

Asymmetry in Measurements near Light Speed

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Abstract

The intentions of this theoretical exercise are two-fold. Firstly, the relationship between measurement and the theory or hypothesis that is tested is discussed as a methodological challenge. It is argued that measurements will always lead to multiple explanations of the data. Secondly the consequences of this stance are explored with measurements of objects moving with high velocities. The generally accepted equations of such objects are mirrored against an alternative interpretation, that is based on ‘deconstructing’ the way that such measurements are carried out. More specifically, this contribution concentrates on asymmetry in *point measurements*, which are measurements that are conducted from one spatial location. As many measurements require multiple samples, this may imply that consecutive measurements move with respect to the measuring device. This may cause an asymmetry, or *myopia*, in the data that is collected. Such measurements should therefore be corrected for the corresponding effects.

This article will give a theoretical description of the myopia in point measurements specifically for objects moving with high velocity, in particular near the speed of light. It is demonstrated that the results are in correspondence with the equations that are commonly used to describe the velocities of such particles, such as the Lorentz transformations or the energy-momentum relationship, although the interpretation of these outcomes are somewhat different.

1 Introduction

Many measurements require subsequent samples in order to detect the qualities that the measuring device aims to discover. Speed, for instance, requires at least two subsequent measurements of location within a given time. Simple Newtonian mechanics then states that the difference of the two locations divided by the time gives the speed.[8]

The theory of special relativity tells us that this type of measurement becomes complicated at high velocities, especially near the speed of light.[5] The theory suggests that space and time ‘bend’ around objects moving with such high velocities, and that the measurements therefore yield different results than those of particles travelling at relatively low speed, which tend to be more or less linear.

There is a deeply philosophical problem related to this interpretation of the relationship between space and time. Although scientific methodology often takes care to accentuate the transient nature of scientific theory [18], many practitioners are trained in what could be called an ‘objectifying world-view’ [1] where theory, if supported by solid experimental evidence, is considered to accurately describe certain aspects of reality.[6] If a fundamental problem of measurement is overlooked, the resulting *myopia* will be included in the models, as if this myopia is part of that reality

(and in a way it is, because it is fundamental). The question then becomes: how can we be sure if a measured phenomenon is ‘part’ of the reality under investigation, or whether it is the result of fundamental myopia?

The theoretical premises on which this particular contribution is based, does not follow this notion of objectification, but instead follows the ideas of classical dialectics.[17] Dialectics is an accepted methodological foundation in the social sciences and the humanities,[7] but because of the focus on humans and human societies, it is easy overlooked that dialectics originally was considered to be a natural philosophy, which is highly suspicious of our means to ‘truly’ and ‘exactly’ model our observed reality. Hence classical dialectics, rather than an objectifying approach to measurement, supports a more ‘in-ward’ looking approach, where the nature of observation is included in that what is observed. This resonates with the ideas of contemporary thinkers, such as Edgar Morin [13] and Paul Cilliers.[2]

For this particular exercise the question arises if a dialectical interpretation can be developed that respects the results of scientific research, but offers a different explanation of the observed phenomena, based on modelling the manner of measurement itself. Preferably this approach should be able to derive the essential equations of generally accepted scientific interpretations, without the need of postulates or other ‘fixes’, in order to match the models with the corresponding measurements. The goal of such an exercise is therefore not to disprove existing theories, but to offer an alternative lens that allows to critically assess them.[14, 15]

This contribution aims to engage in such an exercise when measuring objects that are travelling at relatively high velocities. If, as Heisenberg already pointed out, speed requires at least two measurements [10], then the relative distance between consecutive measurements changes with respect to the measuring device. Such measurements that are performed from one location will be called a *point measurement*. The exercise sets out to offer an interpretation of measurements of presences at high velocities that derives a number of essential equations that are currently used to explain the observed behaviour at these velocities:

1. The Lorentz equation
2. Length contraction
3. The Lorentz transformations
4. The energy-momentum relationship
5. Gravitational potential energy

Even though the exercise will focus on the measurement of high velocities, the general ideas can be extrapolated to any sequence of measurements that cause asymmetries with respect to the measurement device. This exercise can therefore contribute to the methodological foundations of metrology and may advance a critical attitude towards the approaches of metrology in general.

2 A First Exploration

Figure 1 gives an overview of a point measurement, in this case of a particle p travelling with speed v past a measuring device located at O . We will focus on this very simple example as a first exploration for the theoretical exercise given here.

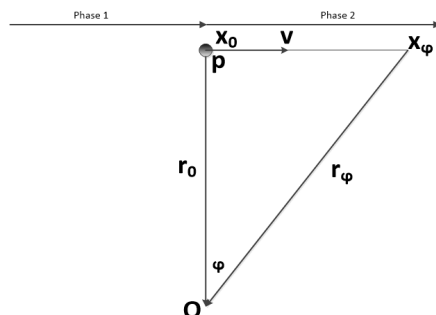


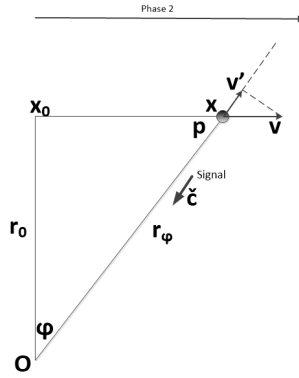
Figure 1: Presence traveling with velocity v near measuring device O

A complication of this type of measurement is that the data is not sampled at the locations of x_0 and x_φ itself. Instead information *about* these locations are transferred to the measuring device, which are then *interpreted* to yield information about the location and the time it took to detect consecutive samples. For instance, if one wants to measure the velocity of a planet with a telescope, then one will use (sun-) light that is reflected against the surface of the celestial body at (at least) two consecutive moments, and measure the displacement of the celestial body between these. This may sound trivial at first glance, but we have to remember that we are not measuring the actual location of the planet, but instead we are *interpreting* the light that the telescope is detecting. This manner of measurement is quite common, and so we can abstract this idea by stating that such measurements always involves a flow of *signals* that relay the requested information between the object under investigation and the measuring device. Following Terence Deacon, we will call such objects in a certain observed reality a ‘*presence*’.[4]

The example of the telescope also tells us that these signals travel with a finite speed, which in this case is the speed of light, but for the sake of this theoretical exploration this idea can be abstracted to a certain speed \check{c} . Note that in this configuration, the measurement is not symmetrical, because the velocity v of the presence is causing an offset. Lastly, figure 1 tells us that there are three distinct situations of the measurement of speed:

1. (Phase 1): Measurements when a presence is moving in the direction of the measuring device
2. The measurement when the distance between the presence and the measuring device is the shortest.
3. (Phase 2): Measurements when the particle is moving away from the measuring device.

The interesting question now becomes what happens if the velocity of the presence starts to converge towards the speed \check{c} of the signals. We will analyse this situation using straightforward Newtonian mechanics, beginning with phase 2 of the measurement.[8]

Figure 2: Particle p traveling with speed v

Suppose that a presence p is travelling with speed v in horizontal direction, as is depicted in figure 2. The presence emits (or reflects) signals regularly, that are detected by O . These signals are used in O to measure the properties of p . Suppose also that there is a certain ‘slowness’ [3] before signals coming from p are detected by O . This means that if p is sending a signal to O at location x_φ , and it takes a certain time t_φ before the signal reaches O , then we can define the speed \check{c} of the signal as:

$$\check{c} = r_\varphi/t_\varphi \quad (1)$$

Note that \check{c} is not necessarily the speed of light.

If observer O aims to measure the velocity of the particle, then at least two measurements have to be made, but as the position of O is fixed, this means that there is a slight difference between the measurements, as some signals follow r_0 and others r_φ . Suppose that:

- t_φ is the time that it takes for a signal to travel from x_φ to O , along r_φ
- the velocity of the signal is affected by the speed of p
- $\check{c} = r_\varphi/t_\varphi$ is a constant
- $v' = v \cdot \sin\varphi = \frac{vx}{r_\varphi}$

then we can infer for a signal travelling along r_φ :

$$r_\varphi = (\check{c} - v')t_\varphi \rightarrow r_\varphi = \left(\check{c} - \frac{vx}{r_\varphi}\right)t_\varphi \quad (2)$$

This yields two situations when $r_\varphi = 0$:

$$\begin{aligned} r_\varphi = 0 &\rightarrow t_\varphi = 0 \vee \\ \check{c} = \frac{vx}{r_\varphi} &\rightarrow \frac{r_\varphi}{x} = \frac{v}{\check{c}} = \beta \end{aligned} \quad (3)$$

The first solution applies if O is in the same coordinate frame as p , while the latter solution is only possible if $v = \check{c}$, and $x \geq r_\varphi$. Obviously r_φ is determined by geometrical properties, and so equation (3) actually suggests that (2) only yields real results if $0 \leq v \leq \check{c}$. Likewise, $r_\varphi \geq \beta x$ suggests a boundary condition for O when this type of measurement is possible. If $v \geq \check{c}$, then $t_\varphi \rightarrow \infty$, and

it is no longer possible to measure v in any location for O . The velocity \check{c} of the signals therefore designates an upper limit for a point measurement of v .

Given that $r_\varphi = \sqrt{r_0^2 + x^2}$, $r_0 = \check{c}t_0$, and if:

$$\theta = \frac{v \cdot t_\varphi}{r_\varphi} \quad (4)$$

Then (2) can be rewritten as:

$$\begin{aligned} r_\varphi &= \sqrt{r_0^2 + x^2} = (\check{c} - v \frac{x}{r_\varphi}) t_\varphi = \check{c}t_\varphi - \theta x \rightarrow \\ r_0^2 + x^2 &= (\check{c}t_\varphi - \theta x)^2 \rightarrow \\ r_0^2 + x^2 &= \check{c}^2 t_\varphi^2 - 2\check{c}t_\varphi \theta x + \theta^2 x^2 \rightarrow \\ (1 - \theta^2)x^2 &= \check{c}^2(t_\varphi^2 - t_0^2) - 2\theta x \check{c}t_\varphi \rightarrow \\ (1 - \theta^2)x^2 &= \check{c}^2(t_\varphi^2 - t_0^2 - \frac{2\theta x t_\varphi}{\check{c}}) \end{aligned} \quad (5)$$

Note here that phase 1 of the measurement is only marginally different:

$$r_\varphi = \sqrt{r_0^2 + x^2} = (\check{c} + v \frac{x}{r_\varphi}) t_\varphi \rightarrow (1 - \theta^2)x^2 = \check{c}^2(t_\varphi^2 - t_0^2 + \frac{2\theta x t_\varphi}{\check{c}}) \quad (6)$$

(5) and (6) can be somewhat simplified if the following approximations are allowed:

- $t_\varphi \gg t_0$
- $v' \ll \check{c} \rightarrow r_\varphi \approx \check{c}t_\varphi$

These conditions apply for high velocities in phase 2, when the presence is still relatively close to the measuring device but is already significantly moving away from O :

$$\begin{aligned} \theta &\approx \frac{v}{\check{c}} = \beta \rightarrow \\ (1 - \beta^2)x^2 &\approx \check{c}^2 t_\varphi^2 \rightarrow \\ x &= \frac{\check{c}t_\varphi}{\sqrt{1 - \beta^2}} = \frac{r_\varphi}{\sqrt{1 - \beta^2}} = \gamma r_\varphi \rightarrow \\ \gamma &= \frac{x}{r_\varphi} \end{aligned} \quad (7)$$

Where:

$$\gamma = (1 - \frac{v^2}{c^2})^{-1} \quad (8)$$

is the *Lorentz factor*.^[16] So you can derive the Lorentz factor as an approximation of (5) and (6), given the two approximations that yield (7). The Lorentz factor is generally seen as a crucial equation to understand the concept of space-time in physics, when velocities approach the speed of light.^[8]

It is worthwhile here to note that the approximations that are used here to derive the Lorentz factor are *not* generalisations. The approximations are actually consciously used to yield a generally accepted outcome in physics. One could say that, from a dialectical perspective, the Lorentz factor *is* already an approximation of a more complex equation(5) that has been verified experimentally and is sufficiently precise to further our understanding of the relationship between space and time. Conversely, if the approximations used here are questionable, equations (5) and (6) still stand as a more precise description of the phenomena under investigation. The dialectical argument would therefore be that it yields more precise results than currently accepted theory, but uses approximations to demonstrate that it *does* comply with the outcomes of special and general relativity. This particular use of approximations will occur more often in this expose.

A similar approach can be taken for the (perceived) *length contraction* of the presence. If the total time of two consecutive measurements is:

$$t = -t_0 + \tau + t_\varphi \quad (9)$$

Where τ is the actual time that the presence travels from x_0 to x_φ then:

$$\begin{aligned} vt &= v(t_\varphi - t_0 + \tau) \rightarrow \\ x &= v(t_\varphi - t_0) + x' \rightarrow \\ x &\approx \beta(r_\varphi - r_0) + x' \rightarrow \\ x &\approx \beta\Delta r + x' \end{aligned} \quad (10)$$

Or:

$$\begin{aligned} x^2 &\approx \beta^2(r_\varphi^2 - 2r_\varphi r_0 + r_0^2) + 2\beta\Delta r x' + x'^2 \rightarrow \\ x^2 &\approx \beta^2(x^2 - 2r_\varphi r_0 + 2r_0^2) + 2\beta\Delta r x' + x'^2 \rightarrow \\ (1 - \beta)^2 x^2 &\approx -2\beta^2 r_\varphi r_0 + 2\beta^2 r_0^2 + 2\beta\Delta r x' + x'^2 \rightarrow \\ (1 - \beta)^2 x^2 &\approx -2\beta^2 r_0 \Delta r + 2\beta\Delta r x' + x'^2 \rightarrow \\ (1 - \beta)^2 x^2 &\approx 2\beta\Delta r(x' - \beta r_0) + x'^2 \rightarrow \\ (1 - \beta)^2 x^2 &\approx x'^2 \rightarrow x \approx \frac{x'}{\gamma} \end{aligned} \quad (11)$$

If x' therefore is the actual distance travelled by the presence, then the *measured* distance is somewhat smaller, with a factor $1/\gamma$, just as the theory of *length contraction* suggests. However, in this case the interpretation of the data is not that there are different frames with their own specific time, rather the difference is the result of measuring the actual locations with a local time of the measuring device, thereby omitting the slowing down of the signals t_φ .

3 Non-linear Measurements

The dialectical interpretation that is developed here suggests that point measurements on velocity are not linear, which begs the question how the actual speed of a moving presence relates to the measured values recorded by the observer, or how the vector $\begin{bmatrix} x & t \end{bmatrix}$ of the presence relates to the vector $\begin{bmatrix} r_\varphi & t_\varphi \end{bmatrix}$ that is measured. From (7) it follows that:

$$x = \gamma r_\varphi \quad (12)$$

A corresponding time t' can be defined as:

$$x = \check{c}t' = \gamma r_\varphi = \gamma(\check{c}t - \beta x) \quad (13)$$

As a result:

$$\begin{aligned} x &= \gamma r_\varphi \\ \check{c}t' &= \gamma(\check{c}t - \beta x) \end{aligned} \quad (14)$$

At first glance these equations seem to be a bit unnecessary, especially since t' does not have a real meaning. The combined equations however actually closely resemble the *Lorentz transformations*, which are used to calculate the curvature of space and time in O when a presence passes by with a certain velocity.[9] Apparently the Lorentz transformations can also be seen as an approximation of the adjustment needed when measuring a presence travelling with a high velocity. This means that experiments that have been carried out to demonstrate special relativity also confirm the theoretical findings offered by this expose. However, the interpretation of myopia offered here allows for a somewhat simpler explanation of the correction factors. If we simply consider $x = vt$ then:

$$\begin{aligned} r_\varphi &= (\check{c}t - \beta vt) = \check{c}(1 - \beta^2)t = \frac{\check{c}t}{\gamma^2} \rightarrow \\ t_\varphi &= \frac{t}{\gamma^2} \end{aligned} \quad (15)$$

Therefore the necessary correction factor for the measured values of $[x, t]$ is:

$$\begin{bmatrix} x \\ t \end{bmatrix} = \gamma \begin{bmatrix} 1 & 0 \\ 0 & \gamma \end{bmatrix} \begin{bmatrix} r_\varphi \\ t_\varphi \end{bmatrix} \quad (16)$$

4 A General Description of Point Measurements

In the previous section, the Lorentz factor and transformations can be calculated when making certain approximations about t_φ and v' . Also v is presumed to be perpendicular to the line r_0 . A more generalised situation is given below in figure 3.

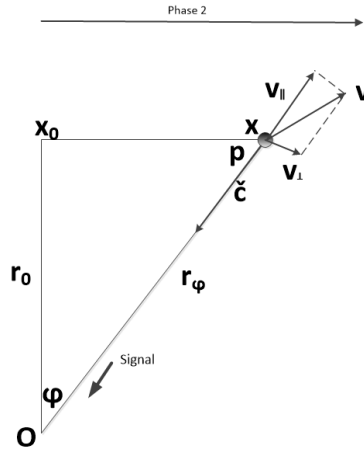


Figure 3: Presence p travelling with velocity v

As a more general take on a point measurement, a factor ς can be defined so that $r_\varphi = \varsigma t_\varphi$. If this is applied to (2) we get:

$$\begin{aligned} \varsigma t_\varphi &= \left(\check{c} - v_{\parallel} - \frac{x}{r_\varphi} v_{\perp} \right) \cdot t_\varphi \rightarrow \varsigma = \check{c} - v_{\parallel} - \frac{x}{r_\varphi} v_{\perp} \rightarrow \\ \frac{\varsigma}{\check{c}} &= 1 - \frac{1}{\check{c}} (v_{\parallel} + \frac{x}{r_\varphi} v_{\perp}) = 1 - \frac{1}{\check{c}} (v \cos \varphi + \beta v \sin \varphi) \rightarrow \\ \frac{\varsigma}{\check{c}} &= 1 - \beta (\cos \varphi + \beta \sin \varphi) \end{aligned} \quad (17)$$

The transformation factor $\frac{\varsigma}{\check{c}}$ gives a measure how velocity v is *experienced* in O . This experience is influenced by three factors:

- The ‘normal’ Newtonian situation
- The effect of v_{\parallel}
- The effect of the previously described myopia on v_{\parallel} , which is a function of v_{\perp}

In other words, when measuring velocity:

$$v_O = \frac{\varsigma}{\check{c}} v = (1 - \beta (\cos \varphi + \beta \sin \varphi)) v \quad (18)$$

But owing to the nature of the measurement, one can assume that $x_{jj}r$ and thus that $\varphi \approx 0$. Therefore:

$$v_O \approx (1 - \beta) v \quad (19)$$

This equation can be interpreted as an extra component on v_{\parallel} that is determined by v_{\perp} . The factor determined by myopia therefore can simply be written as:

$$v_{O\perp} = \beta v_{\perp} \quad (20)$$

For instance, the momentum of a mass bearing particle experienced at O will be:

$$p_O = m \cdot v_O = (1 - \beta) p \quad (21)$$

Likewise, the kinetic energy of that presence will appear to be in O :

$$E_O = \frac{1}{2}m.v_O^2 = (1 - \beta)^2 \frac{1}{2}m.v^2 = (1 - \beta)^2 E_{kin} \quad (22)$$

If the expected theoretical models suggest conservation of energy, then a certain factor needs to be *added* to the equation in order to compensate for the loss that is experienced, but (20) also suggests that the energy distribution in x has to be understood by the qualities of the *vector* \vec{v} . Equation (22) can therefore be replaced by an alternative, which *assumes* the conservation of energy as measured in O :

$$E_O^2 = E_{\parallel}^2 + E_{\perp}^2 = (1 + \beta^2)E_{tot}^2 \quad (23)$$

Suppose now that $E_{tot} = m\check{c}^2$ describes the maximum energy that a presence with mass m can convey in O when signals travel with velocity \check{c} :

$$E_O^2 = \left(1 + \frac{v^2}{\check{c}^2}\right)(m\check{c}^2)^2 = (m\check{c}^2)^2 + (m\check{c}v)^2 = (m\check{c}^2)^2 + (p\check{c})^2 \quad (24)$$

This equation is similar to the *energy-momentum relationship*, [20] but in this case the relationship is found by compensating for the myopia, with a factor β^2 . In other words, the apparent loss of E in O is compensated by adding extra energy to the equation in order to make the model ‘fit’ with the expected results, where the energy is conserved from the perspective of O . Equation (20) therefore offers the crucial insight of the asymmetry that is measured in O , as the energy balance between the lateral component E_{\parallel} and the transversal component E_{\perp} seems to shift with a factor β^2 . This leaves the theoretician with a challenge to explain the change in the total energy that is measured, if energy is conserved.

5 Centrifugal Forces

So far, the mismatch between expected results and the actual measurements have become clear in the case of conservation of energy and momentum. There is one other situation when the nature of velocity is theoretically evident, which is when dealing with centrifugal forces. In this case the force is pointing in the direction of O , and the lateral component $v_{\parallel} = 0$. Besides this, there is a clear relationship between E_{\parallel} and E_{\perp} .

In order to understand the myopia in this configuration, it is worthwhile to make an additional refinement of figure 3. It was argued earlier that a measurement of velocity always involves a pair of measurements, as is depicted in figure 4:

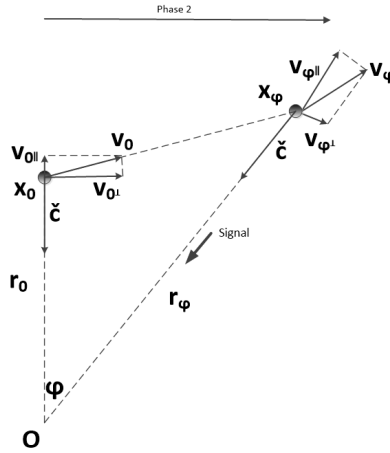


Figure 4: consecutive measurements of presence p traveling with speed v

As opposed to figure 3, the following applies:

$$\begin{aligned}
 v_{O\varphi} - v_{O0} &= \frac{v_{\varphi}}{\check{c}} - \frac{v_0}{\check{c}} \rightarrow \\
 \Delta v_O &= v_{\varphi} \left(1 - \frac{v_{\varphi||}}{\check{c}} - \frac{x_{\varphi}}{\check{c}r_{\varphi}} v_{\varphi\perp}\right) - v_0 \left(1 - \frac{v_{0||}}{\check{c}} - \frac{x_0}{\check{c}r_0} v_{0\perp}\right) \rightarrow \\
 \Delta v_O &= \Delta v - \frac{1}{\check{c}}(v_{\varphi} v_{\varphi||} - v_0 v_{0||}) - \frac{1}{\check{c}} \left(\frac{v_{\varphi} x_{\varphi}}{r_{\varphi}} v_{\varphi\perp} - \frac{v_0 x_0}{r_0} v_{0\perp}\right)
 \end{aligned}
 \tag{25}$$

Because $x_0 = 0$, and (thus) $x_{\varphi} = \Delta x$:

$$\Delta v_O = \Delta v - \frac{1}{\check{c}}(v_{\varphi} \cdot v_{\varphi||} - v_0 v_{0||}) - \frac{\beta \Delta x}{r_{\varphi}} v_{\varphi\perp}
 \tag{26}$$

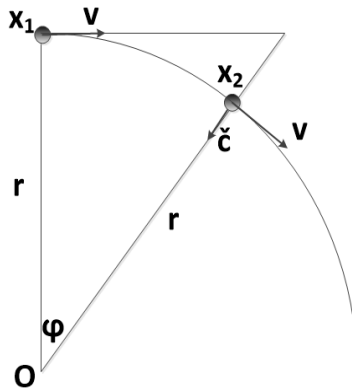


Figure 5: Presence p travelling with speed v in a circular motion around O

A special circumstance occurs if the particle is in circular motion around O , as is depicted in figure 5. In this case v is constant, and $r_{\varphi} = r_0 = r$:

$$\Delta v_O = \frac{-\beta v_{\perp}}{r} \Delta x
 \tag{27}$$

If (27) is depicted as a differentiation over time, then:

$$G_O = \frac{dv_O}{dt} = -\frac{\beta v_{\perp}}{r} \frac{dx}{dt} = -\frac{\beta v^2}{r} \quad (28)$$

Or:

$$G_O = -\frac{\beta v^2}{r} = -\beta G \quad (29)$$

The apparent *centripetal acceleration* G_O [12] therefore includes a loss factor β owing to the myopia, which yet again confirms (20). If the presence contains mass, and a centrifugal force in O is determining the motion, then the total force becomes:

$$F_O = (1 - \beta) \frac{mv^2}{r} = (1 - \beta)mG = (1 - \beta)F \quad (30)$$

Here again we can witness the challenge of ‘fitting’ the results of the measurement with the theoretical models. Equation (30) suggests that the experienced force becomes weaker when v increases, but if the theory suggests that F_O *ought* to have a certain value F , then this must somehow be compensated, by a certain unknown phenomenon ‘in reality’. So a factor βF has to be added to the theoretical models in order to compensate for the measured losses.

This problem of ‘fitting’ becomes particularly apparent when looking at the energy of the presence. In the particular case of centrifugal force, the energy balance between U_{\parallel} and U_{\perp} becomes a bit more specific. The total apparent energy in O of the particle with mass M can be written as the sum of three components:

$$U_O(m) = -U_{\parallel} + U_{\perp} - U_R \quad (31)$$

- U_{\parallel} is the (lateral) energy of the force acting on the particle, from O
- U_{\perp} is the (resulting) kinetic energy of the particle in orbit around O
- $U_R = \beta^2 U_{\perp}$ is the apparent ‘loss’ due to the myopia

The negative signs of the two lateral components follow the direction away from O . Newtonian mechanics suggests that: [19]

$$\begin{aligned} U_{\parallel} &= \frac{GMm}{r} \\ U_{\perp} &= \frac{L^2}{2mr^2} \end{aligned} \quad (32)$$

Where the angular momentum $\vec{L} = \vec{r} \cdot \vec{p} = \vec{r} \cdot m\vec{v} = m(\vec{r} \cdot \vec{v})$

In this particular case, U_{\parallel} and U_{\perp} are also mutually related, as both are the result of the same force. As $U_R = \beta^2 U_{\perp}$, it is possible to write $U_R = k\beta^2 U_{\parallel}$, where k is an unknown constant that scales U_{\parallel} and U_{\perp} . As a result, when adopting a vector notation:

$$\begin{aligned} U_R &= k|\beta^2|U_{\parallel} = k(\vec{1} \cdot \vec{\beta})^2 \frac{GMm}{r} \\ k \frac{GM}{mr^3} (\vec{r} \cdot \frac{m\vec{v}}{c})^2 &= k \frac{GM}{m\check{c}^2 r^3} (\vec{r} \cdot m\vec{v})^2 = k \frac{GML^2}{m\check{c}^2 r^3} \rightarrow \\ k \frac{GMm}{r} \frac{L^2}{2mr^2} \frac{2}{m\check{c}^2} &= 2k \frac{U_{\perp} U_{\parallel}}{m\check{c}^2} \end{aligned} \quad (33)$$

If this is applied in (31) then:

$$U_O(m) = -U_{\parallel} + U_{\perp} - U_R = \frac{-GMm}{r} + \frac{L^2}{2mr^2} - k \frac{GML^2}{m\check{c}^2 r^3} \quad (34)$$

Interestingly enough, if $k=1$, then this equation is equivalent to the *gravitational potential energy*, [19] with the exception that it applies for any given speed \check{c} of signals instead of just the speed of light. It was argued earlier that $E = m\check{c}^2$ is the maximum energy that can be measured at O , given a certain speed \check{c} of the signals, and so (33) suggests that U_R is simply a measure for the scaling of U_{\parallel} and U_{\perp} in O , which divides the total energy over the lateral and transversal component. For instance, U_{\perp} can also be rewritten to:

$$U_{\perp} = \frac{L^2}{2mr^2} = \frac{(\vec{r} \cdot \frac{m\vec{v}}{\check{c}})^2 \check{c}^2}{2mr^2} = \frac{(\vec{r} \cdot \vec{\beta})^2 m\check{c}^2}{2r^2} = (\vec{1} \cdot \vec{\beta})^2 \frac{1}{2} m\check{c}^2 = |\beta^2| \frac{1}{2} E \quad (35)$$

The above equation is a somewhat superfluous way to demonstrate that β can be considered a factor that scales the energy U_{\perp} against a certain maximum potential energy, owing to the fact that v has an upper limit in \check{c} . This basically reaffirms the outcome of (20) and (22). In other words, the total potential energy $U_O(m)$ of the system as perceived in O equals:

$$U_O(m) = U_{\perp} - (1 + \beta^2)U_{\parallel} = \frac{1}{2}\beta^2 E - (1 + \beta^2)U_{\parallel} \quad (36)$$

This offers a much simpler explanation of the gravitational potential energy than current interpretations of the measured effects.

6 Uncertainty, Sensitivity and Confidence Interval

the alternative interpretation of fundamental myopia offered demonstrates an *apparent* loss of velocity, momentum and energy in O when high velocities are being measured. This loss concerns a factor β along the lateral line between the measuring device and the presence under investigation, as is concisely summarised by equation (20). It is suggested that measurements of speed near \check{c} become skewed in O if one accepts that, with a point measurement, not the *actual* locations are measured, but instead that a flow of signals are interpreted by the measuring device. This skewing of the measurements, or myopia, is caused by:

1. the velocity v of the presence
2. the nature of the measurement, in this case a point measurement.
3. the assumptions behind the models that are tested, such as conservation laws.

The theoretical expose demonstrates that this does not only apply for the speed of light, but for any speed \check{c} of a signal. This means that the theory can be easily verified in an experimental setting with relatively low values of \check{c} , for instance the speed of sound.

The dialectical interpretation offered here uses certain approximations to derive well-known outcomes of special and general relativity, but aims to become increasingly precise as the argument develops. The fact that the given approximations provide these outcomes therefore argues that the Lorentz transforms provide the necessary correction that is needed for point measurements on velocity, as this has been confirmed on many different occasions, such as the Michelson-Morley experiments.[11] These experiments suggest that the given approximations yield good enough results for most measurements near light speed.

Conversely one could state that the arguments given here provide a framework for more accurate readings of velocities near light speed, when these approximations are not used. It could even provide a measure for the accuracy of currently accepted theories. For instance, one could state that the *uncertainty* of the Lorentz transformations is mainly determined by (4):

$$\theta = \frac{v \cdot t_\varphi}{r_\varphi} = \frac{v}{\tilde{c} - v'} = \frac{v}{\tilde{c}} \left(\frac{1}{1 - \frac{v'}{\tilde{c}}} \right) = \beta \left(\frac{1}{1 - \frac{v'}{\tilde{c}}} \right), \text{ with } \frac{v'}{\tilde{c}} \in (0, 1) \quad (37)$$

This suggests that the uncertainty of the measurement increases with v' . Apparently the accuracy is the highest when the distance between the presence and O or v' is relatively small.

In a similar fashion, the *sensitivity* of the measurement is largely determined by equation (26):

$$\Delta v > \frac{1}{\tilde{c}} (v_\varphi \cdot v_{\varphi\parallel} - v_0 v_{0\parallel}) + \beta v_{\varphi\perp} \sin \varphi \quad (38)$$

Thus the *confidence interval* is largely determined by the angle of consecutive measurements, and is between:

$$\frac{1}{\tilde{c}} (v_\varphi \cdot v_{\varphi\parallel} - v_0 v_{0\parallel}) \wedge \frac{1}{\tilde{c}} (v_\varphi \cdot v_{\varphi\parallel} - v_0 v_{0\parallel} + v v_{\varphi\perp}) \quad (39)$$

So a dialectical approach to these measurements not only allows us to derive the main equations of presences travelling near light speed, but also gives a measure for the accuracy of the values measured in O .

7 Conclusions

This theoretical exercise aims to demonstrate that an alternative interpretation of the behaviour of a presence travelling at high velocities can be developed, owing to a fundamental asymmetry in point measurements when measuring speed. The proof of this alternative interpretation is given by deriving five generally accepted equations that are currently used to describe the behaviour of such particles:

1. The Lorentz equation (8)
2. Length contraction (11)
3. The Lorentz transformations (14)
4. The Energy-Momentum relationship (24)
5. Gravitational Potential Energy (34)

These are all derived without the need of postulates, and using fairly standard principles of Newtonian mechanics. Besides this, the dialectical approach to measurements at relatively high velocities that is explored here allows for a measure of the accuracy of the measured values in O . The accuracy is the highest when the distance between the presence and O is relatively small.

Most importantly, this theoretical expose draws attention to underlying beliefs that govern the interpretations of measurement. Point measurements are one of the most fundamental ways of detecting other presences in our observed reality, and so the myopia that is present when measuring speed can be witnessed in all particles that are affected by a presence that is cruising by. Above

all, other forms of myopia in other types of measurements could be discovered by adopting the dialectical approach that is explored in this article.

8 Data availability

No data sets have been used for this article and all information provided is based on generally available sources

9 Conflict of interest

The author declares that there is no conflict of interest.

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