A Radical New Perspective on Special Relativity

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Abstract

Over the past 119 years measurable effects have consistently conformed with the postulates of Special Relativity (SR) to a high degree of precision. In that time also, though, advances in understanding of particle-energy interactions have revealed the likelihood that some (possibly all) of those effects are due to causes other than SR as it is conventionally interpreted. For example: to Einstein, Fizeau's experiment [1] was key to his own confidence in SR. He explicitly highlighted "the conclusiveness of [Fizeau's] experiment as a crucial test in favour of the theory of relativity" [2]. However, speed of light through water is now known to result from light being impeded by interaction with the atoms of the water itself. We show that, by considering frequency of interaction of light with atoms of a moving host medium, Fizeau's results can be fully explained without any reference to SR. We further show that relativistic time dilation is arguably the mechanistic consequence of an object's motion and that apparent frame invariance of light speed may be accounted for as a motion-induced subjective experience. The symmetric Lorentz transformation emerges from this basis as likewise a subjective experience, precisely matching the apparently objective reality of SR. Other perceived effects of SR follow from this. Well-defined causal relationships in a preferred-frame universe may therefore possibly be responsible for a cosmos indistinguishable by measurement or experience from the conventional SR interpretation of objective inertial-frame equivalence.

Keywords

Fizeau, Lorentz, "Time dilation", "de Broglie", "Breit-Wheeler", zitterbewegung

1. Introduction

Over the latter half of the 19th Century the scientific community was troubled over the results of Fizeau's 1851 experiment(s) measuring the speed of light in moving water [1]. According to the prevailing wisdom at the time, the speed of light travelling in the same direction as the moving water should result from simple addition of the water's speed to the speed of light in still water (and from subtraction of the water's speed if travelling in the opposite direction). Sure enough, the light's speed was increased in water moving in the same direction – but by significantly less than the speed of the water itself. There seemed no obvious explanation for this discrepancy.

Then in 1905 Einstein offered a solution to this conundrum, in the form of his Special Theory of Relativity [3]. This included a velocity addition formula whereby, as a simple illustration: if a man were walking along inside a train, in the same direction as the train itself was moving, an observer on the embankment would not see the overall speed of the man as the sum of his walking speed and the train's speed; it would be something less than that sum. Treating light as the man in the train, and the water as the train, Einstein's formula applied to those two speeds gives precisely the overall speed of the water-carried light as measured by Fizeau. This led to Einstein describing Fizeau's experiment as "conclusive" and "crucial" in confirming SR as a true descriptor of the nature of physical reality [2].

What, then, are we to make of the fact, now known, that the speed of light in moving water is not a consequence of relativistic addition of velocities, but rather of light being impeded by the particles of the water itself – to a degree which reduces as the water's speed increases and frequency of the light's encounters with those particles likewise reduces? Certainly, if we *a priori* accept the second postulate of SR re the invariance of the speed of light *in vacuo*, and then extend that to the reduced speed of light in a translucent medium, then light-in-moving-water is analogous to man-in-train; but this does appear to be a (slightly stretched) circular argument: invoking an extension of a postulate of SR to provide confirmatory evidence for SR. More than this, if Fizeau's experiment is one of the key issues supposedly resolved by SR but that key issue is in fact fully resolved without reference to SR, then SR becomes irrelevant to that issue.

SR has proved 100% reliable as a predictor of observable outcomes, irrespective of whether or not it provides a causal explanation for the results of Fizeau's experiment. However, this experiment, and the significance accorded to it as confirmation of the fundamental principles of SR, highlights the very real possibility of mis-attribution of causation for some or all of those outcomes. In the century-plus since the advent of SR there have been numerous advances in our understanding of fundamentals of physics which could, like the later perspective on light passing through a translucent medium, give us reason to re-evaluate the mechanisms underlying observed relativistic phenomena. Such re-evaluation could lead to advances in our understanding of the nature of material reality.

Following a brief overview of the mathematics of Fizeau's experiment independently of SR, we consider one of the more obvious potential avenues of exploration.

2. Physical causation of outcomes of Fizeau's experiment

[In this section all speeds are represented as fractions of the speed of light *in vacuo*, c, full light speed itself therefore being represented by the value 1. Except where otherwise stated speeds should be regarded as being relative to the laboratory frame.]

Fizeau derived a formula for net speed of light (denoted here by δ) passing along within a body of water moving at speed v as:

$$\delta = \alpha + v(1 - \alpha^2) ,$$

where α = the speed of light through still water. This formula was found to be highly accurate for all flow speeds and all fluids tested.

Einstein proposed that this result was clear evidence of SR. He himself was persuaded of this, as was (and still is) the scientific community at large, by the perfect fit of his SR velocity addition formula to all observed outcomes:

$$\delta = (\alpha + v)/(1 + \alpha v) = (\alpha + v)(1 + \alpha v)^{-1}.$$

Binomial expansion of the latter bracket gives the result:

$$\delta = \alpha + v(1 - \alpha^2) - \alpha v^2(1 - \alpha^2) + O(v^3)$$

This corresponds to Fizeau's formula, plus a term in v^2 (ignoring $O(v^3)$), giving accuracy not available to Fizeau.

Two months before publication of Einstein's seminal paper on SR, he also published a paper on Brownian motion [4]. In this paper he showed apparently random motion of macroscopic particles suspended in a fluid to be due to perturbation by the atoms of the fluid itself. Some while later the reduction of the speed of light whilst passing through a translucent medium was found to be due to an analogous process: the full speed of light is effectively damped by interaction with the atoms in the medium itself.

The precise nature of this damping effect is now well understood [5]. However, whatever its nature it is virtually axiomatic that the degree of damping will be in some way dependent on the frequency of such interaction, *i.e.* the (mean) frequency with which light encounters those atoms. It is also to be expected that such an internal influence will act in a way that is mathematically orthogonal to the resultant speed of light energy flow (the standard energy-momentum relation provides a useful analogy in this respect, combining linear and internal components orthogonally to give overall energy [6]). This working hypothesis yields an interesting result.

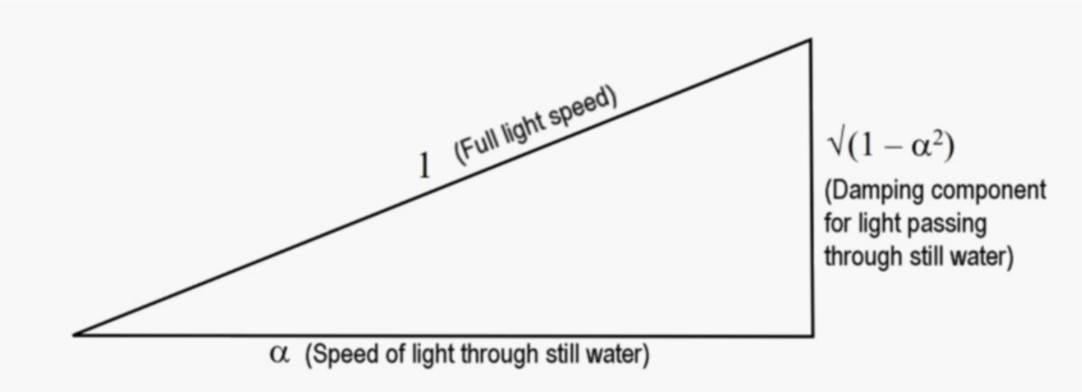

Fig. 1
Velocity triangle for light passing through still water, showing: full light speed; speed of light as reduced on passing through the water; damping component from interaction with atoms of the water.

If we consider light passing through static water at speed α, then the effective transverse damping component is as shown in Fig 1: $(1-\alpha^2)^{1/2}$. If the water is moving at speed v, giving a resultant effective light flow at speed δ, then the speed of effective light flow relative to the atoms in the water (as observed in the laboratory frame) is $\delta-v$. The resultant transverse damping effect, proportional to frequency of encounters with those atoms, will be altered accordingly by a factor $(\delta-v)/\alpha$, as shown in Fig. 2.

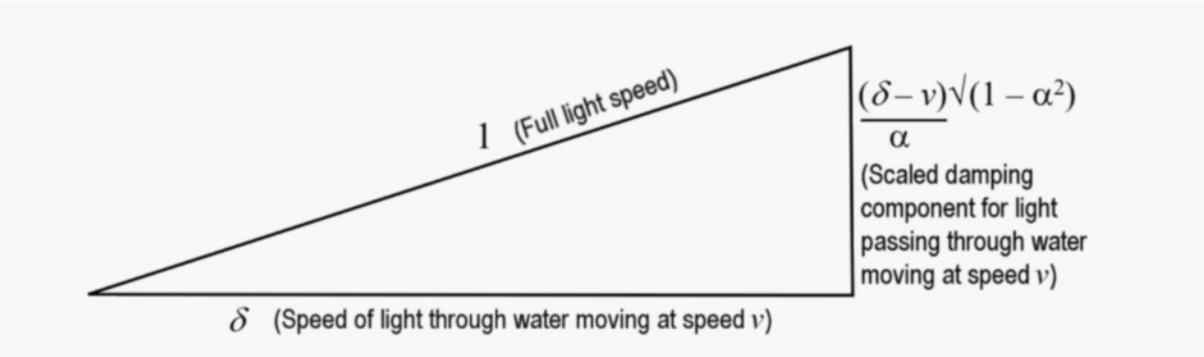

Fig. 2
Velocity triangle for light passing through moving water, showing: full light speed; speed of light as reduced on passing through the water; scaled damping component from interaction with atoms of the moving water.

The relationship between velocity components as shown in Fig. 2 leads to the result:
$\delta^2 + [(\delta - v)^2/ \alpha^2](1 - \alpha^2) = 1$
This quadratic equation in δ yields the solution:
$\delta = v(1 - \alpha^2) + \alpha[1 - v^2(1 - \alpha^2)]^{1/2}$
Binomial expansion of the square-root term gives:
$\delta = v(1 - \alpha^2) + \alpha[1 - \frac{1}{2}v^2(1 - \alpha^2)] + O(v^4)$
which can be written as:
$\delta = \alpha + v(1 - \alpha^2) - \frac{1}{2}\alpha v^2(1 - \alpha^2) + O(v^4)$

This is identical, as far as the term in v, to both Einstein's and Fizeau's equations for δ. In the v^2 term it differs from both by $\frac{1}{2}v^2(1-\alpha^2)$ – in opposite directions, *i.e.* it is the mean of the two.

To give some perspective, this gives a value for δ which matches the value from both Einstein's and Fizeau's formulae to 10 significant figures for the extreme case of light passing through water flowing at 10,000 miles an hour. In other words this proposed explanation matches all reliable experimental results to an accuracy well beyond the practical limits for any such experiment. This explanation also has a clear well-defined causation not reliant on any aspect of SR.

Of course, if v and δ are in opposite directions then the light-flow will encounter atoms in the translucent medium correspondingly *more* frequently and light will be slowed to a correspondingly *greater* degree; this result is given in all three of these formulae (Einstein's, Fizeau's, simple analysis) by replacing v with $-v$.

From this it is quite apparent that the issue which puzzled physicists in Fizeau's time, which Einstein saw as crucial to validation of his Theory of Relativity, can be fully explained by consideration of the interaction of light with the particles of the water itself (details of the exact nature of that interaction are not required in order to reach this conclusion – though electromagnetic 'damping', as actually applies, is a prime candidate with hindsight). If this possibility had been explored before 1905 then there would have been no issue in respect of Fizeau's results to be addressed by SR.

None of this, of course, proves the invalidity of SR, which has been exhaustively tested across a wide range of situations and never found wanting. What is does do, though, is to show that there can be more than one explanation for observed phenomena – and Occam's razor tells us that if there is a clear explicit causal explanation for any such phenomenon then additional proposals, such as esoteric properties of the universe (for which no causal explanation is offered), are surplus to requirement with regard to that phenomenon.

This point is not made lightly; over more than a century SR has made a virtually watertight case for itself, in terms of matching observation to theory. But, as Fizeau's experiment shows, this does not prove the correctness of that theory as causation; there could be a totally different explanation which produces identical results.

Section 3 considers findings since 1905 which offer a radically new perspective on possible mechanisms for all effects attributed to SR – effects which from this perspective are seen to be due to subjective experience on the part of a moving person or object, rather than being properties of objective reality. This new perspective mirrors all documented effects attributed to SR, including notably $E=mc^2$, apparent invariance of the speed of light relative to all inertial states of motion, speed-related time dilation, and the Lorentz transformation for transferring between inertial reference frames (the latter three of these providing explanations for many other observed phenomena).

3. Matter as Light

3.1. Considering the Evidence

Count Louis de Broglie first put forward the notion that material particles are wavelike in nature [7], an idea that was shown to be true just two years later [8]. Since that time both simple observation and an extensive range of research studies have repeatedly shown an intimate connection between the structure of material particles and electromagnetic radiation – light, including non-visible frequencies: photons are constantly being emitted from and absorbed by particles of matter, transitioning between forming part of the energetic composition of an atom and existing as free energy; particle-antiparticle pairs are known to be capable of annihilating one another totally or in part, transforming matter into energy [9 - 13]. The reverse process is also well established both in theory and (indirectly) in practice [14 -17]. Notably, as highlighted by Ginzburg ([17], p. 657), in 1934 Landau & Lifshitz observed that a characteristic precursor to production of electron-positron pairs from particle collisions is the release of high-energy opposing photons [18]; Ginzburg continues by citing another study that same year in which an identical dual-photon subprocess leads to electron-positron pair production [19].

Also in 1934, Breit and Wheeler proposed the (then) hypothetical *Breit-Wheeler Process* [20] in which two photons of suitable energies might be collided so as to create an electron-positron pair. A multi-stage version of this process was realised in practice at the Stanford University Linear Accelerator (now SLAC National Accelerator Laboratory) in 1997 [21]. Twenty-four years later direct production of thousands of electron-positron pairs was achieved through head-on collisions of high-energy pairs of photons at the RHIC, US Brookhaven National Laboratory [22].

The case for particles of matter being localised configurations of photonic energy is further strengthened by the phenomenon of zitterbewegung [23]; various studies have pointed to this light-speed fluctuation as being indicative of a characteristic oscillation at that speed within the form of an electron [24 - 26]. This periodic oscillation has been demonstrated empirically by Catillon *et al*. [27].

A number of studies have considered the formation of localised particle-like configurations of electromagnetic [EM] fields [28 - 36]. The last of these shows analytically that a closed-loop electromagnetic wave construct could account for the characteristics of spin, magnetic moment and static charge as measured in an electron.

The proposal, then, that subatomic particles are localised configurations of EM energy – 'cyclic photons' – is not a trivial one; it has excellent credentials. More than this, following that line of reasoning leads to comprehensive coverage of all phenomena attributed to SR – identifying many of them as motion-induced subjective experience rather than objective reality ([37] – see also Section 4 below on fully symmetric Lorentz transformation).

3.2. Time Dilation

[This section and Section 3.3 make no prior assumption of inertial frame invariance. Matters are considered from the perspective of a laboratory frame in which it is taken for the time being that the objective speed of light is indeed c and objects at rest in that frame are objectively static. That view is then considered in more detail.]

If a static subatomic particle is formed from a localised cyclic pattern of EM energy, then when that particle is in motion its formative energy will necessarily have a linear component, thus describing a (possibly complex) helical-style flow pattern along the particle's line of motion. Unless the formative energy flow increases its speed – which is inconsistent with that flow being the underlying reality generating matter – the cyclic component of that formative energy, circulating around the particle itself, will be reduced. Since time effects must necessarily be carried around the particle by this energy flow, the rate of time-experience for that particle will likewise be reduced. Simple analysis shows this time dilation corresponds identically to that same effect as attributed to SR, an effect well documented in the slowed decay of muons (elementary particles with no particulate substructure) travelling at relativistic speeds [38]. This empirical evidence also provides confirmation that the speed of cyclic energy flow forming material particles is indeed c, the speed of light *in vacuo*.

Extension of this principle to multi-particle objects – which must be sustained by cycling energy flows within and between those particles – gives a clear rationale for time dilation in macroscopic objects. This concept has been well demonstrated in a video awarded the 2015 Breakthrough Junior Challenge prize which clearly illustrates exactly this principle [39]. This video gives an overview of aspects of SR, and does it very well. However, starting at 4 mins 18 secs into the video, Chester gives a cogent explanation of relativistic time dilation – an explanation which does not rely in any way on SR. He refers to the constancy of the speed of light, but frame invariance has no bearing on his explanation; indeed, he explicitly identifies time dilation in a speeding craft as a subjective (non-)experience for the pilot, whose own bodily functions are correspondingly slowed by the same process. This view is endorsed by a distinguished panel of leading scientists in their conferring of that prestigious award.

Detailed analysis shows this effect to be independent of size or complexity of a particle or ensemble of linked particles ([40], Appendix A). It depends only on the speed of that particle or object. This applies irrespective of any motion-related length contraction as referred to in Section 4 below.

Symmetry of time dilation between frames is not supported by this explanation; however, apparent symmetry, seen as objective fact in SR, is fully consistent with the broader view of apparent frame symmetry presented in Sections 3.3 and 4 below.

Hence, time dilation is arguably a direct consequence of the underlying structure of material particles, and of the effect of motion on that structure as well as, similarly, on ensembles of those particles to any order of magnitude. In common with results of Fizeau's experiment, then, it raises a serious question as to whether SR has any relevance in respect of this effect other than providing a reliable mathematical basis for calculating its perceived effects.

3.3. Frame Invariance of Light Speed

If elementary particles are formed from flows of EM energy, it is axiomatic that those flows must be configured differently for moving particles than for their static counterparts. One likely consequence of this is detailed in 3.2. More broadly, it will change the orientation of the formative energy flow(s) of a moving particle from those of that same particle when static: a static particle's energy-flow is 100% cyclic, contributing fully to the time-experience of that particle; whereas that of a moving particle is both cyclic (forming the particle and giving it time-experience) and linear (giving a velocity component to the particle).

In respect of notional space-time axes, vertical for time and horizontal for spatial direction of motion, the energy-flow pattern for a static particle is fully time-oriented with no spatial component (shown as particle A in Fig. 3, below); whereas the flow pattern for a moving particle is tilted in the spatial direction of motion (particle B in Fig. 3).

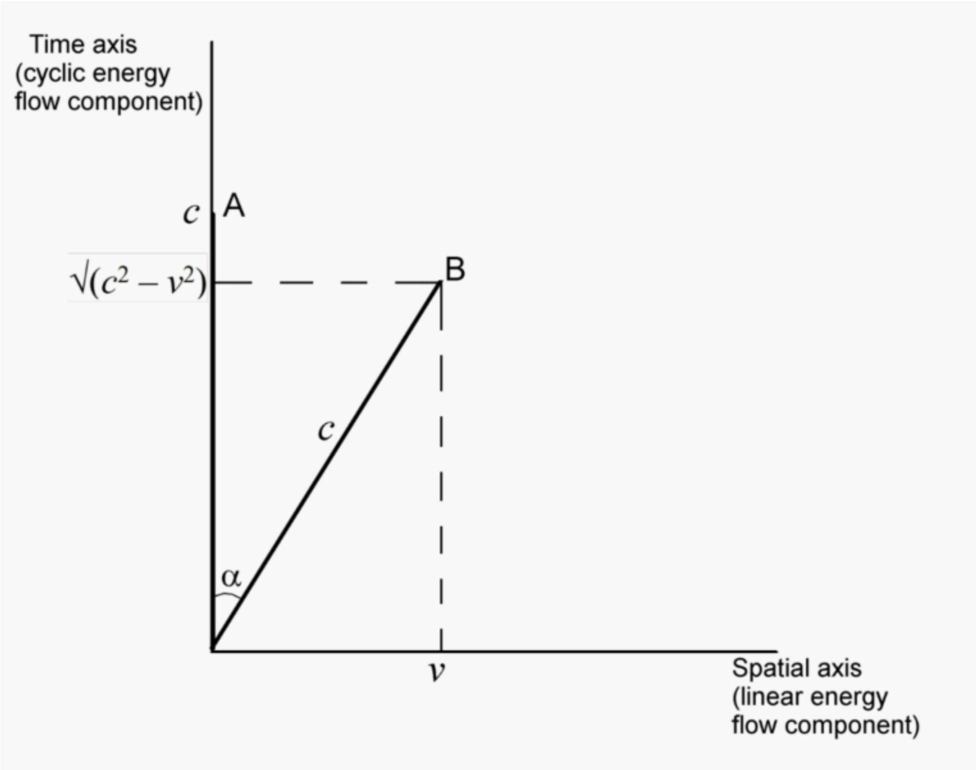

Fig. 3
Particle energy-flow orientation for particle A (static) and particle B (moving with constant velocity v). α is the helix angle for the helical-style flow pattern of the energy forming particle B.

This may be likened to a man who is leaning forward but thinks he is standing upright; his experience of reality will be from that tilted perspective. The parallel in the space-time scenario is that a moving particle or object will experience linear energy flows from an oblique space-time orientation.

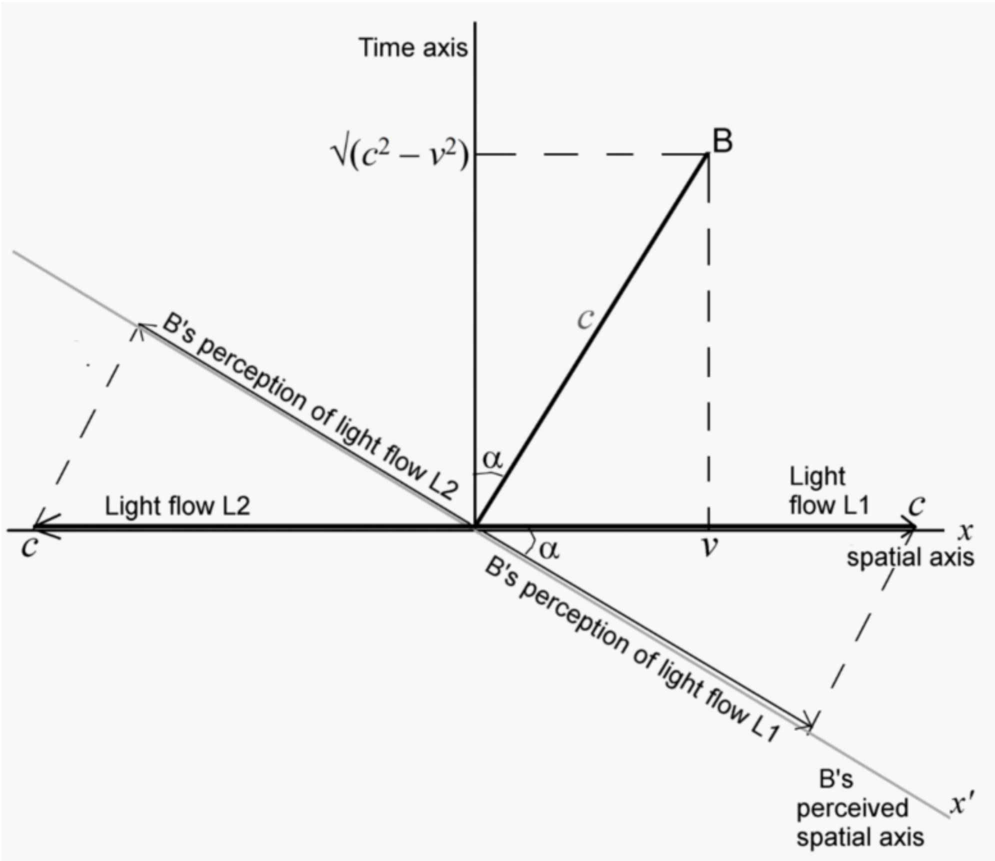

Fig. 4
Energy-flow orientation for particle B, moving at velocity v in direction x, also for linear light-flows L1 and L2 travelling in the same direction as B and opposite direction, respectively, together with projection of L1 & L2 as experienced by B on B's perceived spatial axis x'. α is as defined for Fig. 3.

Fig. 4 shows light flows L1 and L2 travelling in the same direction *x* as particle B and the opposite direction, respectively. These energy flows are of course fully spatial with no time component. Particle B will experience these flows as projected onto its own perceived spatial axis, *x*' (*i.e.* perceived spatial component in each case); when adjusted for B's time dilation, both of those light flows are experienced in B's personal spatial dimension as travelling at speed *c*. This result can be extended to apply to light incident at any angle to the line of motion of a particle moving at any speed ([40], Appendix B).

Hence, if there were a unique objectively static universal rest state relative to which the speed of light is *c*, the speed of light relative to all other inertial states of motion would also be experienced as *c* – as a subjective motion-induced effect. This corresponds precisely to observed reality. The universal rest state would not in fact be any laboratory frame on Earth, since Earth itself is not at rest with respect to any meaningful reference. The most likely candidate is the cosmic microwave background, used throughout the field of astrophysics as a reference frame for all astronomical states of motion. This view is consistent with observations on the Smoot Group website ([41], para 10).

4. The Lorentz Transformation

In addressing the issue of the Lorentz transformation one further factor needs to be taken into account: speed-related length contraction. This objective feature of space-time reality was proposed by various contemporaries of Einstein some years before his publication of SR [42 - 44], and forms an integral element of SR itself. It has been well confirmed by practical application in ultra-high-energy supercollider experiments: see, *e.g.*, [45].

Consideration of a simple railway scenario, involving only time dilation and subjective impression of frame-invariant light speed, as derived in 3.2 & 3.3 above, plus speed-related contraction (formula as for SR), yields (remarkably) the fully symmetric Lorentz transformation identical to that for SR – but as a subjective motion-induced experience rather than the objective reality proposed by SR ([40], pp. 67-75). It follows that a unique objectively static reference frame, as referred to in section 3.3, would be mimicked in every detail by every other inertial frame in motion with respect to that unique static frame; hence it would appear that no such unique static inertial state of motion exists. Detailed analysis of Hasselkamp's experiment offers a clear illustration of this ([40], Appendix C3).

From this basis every aspect of the mathematics of SR ensues, but with the proviso that this maths relates to subjective experiences – of observers, particles, or objects – rather than objective realities.

5. Conclusion

(a) Results of Fizeau's experiment as measured in the laboratory frame are fully accountable for as consequences of physical principles and conditions which apply in that laboratory frame; SR would therefore not appear relevant to any explanation as to causation.

(b) Given the now well-accredited phenomenon of formation of elementary particles from photons of EM energy, it would seem probable that the EM structural flow pattern of a particle on the move would differ from that of the same particle when static. Motion-related time dilation may thus be accounted for by well-definable processes arising from the energetic structure of particles and objects; should this be so then SR would appear to be redundant also to explanation of causation of that effect.

(c) Furthermore, it would seem clear that the response to light of a moving particle would thus be different from that of the static particle; simple analysis shows, as a probable outcome, that a particle or object moving at any speed would experience incoming light as travelling at full light speed *c*, whatever its actual relative speed; this would appear to render SR redundant as an explanation for this universal experience.

(d) Apparent inertial-frame invariance of the speed of light, coupled with the mechanistic processes of time dilation and length contraction in a moving object, together create an environment in which transfer between different inertial states of motion is represented – as a subjective experience – by the fully symmetric Lorentz transformation. Without any reference to SR, the situation portrayed by SR as objective fact is found to be very possibly a direct (subjective) consequence of conventional interactions between matter and energy, including the formative energy of static or moving particles of matter.

(e) Should this prove to be the case, in general any laboratory frame will not correspond to the objectively static universal rest frame (***R***). It follows that physical principles which apply in the laboratory frame will in general include the externalisation of a component of the formative energy of every particle 'at rest' in that frame as energy of motion. This is wholly accounted for by subjective frame symmetry of the Lorentz transformation, leading to all experimental results taken in any inertial laboratory frame precisely matching those that would be taken in ***R*** in corresponding circumstances. In this respect any measurements taken in any such a frame may be regarded as applicable for the corresponding situation in ***R*** and vice versa.

It appears possible, then, that every observable phenomenon or circumstance attributed to SR may be traced back to more conventional properties of matter and energy. This does not in any way lessen the efficacy or usefulness of the mathematical formalisations of SR, however it could be obscuring potentially highly significant avenues for future research. This alternative perspective on empirical evidence relating to relativistic phenomena would appear to merit serious consideration.

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