A NEO-PHENOMENALIST ALTERNATIVE TO SPECIAL RELATIVITY

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Abstract

It is said that 'All the keys hang not at one man's girdle'. If what Einstein discovered about space and time is a natural truth, then that same truth has to be discoverable by others in perhaps radically different ways in what Eduard de Bono called 'lateral thinking alternatives'. Einstein was a Realist, as opposed to Mach and Bohr, who were phenomenalists. This paper adopts the phenomenalist stance in deriving a logical facsimile of Einstein's Special Relativity from a radically different, neo-phenomenalist perspective. This is based on a logical re-interpretation of the constant c *as what Bondi has called a distance-time conversion factor rather than as the conventional 'speed of light'. In this altogether different approach. The time dilation formula, so crucial to Special Relativity, is derived first. This is in purely ahistorical terms, without reference to the Lorentz transformation and its 'electrodynamical' precedents. We demonstrate here how the special Lorentz transformation and other aspects of the standard theory then follow directly as a consequence of the time dilation formula. In conclusion, we discuss some of the philosophical implications of this neo-phenomenalist reinterpretation of* c *for the increasing observationist trends in modern physics.*

Key Words: Special Relativity, Einstein, time dilation, Normal Realism, Lorentz transformation, Mach, proper time, phenomenalism.

1. INTRODUCTION

In our neo-phenomenalist approach to Special Relativity (SR), Einstein's Second Axiom concerning the 'constant speed, *c*, of light *in vacuo*' is replaced with an axiom which states no more than the simple fact that there is a universal distance-time conversion factor *c* which is the same in every observer's phenomenological perspective of the world around us. This New Approach to SR first appeared in 1987,[1] although Viv Pope had corresponded with Hermann Bondi earlier concerning the possibility of interpreting *c* purely as a conversion factor.[2] Initially, this New Approach had two main aims. First was to argue that Einstein's interpretation of the constant *c* as a speed is not only logically redundant but that it also creates a chronic stumbling block to commonsense understanding of SR. Second was to provide a simple derivation of the standard time dilation formula in a way which is independent of the Lorentz transformation and its traditional 'electrodynamical' underpinnings.

Although our first paper was presented simply as a teaching aid, in full agreement with Bondi, its basic aim had been developed from a philosophical point of view and has since substantially evolved.[3] The interpretation of *c* as a distance-time conversion factor rather than as a physical speed now lies at the heart of a neo-phenomenalist philosophy known as **Normal Realism**.[4] This follows along the lines of a version of phenomenalism once known as English Empiricism.[5] Culminating in the relativistic physics of Ernst Mach,[3] it was this from which from this that Einstein took his 'relativistic' cue. For the Empiricists, and especially for Mach, all our knowledge of the world is based on sense-impressions, or 'sense-data'. Normal Realism takes this to include not only instrument data (right down to the fundamental quantum level) but also the informational data transacted between observers in general communication – *language*, in effect. Consequently, because in any phenomenalist account of physics, *phenomena* are fundamental to any scientific enquiry, there is no way to reconcile phenomenalism with Einstein's Second Postulate, whereby our observations of physical phenomena are mediated by light travelling at a constant speed *in vacuo* in what has been called the 'Einstein separation' between phenomena and their theoretical 'sources'.

With regards to the second aim of the New Approach, our derivation of the time dilation formula is based on the simple fact that there is a distance-time conversion factor *c* relative to all observers. This replaces the usual two-dimensional distance-*versus*-time scalar graph depicting linear motion, with a geometrical linear time-*versus*-time graph. This derivation leads to the fact that motion is properly depicted by a *three*-dimensional time-graph which illustrates the relationship between the three variables: i) the *observed distance* of a body converted to a time by the conversion factor *c*; ii) the *observational time* (the time of the motion registered by the observer of the motion) and iii) the *proper time* (the time the observer records as registered on the moving body itself). In this case, the graph of the motion is represented on a conic surface – in fact, that of a rectangular cone.[1]

Since our 1987 paper, the Normal Realist programme of phenomenalism has been applied to the *phenomenon* of motion in an alternative approach known as the Pope-Osborne Angular Momentum Synthesis (POAMS). This rejects as unempirical Newton's First Law of rectilinear motion on the grounds that truly straight-line motion, *in extension*, is never observed. It reinstates, instead, the Aristotelian view of all free motion as naturally orbital. In this way, the orbital motions of masses are seen as manifestations of overall-conserved angular momentum, without the need for any *in vacuo* 'gravitational force'. This approach also dispenses with other *in vacuo* forces such as, *e.g.*, 'electrostatic force'. This is on the basis that in an overall-conserved angular momentum nexus, the orbital parameters of a spinning body are not the same as for a non-spinning one. In POAMS this accounts for the huge difference between an 'electronic' orbit and a 'gravitational' orbit without having to assume the usual radical difference between types of 'forces' involved. This provides an alternative derivation of the parameters of the hydrogen atom, including the masses of the so-called 'electron' and 'proton'.[6][7]

More recently, the same POAMS approach has extended the time dilation formula into the domain of General Relativity (GR), where it applies directly – that is, without involving either 'gravitation' or the usual rationale of a 'warped space-time continuum' – to orbital motion as observed in the case of, *e.g.*, the Global Positioning System (GPS) satellites. A seamless join is thus facilitated between the domains of SR and GR. This also leads to Schwarzschild Space-time and hence to the same

predictions as Einstein's for the observed perihelion shift of Mercury and the other planets.[8]

Thus, although POAMS dispenses with the traditional concepts of 'light *in vacuo*' as well as 'gravitational' and other *in vacuo* field-forces, it retains all the purely *empirical* or *observational* features of the actual physical *phenomena*. In this respect, we claim that our Normal Realist alternative approach to Relativity makes a valid contribution to modern physics. However, a common criticism of this New Approach to SR has been that it has not explicitly derived the Lorentz transformation, which is taken to be one of the foundations of SR as applied in practice. One of the aims of the present paper is to answer this criticism, not only by showing that the Lorentz transformation can be derived in a simple way from the time dilation formula, but also by demonstrating that our neo-phenomenalist approach, with its systematic employment of 'Ockham's razor', provides all the usual results of SR much more simply without having to interpret the constant *c* as a speed. We also discuss some of the philosophical and non-philosophical advantages of this consistently *phenomenalist* approach to SR over the traditional *theoretical* approach.

2. ALTERNATIVE AXIOMS FOR SPECIAL RELATIVITY

The two fundamental axioms on which Einstein's approach to SR is based are:

> (A1) (The *Relativity Principal*) The laws of physics are the same in all inertial frames. (An inertial frame is a frame of reference in which spatial relations, as determined by rigid scales at rest in the frame, are Euclidean and in which there exists a universal time in terms of which free particles remain at rest or continue to move with constant speed along straight lines).
>
> (A2) Light travels rectilinearly at speed *c* in every direction in all inertial frames.

The first axiom is well-founded and agrees well enough with observation and empirical evidence concerning uniform motion, whilst the second axiom appears to contradict the first, for how can anything truly have a 'speed' which is the same in all differently moving inertial frames? However, it is well-known that Einstein, heavily influenced as he was by Maxwell,[9] postulated that the constant *c* which appears in Maxwell's equations is the same for all observers since, otherwise, Maxwell's equations and hence at least some of the laws of physics would be observer-dependent, contradicting axiom (A1). It was Maxwell who associated the constant *c* in his equations with the 'speed of light', thereby inferring that light travels in the form of Maxwellian electromagnetic waves. It may be that Einstein retained the 'speed of light' interpretation of the constant *c* due to Maxwell's influence, but there was no *logical necessity* for him to interpret the constant *c* in that way. This essentially redundant additional interpretation therefore appears rather odd, given the fact that one of the achievements of SR was to make redundant the concept of the luminiferous æther as the hypothetical medium for the transport of 'light waves'. In addition, this interpretation creates unnecessary confusion since axiom (A1) then implies that all speeds are relative (agreeing with everyday experience) *except* for the 'speed of light'.

As stated in the introduction, in any phenomenalist approach to physics, it makes no sense to interpret the constant *c* as a speed in the usual physical sense. Since this constant has the *dimensions* of a speed, the alternative is to interpret it simply as a conversion factor for interrelating observer-projected measures of distance and time. Hence, our two alternative fundamental axioms for SR are (A1), as in Einstein's approach and

(A2)* Observational distance and time have a constant ratio of units, *c*, for all observers sharing that same conventional choice of units.

Note that there is no apparent contradiction between these two axioms as there is with Einstein's. In accordance with this new set of axioms, if units of distance and time are chosen so that $c \approx 3 \times 10^8$ m s^{-1}, then our axiom $(A2)^*$ states that a distance of one metre may be recorded as $1/3 \times 10^{-8}$ seconds relative to all observers. Here, the 'second' is being used in two different senses; one in the sense of *duration* and the other in the sense of a distance equivalent. (Essentially, there is no material difference between this idea and measuring a car journey by the time it takes rather than by the distance travelled.)

3. THE TIME DILATION FORMULA

We now provide a simple derivation of the time dilation formula using axiom (A2)*, without any reference to the special Lorentz transformation. Consider a clock X moving with uniform velocity, *i.e.* with constant speed v along a rectilinear path, relative to an observer O. In a time t recorded by O, X has moved a distance $r = vt$ from O. Let that the same time interval as recorded by X's clock be τ, as observed by O. The distance of X from O after this time τ is given by a standard distance versus time linear graph, as shown in fig. 1. However, it follows by axiom $(A2)^*$, that X moves a distance-time r/c relative to O. Hence, this first graph may be replaced by a *time-versus-time* linear graph as also shown in fig. 1. It follows that all measurements in this second graph represent times. Bearing in mind that OX represents that path of clock X relative to O, it follows that OX in this second graph is the time t taken for clock X to reach its position relative to O after time τ. Hence, by Pythagoras' theorem,

$$t^2 = \tau^2 + (r/c)^2 \,. \tag{3.1}$$

Note that this is the equation of a rectangular cone in three-dimensions.[1]

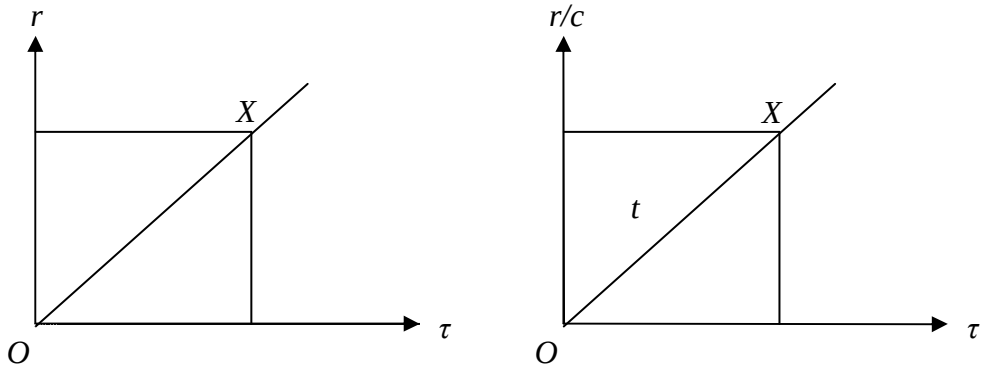

Figure 1

Since $r = vt$ it follows from (3.1) that

$$\tau = (1 - (v^2/c^2))^{1/2} t \,, \tag{3.2}$$

which is the standard time dilation formula of SR.[10]

Note that this formula has been derived simply from Pythagoras' theorem as applied to purely phenomenal dimensions without in any way involving orthodox Relativity or its traditional 'electrodynamics' underpinnings. In the next section we demonstrate how the standard Lorentz transformation can be derived from axiom (A1) together with the Pythagorean equation (3.2).

4. DERIVATION OF THE SPECIAL LORENTZ TRANSFORMATION

As in standard SR, consider two observers O and O', each situated at the origin of a set of Cartesian axes labelled x, y, z, and x', y', z' respectively. We suppose that O' moves along the x-axis in the positive direction with constant speed v relative to O such that the x', y' and z' axes remain parallel to the x, y and z axes respectively. Let t be some passage of time as recorded by a clock in O's observational frame and let t' be the corresponding passage of time as recorded by a clock in O''s observational frame. We suppose that the observers O and O' synchronise clocks when they coincide at $t = 0$, so that when $t = 0$ at (0, 0, 0,) relative to O, $t' = 0$ at (0, 0, 0,) relative to O'. Since, by hypothesis, if O' moves with constant velocity relative to O, then O must move with constant velocity relative to O', hence it follows from our initial condition concerning the times that the most general transformation which maps (x, t) to (x', t') under these conditions must be linear. By hypothesis, after time t relative to O, O' has moved a distance $x = vt$, so, altogether, we obtain

$$x' = \gamma(x - vt) \tag{4.1}$$

for some constant γ to be determined. It follows from (4.1) and (A1) that since O travels at speed v in the negative x' direction relative to O', then

$$x = \gamma(x' + vt') \ . \tag{4.2}$$

From (4.1) and (4.2) we have

$$x = \gamma(\gamma x - \gamma vt + vt') \ ,$$

so that

$$t' = \gamma(t - (1 - 1/\gamma^2)x/v) \ . \tag{4.3}$$

Of course, there are no surprises here; these are the same equations which appear in both standard SR and Newtonian theory (when $\gamma = 1$). However, whereas standard SR uses the behaviour of 'travelling light signals' in order to deduce the value of γ in (4.1), in our approach this value is obtained directly by using (4.3) and the time dilation formula, (3.2).

To reiterate, after time t relative to O, O' has moved a distance $x = vt$. The same passage of time, t', as recorded by O''s clock relative to O is then given by (4.3) with $x = vt$, so that

$$t' = \gamma(t - (1 - 1/\gamma^2)t) = t/\gamma \ . \tag{4.4}$$

But here, $t' = \tau$, the proper time recorded by the travelling clock, so that (4.4) is the same as (4.2), immediately giving

$$\gamma = (1 - v^2/c^2)^{-1/2}, \tag{4.5}$$

which is, of course, the Lorentz factor of standard SR.

With this value of γ, we have

$$1 - 1/\gamma^2 = v^2/c^2,$$

and so (4.3) reads

$$t' = \gamma(t - vx/c^2) \ . \tag{4.6}$$

Since, in the case that the observers O and O' described, positions in the y and z direction are not affected by relative motion in the x-direction, it follows that

$$y' = y,\ z' = z. \tag{4.7}$$

Equations (4.1), (4.5), (4.6) and (4.7) constitute the **special Lorentz transformation** (SLT) for SR. Once we have the special Lorentz transformation, all the standard applications and consequences of SR follow.[11] However, it is necessary to re-emphasise here that, in our approach, light does not *travel* in the usual sense of the word. Indeed, the relativistic addition of speeds formula follows from the special Lorentz transformation in the usual way and dictates that two *observable* or *real* speeds (both of which are less than c) cannot be combined to give a possible speed of magnitude c. Thus, as in Einsteinian relativity, c is an unreachable limit of all real speeds, except, of course, that in POAMS c not a *speed*, as Einstein envisaged it but is simply a dimensional constant or conversion factor.

5. AN ADVANTAGE OF THE ALTERNATIVE APPROACH

We maintain that a big advantage of our approach is that the time dilation formula (3.2) is derived in the very first instance (that is, *a priori*) using a very simple argument. This places the formula where it rightly belongs, in the correct logical order of priority, since the many salient results in SR are ultimately derivable from this formula alone without any reference to the orthodox Lorentz transformation and its 'electrodynamical' rationale.

For example, the metric for Minkowski Space-Time (MST), which is the basis for relativistic kinematics and dynamics, can be derived directly from the time dilation formula as follows. Consider any clock X which moves with uniform velocity relative to an observer O. Then relative to O's spatial Cartesian coordinates x, y and z, after a passage of time t relative to O, X travels a distance r where

$$r^2 = x^2 + y^2 + z^2,$$

so that by (3.1),

$$-c^2\tau^2 = -c^2t^2 + x^2 + y^2 + z^2 \tag{5.1}$$

Since the proper time τ is a physical parameter which is invariant with respect to all observers and c is also invariant, it follows that the right-hand-side of (5.1) immediately provides an invariant quantity for all inertial observers. This is the **separation** or **interval** between two events which is the basis for Minkowski Space-Time. In the usual way, any transformation which is linear in the coordinates of an event (t, x, y, z) and which leaves the right-hand-side of (5.1) invariant, is a Lorentz transformation.[12]

More generally, suppose that the clock X moves with *non*-constant velocity $\mathbf{v}(t)$ relative to observer O. It follows by (3.2) and the definition of the Riemann integral that in this case, the relatively moving clock X records proper time τ given by

$$\tau = \int (1 - v^2(t)/c^2)^{1/2}\, \mathrm{d}t \tag{5.2}$$

where $v(t) = \|\mathbf{v}(t)\|$ is the relative speed of X. In this case, relative to Cartesian coordinates,

$$\mathbf{v}(t) = (dx/dt,\ dy/dt,\ dz/dt)\ ,$$

so that (5.2) gives

$$(d\tau/dt)^2 = 1 - v^2(t)/c^2 \implies c^2(d\tau/dt)^2 = c^2 - v^2(t) = c^2 - (dx/dt)^2 - (dy/dt)^2 - (dz/dt)^2$$

and hence

$$-c^2d\tau^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2. \qquad (5.3)$$

Equation (5.3) provides the *metric* for MST, the basis for special relativistic kinematics and dynamics. Once again, it follows that since the proper time is a physical invariant, the right-hand-side of (5.3) is invariant with respect to all inertial observers.

Another example of this direct deduction from the Pythagorean time-formula is that in the same way that c is a constant for distance-time conversion, c^2 is a constant for mass-energy conversion. In our new approach it follows directly from (5.2) that

$$dt/d\tau = (1 - v^2(t)/c^2)^{-1/2} = \gamma(t)\ . \qquad (5.4)$$

This result is crucial in relativistic dynamics. From (5.4), considerations of conservation of momentum require that any particle of rest mass m_0 moving at velocity $\mathbf{v}(t)$ relative to an observer O has an effective mass of $m(t) = \gamma(t)m_0$ relative to O. It also provides the equivalence of mass and energy, since from (5.4),

$$c^2d\gamma/dt = \gamma^3(\mathbf{v}.\mathbf{a}) \implies c^2d\gamma/dt = \mathbf{v}.d(\gamma\mathbf{v})/dt$$

where $\mathbf{a} = d\mathbf{v}/dt$. Then multiplying by m_0 gives

$$c^2dm/dt = \mathbf{v}.d(m\mathbf{v})/dt$$

It follows by integrating this expression that if a particle starts from rest relative to some observer and finally attains velocity **v,** then

$$c^2(m - m_0) = \int \mathbf{f}.d\mathbf{r}$$

where $\mathbf{r} = (x, y, z)$ and $\mathbf{f} = d(m\mathbf{v})/dt$. The integral on the right-hand-side of this equation is the standard expression for work, so that the mass-increment $(m - m_0)$ represents an increase in energy in the ratio c^2 of joules to kilograms. From this, of course, we have the familiar relativistic mass-energy formula, $E = Mc^2$.

Of course, these are well-known results. Here, the purpose of these arguments is to illustrate that many of the major results of SR can be derived directly from the time dilation formula, without any reference to the standard orthodox Lorentz transformation and its classical theoretical infrastructure.

6. CONCLUSION: THE PHILOSOPHICAL ADVANTAGE OF THE ALTERNATIVE APPROACH

In this paper, we have presented a new approach to SR based on the philosophy of Normal Realism, a development of phenomenalism along the lines advocated by Mach. Central to this new approach, to both physics and philosophy, is that it dispenses with the traditional interpretation of the constant c as a speed. We propose

that this new, more empirical and consistently phenomenalist interpretation of *c* as no more than a dimensional constant gives a simpler and more coherent explanation of SR in which time dilation plays a central, pivotal role. In addition, the implications for modern physics of this non-velocity, phenomenalist interpretation of *c* are philosophically profound. This is for the following reasons.

What we think of nowadays as 'Physics' was originally known as Natural Philosophy. Following from the Renaissance, this developed along the lines of Empiricism, which favours the most *direct* descriptions of phenomena in the pursuit of physical science. The purest form of this programme is *phenomenalism*. However, from the time of Römer's discovery, in 1676, of what has since been interpreted as 'the speed of light in space', Natural Philosophy began to change. No longer could scientists claim to have direct factual knowledge of the physical world in the form of phenomena. These phenomena were thenceforward relegated to the status of 'mere images', mostly subjective, of essentially *theoretical* objects considered to be the realities of nature behind and beyond direct observation. This was where physics began its radical departure from empiricism towards what has since been called *Realism*, a form of Rationalism in which reason is applied, not to the interpreting of actual phenomena but to the building of projective theories as to what might be the underlying and remote 'sources' of these observational 'appearances'.

Following Römer's discovery, therefore, especially in those experiments on 'light-speed' conducted by Michelson, *et al*., the phenomenalism developed by the English Empiricists, Locke, Berkeley and Hume, as articulated eventually by Mach, came under a growing threat from the Theoretical Realists. From the beginning of the 20^{th} century, this threat became crucial. This was due to Einstein's peculiar rendering of Machian relativism on the basis of his interpretation of the constant *c*, not only as the classical 'speed of light in space' but also as the ultimate inexorable divide (subsequently called Einstein separation) between the world as it supposedly *is* – that is, absolutely, as 'God' might be presumed to see it – and as it is *observed* by the likes of ourselves. This led to the gradual decline of phenomenalism as the standard empirical approach to physics and to the consequent substitution, instead, of the Theoretical Realism of Einstein and his followers.

However, nowadays, this has been opposed by a gradual drift back to phenomenalism *of a sort*. This is in the direct observer-*interventional* approach to physics assumed by modern quantum phenomenology after Bohr, Heisenberg and Schrödinger. The clash between the mechanical absolutism of the Realists and the 'collapse-of-the-wave-function' version of observationism in Standard Model quantum physics has created a modern 'revolution' in physics that has not been fully consummated and understood.

By contrast, this paper presents for general consideration, a solid philosophical basis for *phenomenalism* as a new – or, rather, regenerated – paradigm approach to modern physics. Crucial to this regeneration is the re-interpretation of the constant *c* along the conceptually minimalist and empirical lines of Bondi and Pope. This makes good the failure of the traditional phenomenalists to find any logical way of dealing with Römer's 1676 discovery of what was hailed as 'the speed of light'. Thus by removing the Einstein light-separation between the observer and physical reality, we restore phenomenalism to its original status as the empirical 'square one' of natural philosophy. This also restores *relativity* to Mach's original meaning of the word, which signified a *direct relation*, in physics, between the observer and the object observed. By contrast, Einstein's idiosyncratic rendering of Mach's 'relativity' creates

a paradoxical form of 'relativity by proxy', in which light as a travelling mediator *in vacuo* separates the *referent* (the observer) inexorably from the *relatum* (the object) in a *relation* that is impossible logically to contemplate.

In short, the removal of that supposed mediatory role of light in our quantum contacts with physical objects and processes re-connects Einstein's philosophically unidentifiable 'Relativity' with its true origins in Machian phenomenalism, thereby filling the philosophical void that becomes more and more conspicuous in current relativistic physics. The fact that this lateral-thinking alternative to SR produces an exact mathematical and practical facsimile of that theory which is intrinsically simpler and more conceptually economical, and in which relativistic time-dilation plays the same central role, can scarcely be regarded as trivial.

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