Is the String Theorists' Concept of Ten Dimensions of Reality Really All That Weird?[1]

by Fred Vaughan

Multidimensionality does seem to be an "Ooh, Ah!" sort of thing that mathematicians and physicists pull out of their hats like rabbits when they play at being amateur magicians. But quite mundane (though nonetheless complex) systems are described with multidimensional spaces and the fact that some function may have more variables than three is hardly the stuff of wizardry. But the very issue of what is meant by a dimension should be considered when one tries to make sense of the currently popular concept of 'curled-up' dimensions.

To the extent that we are familiar with the concept of three dimensions, it is because it encompasses the commonsense notion that the simplest description of a location in space involves three real values with regard to distances along three mutually orthogonal directions such as *Forward*, *Left*, *Up*; or *North*, *East*, *Down*; etc. It is difficult to visualize (as against merely conjecture) more dimensions than these usual three that involve traditional mutual orthogonality in everyday experience. But in the book *The Elegant Universe* an excellent illustration and discussion is provided involving an ant walking on a cylindrical hose in the context of explaining the curled-up dimensions that string theorists have posited.[1] If the ant wishes to proceed along the general direction of the hose, he still has two additional degrees of freedom with regard to his motion. So if progress along an x-axis (in say the *positive x* direction) were constrained by some distortion of reality to include excursions involving such additional degrees of freedom, it would be presumptuous to protest too loudly about whether those degrees of freedom constitute additional dimensions I would guess.

Our sense of both direction and distance in space as well as temporal relations of a traditional fourth dimension are all intimately tied up with the propagation of light as elaborated under the rubric of the special theory of relativity. So it should not be surprising if what is meant by legitimate degrees of freedom and dimensionality in general involves the *modus operandi* of photons rather than ants. With that in mind I propose to consider aspects of the electromagnetic and relativity theories rather than entomology to clarify what is meant when such "dimensions" are discussed.

In seminal papers published in the 1940s, Wheeler and Feynman[2] elaborated earlier intuitions of Schwarzschild, Ritz, Tetrode, Lewis,[3] and others concerning various electromagnetic absorption theories. Later (in the 1980s) Cramer[4] introduced a commensurable *Transaction Interpretation* of quantum mechanics. With such an extensive background of serious work, it should hardly be considered a wild speculation to suggest at this juncture that vector fields from both an emitting and an absorbing atom might contribute equally to the energy and momentum of photons producing the transmission of energy and momentum between atoms. The momentum carried in the propagating electromagnetic fields is traditionally characterized by a *Poynting* pseudo vector cross

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[1] A version of the article was formerly published as,'*What's a 'Curled Up' Dimension Supposed to <u>Do</u> Anyway?*'

[1] Brian Greene, ***The Elegant Universe***, W. W. Norton, New York (1999), p. 186.

[2] J. A. Wheeler and R. P. Feynman, "Interaction with the Absorber as the Mechanism of Radiation," ***Rev. Mod. Phys.***, 17, 157-181 (1945), and J. A. Wheeler and R. P. Feynman, "Classical Electrodynamics in Terms of Direct Interparticle Action," ***Rev. Mod. Phys.***, 17, 157-181 (1949).

[3] Gilbert N. Lewis, "The Nature of Light," ***Proc. N. A. S.***, 12, 22-29 (1926).

[4] John G. Cramer, "The transaction Interpretation of Quantum Mechanics," ***Rev. Mod. Phys.***, 58,3, 647-687 (1986), and John G. Cramer, "Generalized Absorber Theory and the Einstein-Podolsky-Rosen Paradox," ***Phys. Rev. D***, 22, 2, 362-376 (1980).

product ***P*** of a *microscopic* electric field ***E*** (associated with the emitter) and a *macroscopic* magnetic field ***H*** (associated with the absorber) as follows:

$$\boldsymbol{P} = \boldsymbol{E} \times \boldsymbol{H}$$

Similarly, the energy density $\mathcal{E}$ of such radiation involves all four fields of electrodynamics, two associated with emission and two with absorption as follows:

$$\mathcal{E} = \tfrac{1}{2} (\boldsymbol{E} \bullet \boldsymbol{D} + \boldsymbol{B} \bullet \boldsymbol{H})$$

where ***D*** is the *electric induction* field associated with absorption as defined by Maxwell, and ***B*** the magnetic field associated with emission.

When there is no relative motion between the emitter and absorber (intraframe) the transverse wave that is circularly polarized in the most general solution to Maxwell's equations, proceeds directly along the line-of-sight direction of the Poynting vector between the two interacting atoms. This is shown at the top of the diagram in figure 1; either field (***E*** or ***H***) is very much like the 'hand of a stop-watch' traveling with the photon as described so admirably by Feynman in his fascinating treatment in his *QED*.[6] This is just how light works.

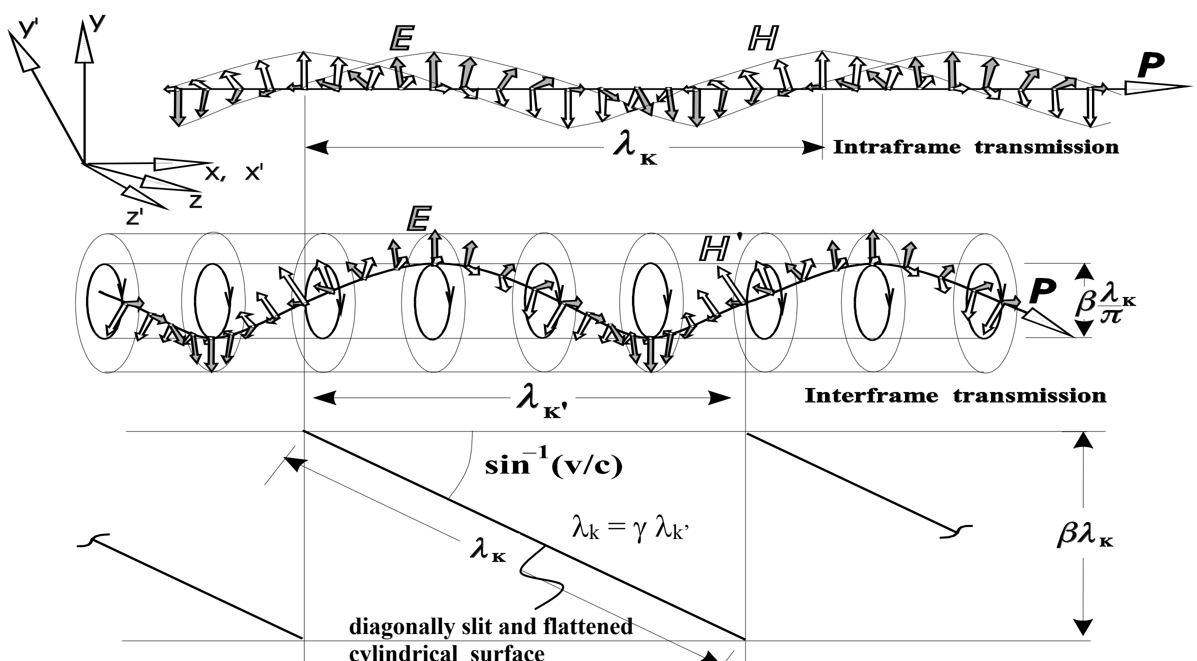

Figure 1: Circuitous interframe light path imposed by relative motion

However, relative motion of the interacting atoms substantially alters the momentum and energy transfer of such transactions. So let us consider in what way this classical (and even quantum mechanical) picture of transverse wave propagation must be altered by the relativistic aberration formula in cases where the emitter and absorber experience uniform relative motion.

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[6] Richard Feynman, ***QED – The Strange Theory of Light and Matter***, Princeton Univ. Press, Princeton, (1985), p. 28.

The appearance of any Lorentz reference frame fitted with three perpendicular rods to represent the basis vector directions as viewed by an observer in uniform relative motion would be affected by aberration as described in another paper on this site.[2] Remember that in a very real sense, 'appearance' via photons of light is the *reality* of every observer. The author has discussed various aspects of this straight-forward observational interpretation of the Lorentz transformation in several articles appearing in the monograph by Vaughan.[3] Spatial distances to corresponding events observed by coincident observers are related by the temporal Lorentz equation as a distance that light must travel in a corresponding amount of time. This determines both the corresponding spatial distances r and r' and time intervals t and t' to observed events on a source object since the speed of light is assumed identical for observers in both frames such that $r = ct$ and $r' = ct'$ to the corresponding events.

If relative motion of an emitter and absorber were to be along the direction of their common centers, perpendiculars to this direction for the 'other' observer with regard to this common axis would appear 'tipped' by aberration through the angle whose sine is $\beta \equiv v/c$. In this expression v is their relative velocity and c the speed of light. So that any direction perpendicular to a shared direction of relative motion in one frame of reference would appear to be at an acute or obtuse angle (depending on the sense of their relative motion) for the other. (See the orientation of the *perpendicular* y-axis as viewed in the *other* frame of reference in figure 1 above for an illustration of this aberration effect.) You might have to think about whether an electromagnetic field vector aligned with the y-axis in the unprimed (assumed 'stationary') system would be tipped *in actuality* rather than just *appear* to be tipped for an observer in the primed (assumed 'moving') system. But you'll get it – you have been blessed with intelligence.

Now consider the directional relationships of ***E*** and ***H*** field vectors associated respectively with an emitter and absorber in different reference frames sharing their x-axes. For propagation of light from the emitter to the absorber, these vectors will be *tipped* with respect to corresponding vectors in the other frame of reference, with the one that appears tipped depending on whether the emitter's or the absorber's frame of reference is considered the 'other'. In figure 1 the emitter's frame of reference was assumed, so the prime is used on ***H'***, which is therefore aberrant, i. e., tipped. This tipping will be conically symmetric throughout the entire circular polarization cycle so the Poynting vector will spiral tangentially about the outside of a cylinder aligned with the common direction joining the centerlines of the emitter and absorber as shown in the second (interframe) diagram of the figure. Thus, when compared with radiation exchanged between atoms in a single(intraframe) frame of reference there accrue appreciable differences. For transmission along the x axes the light must travel further by the gamma factor of

$$\gamma = 1 / \sqrt{(1 - \beta^2)}$$

along the helical path to cover the same distance for the primed observer, where again $\beta = v/c$. So the 'effective' lineal velocity of the light relative to the *other* frame of reference, even while maintaining its universal speed in both frames will be:

$$c' = c \sqrt{(1 - \beta^2)}$$

[2] 'Necessary Reformulation of Geometrical Relations in Relativistic Situations'

[3] R. F. Vaughan, ***The Relativity of Visual Observations*** (2010)

which produces *the same effect* as the Lorentz transformation equations on round trip travel times between frames or on using values appropriate to different frames on one-way photon interactions. Thus, curled up dimensions provide an accurate interpretation of the physics of uniform relative motion that maps spacetime coordinates. The radius of curvature of the curled up 2-space for the single 3-dimensional coordinate is $\beta\lambda/2\pi$. This is extremely small for usual wavelengths and velocities in our macroscopic world.

10^{-20} cm < $\beta\lambda/2\pi$ < 10^{-10} cm

String theorists found that the unification of the electromagnetic, weak, and strong nuclear forces can most effectively be addressed in a mathematical framework of nine spatial dimensions, where only three of them are observable. Adding ‘time’ makes ten. They have assumed that the remaining two dimensions per spatial dimension are tightly 'curled up' and we have seen that they are indeed. So you see, light – and not just ants – may require more than one dimension to screw around with, even while more or less proceeding along straight lines. The preeminence of light to not only inst physics rument measurements, but also to determine our epistemological understanding, of time and space must surely lend to this curled up dimensionality some universal significance. Sure, maybe it's “green eggs and ham” (as someone once opined about what a mathematician could do with multiple dimensions) or just another way of looking at things, which is, you'll have to admit, the only way we have of observing the universe around us.

This multidimensionality resulting from the transverse nature of light transmission and relativistic aberration provides the explanation from a physics perspective of why Lorentz contraction and time dilation seem to apply to relativity. They don’t. This actual explanation applies exclusively to situations where there is relative motion between the objects upon which the emission and absorption events take place. It is a property of light transmission where relative motion is involved. Those ostensible distortions of length and time ‘features’ of relativity are not acquired properties of observers whose clocks and rulers become somehow at odds. Aberration is the consequential observable of relativity.