and exist in a superluminal state, the v/c becomes greater than 1, resulting in the square root of a negative number. This becomes mathematically complex and thus imposes an imaginary term to the relativistic quantities.

The concept of relativistic symmetry can thus be derived from the mathematics. When the relativistic mass m is substituted for the proper mass m_o, relativistic energy in terms of mass and velocity becomes defined (2). Puscher (1980) provides sufficient mathematical derivation, but only the highlights will be summarized here. The function and figures that illustrate relativistic symmetry are given below.

$$\frac{E}{|m_o|c^2} = \frac{1}{\pm\sqrt{1-\left(\frac{v}{c}\right)^2}} \tag{2}$$

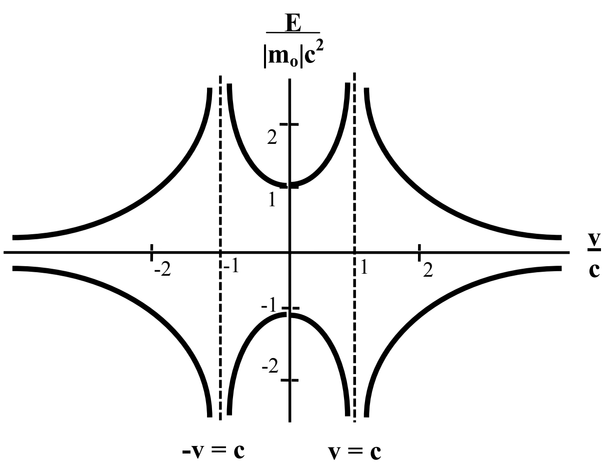


FIGURE 1. Dependence of Relativistic Energy on Velocity.

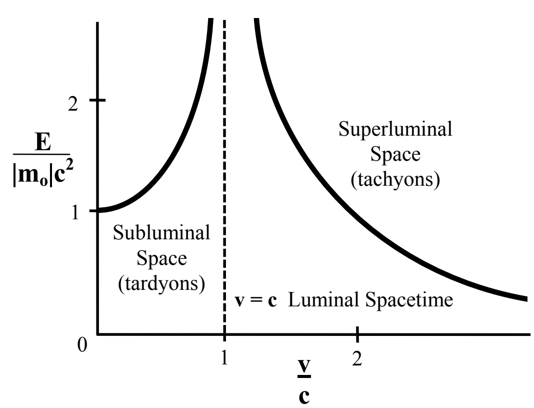


FIGURE 2. Positive Energy vs. Velocity from Fig. 1.

Since Figure 1 illustrates quantities such as negative energy and velocity (which current physics resolves as either undefined or matters of convention), Figure 2 shows only the more familiar positive magnitudes of these quantities.

The v=c vertical asymptote the function divides Figure 2 into three portions with the asymptote inclusive. Thus for a given absolute energy and real rest mass ratio (the vertical axis), there could exist three realms of permissible velocities based on the speed of light. Current physics can accurately describe the natural laws of both subluminal space (the left curve) and luminal spacetime (where v is always equal to c) and demonstrate that they co-exist in the same space and time. In the former, particles can never reach light speed and proper mass is always a positive, real value. Relativistic symmetry, however, proposes the existence of a third, additional realm for a given energy/mass ratio where v is always *greater* than c (the right-most curve). This is defined as superluminal space and has not been accurately characterized since no natural or empirical phenomena exist from which to derive a set of physical laws. Here, the speed of light is an asymptotic rest state and since v/c is greater than unity, the relativity equations must contend with the square root of a negative value, thus introducing imaginary quantities. This is where mathematics begins to diverge from physical understanding and is one reason why more subluminal, conventional approaches have been taken to examine the characteristics of superluminal motion. Nonetheless, the conditions of relativistic symmetry propose that there are indeed *three* coincident and coexisting continua occupying the same space and the same time together making up the "tri-space universe" (Meholic, 1998).

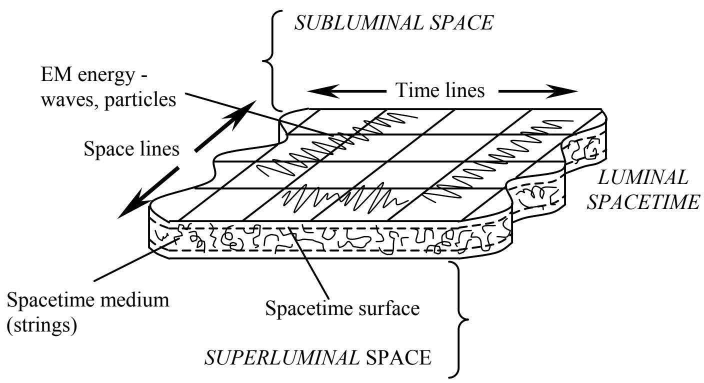


FIGURE 3. A Segment of the Tri-Space Universe.

Figure 3 shows the tri-space universe model where two realms of *space* are separated by a *spacetime*. The two, co-existing, primary spaces are governed by radically different sets of physical laws (one sublight and the other superlight), but independently permit the existence of real, positive mass and EM energies such as waves and photons. Spacetime, on the other hand, is the fundamental medium that supports the existence and temporal progression of these energies, and behaves, for the most part, as a semi-permeable barrier between the two spaces. The spacetime medium is composed of strings, superstrings and strands of quantum energies that are all meshed together in a cosmic fabric *per se* surrounding every mass in the universe and filling every point in between.

Although the concept of a spacetime membrane, or "brane" for short, that filters energies passing between universes has recently been theorized (Johnson, 2000), there are three characteristics of spacetime that differentiate the tri-space view from string-based cosmology. The first is that spacetime has what could be called a surface *per se* on which all EM energies reside (Figure 3). It is formed at the distinct boundary between mass energy and the spacetime medium, supporting the well-known claim that mass is truly a different *phase* of energy. As with sound, the speed at which EM signals move along the surface is governed by the overall density of the medium, in this case, the combination of the permittivity and permeability of free space, which together define the speed of light. The surface has a natural tendency to remain flat and unperturbed, supporting the recent observations that the universe is indeed flat (not curved as early modern physicists had originally thought [Musser, 2000]) and is easily distorted in the presence of mass energy. The second proposed characteristic is that underneath the surface of spacetime, there is a true *thickness* instead of a planar thinness or infinite depth. This implies that the spacetime medium must, therefore, have two sides as shown in Figure 3. The dynamics of what goes on between the surfaces within the medium itself is better recognized as the zero-point field (ZPF) and is represented by the v=c asymptote of Figure 2. The ZPF spans all energy/mass ratios where v=c supporting the claim that immeasurably vast quantities of energy can exist within it. On the surface and within the quantum-governed ZPF medium, space and time, mass and energy are indistinguishable from one another. Although the actual, measurable thickness has yet to be determined, the sensitivity of spacetime distortion to perturbations implies that it is indeed quite thin. The final distinguishing, tri-space concept is that spacetime exhibits quasi-fluidic properties. The surfaces and the region in between are proposed to have properties analogous to viscosity, density, compliance and surface tension (Meholic, 2002). These will not be discussed in detail here, but modeling spacetime with such familiar concepts permits explanations of many mysterious details about the small fraction of the universe science has observed.

As for the interaction of the two spaces across the spacetime medium, each realm has congruent location and time and are all equally influenced by mass, gravity, and quantum phenomena. Since luminal spacetime acts as a common boundary for the sublight and superlight realms. Nothing exists in this unique state other than EM energies and photons; therefore, nothing can "cross" from one space to the other without first passing through luminal spacetime and becoming light itself. The three realms also have common energy. The existence and definition of tri-space is dependent on the vertical axis in Figure 2 representing an absolute energy such that every point in the universe has a positive energy value (defining absolute energy also provides a normalization reference for the three spaces to compare their respective states). Common energy leads to an important supposition that the total energy of any point in space can be represented by either of the three distinct sets of physical laws coexisting in that location. More simply, the given energy state of a point in sublight space is also present in both the luminal and superluminal realms at the same point. Due to its complex nature, however, mass energy can only exist in one space at a given location (excluding luminal spacetime where m_o is always zero). This is a result of how mass energy affects spacetime and its topography with respect to gravitational curvature. But regardless of what kind of energy is present in one space, the same energy is *always* mirrored in the adjacent spaces, often in different forms. This will be explained in more detail in the section to follow.

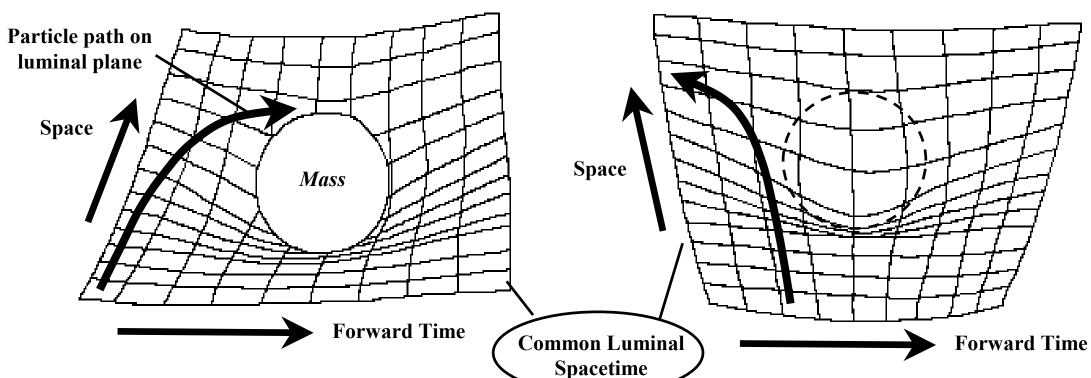
CHARACTERISTICS OF SUPERLUMINAL SPACE

Because subluminal and superluminal spaces have c as an asymptotic boundary, there are fundamental similarities between them that can be defined through Einstein's and Minkowski's work on mass, gravity, light, and time. Since their work has been experimentally proven in sublight space, variations on those truths should hold for similar, coexisting continua as well (i.e. superluminal space). What must be implicitly recognized in such comparisons is that each space has its own unique set of laws which may not make mathematical (or physical) sense when viewed from the adjacent space, but are consistent within its own. This concept is paramount to understanding how the two spaces coexist without interference or direct observation.

In the same way that subluminal mass is composed of tardyons, superluminal mass is composed of tachyons. Tachyons are the superluminal equivalent of tardyons including all forms of subatomic particles and antiparticles. Since they exist in a realm partially governed by imaginary mathematics, their properties must be defined in order to adequately compare them to their tardyon cousins. Puscher (1980) details proposed tachyon properties with sufficient mathematical derivations, but only the highlights will be mentioned here. With respect to mass, an imaginary denominator results in (1) when $v > c$. To contend with this, Puscher (1980) suggests that the superluminal proper mass, m_o, must also be imaginary. The imaginary terms in the numerator and denominator then cancel, leaving only the real terms for relativistic mass. In short, superluminal m_o is imaginary, but m remains positive and real when moving faster than c. The implication is that tachyons can be real, measurable entities that have length, momentum, spin, quantum states, and all of the related properties indigenous to tardyon matter, but they can not be *slowed down* to the speed of light regardless of energy *input* (the right-most curve of Figure 2).

Since the relativistic, proper quantities of tachyons are imaginary, the mathematics implies that superluminal masses are subject to relativistic effects opposite of subluminal mass. For example, Figure 2 shows that as energy is withdrawn from a positive, real, superluminal mass, velocity increases and relativistic mass decreases in order to approach true, imaginary rest mass. Physical dimensions would also elongate instead of shorten as velocity decreases. If an imaginary proper time were employed in (1), a similar cancellation of imaginary terms as would yield that tachyons would seem to obey a forward time progression as their subluminal counterparts. Superlight relativity governs that time would normally proceed forward and reverse only when v became less than c, which is impossible. According to the discussions about the superluminal continuum and its mass-energy similarity to sublight space, a prudent assumption would be that time travels forward in both spaces since each is bounded by the same luminal spacetime continuum. And from an entropy standpoint, when energy is added to a superluminal system, entropy drops. This is exactly opposite to all phenomenon observed in sublight space (Hey, 1997) that when energy is added to a system, heat is usually produced yielding an increase in entropy. This is a unique perspective in that if entropy naturally wants to increase for sublight space, the natural order may be for it to decrease in superlight space, thereby developing a net balance (or conservation) across the tri-space universe.

Extrapolations of the three spaces into Riemann representations (Figure 4) illustrate how luminal spacetime is sufficiently curved by a real, positive mass to create gravity. Figure 4a shows the familiar influence of the mass in sublight space based on current physics. The mass can be observed directly and induces a gravitational "dent" in luminal spacetime resulting in the inward curvature of an approaching particle's path towards the mass. This represents the bending of both light and time due to the mass's attractive gravity force. Figure 4b illustrates how the real, observable mass in sublight space from Figure 4a may be viewed from the other side of luminal spacetime in superluminal space, rendering an inverse distortion appearing as a "bulge" whose source mass is blanketed by luminal spacetime. The approaching particle path in this case is curved away from the distortion, representing a repulsive or anti-gravity effect. Even if the source mass were in superluminal space instead, gravity would still behave as normal: it would attract particles in the same space as the source mass while repelling particles in the opposite space. Light would still be bent from the gravity curvature in either space, but in opposite directions. It is important to note that regardless of which space contains the true mass energy, the mass-induced, gravitational energy is *equal* in both spaces, even though the source mass can only exist in one. This concept is paramount in describing the proposed method of FTL travel to be introduced later. In short, both mass and energy are conserved such that where there is mass in one space, there is only an equivalent energy in the other, and that an energy state in one space does not necessarily require an equivalent mass in the other. Because of this, tachyons and tardyons will never directly interact due to the presence of the bounding luminal spacetime, nor will one space be directly "visible" from the other. The influence of gravity on luminal spacetime may be the only effect by which to detect the presence of superlight masses.



(a) Subluminal Space. (b) Superluminal Space.

FIGURE 4. Influence of a Gravitational Mass on Subluminal and Superluminal Spacetimes.

If tachyons can exhibit real mass, then they would generate a real gravity in the same way as tardyons. According to the previous discussion, the tachyon mass energy would be reflected in subluminal space as an equal gravitational energy with no observable mass. Such disturbances, by interesting coincidence, is exactly what astronomers seek when searching for dark matter. Recent discoveries have also concluded that enormous dark matter "halos" surround most galaxies (IAU, 2003). Based on the prior discussions, the tri-space model proposes that dark matter is, in fact, tachyon mass in superluminal space whose presence is only observed by its gravitational effect on subluminal space. Although no detail will be given here, the tri-space premise can also explain the formation of such halos and can model the interactions of dark matter and dark energy on the accelerated expansion of the universe.

The distinct relativistic differences between subluminal and superluminal realms dictate that tachyons cannot exist in sublight space and, conversely, tardyons cannot exist in superlight space. There is the possibility, however, that certain particles already discovered in the subluminal realm may have properties allowing them to exist in either space. Quarks seem to fit this description, and as with all particles, are subject to the strange laws of quantum mechanics.

During the early evolution of quantum physics some 60 years ago, Erwin Schrödinger and Paul Dirac were able to calculate the quantum wave functions for tachyons. They showed that only subluminal speeds were possible if tachyons were represented by their wave functions, and that only superluminal speeds could be achieved if they were represented by particles (Herbert, 1989). This indirectly relates to several instantaneous and randomly occurring quantum phenomena including annihilation, creation, jumping, and tunneling (Herbert, 1989). Based on the characteristics of superluminal space and its relationship to subluminal space, quarks, tachyons, and the tri-space theory can be employed to postulate how and why these quantum events can occur (Meholic, 1998).

One such example of a quantum-tri-space connection arises in Bell's theorem of quantum tunneling. The experimentally proven theorem (Herbert, 1989) verifies that two particles are somehow "linked" by an invisible medium of instantaneous information transfer such that when the state of one changes, the state of the other changes to conserve momentum, energy, etc. These effects appear instantaneous from a sublight point of view, but may actually be superluminal processes partially explained by the tri-space model. According to (1) and the supposition of equivalent energy and mass in sub- and superluminal spaces, when a particle pair is created, energy signatures of the pair are inherently created in superlight space reflecting the energy state of the particles' quarks. The sublight pair is then separated, and the state of the one particle is altered (the parent), causing a change in its quantum state, and thus the condition of its quarks. Since the parent's superluminal energy pattern simultaneously reflects the alteration across spacetime, the change in energy produces a signal *per se*, congruent with the quark's wave function, that travels through superlight space to the child particle's energy pattern, which then rearranges its signature to indicate a change. The final step is for the child's energy pattern to be reflected in the sublight mass, manifesting as an equivalent alteration. Since the signal can travel FTL in superluminal space, but is restricted to slower-than-light travel elsewhere, the overall change appears instantaneous when observed from the sublight world. Tri-space also considers the spacetime medium and the quantum string connection between the particles to have a profound influence on the signal transmission, but the overall resulting effect is, in fact, superluminal and at very low energy. In summary, quarks may be the entities capable of bridging the gap between sub- and superluminal spaces.

THE TRANS-SPACE METHOD OF FTL TRAVEL

From the discussions on the characteristics of sub- and superluminal spaces, the mass-energy relation between the two, and the possible quantum contribution of quarks, the trans-space method of FTL travel can be introduced. The proposed technique is to switch mass and energy between the spaces by simultaneously converting tachyon energy into real mass and tardyon mass into real energy. By virtue of mirrored energy across the three spaces, a sublight mass particle moving with a known velocity has an equivalent, superlight energy. By transforming that energy into equivalent mass in superlight space, the particle would enter superluminal space and be traveling faster than light the moment it is created. At the same time, the new superluminal mass would generate an energy signature in the subluminal realm. Once the destination is reached, the energy and mass would again switch as the particle's sublight energy converts back to its original, equivalent mass. When the process is complete, the subluminal mass particle traversed sublight space by traveling through superlight space without violating any special relativity or causal constraints.

The mass/energy conversion would be initiated at the subatomic level of matter, where the associated energies are orders of magnitude less than those of cosmic entities. The quarks of the matter would undergo a quantum-level conversion from tardyon to tachyon, while the nature of the particles themselves would be unchanged (that is, tachyon particles would retain the spin, momentum, charge, etc. of tardyon particles). While tachyonic energy would be converted to tachyon mass, tardyon mass would be converted to tardyonic energy, thus transferring (and conserving) mass between the spaces. In this way, the particle would be subatomically filtered through spacetime from one continuum to the next until fully becoming tachyonic mass in superlight space, reflected only by a sublight energy pattern. Since this process does not require that the particle accelerate to $v=c$ and acquire a zero rest mass in transit through luminal spacetime (i.e. become photonic), it would best be defined as a "jump" from one space to the next.

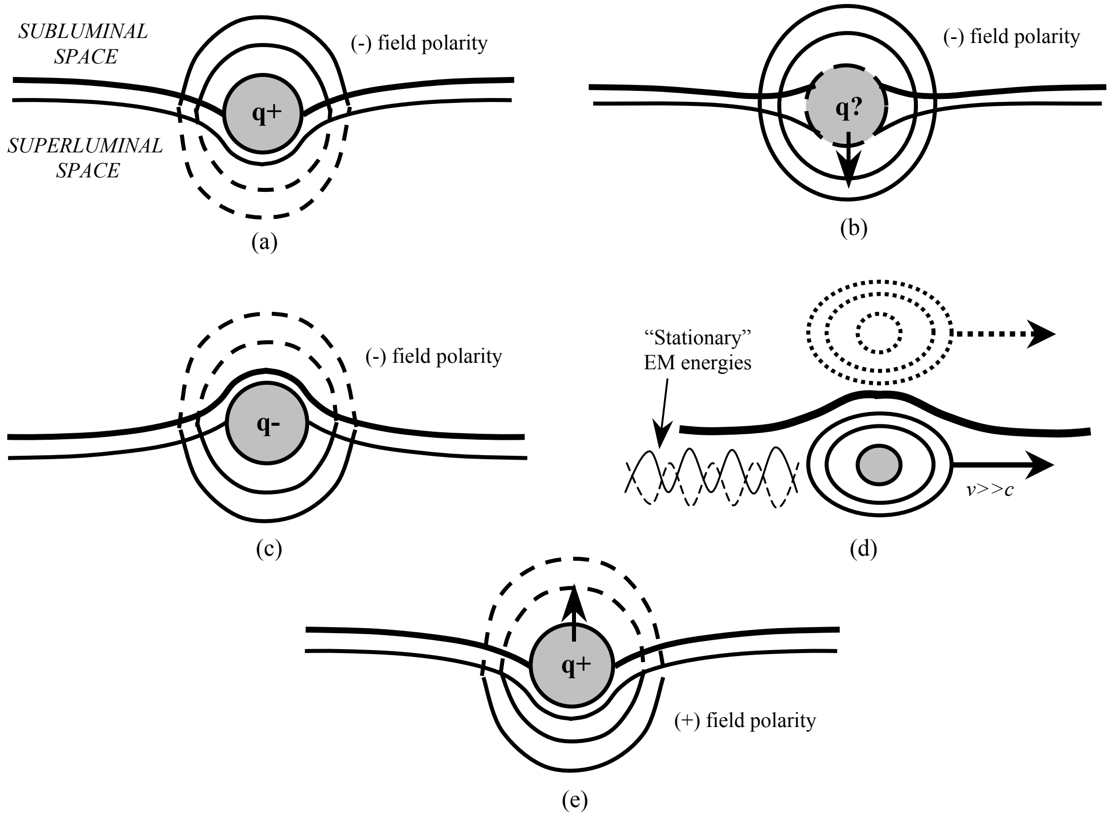


FIGURE 5. The Trans-Space Method of FTL Travel.

Figure 5 depicts the steps described earlier. In Figure 5a, the subluminal, tardyon mass exhibits some quark quantum state generically denoted as *q+*. The mass perturbs luminal spacetime and creates gravity in both spaces according to the tri-space model. To initiate the quantum state transformation from tardyon to tachyon, a field in the form of some specially-conditioned EM energy or radiation is enabled with a polarity that converts the quark quantum state within it from *q+* to *q-*. Figure 5b shows that as the quarks of the mass begin to convert to a tachyon state, the mass energy begins to slip through the luminal plane from one space to the other. The transformation is complete in Figure 5c where the mass is now completely in superluminal space with a new quark state, *q-*. Due to the nature of the naturally tardyonic quarks, the field will most likely need to be maintained while in superluminal space to continuously force the quarks to retain their new tachyon (*q-*) state. Luminal spacetime reacts accordingly, reflecting only the mass's gravitational energy signature in subluminal space. Figure 5d shows that once in superluminal space, the mass could propel itself against "stationary" EM energies. EM energies can only travel at *c* and would be considered at rest in the superluminal realm. This implies that other mass-like energies that would naturally move faster could use these stationary energies to push against for propulsion (something that can not be done in subluminal space). The mass's velocity is governed by its overall energy state. The lowest, sublight, energy state possible is when the mass-energy relation (1) equals unity, denoting no absolute motion through space (a condition considered impossible). This state translates into a superlight velocity of just under 2.0*c* (Figure 2) meaning that a purely stationary particle in sublight space would be moving at twice light speed if transferred to superlight space. The superluminal side of Figure 2 shows that the mass-energy ratio can be less than unity, but only in superluminal space. Although this makes sense in the superlight realm, it seems inconceivable in sublight space. Nonetheless, more available energy exists for tachyon-based systems than for their tardyon equivalents. Although this additional energy allows speeds of many times *c* to be possible, infinite velocity is not. To travel at infinite speed would require that all absolute energy be *removed* from a tachyon system, leading to a state of absolute non-existence. The faster the velocity in superlight space, the more diminished the relativistic effects. Finally, Figure 5e shows that when the destination is reached, the field polarity is reversed and the quarks filter back through spacetime into their original, tardyon quantum state.

In the end, the mass traversed sublight space by traveling through superlight space with no relativistic or causal effects. Since the tri-space model connects three realms to make up the universe, conservation of mass, momentum and energy are referenced to the *universe* as a whole instead of individual spaces (as is the common convention). In that respect, the trans-space method of FTL travel adequately conserves all three.

CONCLUSIONS

Through logical evaluation of special relativity and the mathematically-supported characteristics of superluminal particles, the supposition that there are three, coexisting spatial realms with unique fundamental properties was proposed. The tri-space universe concept may provide a consistent framework with which to model many phenomena in various disciplines of physics and cosmology, and could possibly establish the fundamentals of trans-space FTL travel. The construct and behavior of spacetime is key to the model and its proposed analogous nature to more orthodox disciplines like fluid mechanics should be explored as well as relevant contributions from string theory. The relationship between the sub- and superluminal realms may be more extensive than imagined, especially in light of recent discoveries, and may become paramount in the development of future propulsion systems.

If trans-space FTL propulsion is feasible, a thorough understanding of quantum behavior and particle interactions must first be reached in order to experimentally validate the existence of the superluminal realm. This could be accomplished through an extensive exploration into quark dynamics and their effects on the quantum state of matter. On a cosmological scale, an investigation to validate superluminal space would be to characterize the behavior and effects of dark matter on subluminal space. Dark matter is known to leave a gravitational distortion in sublight space, which may account for the true presence of superluminal mass as described earlier, and programs currently exist that are quantifying such effects. Analytically, a dedicated program should be formed to evaluate superlight particle (tachyon) dynamics from a mathematical perspective. The complete, mathematical representation of the natural laws of the superlight continuum regarding mass, relativistic effects, and time must be thoroughly modeled and understood before any experimentation could be carried out.

Within the advanced propulsion arena, there is strong recognition and need for a new physics that redefines the perception of the universe. Certain cosmic and quantum phenomena observed with present technology elude to a set of natural rules that defy those of current physics, and may hold the key to revealing the presence of another space or alternate dimension, namely the superluminal realm. The tri-space model provides a different perception of the universe based on well-established ideas and current scientific findings. Since the model is a unique approach to the nature of spacetime and advanced propulsion encompassing many disciplines of modern physics, an appropriate level of scrutiny must certainly be employed.

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