Excerpt from Relativity of Visual Observations

(The first 20 pages that motivate the discovery.)

1. Introduction

Over a half century after Einstein published his seminal paper on relativity, the perception persisted that objects viewed by an observer in relative motion would be seen as having been contracted – a sphere appearing to be an oblate spheroid, etc.. It has now been another half century since Roger Penrose corrected that perception in a relatively unheralded paper (1959, pp. 137-139). He stated: "It is therefore only necessary to consider what transformation of the field of vision must be employed when passing from a stationary to moving observer at the same point, and to show that this transformation is one which sends apparent circles into apparent circles." However, this discovery was apparently not considered (even by its author) as having much significance since his demonstration involved transforming the events on a Lorentz-contracted object back into a non-contracted visual observation, seemingly a mere 'appearance' or 'optical illusion' derived from a supposedly *deeper*, although greatly distorted, 'reality'.

To qualify as science, a theory must produce predictions that can be observed, not just inferred from theory as being 'true'. Therefore, a theory purporting to be scientific with regard to relative motion must address the fact that the Lorentz transformation is (by itself) insufficient to map what are typically considered to be 'observations' between observers in uniform relative motion. In addition to the misperception concerning whether contraction is an observable phenomenon implied by the Lorentz transformation equations, the associated formalities ignore the observable fact that the coordinate axes of another observer appear rotated such that treating those axes as mutually orthogonal is questionable at best. Observed angles differ for two relatively moving observers. This disparity includes the angles of orientation of electromagnetic fields that affect the propagation properties of light wave transmissions between relatively moving observers. The implications of this difference are even more significant than those associated with rods, pipes, or telescopes used in determining directions to surrounding events. Events occurring on an object that are clearly at right angles to the direction of relative motion for one observer will be observed to occur at a very different angle for any other observer in relative motion as illustrated by the two protractors in figure 1 below. Importantly, the orthogonality of coordinate axes required in establishing mutually aligned inertial reference frames is at issue. The implications of angular disparities on the alignment of coordinate axes are not the kind of geometrical or observational problems to be ignored by a scientific theory.

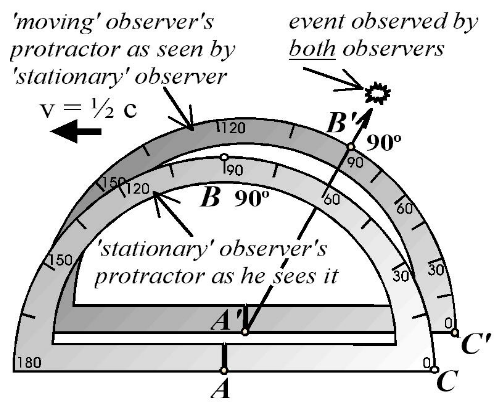

Figure 1: The ostensible effect of relative motion on observations

That naïve application of Lorentz transformation equations to phenomena observed by one observer does *not* produce what another observer would observe in any direct sense is now a well-known fact. Another transformation is required. Penrose referred to this second transformation as the "transformation of the field of vision". He showed that it does not merely apply to 'uniform' relative motion but to observations made by observers in relative motion in a much more general sense appropriate also to the general theory of relativity. To see how these two transformations can be properly applied to determine from the observations of one observer what would actually be observed by another, refer to figure 2 below.

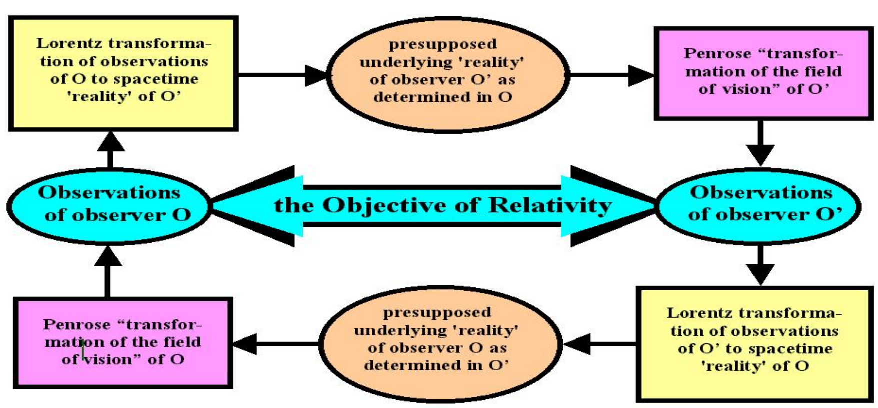

Figure 2: The constructs of Einstein-Penrose relativity

2. Transformation of the field of vision

The result of the two-transformation set is to produce a skew rotation of an object as illustrated in figure 1 rather than an apparent contraction as Einstein had predicted. Of course the skew rotation also involves an unobservable elongation along the line of sight. With the rest of establishment, including Penrose, Terrell (1959, pp. 1041-1045), and virtually everyone else of note since, we tentatively accept that incorporating this transformation resolves the problem of transforming (and therefore predicting) visual observations that are directly verifiable in the 'other' frame of reference. However, when it is conjoined transformations that produce a desired result, Pandora's box is left open with regard to the possibility of *other* combinations of transformations that would equally suffice. More significantly, it implies the possibility of a single transformation to effect the very same predictions without presuming an intermediate metaphysical reality or unobservable side effects as illustrated in figure 2. This simplified approach is illustrated in figure 3.

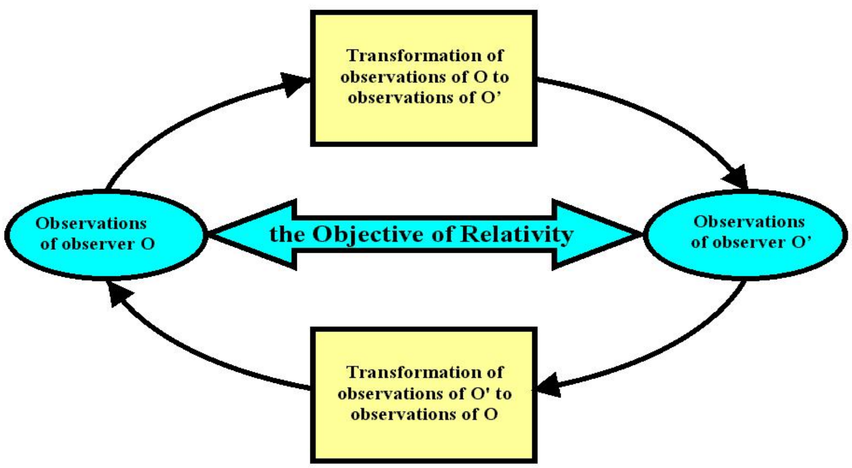

Figure 3: The simplified constructs of observational relativity

But before attempting to derive such a one-step transformation mapping, let's look at what Penrose demonstrated. He showed that in transforming an entire field of view, each 'pixel' (if you will) of that field will involve emission of light from a different event, located at a unique position on an object, for example, with a unique emission time as well. In Penrose's resolution an observed object is taken into a differently situated, as well as contracted, shape in the metaphysical 'reality' of the other observer using the Lorentz transformation equations. See figure 4 for an example of two such relatively moving observers, both looking at a basketball situated in the frame of observer

O. It is situated at right angles to the direction of their relative motion for O. The angle ψ is the characteristic relativistic aberration of the direction to which an event will be seen by the other observer, O', who is in relative motion with respect to what is being observed.

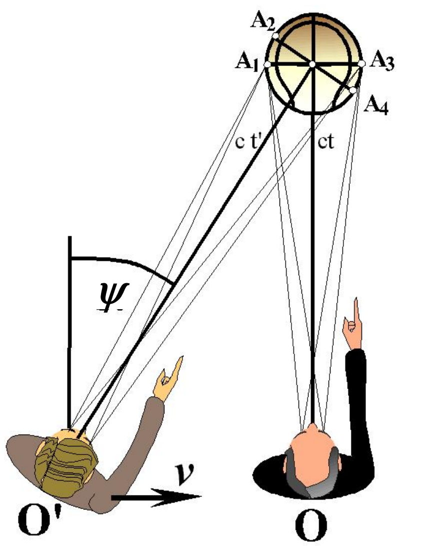

Figure 4: Observers in relative motion observe a ball

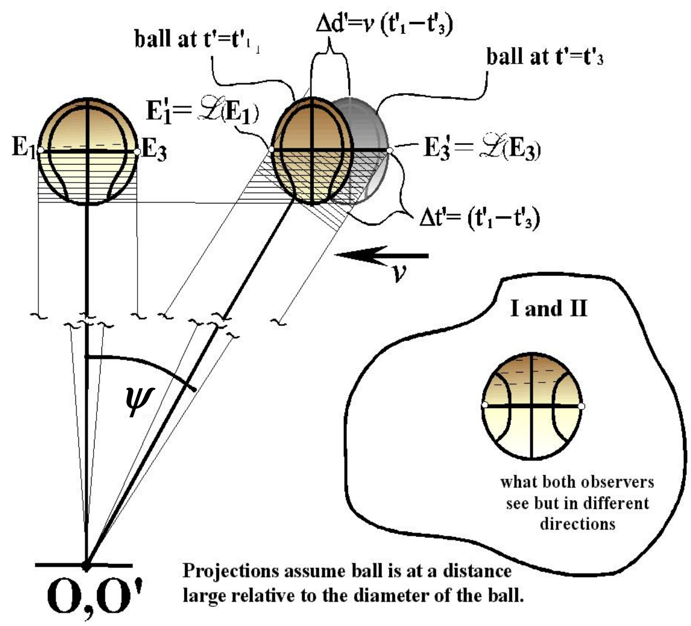

Figure 5: Observations of events on a ball by observers in relative motion

Locations on the ball are labeled A_i to correspond with events E_i of light being emitted from the surface at those locations at designated times t_i. Locations are specified in Cartesian coordinates as (x, y, z) in the frame of O. Events E_i are specified by four values:

$E_i \equiv (t, x, y, z)$

to include a time of occurrence of the respective events as well as the three parameter specification of a point in space.. The Lorentz transformation of event E_i is defined as:

$E_i' = \mathcal{L}(E_i)$

It is elaborated by specifying the following parameter definitions and equations:

Parameter definitions:

$\beta \equiv v/c = \sin\psi$,

where c is the speed of light in a vacuum, v is the relative velocity of the observers along the direction of their x-axes, and ψ is the relativistic aberration angle; and also,

$\gamma \equiv 1 / \sqrt{1-\beta^2}$

Lorentz transformation $\mathcal{L}$ (E_i) equations:

$t_i' = \gamma (t_i - v x_i / c^2)$

$x_i' = \gamma (x_i - v t_i)$

$y_i' = y_i$,

$z_i' = z_i$

This Lorentz transformation must be performed on each event on the surface of the Lorentz-contracted object in order to determine where that event will appear within the field of view for O'. Before publication of Penrose's and Terrell's articles in 1959 that would have been thought to produce a Lorentz contracted image of what is 'seen' by O. But it doesn't. Performing this operation over the surface of the ball as a point-by-point process *appropriate to a given instant in O* does produce the corresponding coordinates of the surface of a contracted ball as portrayed in gray at the right in figure 5. But the component events at the circumference of the ball seen as circular by O would be simultaneous for O, and therefore not what one should expect to be 'seen' by O'. The fact that the trailing edge is further away from O' implies that the observed light from that edge would have to have been emitted earlier, and therefore when the ball was further away, etc.. The (also contracted) ball shown slightly to the left of the gray one corresponds to the same ball at the time light would have to have been emitted from the leading edge to arrive at O' at the same instant as that from the trailing edge. When the disparate times of departure over the entire surface are integrated into a single observed image using this process that Penrose referred to as the 'transformation of the field of vision', the contracted ball will have been stretched back to its original shape. The result is that there will be *no* observed contraction at all. Of course this illustration applies to a sphere at a large distance relative to the dimensions of the sphere such that the circumference is visible by O and therefore also by O', otherwise they would *both* observe the same circumference of a smaller cross section of the sphere. More generally a skew rotation of the original shape results – rotated, in fact, so that the face seen by observer O is also that seen by observer O' as shown at the right in the figure. Notice that the resultant transformation is *not* a 'rigid body rotation'; there is an unseen elongation along the line of sight that is discussed also by Terrell; there is some distortion of objects that are not at 90 degrees to the direction of relative motion and of large angular dimension. The'skew' rotation results in what was shown in figure 1.

How imaging results from theory is in accordance with the following steps illustrated in figure 6:

1) To resolve kinematics problems, Einstein realized that *only* if a rigid body were contracted would the location of events coincide (as they must) with associated regions on the surface of that rigid body as it moved through space. We will see how this plays out in later discussions of clock synchronization procedures. This was the justification for accepting Fitzgerald-Lorentz contraction as a reality.
2) This compatibility of events on the surface of the rigid bodies being transformed using the Lorentz transformation equations requires the incorporation of time dilation into the theory.
3) The distance to events on the surface of a contracted rigid body is tantamount to the elapsed time to these events if the speed of light is to be considered a universal constant, the same for both observers. So this distance must be registered in such a way that observation of all events is simultaneous *at the eye of the observer* rather than on external objects whether they are in relative motion or not.

3. Do the Lorentz equations constitute a geometrical 'transformation'?

What about that other ostensible 'feature' of relativity, whose appearance was ignored by Penrose, clock time dilation? In figure 7 the setup illustrated above for a basketball is shown for a wall clock embedded as a plane surface (seen end-on as the diagonal) through the center of a spherical glass globe. In figure 8 we see what both observers observe of a basketball and of a clock situated in the frame of reference of observer O.

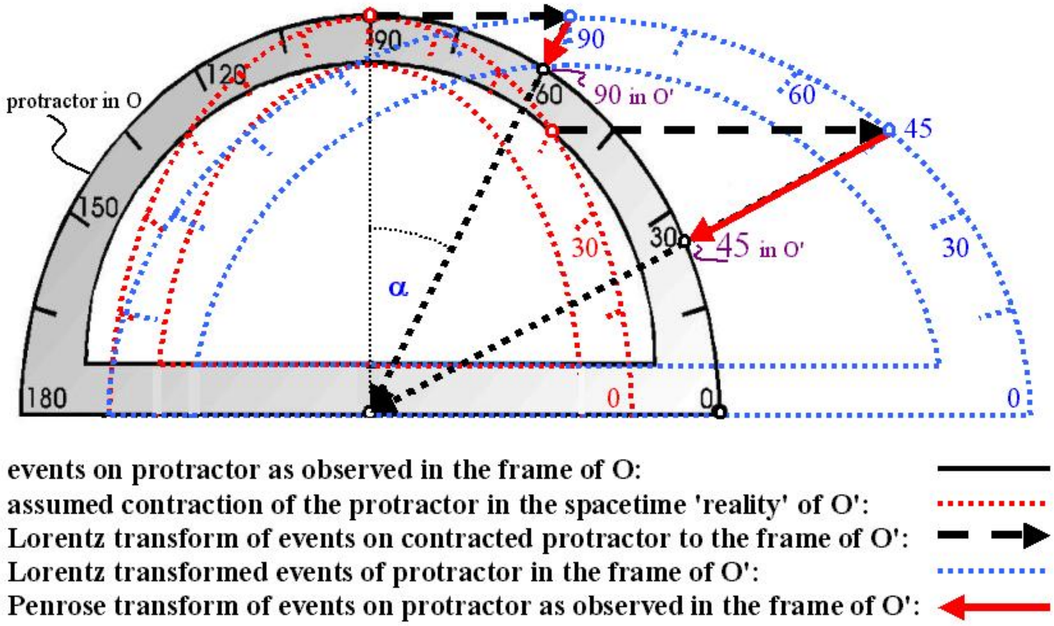

Figure 6: The procedures involved in the ‘transformation of the field of vision’

Just as in the case of the basketball, the transparent globe and embedded clock face at its equatorial plane will appear rotated for observer O' in agreement with what is seen by observer O although in a different direction relative to their direction of relative motion. Can one doubt that this includes the rigid body aspects of the clock face and clock hands? The positions of the hands might as well be repainted on the face every second as part of the object. There are no unique provisions in these determinations using either Einstein's or Penrose's analyses for what will either *constitute* or *be seen as* a clock rather than *as a ball* or any other object. It is only the length of the light paths to the events on the clock face that are involved in the assessment of time in this treatment. The distance to the clock seen by each observer is unique – the speed of light is the same for both – so why would the time they each see displayed not differ accordingly?

According to our understanding of Penrose's and Terrell’s conclusions, a dilated time would not appear on the clock image that is observed by the relatively moving observer since the clock in this treatment is only an object on which *the very same* events (in this case portraying a time stamp) are being visually inspected from alternative perspectives. They supposed that a neighborhood of events was being geometrically transformed from one frame of reference to another. However, to force consistency with the temporal Lorentz transformation equation for the additional distance light must travel to the clock in the frame of reference of O', shouldn't O' actually see a different time displayed than would O? When both observers are in coincidence and look at the clock face, will they see the same clock time value displayed no matter which frame of reference they themselves reside in? That is the question. And however naïve it may sound when you first hear it, it is indeed a most profound question. We illustrate it in figure 9.

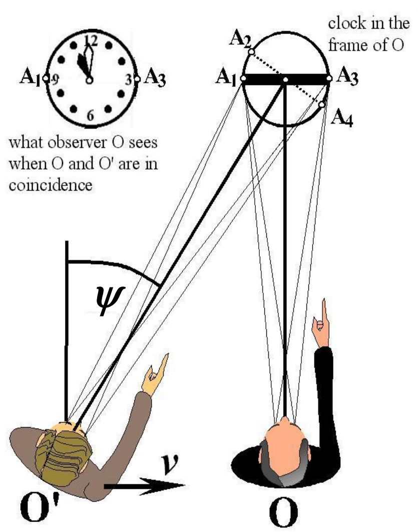

Figure 7: Observers in relative motion observe a clock

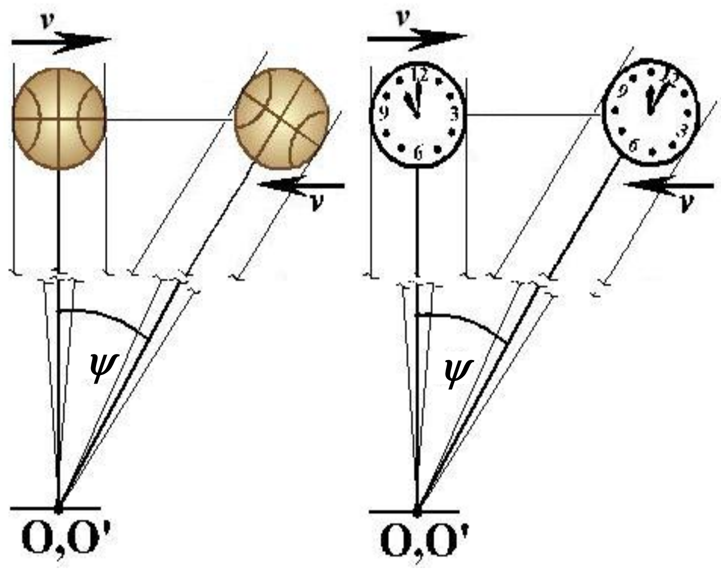

Figure 8: Observations made by the observers when in relative motion

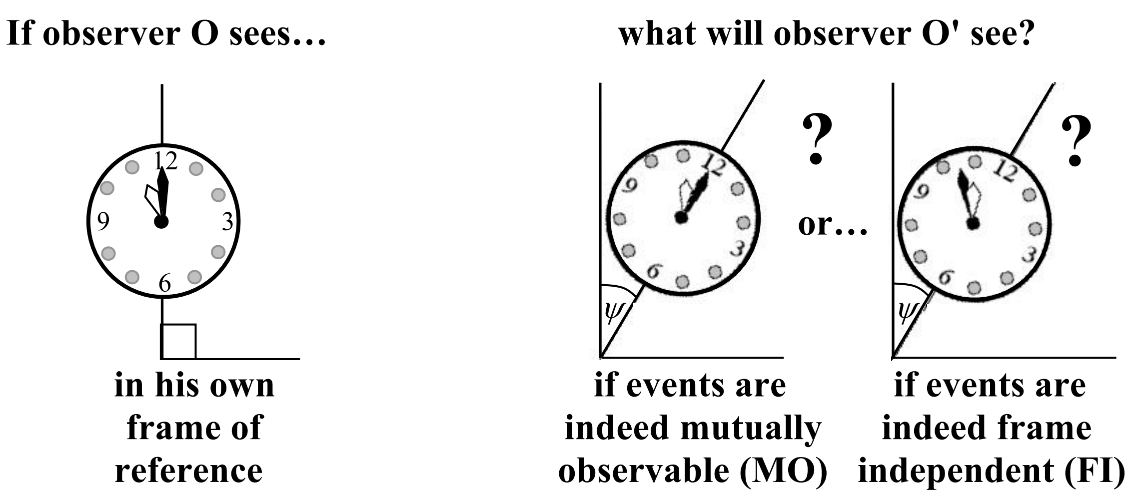

Figure 9: The paradox concerning the transformation of clock face images

It is a tenet of Einstein's theory that events are 'indivisible'; they are mutually observable (MO) by any coincident observer. Events are also assumed to be independent of the frame of reference (FI) of coincident source objects on which the events occur. In short, according to the special theory each 'pair' of events related by the Lorentz transformation between O and O' must pertain to *one* mutually observable event, not *two*. Therefore the clock image that is nothing more than a cluster of events originating at the clock face must display one value – the same for each observer. It is after all only indivisible events that *can* be 'transformed from' (as against merely 'correlated with') events in another frame of reference. This indivisibility is claimed with regard to events associated with emission as well as those associated with the detection of light. This is Einstein's 'law of the transmission of light'. Aharoni (1985, p. 38) addressed this interpretation of the Lorentz transformation equations as constituting a geometrical transformation rather than a mere physical correlation by averring that, "Had an event not possessed absolute significance there could be no question of transforming its coordinates from one frame to another." However, since the principle of relativity cannot prefer one observer over another, the temporal Lorentz transformation equation would seem to assign two distinct time values to respectively observed faces of the clock. The clock itself is assigned (by these Lorentz equations) to two unique distances away from the coincident observers, so the questions remain: "What clock times would be observed by coincident relatively moving observers?" "What clock times would actually occur on coincident relatively moving clocks?" And "Why are we so sure that the Penrose-Terrell rotation is just an optical illusion?"

The alternative clock time value shown at the far right in figure 9 is compatible with an alternative interpretation of a mere correspondence of separate events on the 'world line' of points on the same clock face. This would also accommodate coincident clocks displaying the same times, one corresponding to the Lorentz transformation of what is observed by O and the other being the time of the clock in O but at the earlier time when it was in coincidence with a similar clock in O'. Both sets of time and distance coordinate values fall precisely at the same event 'location' on the ball/clock but as having been emitted at an earlier time in its history, namely that determined by the Lorentz equations. Therefore, the equations themselves are compatible with a different interpretation than Einstein (and Aharoni) have given them. And although a wall clock has only one face, the appearance of that face differs from one moment to the next. So the difference in the Lorentz values support the argument that there might indeed be a different 'clock time' display observed of the one clock by O than by O' when the observers are in coincidence.

A co-located clock in O' at the instant and location specified by the Lorentz equations would also display that earlier time determined by the equations as shown at the far right of figure 9, collaborating this interpretation. In that sense the images would be somewhat frame-independent, i. e., at the site of the coincident clocks. But that would not be the same synchronized clock face display seen by O in his frame because the clock would be closer to the observer O when the light was emitted. It would therefore, require emission events to occur later with the clock registering a commensurably later time. Thus we arrive at the crux of the dilemma of what will be observed following combined Lorentz and Penrose transformations. Is the Lorentz transformation perhaps not a geometrical transformation of indivisible events after all but a correlation between observations of an object (but *not* the same events) seen by coincident observers?

Time and distance are inextricably linked. It seems as though analyses employing the field of vision obfuscate the issue of whether one can 'observe' clock time dilation although it clarified the issue of observing Lorentz contraction. Acceptance of indivisibility of observed events demands that observed clock face images must display exactly the same time. However frame independence of emission events implies that the displayed images must be different. The time that O will see displayed on the clock will clearly be compatible with the clock's distance from him but it would not be for O'. By Penrose's analysis the time that O' would see displayed should be compatible with what is seen by O and *also* with the time of a coincident clock at the same distance in his own frame of reference viewed at that instant. But that is logically impossible. Therefore, one must wonder whether a ball is 'really' contracted and whether clock time is 'really' dilated. Do the observers actually observe the "absolutely" same events or not? Certainly we can infer the spatial and temporal situation that will be observed for an inanimate object based upon a supposed intermediate reality between the transformation equations shown in figure 2 as Penrose did. That works. But it does *not* work for a time-stamped object as in the situation of the wall clock in which case an inconsistency arises between conflicting theoretical constraints on the events they observe.

This brings the 'intermediate reality' basis of Penrose's analyses into question. There is no directly verifiable proof of this 'reality' even though it is often propounded as irrefutable. We must reevaluate the sense in which that which can never be observed might at the same time constitute a fact of 'reality', particularly when it leads us into logical conflicts. A theory in the physical sciences is more or less defined as a formal mathematical system that predicts observed *physical* phenomena. Such a theory of relative motion would act as a function or formula into which one could insert a set of observed data to predict the observations of another observer as was illustrated in figure 3. Shouldn't this eliminate the need to deal with the awkwardness of inferring *actual* rigid body contraction and *actual* clock time dilation in spite of observable facts to the contrary? And shouldn't it provide a non-ambiguous result?

4. Counterintuitive definition of observation in current relativity theory

Naturally we must characterize what constitutes an 'observation' as established by the theory. This is where we run into trouble. Einstein (1961, p. 32) stated, "It has already been set forth how these magnitudes [of coordinate values x, y, z, and t] are to be regarded as results of physical measurements." Intuitively, and indeed in quantum theories and earlier classical theories, an observation is what a scientific observer (i. e., a scientist) 'detects' using some instrument or other, thus obtaining just such "physical measurements". However, in relativity theories as currently envisioned that is not at all the case. Despite Einstein's initial intentions, observation is a concept that relativity theorists have subsequently taken the liberty of redefining such that it is at odds with what constitutes an observation according to all other physical theories. For example, in his "A first course in general relativity", Shutz (1988, p. 4) states that:

> "It is important to realize that an 'observer' is in fact a huge information-gathering system, not simply one man with binoculars. In fact, we shall remove the human element entirely from our definition, and say that an inertial observer is simply a coordinate system for spacetime, which makes an observation simply by recording the location (x,y,z) and time (t) of any event. …An observation made by an inertial observer is an act of assigning to any event the coordinates x, y, z, of the location of its occurrence, and the time read by the clock at (x,y,z) when the event occurred. It is *not* the time t on the wristwatch worn by a scientist located at (0,0,0) when he first learns of the event. A *visual* observation is of this second type: The eye regards as simultaneous all events it sees at the same time: an inertial observer regards as simultaneous all events that *occur* at the same time as recorded by the clock nearest them when they occurred. This distinction is important and must be borne in mind.

> Sometimes we will say 'an observer sees...' but this will only be shorthand for 'measures'. We will never mean a *visual* observation unless we say so explicitly. …An inertial observer is also called an *inertial reference frame*, which we will often abbreviate to 'reference frame' or simply 'frame'."

Beside the awkwardness of this exceptional definition of observation there is an additional issue with regard to determinism that places the theory of relativity at variance with quantum theories. This latter disparity derives in large part from the oversimplification of just assuming without proof that observed events throughout all spacetime can be mapped from one observer to another independent of the frame of reference in which the events actually occur and are observed. Although the images observed by relatively moving observers are similar as Penrose's and Terrell's analyses illustrate, they differ considerably with regard to both the direction from which they derive and the time that would be read on a clock at the location if the clock were in the 'other' frame of reference. This was suggested in figures 8 and 9, which paradox we have yet to fully explicate. Furthermore, as indicated in the same figures, observations of events on coincident objects that reside in different frames of reference differ appreciably. These differences do not just involve angles but also Doppler shifts in color and associated clock times if we take Penrose's transformation of the field of vision and frame independence at face value. And why would scientists *not* take observations of clock face values at face value?

Intuitively, there are four categories of visual observations that can be performed in situations of relative motion as suggested in figures 4 and 7 above and more specifically in figure 10 below. These four categories are the following:

I. Observations made by Observer O of a ball or clock situated in his own frame of reference, i. e., stationary with respect to O.

II. Observations made by Observer O' of a ball or clock that is situated to correspond with the ball or clock in O but in his own frame of reference, i. e., stationary with respect to O'.

III. Observations made by Observer O' of a ball or clock situated in the frame of reference of observer O, i. e., stationary with respect to O.

IV. Observations made by Observer O of a ball or clock that is situated to correspond with a ball or clock in his own frame of reference, i. e., stationary with respect to O'.

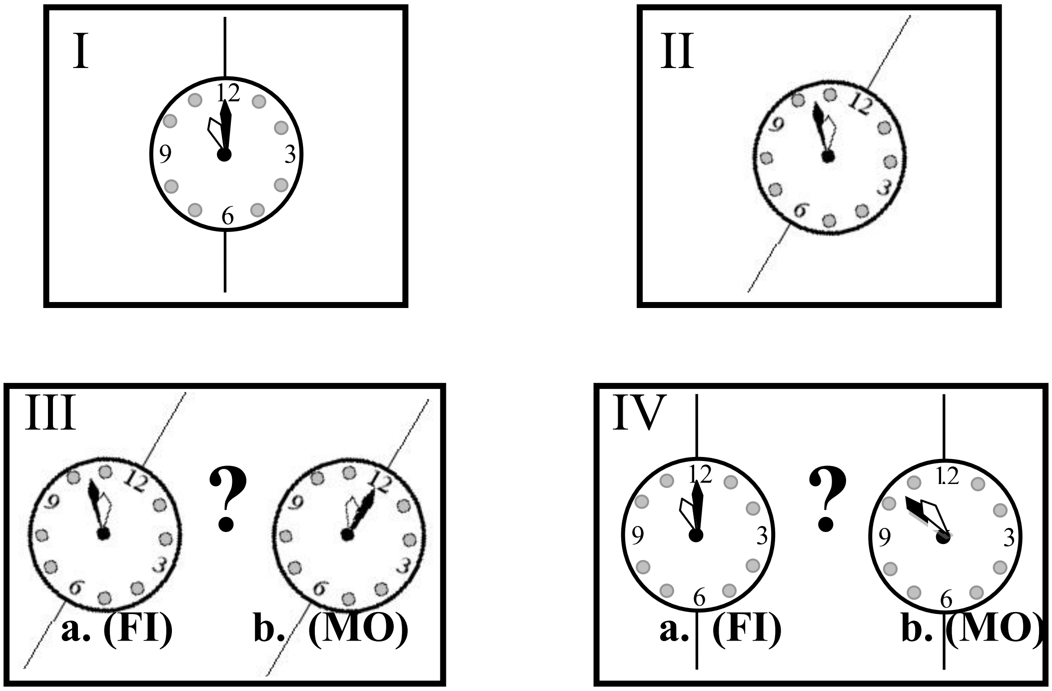

Figure 10: The four possible observations of two relatively moving observers

However, Shutz would replace these four categories with the following expurgated set, blurring distinctions with regard to whether events including the image of a ball or clock or whatever material object that is being observed is fixed with regard to one frame of reference or the other as follows:

I and IV: Observations made by Observer O of events that take place on a mutually observed object

II and III: Observations made by Observer O' of events that take place on a mutually observed object

So whereas current relativity theory concerns itself with undoubted 'realities' (renamed 'observations') of two observers in uniform relative motion based exclusively on a mathematical relation, it does *not* directly relate – nor even entertain the possibility of – the full scope of logically conceivable observations from which one could validate Shutz's proclamation. It does not address the full range of possibilities that 'observation' traditionally implies. The obvious questions we have asked with regard to Penrose's analyses are left unanswered, i. e., what times will be displayed in the images seen by the two observers? Will both observers visually 'observe' the same events arising on the clock face or not? Shutz's 'observations' cannot resolve those issues. Since I and IV as well as II and III above are grouped by Shutz as shown in figure 11, he is assuming there *must necessarily* be one clock image in our example, even though it contradicts either what one of the observers actually sees or the Lorentz temporal equation and frame independence of coincident sources of the observed events. Relativity thus conceived addresses the relativity of a metaphysical concept of spacetime independent of actual observations of relatively moving objects and observers. Indeed, that is what the discipline seems to have come to encompass.

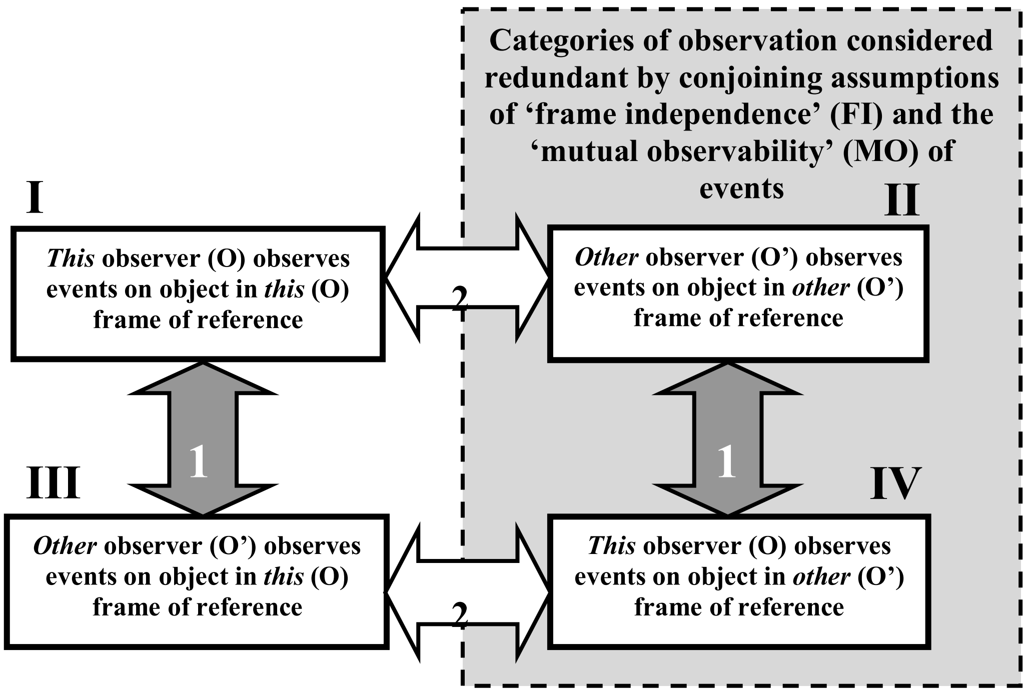

Figure 11: Four categories of observations and their amenability to experimental test

Let us consider the patently absurd notion that what is observed by observers in relative motion is independent of the frame of reference to which the observed object is attached. For starters there is the obvious Doppler red or blue shift of the wavelength of the observed radiation. There is also the required 'transformation of the field of vision' in the one case but not in the other.

Very significantly also, observation requires photons of radiation that are not instantaneous transmissions of light but involve wave trains of millions of wavelengths whose total coherence length is many centimeters for visible light, requiring a commensurable amount of time to transmit a single 'piece' of observation, so that the object emitting the light in one frame could not be coincident during the entire transmission.

What Shutz deigns to call 'visual observations' as against what he would no doubt consider to constitute 'real observations' in the Platonic sense are, in point of fact, the only type of *actual* measurements that it makes any sense to refer to as 'observations' as against direct 'inferences' from the theory in question. So the reasonable objective of 'the principle of relativity' has been hijacked. That distorted objective is shown in the diagram of figure 12 as the transformation of the geometrical spacetime 'reality' of one observer into that of the other. Observations – in a sense that a scientist could actually set up an experiment or astronomical observation to measure the value of some particular parameter or other – don't even show up as central to the diagram. To rectify that situation and effect that necessary function, Penrose's transformation was defined to convert the Lorentz transformed mapping from *this* observer's 'reality' (that of observer O) into what would be 'observed' ('visually', if you must) by *that* (the *other*) observer, O'. Penrose did this by lashing together a second transformation that would take the result of what theorists had for half a century held to be sufficient in and of itself to accommodate actual experimentation. Figure 12 illustrates how relativity theorists (no doubt including Roger Penrose) see his contribution fitting into the overall scheme as a very minor caveat.

Thus hijacked, 'observation' becomes a presumptive network of inferences from theory whose refutation is all but impossible. The peculiar structure of this "huge information-gathering system" that *is* spacetime is, in fact, a primary 'inference' – if you will – of the theory. It is *inferred* from the formalism of the theory; it is not what some scientist can in any way 'detect' with any conceivable instrument. To endow this *presumed* structure with the authority of scientific 'observation', actually to the extent that we somehow fool ourselves into supposing that each point in space is instrumented with a clock and court stenographer, is patently absurd. But that is indeed what has been assumed to qualify as an 'observation' in relativity analyses. It is *not* what 'observation' means to any of us by any stretch of the imagination. We are left with a tautology –

an inference from the formality of the theory that is treated as though it were a legitimate confirmation of that same theory. The circular loop at the center of figure 12 depicts the questionable logic of the situation envisioned. This stand on observation is not a good position for physicists to take. The approach insists that somehow each observer's perceived reality must be inferred from sighted angle and inferred distance data with the results manipulated to effect Lorentz contraction and time dilation before he or she can even pretend to comprehend the observed 'reality' of another observer.

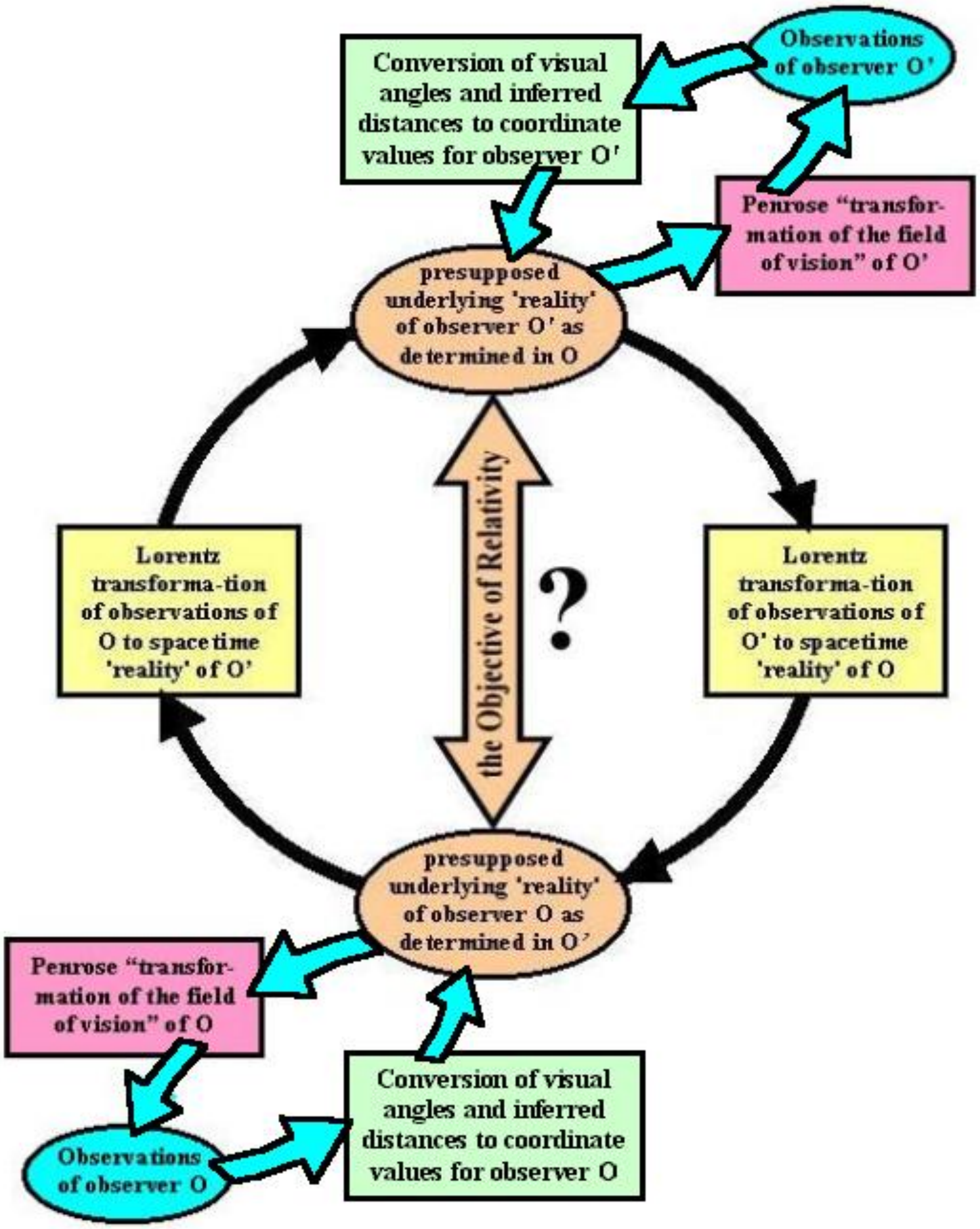

Figure 12: Incorporation of the transformation of the field of vision into the current scheme of relativity theory

So we must investigate the implications of such a brash assumption. Blaming the lack of simultaneity of the precipitating events of all we observe is not a valid excuse for the unique treatment of observations for those in relative motion. That difficulty is a fact of scientific observation generally not essentially different from what would be required in any classical or quantum theory for which the observer has registration responsibilities over and above mere 'detection'. It certainly is not a good reason for divorcing the experimental methodologies of all other major branches of physics. Furthermore, to indicate that the theory implies that two of the four logically required observation categories (identified above and shown in figures 10 and 11) would be superfluous is only a reasonable stand to take if that position had been subjected to refutation testing. But it has not been. It is merely a tenet of a belief system. However advantageous the assumption may be in some context, there is reason to believe it is incompatible with the legitimate application of the Lorentz equations.

Penrose's analyses should have been sufficient to re-open that debate – or more accurately to *initiate* that debate. That did not happen. For whatever reason, Penrose opted to accept the established position with regard to observation. What he accepted was a lashing together of kludges rather than addressing the need for a systematic re-evaluation and integration of requirements for comparing observations as shown in figures above.

[The text proceeds to explore a single transformation rather than the multi-step process suggested by Penrose.]