Are There Inevitable Uncertainties in our Maps of the Universe?

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Einstein was uncomfortable with notions associated with an inherent uncertainty implied by the Copenhagen Interpretation of quantum mechanics. Whether we ourselves might ever know the precise locations and/or momenta of particular particles at particular moments in time, Einstein had faith that at least God had reason to know such things. Far from this revealing an unwavering belief in an omniscient personal savior, it merely expressed the metaphysical perspective that everything has to be somewhere, whether we know it or not. And I guess we must grant some, even if minimal, credulity to that presumption.

This insistence on knowledge of the way things *are*, as against what is measured or observed, came increasingly to haunt his work and that of the many dedicated theorists who have religiously pursued those paradigms Einstein established. The Great Divide between two major branches of physics – on both sides of which Einstein's influence was monumental – involves this very issue. He opted in favor of determinism early on in his work with relativity, although his initial philosophical leanings seemed more definitely positivistic. Those early tendencies are revealed by comments such as, "we entirely shun the vague word 'space,' of which we must honestly acknowledge, we cannot form the slightest conception, and we replace it by 'motion relative to a practically rigid body of reference'." He had also indicated that spacetime coordinate magnitudes should be regarded as though the actual "results of physical measurements." But in interpreting values that result from the Lorentz transformation equations – the formal basis of his theory that he had thus insisted be directly measurable – he failed to question all of the common-sense notions of his time. Valid explanations of 'double slit' and other high-profile experiments and related phenomena that assure us that light is anything but common sense, were unknown when Einstein coined his phrase "the law of transmission of light" for this common-sense notion that even a photon must be somewhere. But we know they are not some particular where! They seem, in fact, to be nowhere until and unless they are observed. But this "law" was not specifically about how light is transmitted per se, but about the meaning of relativistic aberration – a legitimate hypothesis in as much as it is certainly refutable. But because it seemed merely 'common-sense,' apparently no one ever bothered to doubt it sufficiently to attempt a refutation. But in this universe any legitimate God who could be invoked in a scientific context, blesses doubt!

Aberration caused by relative motion was familiar phenomena years before Einstein's relativity came along. It is very much like parallax in which separated sightings of the same field of objects result in distortions between observers' fields of view. The illustrations below illustrate this effect for parallax where observers have different perspectives on objects arising from differences in their viewing locations.

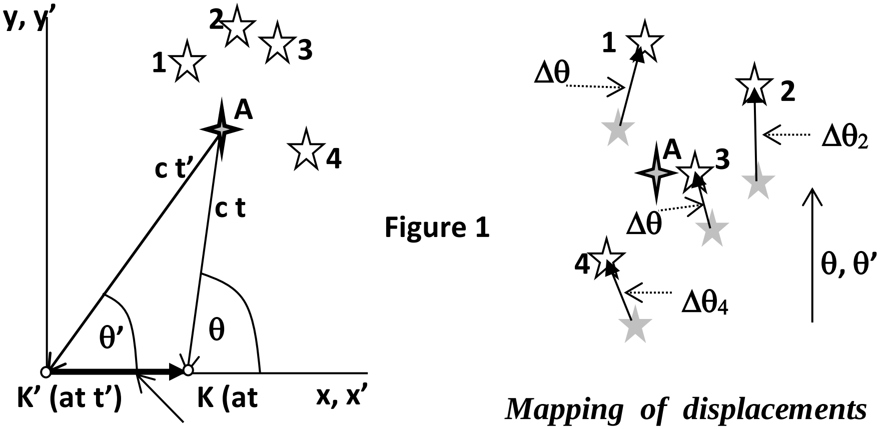


Figure 1

Separation x'=X (or x'= β t') of K and K' observers is responsible for perspective differences in both parallax and aberration effects.

Mapping of displacements $\Delta\theta_m$ for each object m about a point A (the fixed center of alignment of the fields of view) of K and K'

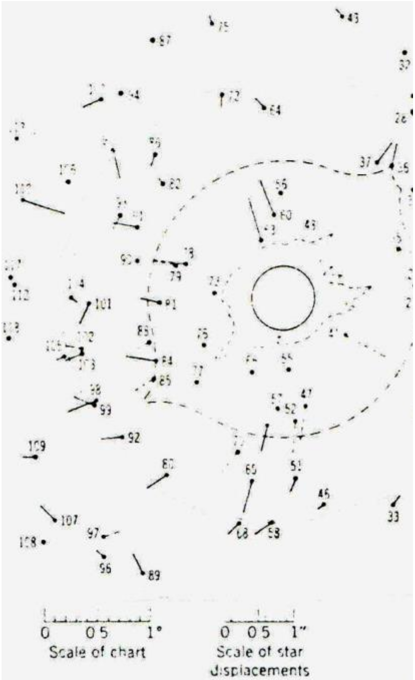
Parallax provides a useful analogy for explaining aberration. And it is easy to show that differences as well as similarities between parallax and aberration effects derive from the finiteness of the speed of light. Further, the fact that its speed can be considered the same (in a vacuum) for every observer accounts for relativistic aberration differing slightly from what had been thought to be the case earlier. These facts necessitate that the distances that light travels, c t and c t', in the first panel of the figure above, differ for two observers both for parallax and for aberration – except, of course, for the special case of an object occupying a position on the perpendicular plane bisecting their line of separation.

In the analogy of relative motion, for which relativistic aberration applies, the universality of the speed of light imposes constraints associated with the triangle K'KA, the geometric details of which define coincident observation of such relatively moving observers. Apparent differences in perspective for such coincident observers caused by their relative motion are extremely similar to those caused by a separation between relatively stationary observers since there had, in fact, to have been spatial separation between the observers at the time the observed light would have been emitted from the object. In the figure, observer K' moves with respect to K such that β t' = X, the analogous separation in a parallax situation. The two angles θ and θ' at which an object is observed will be given by the relativistic aberration formula to be discussed in detail later. The extent of the difference between Einstein's relativity and previous considerations involves the constancy of the speed of light to produce the relationship, i. e., it derives from Einstein's Second Postulate.

However, where there are multiple objects at various distances (and velocities) being observed, distortions resulting from parallax computations become largely unpredictable from a single observation point as shown in the second panel of the figure above. Displacements $\Delta\theta_m$ of objects within a field of view of K' relative to where the object was viewed by K cannot be determined exclusively from angular measurements made by K of the object m. For its determination there must be some *a priori* knowledge of the relative distance and directional velocity of m. It is a singular fact, however, that such nondeterminism does not arise in relativistic aberration formulas when (or because) Einstein's 'law of the transmission of light' is applied. In that theory, whatever is observed by K can be unilaterally transformed to obtain a corresponding observation in K' with absolutely no knowledge of static or dynamic information of the objects being viewed relative to either observer!

Does observation bear this out? Even the closest of the distant stars are so remote that during the course of an entire year their considerable velocities do not appreciably alter their apparent positions in the sky. This fact is used in analyzing eclipse data to determine the bending of starlight around the sun; whatever differences appear in star field observations made six months apart can be used to measure the effect of gravity on the photons of the light from these stars during eclipse. However, gravitational effects of the sun and moon that intervene in the one image and not the other do not produce the most significant differences in registration of these star fields. The fact that the earth is moving in the opposite direction at orbital velocity in the two instances produces a much larger effect.

The duplicate star maps that are used have inevitably been 'observed' while in approximately uniform relative motion with relative velocity twice the orbital velocity, i. e., about 36 miles per second, producing a special relativistic aberration effect much larger than the gravitational (general relativistic) effect. This aberration effect produces an angular displacement of more than 40 arc seconds (see figure on page 5), whereas the gravitational effect is less than 1 arc second at two angular radii from the sun. So displacements in stellar images, obtained at observations six months apart by (effectively two separate) relatively moving observers superimposed upon one another in a best fit (as in the figure of data from the 1922 eclipse on the next page) but offset by 41 arc seconds, are all that can then be used to register maps as a basis for measuring the gravitational effect. Over the extent of the several-degree star field, differences in morphology (as against the total aberration effect) caused by annual motion of the earth about the sun should be less than about 0.2 arc seconds. This is according to Einstein's conjecture of the applicability of the Lorentz transformation calculations employed by the special theory of relativity to account for such cascaded phenomena.



stellar displacements (away from filled circles) as they were prepared by Campbell and Trumpler (1923) in analysis of eclipse of 1922. (Dotted lines represent the sun's corona.)

But actual data taken during solar eclipses reveal much broader variation than this. (See the figure at left.) Error analyses suggest that even though a least-squares fit of data does confirm predicted gravitational effects – actually in excess by an appreciable percentage across the entire star field – a satisfying rationale for the magnitude of variation has not been achieved. This has not changed in all the years since this effect was first observed. Misner, Thorne, and Wheeler provide Dicke's summary of results through 1964, "The scatter would not be too bad if one could believe that the technique was free of systematic errors. It appears that one must consider this observation uncertain to at least 10 percent, and perhaps as much as 20 percent."1 Radio astronomical results reveal the same order of magnitude uncertainties as do the optical observations. There is some azimuthal dependence in the uncertainties as one might have suspected, but as shown for the displacement identified as "113" in the figure, oppositely-directed displacements far exceeding the magnitudes of the predicted gravitational effect occur as well. (Notice that in the figure the displacement scale is greatly expanded relative to stellar positions.)

Might this be a refutation of Einstein's conjecture concerning that law of the transmission of light or just some fluke of a truly difficult observation? What if stars winged about at appreciable fractions of the speed of light as occurs at submicroscopic levels of our universe rather than mere tens of miles per second? Could usable maps be constructed that would have even nominal utility by another observer?

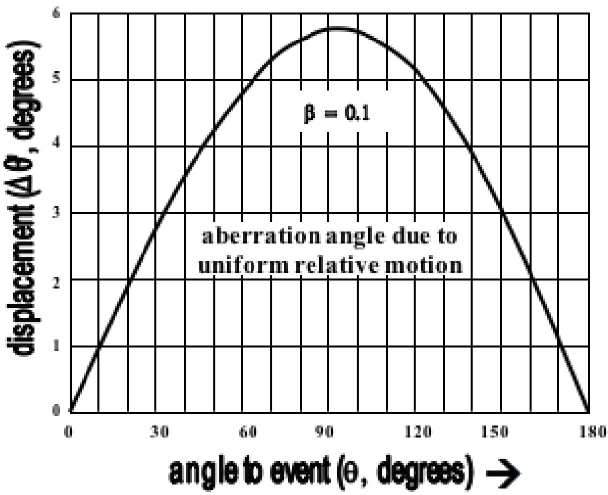
Einstein's special theory provides deterministic mappings of observations of one observer onto those of another in uniform relative motion. This is true even in cases where observations pertain to events on world lines of objects at widely varying distances and velocities. When interpreting the results of Lorentz transformations according to Einstein's hypothesis of the law of transmission of light, all variation becomes moot. This "law" is effected by imposing an additional constraint on the Lorentz equations, namely the "velocity addition formula", that has never been independently confirmed, or non-refuted as a scientist would prefer to say, by any experiment but is a 'necessary' consequence of one interpretation of the Lorentz equations as a 'transformation' rather than as merely establishing a 'correspondence' between actually observed events on the world line of the same object.

This peripheral dogma only comes into play with regard to events on 'third party' platforms; they would otherwise need to be mapped using direct assessments of relative velocity. What this frame independent 'buddy system' enforces is that the Lorentz equations produce a single coordinate direction independent of differences in the relative positions and velocities of the sources of all the events seen as occurring in this direction by one particular observer in his spacetime. That seems to the author to negate the very purpose and usefulness of relativity as a coordination (as against a pre-determination) of 'observations'.

In 'observing' an event as against one merely 'hypothesizing' it for someone else whose composite relative spacetime situation we cannot assess – as indeed we do not even completely know our own – with regard to the source of events before the observation is made, actual observation is key. By various inferences one observer might be able to deduce from line spectra that the object has a specific radial velocity, but one still would not know its tangential velocity with any accuracy at all. The supposition that relativity can precisely transform observations made by one observer into what *any* other observer with a known relative motion (with respect to the first observer) could expect to observe – independent of the nature of what is to be observed – seems to the author patently absurd.

Certainly the conjecture is refutable, and yet, refutation pends an actual two-observer observation situation, foregoing a natural urge to gedanken experiments that are particularly vulnerable when testing common sense notions!

But first we must know what to look for. We'll discuss that next.

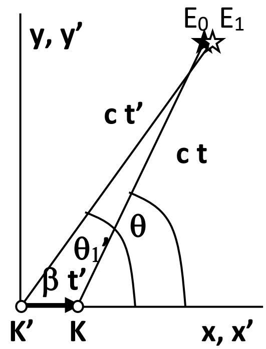


The Certainty Principle

As stated earlier Einstein's use of a common-sense notion of ‘the law of transmission of light’ that was prevalent at the time, constrained his interpretation of the Lorentz transformation equations – determinism being the inevitable result. Let's consider this in more detail:

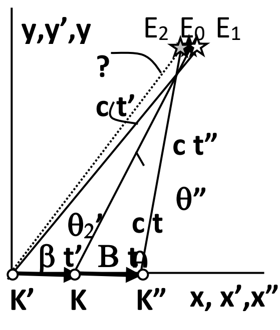
Suppose that we (observer K) are coincident with another observer K' who is moving at the velocity β = 0.1 in units of c with respect to us in frame K. And let's suppose further that there are stars or other sources of radiation observable from a distance, and that these sources have random velocities that are as high as half the speed of light. To coordinate observations with K' we employ the relativistic aberration formula derived directly from the Lorentz's equations:

$\cos\theta' = (\cos\theta - \beta) / (1 - \beta\cos\theta)$



Notice in the figure at right that lines ct', ct, and βt' do *not* form a triangle. (At least formally there are two events.) The deviation between angles, Δθ' = θ – θ' is shown as the curve in the figure on the previous page. This curve shows the amount of aberration between the two observers' observations as a function of the angle of the observation with respect to the direction of their relative motion. Whereas with only twice earth's orbital velocity the aberration would reach merely 41 arc seconds as mentioned in the previous article, here it is nearly six degrees. But other than the differences across a field of view, this can easily (and deterministically) be compensated. But with regard to events on objects moving relative to both observers what is the situation?

Let us consider light from an event on an object whose velocity is B = 0.5 relative to us in K and along the direction of our relative velocity with K'. And suppose that there is a third observer K'' – stationary with respect to that object who just happens to be coincident with K and K' at the moment we all make our observations for comparison. K'' sees the event at θ'', as shown at right. K will see the same event at the angle given by the following:



$\cos\theta = (\cos\theta'' - B) / (1 - B\cos\theta'')$,

and likewise, therefore, we have:

$\cos\theta'' = (\cos\theta + B) / (1 + B\cos\theta)$

We wish now to determine where such an event will appear for K' who happens at that instant to be coincident with both K" and K when they observe the event. To accomplish this goal of third-party coordination according to the established theory, the following relativistic velocity addition formula (what is called 'boosting') must be employed:

$$B' = (B + \beta) / (1 + \beta B).$$

By substitution we obtain:

$$\cos \theta_2' = (\cos \theta'' - B') / (1 - B' \cos \theta'')$$

$$= [(1 + \beta B) \cos \theta'' - (B + \beta)] / [(1 + \beta B) - (B + \beta) \cos \theta'']$$

To assess how this affects the displacement of events from the perspective of K' corresponding to event transformations from our own relatively stationary apparatus in K, θ_1, we must substitute now for cos θ" from the equation above, so that now we obtain the following:

$$\cos \theta_2' = [(1 + \beta B) (\cos \theta + B) - (B + \beta) (1 + B \cos \theta)]$$

$$/ [(1+ \beta B) (1 + B \cos \theta) - (B + \beta) (\cos \theta + B)]$$

Then by carrying out the operations indicated and canceling factors we find that:

$$\cos \theta_2' = (\cos \theta - \beta) / (1 - \beta \cos \theta) = \cos \theta_1'$$

This is not dependent on B, such that the very same angle results between K' and K in both cases, which is rather amazing if you think about it – or I guess more assuredly, if you don't. As shown in the figure above the events labeled E1 and E2, which are at least by formality treated as separate events, are situated to the right and left of E0 respectively, and yet all three are hereby said to be at the very same angle for K' no matter how this defies depiction.

It is very obvious why in all cases it turns out this way. According to the common-sense notion embodied in the law of transmission of light, whatever anyone sees at a point in spacetime, any other coincident observer should also be able to see so that all events seen while in coincidence are mutually shared. (The velocity addition formula guarantees this will be the case.) 'Seeing' just involves photons, after all, that happen to hit one observer in the eye rather than another coincident observer…right? Well, I don't think light works that way, but pursuing this as though we do, we find that the velocity addition formula is shorthand for a cascading of the Lorentz equations to substantiate the claim that they form a 'transformation group'. The logic behind this accepted approach to coordination of observations is the following:

If we let $L(\varepsilon)$ represent the Lorentz transformation of event, ε, such that:

$$(t', x', y', z') = L_\beta (t, x, y, z)$$

and

$$(t, x, y, z) = L_B (t'', x'', y'', z''),$$

then, does that imply:

$$(t', x', y', z') = L_\beta (L_B (t'', x'', y'', z''))$$

or not? That is the question. If so, it would make sense to define:

$$L_{B'} \equiv L_\beta (L_B),$$

which implies:

$$B' = (B + \beta) / (1 + \beta B)$$

as inferred by Einstein and Minkowski.

With this accepted logic there can be no basis in the established theory for any uncertainty in predicted angular positions of events in space no matter what the unknown *and unknowable* variations in the velocities of the objects on which the events arise. The velocity addition formula distorts all space and time to collapse separate events E_0, E_1 and E_2 to the net effect of preserving determinism.

But what – other than an archaic notion of 'common sense' and expediency – necessitate that the Lorentz relationships must constitute a coordinate transformation rather than a mere transactional correspondence? The answer is: Nothing!

All this abracadabra is unnecessary if we free ourselves from the notion that even a photon must be somewhere available for scrutiny by either of alternative observers as dictated by the so-called ‘law of the transmission of light’. We'll have to determine whether discarding such an obsolete notion brings relativity into agreement with observations of course. It is tempting to suggest that possibly the eclipse data, discussed earlier, refute Einstein's velocity addition formula, but the uncertainties there are too large to be due to the instantaneous relative velocities, so it is felt that the magnitude of those uncertainties relate more directly to something else entirely, like possibly the range of likely accelerations of stars in the star field or scattering phenomena – all interesting issues to discuss sometime.

The Overarching Significance of Angular Observations

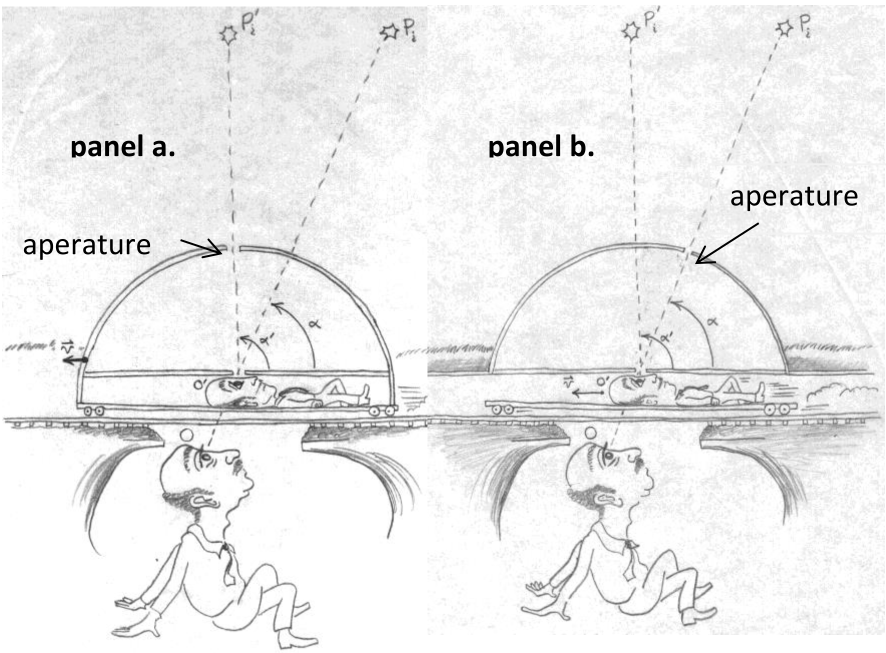
This volume (*Aberrations of Relativity*, from which these articles have been taken) is somewhat dedicated to the idea that aberration is the real phenomenon of relative motion and that one must deal with that first and foremost when trying to understand the manifold ramifications of relativity. Here the attempt is to ferret out a different aspect of that same notion. Although also accepting the same body of experimental data accepted as legitimate by establishment with regard to aberration, the author stubbornly maintains that observations involving this phenomenon are more reasonably accepted as the most essential aspect of relative motion and would more properly be acknowledged as the phenomenological base of any associated theory.

Einstein and Minkowski asserted that the Lorentz equations constitute a transformation in the same mathematical sense as a rotation of spatial coordinates accompanying deterministic shifts in the locations of points on a rigid body. The analogy accommodates (actually enforces) completely deterministic relationships between observations of the universe (however predictably distorted) from any one observer to any other in uniform relative motion through a vacuum. In a very real sense, equations of this form could provide such a function, but the author maintains that it transforms the perspectives of the observers, not the realities that surround them, which distinction has extreme epistemological significance of course, and is thus worthy of some discussion. The equations provide in any case a most likely place to look for a corresponding event viewed from a relatively moving frame of reference. But the inevitable determinism associated with the established interpretation is unnecessary and, since it is incompatible with other highly successful theories of physics, it seems reasonable to attempt to find viable alternatives, subjecting all options to scientifically refutable experimental test.

It has been suggested elsewhere that Einstein's law of the transmission of light which is the ontological basis of the established interpretation of the Lorentz correspondence between measured space and time values is invalid in light of subsequent discoveries. Furthermore, it denies validity to actual measurements since once an event has been observed by one observer, what could be observed by any other observer is, thereby, completely determined. Logical consistency therefore forces us to seek alternative explanations of the pertinent and unilaterally accepted experimental results.

The velocity addition formula, discussed in the previous article, is not a necessary concomitant of maintaining that all motion is relative, but is required merely to support the currently accepted interpretation. In this article we discuss comparisons with the implications of a relativistic theory that retains a traditional velocity addition formula. Notice that abandoning this particular facet while retaining the Lorentz relationship between observed angles and distances to events, in no way jeopardizes any other acknowledged postulate of Einstein's relativity. The speed of light is still accepted as the same for every observer of an event, etc.

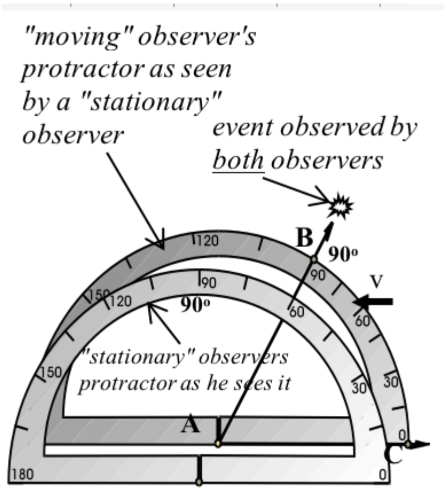
We will make several fascinating observations: First of all, if an observer were to have a firmly affixed transparent celestial sphere marked off with traditional declination and right ascension grid lines for easy reference to the directions of his observations, then the lines marked out on this sphere would transform for another observer in relative motion as determined by the Lorentz transformation equations. But stellar or other external objects that were aligned with those marks for one observer would not possess the same (however distorted) alignment with respect to these grid lines for another observer unless the objects happened to share the motion of the first observer.   If, for example, an object appeared at the interstices between declination 89, 59', 59" – 90 and right ascension 101 – 101, 1', 1", it would not reside between those lines if its motion relative to the first observer were sufficiently great. Where it would actually appear would depend intimately on its unique relative velocity. That is actually what *relative-to-me* rather than *relative-to-him* is all about whether the "him" is taken as an ab solute reference or not.



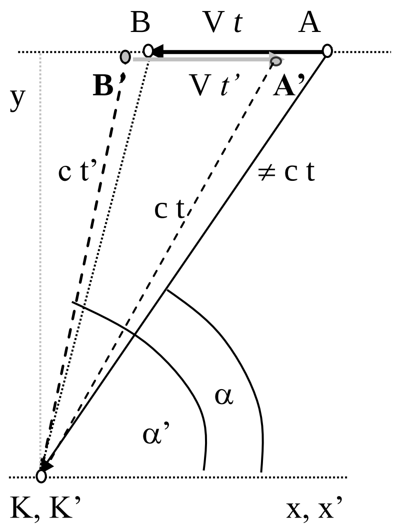
antinomy in the underground observatory,
drawn by R. F. Vaughan author circa 1975

Quite independent of one's stance on the velocity addition formula, one should realize that any constructed celestial spheres would differ considerably even with regard to the 'fixed' observations of another observer. See panels a. and b. in the figure above. Observations that appear straight-up for one observer will be displaced toward the horizon for another in relative motion. This is shown succinctly in the figure at top right, where the geometric distortion between the two becomes painfully obvious.

If its relative velocity were near that of the velocity of light, the source of a light emission event would appear at an increasing distance back along its path of approach. This is all very obvious if you think about it: Trace out a line of sight to a point on the world line of the object to determine the transit time for light from the object, then draw out the motion of the object from this position (A in the figure at bottom right) to a distance V t further along its world line trajectory (B) which will be how far the object travels while light is proceeding to this observer. This construction epitomizes Lorentz relationships between observations of observers in relative motion. A coincident observer stationary with respect to the object would not observe the object at the specific location B obtained by this construction, but at B' only because of the factor of γ. And if it is given that the relatively stationary observer observes the object at location B', then where an observer in relative motion will observe the event is at A ≠ A' which must be determined by reversing the source velocity in the Lorentz equations for that observer. The aberration formula is the following:

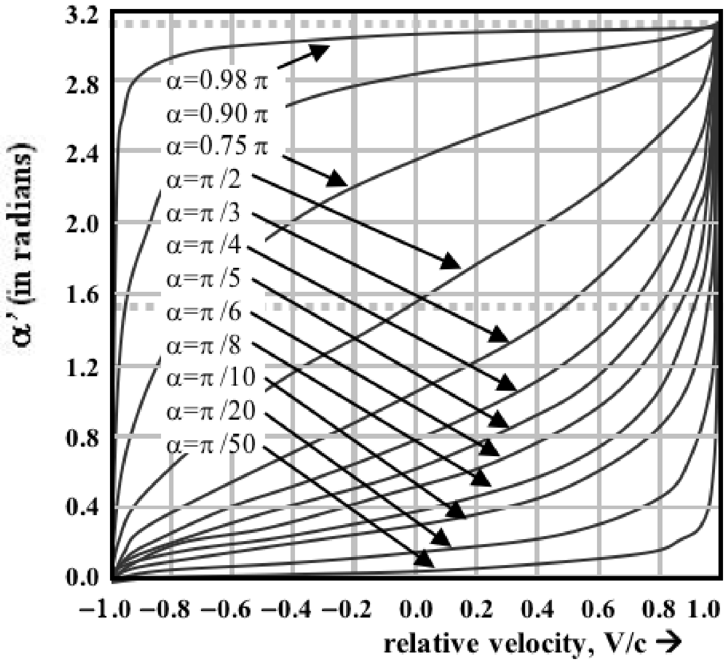


Uniformly moving observers do not share mutual geometrical understandings of events observed "in common".



$$\cos \alpha' = \frac{\cos \alpha - V/c}{1 - [V/c] \cos}$$

In the following figure we use this formula to illustrate the predicted angles α' that correspond to the various angles α with relative velocity ranging between the negative and positive value of the speed of light – approaching and receding sources of observed events. So for any given observed event in one frame of reference, event coordinates that would be observed by another observer is easily calculable.



Aberration as a function of angle α

All this discussion applies without too major disagreements on account of one insisting on one alternative interpretation or the other and the epistemological meaning of the associated Lorentz formulas – at least this is true to the extent of it making an easily quantifiable difference. Most macroscopic 'objects' continuously emit photons and a relatively 'stationary' observer will see all of these events as occurring at the same location and distance in the past. The only question is which one of these continuously replaced events a coincident relatively moving observer will actually witness for appropriate comparison. But this applies only to a world all of whose observable objects are stationary with regard to one observer or the other. What about a truly dynamic world, the real world, the one we live in? Where there are multiple motions such ambiguities must needs be resolved.

In this more generalized case, the observed location and time of occurrence of witnessed events will depend intimately on the individual motions of the platforms upon which the events occur just as we have seen above, and neither observer has a monopoly on the angular orientation of an entire sequence of events occurring on an object. Knowing the individual motions and when and where the events occurred in the stationary frames of the various objects, we could predict precisely where and when each event would be witnessed using the appropriate set of Lorentz 'transformation' equations that relate the frame of the object and that of any particular observer. About that there is no controversy. However, whether knowing the observations of a single observer, but without foreknowledge of where and when the observed events occurred in the various frames of reference of the objects upon which the events actually occurred, is sufficient to determine similar angular observations for another observer in uniform relative motion is what is at issue here.

Undismayed by the fact that a myriad of unique transformations would be required to determine the coordinates of any observer's observations, Einstein's interpretation of the Lorentz equations is that they have sufficient power to disambiguate all the uncertainties in predicting the observations of a second observer knowing only his motion relative to the first. This 'feature' of that interpretation – if you consider it such – is valid if and only if Einstein's velocity addition formula is accepted as true as we saw in the previous article. This formula (if valid) would allow one to group all of the various possible motions of objects upon which observed events appear to occur at a given angle for the first observer into a single transformation group that all transform to the very same angle for a second observer independent of their individual relative motions, again as shown in the previous article. If the set Vi includes all the unknown individual velocities of objects on which events occur that are seen in a given direction by one observer and v is the uniform relative velocity of the two observers, then the velocity addition formula maintains that the set of velocities of the objects in the frame of reference of the second observer would be Vi', as given by:

$$V_i' = \frac{v \pm V_i}{1 \pm v\, V_i / c^2} \;,$$

Here only the velocity component along a single direction of relative motion will be considered. If this formula is valid, then all events designated by i observed as occurring along the given line of sight by one observer will appear along a single line of sight also for any other coincident observer no matter what his motion. This is not 'more relative' than the traditional formula $V_i' = v \pm V_i$, of course, although it is much more handy if one wants to sweep uncertainty under the rug. But if we have learned anything during the last century, it is that uncertainty will not be swept under the rug. So we are left to assess whether – in addition to being handy – this formula happens to be scientifically valid.

The first line of thought to be pursued in this regard should be whether there is a quantifiable difference that would refute one formula or the other. To this endeavor one must compute the difference between the associated aberration angle predictions because that difference is the uncertainty that would pertain if Einstein's and Minkowski's interpretation is incorrect. If they are correct, then uncertainty's entry into our world must be via some other route. The two equations to be tested are:

$$\cos \alpha_{EM}' = \frac{\cos \alpha - (v \pm V_i) / c}{1 - [(v \pm V_i) / c] \cos \alpha}$$

and the boosting alternative,

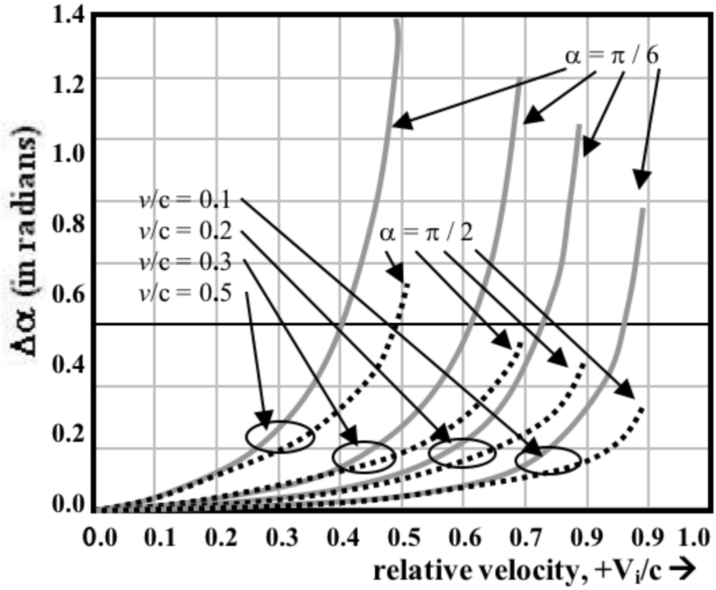
$$\cos \alpha_{EM}' = \frac{\cos \alpha - (v \pm V_i) / (1 \pm v V_i / c^2) c}{1 - [(v \pm V_i) / (1 \pm v V_i / c^2) c] \cos \alpha}$$

Naturally large relative velocities are required to make a measurable difference in the values computed in the two cases. There is also an angular dependence that affects the size of the difference. These variabilities are all exhibited in the figure that plots $\Delta\alpha$ on the following page.

Clearly the predicted uncertainties associated with the traditional formula become very large for large values of v and V_i. But for velocities experienced even by the earth in its orbit about the sun (an annual variation of 2×10^{-4} c) a maximum uncertainty to be expected of stellar observations is smaller than the resolution of telescope observations – in fact, much less than 10^{-9} radians. But we have become accustomed to our macroscopic world not seeming to exhibit uncertainties known to characterize microscopic domains to which quantum realities pertain. But in thermodynamics, where molecular velocities at quite mundane temperatures can attain component velocities that are appreciable relative to the speed of light, some strange things happen.

It should be noted that the velocity addition formula (boosting) as discussed here does not pertain to the velocity of a photon of light emitted from a relatively moving source. Photons are not 'objects' in any similar sense to that of billiard balls. The 'velocity of light' to the extent that light can be considered to travel through space must be handled differently as double slit and other experiments with light have indicated.

So without sufficient instrumental accuracy to refute one interpretation or the other, is it really reasonable to fight quite so vindictively for the established view based on a 1906 vintage 'law of the transmission of light'? Letting it go may be the key to the compatibility of the so disparate theories of physics, the dissimilarities of which involve the treatment of observation and uncertainty both at issue here. Certainly there is reason for confusion in this regard and one can never return to that state of bliss before relative motion was found to legitimately confound all epistemological options concerning our perceptions. The relative locations and times of occurrence that one must associate with observed events that are being viewed here and now differ considerably from one observer to another who does not happen to share the same relative velocity to observed objects. The fact that one of the implications of relative motion may be weirder than was first thought, while others are less so, need hardly alarm a world accepting of uncertainty. That those implications should altogether prohibit laying out mutually agreeable arrays of numbers as a metric of a physical space and time acceptable to any and all observers for all time, giving rise to epistemological problems in dealing with such anomalies should prove little more than fascinating.



The amount of uncertainty in angular position α' to be expected as a function of directions of line-of-sight α, relative velocity of observers v, and the relative velocities V_i of platforms of the various events.

Of course, there are weighty issues at stake with regard to changing the established interpretation. Much of the dogma associated with spacetime would be rendered supercilious were we to embrace something closer to what Kant conceived – space and time (and indeed all mathematics) as logical rather than physical constructs. It seems to the author that space and time are merely associated with our view the world, not empirical knowledge concerning the world itself. This is what we should always have anticipated and questioning an establishmentarian view that has remained sacrosanct for too long, has scientific value as well.

Although one's reputation could be in serious jeopardy if one were to attempt to disassociate what God himself (according to one guru or another) seems to have united in holy matrimony, it can provide a certain amount of exhilaration so necessary for aging curmudgeons such as the current author. So he will allow himself the luxury of contemplating even such a disaster as a divorce of space and time, remembering that idyllic virginity before Minkowski sanctified their holy union with, "henceforth these two shall be one!"