The Concept of Ten Dimensions As Essential to the Transmission of Light

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 one might suppose.

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.

There are four electromagnetic fields, two electric and two magnetic. These are separated into **E** and **B**, are referred to as ‘microscopic’ fields, and two, **D** and **H** that are referred to as

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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).

'macroscopic'. Microscopic fields are involved in emission, macroscopic fields with absorption and scattering. Thus, transmission requires both microscopic and macroscopic fields. The energy density $\mathcal{E}$ of radiation involves all four of the electromagnetic fields, two associated with emission and two with absorption as follows:

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

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

The momentum in propagating electromagnetic fields is characterized by a *Poynting* pseudo vector cross product ***P*** involving a *microscopic* electric field ***E*** (associated with the emitter) and a *macroscopic* magnetic field ***H*** (associated with absorption). The three vector fields associated with propagating wave functions are always orthogonal like basis vectors in the coordinate frame North-East-Down. If one is tipped through an angle, another will be as well as shown in figure 1.

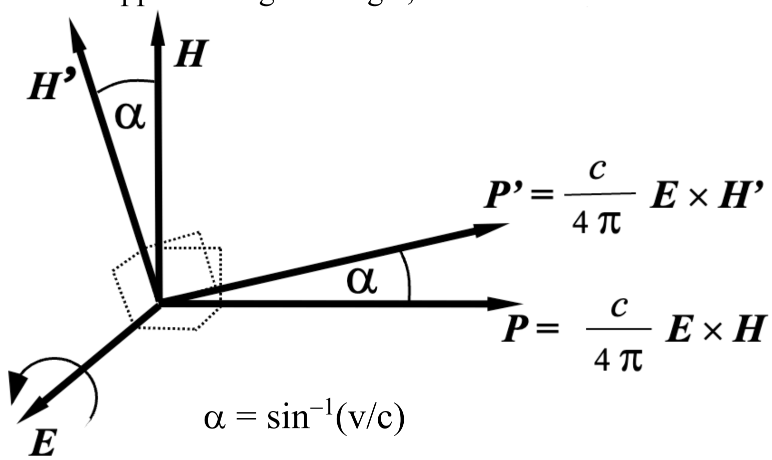

Figure1: The effect of misalignment on electromagnetic field vectors

When there is no relative motion between the emitter and absorber (intraframe transmission) 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 in the diagram of figure 2; either field (***E*** or ***H***) is very much like the 'hand of a stopwatch traveling with the photon on a perfectly straight path as described so admirably by Feynman in his fascinating treatment in his *QED*.[6] This is just how light works as a transverse electromagnetic wave function.

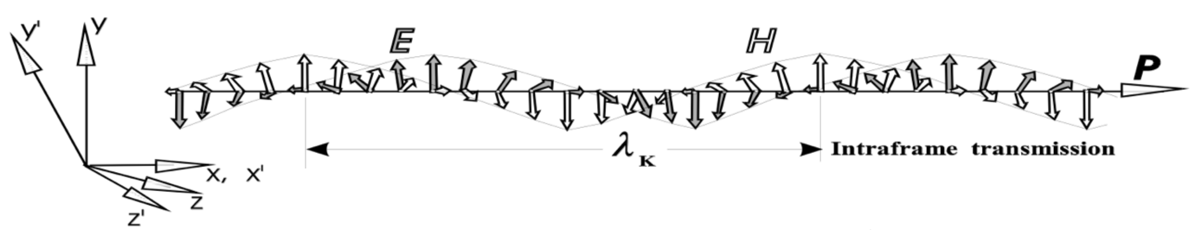

Figure 2: Circularly rotating vectors involved in an intraframe light path

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

However, relative motion of interacting atoms substantially alters the momentum and energy transfer of the transaction. Let us consider how this classical (and even quantum mechanical) picture of transverse wave propagation is altered by the relativistic aberration formula in cases where the emitter and absorber experience uniform relative motion.

A reference frame fitted with three perpendicular 'rods' to represent three-dimensional basis vector directions are necessary for mensurable observations. These were shown as the three arrows at the left of figure 1 with the unprimed labels x, y, and z. A reference frame of a second observer moving relative to the first along mutually aligned x and x' axes would appear to the first observer to have its y' and z' axes tipped relative to his own through the angle whose sine is $\beta \equiv v/c$, where v is their relative velocity and c the speed of light in a vacuum. Any direction perpendicular to a shared direction of relative motion in one frame of reference will appear to be at an angle for the other. (See the orientation of the *perpendicular* y-axis as viewed in the *other* frame of reference in figure 2 for an illustration of this aberration effect.) Whether an electromagnetic field vector aligned with the y-axis in the unprimed system would be tipped *in actuality* rather than just *appear* to have been tipped for an observer is not a scientific distinction.

Now consider the directional relationships of ***E*** and ***H*** field vectors associated respectively with an emitter and absorber in different reference frames with shared x-axes as would relatively moving observers. 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, which appears tipped depends on whether the emitter's or the absorber's frame of reference is considered the 'other'. In figure 2 the emitter's frame of reference was assumed for both the emitter and the absorber of the radiation, but when there is relative motion, the prime is used on ***H'*** associated with the absorber, which is therefore aberrated relative the ***E*** vector of the emitter, i. e., the ***H'*** vector will be tipped as shown in figure 1. 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 interframe diagram of figure 3. Thus, when compared with radiation exchanged between atoms in a single frame of reference (intraframe transmission) there accrue appreciable differences in the propagation characteristic of radiation. For transmission spiraling along the direction of the x axes the light must travel further by the gamma factor of $\gamma = 1 / \sqrt{(1 - \beta^2)}$.

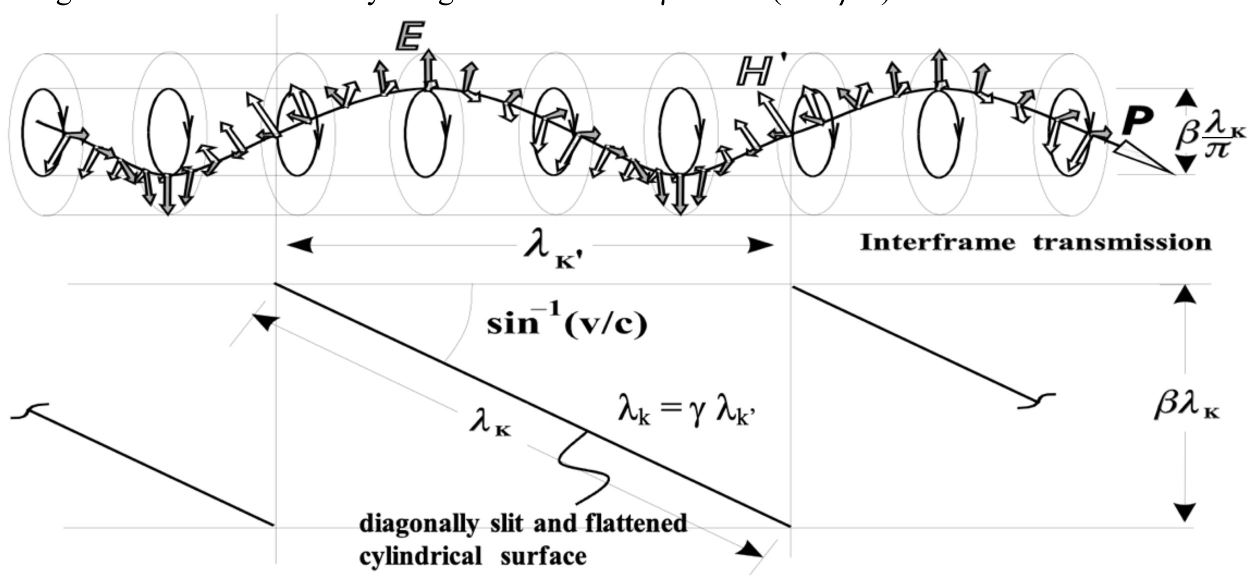

Figure 2: Circularly rotating vectors on a helical interframe light path

So the lineal velocity of the light relative to the *other* frame of reference is slower than c although this universal velocity applies to the actual circuitous path of the radiation. The universal speed of light applies in both frames, but transmission time will be longer (dilated?) on interframe exchanges:

$$t' = t / \sqrt{(1 - \beta^2)}$$

This produces *the same result* 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 description of the physical mechanism of uniform relative motion that has previously been assumed to map all of spacetime rather than individual transactions through space. The radial dimension of the curvature of the 'curled up' surface surrounding a single coordinate is $\beta\lambda/2\pi$, where λ is the wavelength of the radiation This is extremely small for usual wavelengths and relative velocities in our world.

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

String theorists found that the unification of the electromagnetic, weak, and strong nuclear forces could 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', which as we have shown, they are indeed.

So you see, photons of light – and not just ants – may require more than one dimension for their meandering, even while proceeding along straight lines. The preeminent use of radiation in measurements mad by instruments as well as our eyes, but even more significantly to our epistemological understanding of time and space must surely lend significance to this curled up dimensionality. Sure, maybe it's just another way of looking at things, but that 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 physical perspective of why Lorentz contraction and time dilation seem to apply to relativity, although in fact, they don't. This actual explanation applies exclusively to situations where there is relative motion between the objects upon which 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 distortions that can legitimately be attributed to the 'other' observer whose clocks and rulers become suspect. They are merely features of interframe communication, demonstrating that aberration is the consequential observable of relativity.