Paradox-Free FTL Travel in Higher Dimensional Spaces

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Abstract: This paper describes one possibility for rapid round-trip, paradox-free Faster-than-Light (FTL) travel between Earth and distant stars within the human lifetimes of those on-board the ships and Earth. It shows that such rapid transits would require dimensions beyond the 4 dimensions of flat or curved spacetime; with the added dimensions needed to give starships (their worldlines) room to "climb" and "descend" above the spacetime realms of Special Relativity (SR)—realms where nothing travels faster than the speed-of-light *(c)*. The added dimensions would be associated with zero-point field gradients formed within the quantum vacuum by actions of specially conditioned em radiation emitted from accelerating ships. These gradients would result in: STL (slower-than-light) vehicle velocity within the perturbed vacuum surrounding the ship; FTL vehicle velocity with respect to the unperturbed vacuum and Earth; and invisible FTL vehicle travel in all observer-frames that move STL with respect to Earth. For one case of FTL travel, rapid transits to distant stars would result in starship disappearance from human sight after light speed is reached—followed soon thereafter by its reappearance trillions of miles away, in close proximity to its target star. And during the short interval of disappearance, the starship's worldline would *jump* over trillions of miles of distance—arching like a suddenly-formed rainbow within a "spacetimetau" realm of existence that rises above curved or flat spacetime terrain.

INTRODUCTION

Tanaka (1960) and Bilaniuk et al. (1962 and 1969) were among the first to propose the possibility of faster-than-light (FTL) travel by swift entities called *tachyons* in the spacetime realm (4-D Minkowskian space) of Special Relativity (SR). These early FTL proposals were quickly objected to by investigators, such as Straud (1970) and Benford (1970), who held that FTL travel in some inertial frames could be perceived as *backwards-in-time (BIT)* travel (where effects precede causes) in other inertial frames. And, although not unanimous, current scientific consensus is that FTL travel in SR can result in the paradoxes of causality violation. In this respect, Froning (1983) briefly explored the possibility of paradox-free FTL travel within a *hyperspace*—within a complex space whose higher dimensionality encompasses 4-D Minkowskian space of SR. This paper is an elaboration of this work.

HIGHER SPACES THAN 4-D SPACETIME

The Lorentz Transformations of SR—that relate the perceptions of observers in uniform relative motion with respect to each other—are assumed to hold, not only in the Minkowski space (M-space) of 4-D spacetime, but also within each of an infinitude of other M-spaces that would be nested within the higher dimensionality of a realm of existence deep and vast enough to contain them all. And within each of the nested M-spaces, the Lorentz Transformations of SR hold, and the constraints of SR—which in 4-D spacetime forbids group velocities greater than c—are enforced. The idea of invoking additional dimensions to better describe physical behavior is, of course, not new. Examples are "String" and "Brane" physical theories, which utilize as many as 11 dimensions in attempting to unify Quantum Theory with General Relativity. But these additional dimensions usually pertain to additional spatial degrees of freedom, while this paper's additional dimensions pertain to neither distance nor time.

For the special and visualizable case of uniform 1-D relative motion between two observers (that is unaffected by activity in transverse directions), the infinitude of nested M-spaces becomes an infinity of nested M-planes, inclined at an infinitude of angles (θ) ranging from 0 radians to $\pi/2$ radians with respect to a horizontal x-y spacetime plane (where $y=ct$ and nothing can travel faster than c). Figure 1 visualizes the infinitude of possible planes as forming a vast x-y-iz 3-D realm of semi-cylindrical shape—whose breadth (x_0), length (y_0), and height (iz_0) are equal to the distance (u_0) from the edge of the universe to Earth. Here, y_0 is c times the time (t_0) for light to travel from Earth to

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the edge of the universe at velocity *c*; while the magnitude of iz_0 is the product of a constant *(k)* multiplied by a constant τ_0 that is equal in magnitude to ct_0. But, this *x-y-iz* realm can't be viewed as ordinary 3-D Euclidian space. For the *height* of its *iz* dimension is constructed with the mathematical quantity *(i)* that makes this realm a complex space. And the "tau" $(i\tau)$ unfolded on the *iz* coordinate symbolizes a quantifiable—but a non-spatio temporal sense of things that has no correspondence with traversal of distance or passage of time. This complex space of Figure 1 is somewhat similar to the complex *Twistor space* of Penrose and Rindler (1986). Twistor space, part of *Twistor theory*, provides an elegant mathematical arena for describing electromagnetism and for alternative descriptions of spacetime—wherein light rays are single points, and events are represented by *Reiman spheres* and complex *Argand planes* (that are also used in this paper to display complex quantities in our *x-y-iz* space).

Figure 2 shows the most general case of a starship's space travel *(x)* and time + tau travel *(u)* on an *x-u* plane of existence, inclined at an angle θ with respect to the horizontal *x-y* spacetime plane of existence (where $y=ct$) of SR. Here, *u* is a complex quantity equal to $ct + ik\tau$, and the *u* and *x* are measured in the inertial frames of observers who are stationary with respect to (but not necessarily on) Earth. And just as starship *dx/dy* cannot exceed 1.0 upon the horizontal *x-y* plane (in order that starship *dx/dt* not exceed *c*), so starship *dx/du* cannot exceed 1.0 on the *x-u* plane.

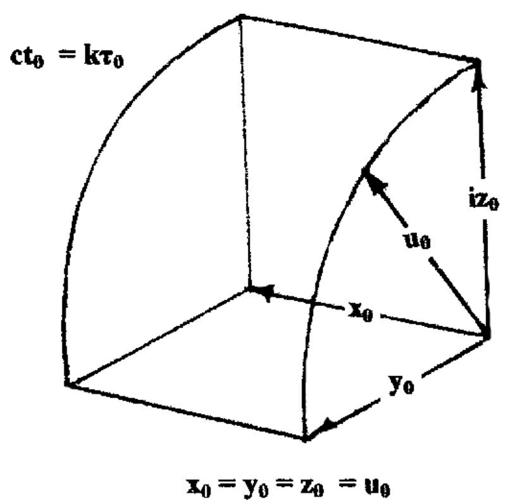

FIGURE 1. Complex X-Y-iZ Realm.

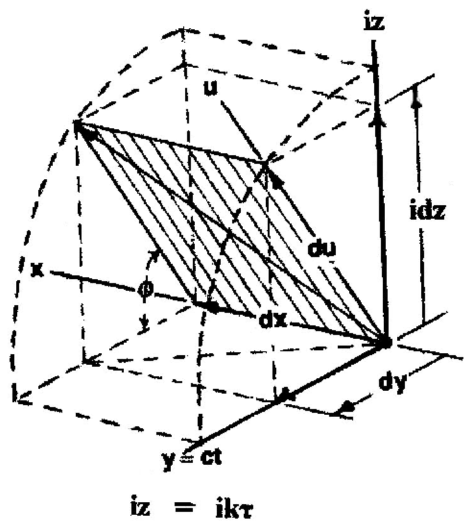

FIGURE 2. Complex X-U Plane.

Figure 2 shows that the horizontal *ct* component of *u* will diminish to much smaller values than *u*, as inclination (θ) of the *x-u* plane from the *x-y* one increases toward a vertical orientation $(\pi/2)$. Thus, even though *dx/du* can never exceed 1.0 on the *x-u* plane (just as *dx/dy* cannot exceed 1.0 on the *x-y* one), vehicle *dx/cdt* with respect to Earth can become much greater than 1.0 as the inclination θ of the *u-x* plane approaches $\pi/2$. This results in vehicle velocity *(dx/dt)* with respect to Earth, reaching many multiples of *c* as inclination of the *x-u* plane approaches the vertical.

LIGHT-SPEED CHANGES IN POLARIZED VACUUM

The infinitude of possible inclinations of *u-x* planes of existence symbolizes the infinitude of possible light-speeds in regions of the quantum vacuum that are perturbed by accelerating starships. The infinitude of possible light-speeds can be visualized as an infinitude of refractive indices—ratios of light-speed in perturbed and unperturbed vacuo. These indices increase from 1.0 to ∞ as θ rotates from 0 *to* $\pi/2$ above *x-ct* spacetime. Puthoff et al. (2002) proposes that "warping" of gravitational metric within localized regions of spacetime can be described in terms of "polarization" of the quantum vacuum—such that the electrical permitivity (ε), magnetic permeability (μ), and lightspeed within the polarized (perturbed) regions of the vacuum are different from their unpeturbed vacuum values $(\varepsilon_0\ \mu_{0,}\ c_0)$. Investigators, such as Froning and Roach (2000), have combined Puthoff's vacuum polarization approach with a fluid dynamic approximation. They showed that favorable vacuum polarization (accomplished by a favorable electrogravitic coupling between the fields of specially conditioned em radiation and those that underlie gravity and intertia) would: diminish vacuum permittivity and permeability; and increase *c* in the vicinity of accelerating starships. This also diminished inertial resistance of the quantum vacuum to accelerated motion (vehicle inertia).

Figure 3 shows a favorable polarization of a moving region of the quantum vacuum—wherein vacuum permittivity and permeability are diminished to lower values by specially conditioned em radiation that is emitted from the ship. Also shown in the region, is the resulting increase in light-speed above its speed in unperturbed vacuum. Figure 4 shows that decrease of $\varepsilon\,\mu$ in perturbed vacuum is equivalent to upward inclination of *x-u p*lanes with respect to the *x-y* one. Here, for vehicle speeds of 0.1c and 1.0c in perturbed vacuum, vehicle velocity with respect to Earth is seen to increase to many multiples of *c* if significant vacuum polarization diminishes $\varepsilon\,\mu$ by many orders of magnitude. And Figure 4 shows that this diminishment corresponds to very small *x-u* plane inclinations from the vertical.

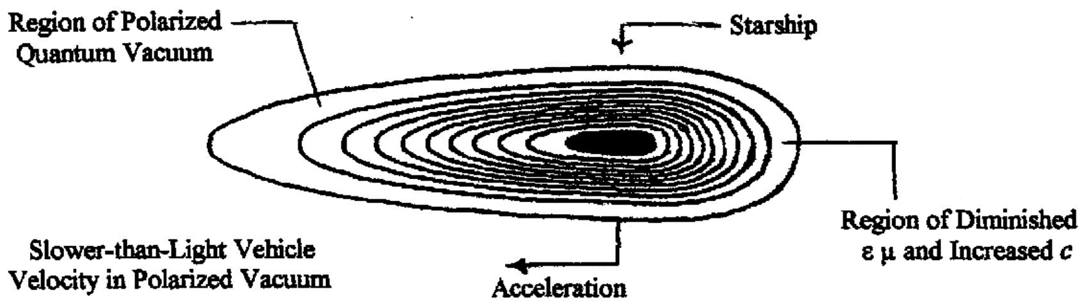

FIGURE 3. FTL Travel (with respect to Earth) by Starships Moving in Polarized Vacuum.

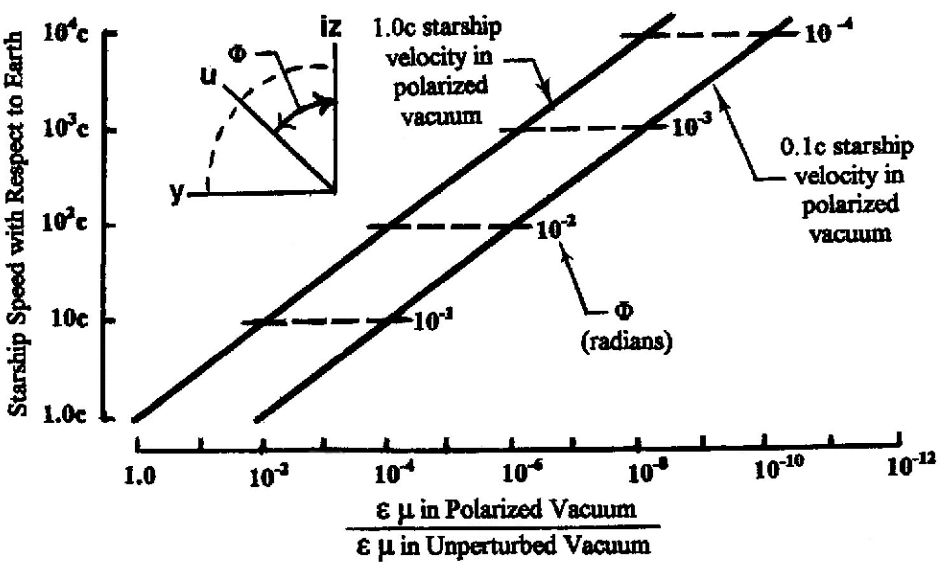

FIGURE 4. FTL Starship-Travel Associated with Vacuum Polarization.

Diminishment of ε and μ by many orders of magnitude—to achieve many multiples of light speed in x-u planes of existence—is, of course, an enormous challenge. One way of addressing this challenge is discussed in Barrett (1993) and in Froning and Roach (2000). This way involves emission of specially conditioned em fields from the ship, with the fields possessing the same global, multiply-connected topologies as the fields that give rise to gravity and inertia.

LORENTZ TRANSFORMATIONS IN INCLINED *X-U* PLANES

On any *x-u* plane of existence, the Lorentz Transformations of SR (that relate the distance traveled *(x)* and the time + tau traveled *(u)* by a starship in observer frames at rest with respect to Earth with the distance traveled *(x_s)* and time + tau *(u_s)* traveled by the starship in observer frames undergoing a rate of change *(dx/du)* with respect to Earth) are:

$$u_s = (u - \alpha\, x) / [1-\alpha^2]^{1/2}\,, \qquad x_s = (x - \alpha\, u) / [1-\alpha^2]^{1/2} \tag{1}$$

For the special case where the observers undergoing *dx/du* with respect to Earth are in the starship (or at rest with it), there is no space travel (x_s) of the starship with respect to itself, and the Transformations simplify to:

$$u_s = u\,[1-\alpha^2]^{1/2}, \quad or: \quad ct_s + ik\tau_s = (ct + ik\tau)\,[1-\alpha^2]^{1/2}, \tag{2}$$

where $\alpha = dx/du$ and where *dx/du* can never exceed 1.0

Time passage (*dts*) experienced in the moving ship frame is, therefore, $[1-(dx/du)^2]^{1/2}$ times that perceived in a frame that is stationary with respect to Earth; while tau unfoldment (τ) in the ship frame is $[1-(dx/du)^2]^{1/2}$ that perceived in a stationary frame. Thus, for values of *dx/du* that approach 1.0 (the maximum value allowed on the *x-u* plane of existence), time passage and tau unfoldment onboard the ship approaches zero; while time passage and tau unfoldment are almost the same in ship and stationary frames for *dx/du* values much smaller than 1.0. It follows that time passage and tau unfolded will be less in ship frames than in stationary frames for all allowable values of *dx/du*.

SPACETAU TRAVEL IN *X-Z* REALMS

If strong and favorable vacuum polarizations diminish $\epsilon\mu$ enough for *c* to increase to enormous values in vicinities of accelerating starships, starship worldlines unfold upon an almost vertical *x-u* plane of existence that contain almost no time travel *(ct)* in frames at rest with respect to Earth. For such small *ct*, the tau component of starship travel is approximately that for travel upon completely vertical *x-iz* planes of existence. Figure 5 shows a typical starship spacetau worldline traced out upon *x-iz* and constrained by SR to values of $dx/kd\tau$ never greater than 1.0.

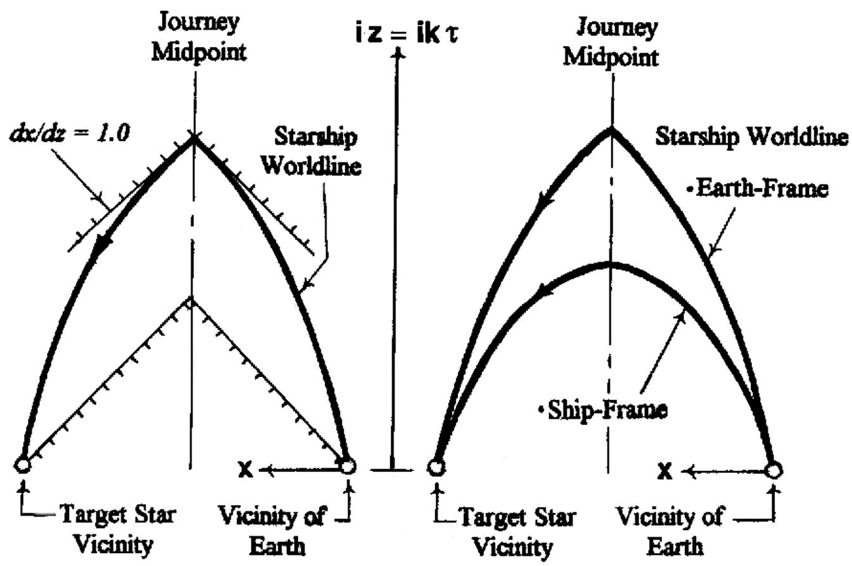

FIGURE 5. Typical Worldline of FTL Starship on X-iZ Plane of Existence.

Shown, in stationary and ship frames, are typical increases in tau with increasing *x* during the initial half of the FTL segment of an interstellar flight, followed by comparable tau decrease with increasing *x* during the final half. For this example, the starship is flown at the maximum allowable value of $dx/kd\tau$ (that is 1.0) at the start, midpoint, and end of the FTL segment; and at lower values than 1.0 during the remainder of the FTL segment. Therefore, because less total tau unfolds in ship frames than in stationary frames for allowable values of $dx/kd\tau$ (between 0 and 1.0) starship worldlines (computed from measurements by onboard instrumentation) and seen to reach lower "altitudes" with more rounded trajectories in the moving ship frame than those measured in frames at rest with respect to Earth.

RAPID TRANSITS TO DISTANT STARS

If favorable vacuum polarization can be achieved, there is, of course, nothing that can prevent initiation of the rotation of starship's *x-u* plane of existence out of the *x-y* spacetime one—even if its velocity *dx/dt* is much less than

c. However, graphical representations of rapid FTL transits to distant stars can be most easily made by constraining accelerating starships to the x-y spacetime plane after earth departure until c is reached. Figure 6 shows the gradual growing of the curving worldlines of accelerating starships that unfold upon x-y spacetime until c is reached.

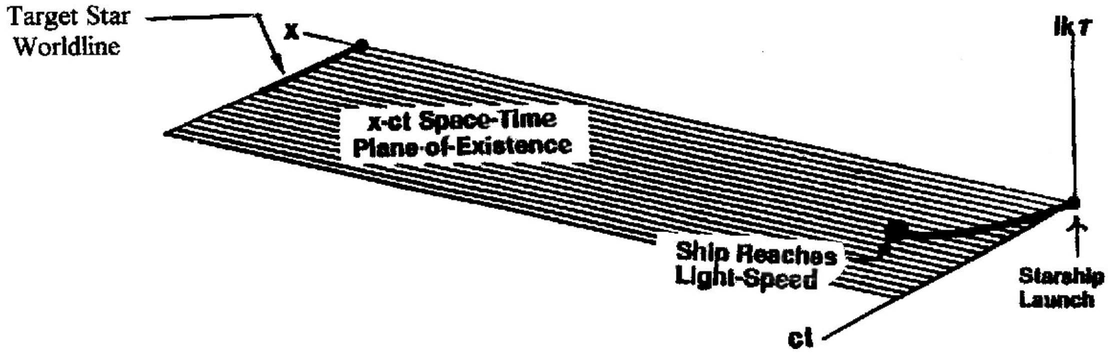

FIGURE 6. Starship Worldline during Acceleration.

After c is reached, and as things such as specially conditioned em radiation and vacuum polarization cause increased c in the perturbed vacuum surrounding the ship, the direction of the starship worldline is shown to rapidly rotate clockwise out of the x-y plane of existence in Figure 7—until an almost vertical x-u plane of existence (that contains very little time passage) is reached. Then, as shown in Figure 8, rapid forward and upward movement of the starship worldline occurs in the almost vertical x-u plane until the midpoint of the long FTL segment of the interstellar journey is reached. Rapid forward and downward movement must then occur during the final half of the long FTL segment of the interstellar journey—followed by transition from the x-u to the x-y plane by appropriate counterclockwise rotation. Therefore, just as an aircraft climbs and descends above the Earth after takeoff speed is reached, so FTL starships would ascend and descend above x-y spacetime after c is surpassed. Finally, just as in the initial phase of the interstellar journey, curving of the starship worldline occurs upon the x-y plane as the ship slows from light-speed in the vicinity of the target star, until achievement of zero (or orbital) speed as the star is reached.

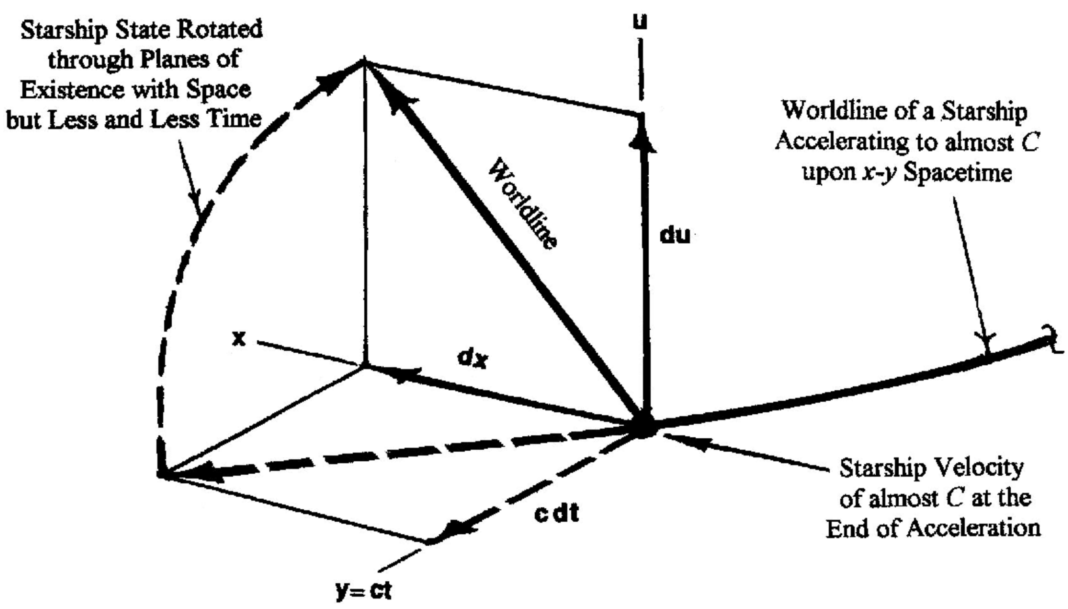

FIGURE 7. Rotation of Starship State into Planes of Existence that Enables FTL Travel.

As shown in Figure 9, rapid transits to distant stars would, therefore, be perceived in x-y spacetime as starship acceleration to light-speed after departure from Earth and disappearance from human sight; then its reappearance soon thereafter—trillions of miles away in the vicinity of its interstellar destination. But during that short interval of disappearance, the starship's worldline (as shown in Figure 8) jumps over trillions of miles of distance—arching like a suddenly-formed rainbow within a *spacetimetau* realm of existence that rises above spacetime terrain. Such starship-travel would be perceived as *forward-in-time* in all *x-y* inertial frames of spacetime, and FTL travel segments would not be detectable in any *x-y* inertial frame. Therefore, FTL causality paradoxes could not occur.

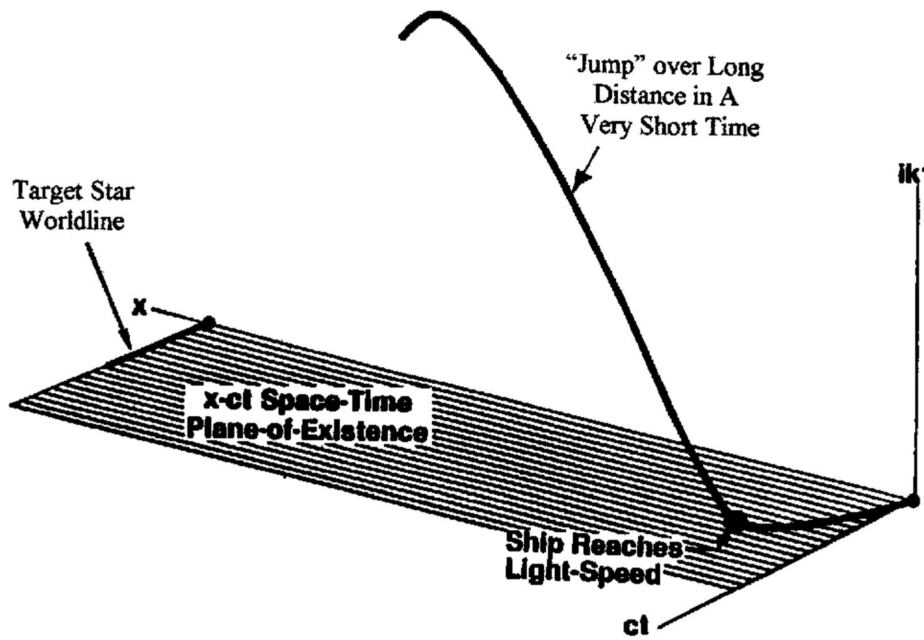

FIGURE 8. Worldlines for Starship Acceleration and FTL "Jump".

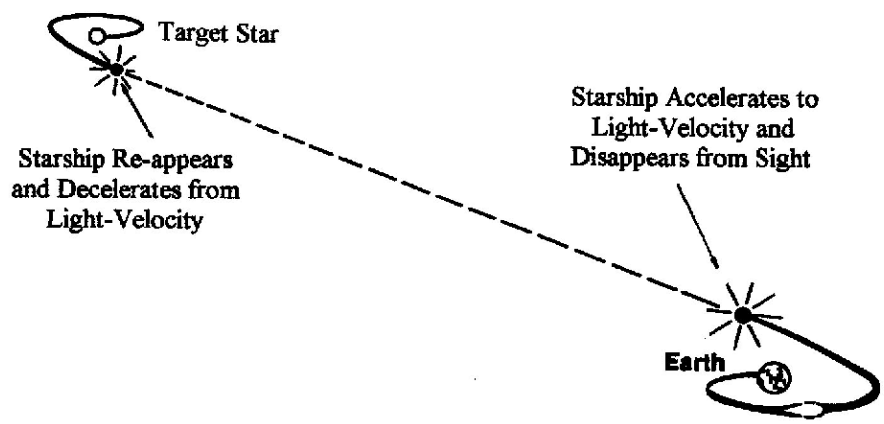

FIGURE 9. Rapid Starship Transit from Earth to A Distant Star.

Finally, if extremely favorable polarization of the vacuum by special fields can rapidly rotate starship states into almost time-*less* planes of existence, no appreciable time elapses during the ship's long jump above the *x-y* plane. Thus, the long FTL segments of interstellar journeys might be traveled in very little time. If so, the durations of starship journeys would be influenced primarily by the time needed to accelerate to light-velocity and to decelerate from light-velocity over relatively short distances—not the time to travel the much longer FTL distances.

NAVIGATION, PROPULSION, AND CONTROL IN *X-U* SPACE

For FTL spacetau travel over stupendous interstellar distances, tau must not only exist in absolute reality, but be a quantifiable perception or intuition—rather than mere feeling or emotion. This, of course, is required in order that tau unfoldment onboard FTL ships be combined with spatio-temporal information, gathered by inertial instruments and detectors. This information must be related and correlated with space, time, tau coordinates of navigational *way-points* to the target star—as determined in the moving and stationary frames of ship and target star. And control of ship space, time, and tau travel is assumed to be accomplishable by modulation of the direction and intensity of the specially conditioned em fields that cause warping of gravitational metric and polarization of quantum vacuum.

Although not demanded by our SR representation—that involves only uniform rates of change upon each of its infinitude of planes—one might intuitively expect rotation of ship-state from the *x-y* plane of existence to require influences that act perpendicular to the *x-y* plane. And this would be consistent with *warping* of spacetime metric in a direction orthogonal to the metric itself. In this respect, Barrett (1993) derives expanded Maxwell Equations with additional terms for specially conditioned em fields, which have been transformed from ordinary abelian U(1) form to higher nonabelian SU(2) form. These additional terms involve actions of A vector potentials which are multiplied by mathematical quantity *(i)* that, as an operator, rotates quantities 90 degrees in the quadrature direction. The field components of nonabelian SU (2) radiation involving A vector potentials can, therefore, be viewed as acting perpendicular to the ordinary em fields of x-*y* spacetime and, thus, as acting perpendicular to *x-y* spacetime itself.

CONCLUSIONS

The paradoxes and ambiguities associated with FTL travel within the Minkowski timespace of SR are resolved by letting FTL travel take place within a realm of higher dimensionality than 4-D Minkowski space—a realm whose additional non-spatiotemporal dimensionality gives room for FTL travel above the 4-D terrain of spacetime. FTL paradoxes are, thus, avoided at the price of invoking a metaphysical cosmos, whose "sky" enables FTL starships (and perhaps consciousness itself) to momentarily soar far above the valleys, plains, and mountains of spacetime terrain. This FTL view will surely be disappointing to tachyon advocates, who hope to someday directly detect the presence of entities with FTL group velocities in physical space. And it will surely be resisted by materialists who hold that the physicality of spacetime, radiation, and matter is all there really is. But it should be less strongly resisted by those who suspect that absolute reality may have a non-physical component—and that absolute reality (including the whole of the human psyche) is more than the complex physics of spacetime, energy, and matter.

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