Theoretical article

Lorentz transformation and relativistic Doppler derived from a particle mechanics

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Abstract

PROBLEM: *General and special relativity provide the formulations for how an observer in one frame of reference perceives motion in another. These cosmological principles arise from application of continuum mechanics, and are inaccessible to the particle perspective.* ***PURPOSE:*** *This paper derives the relativity formulations from a particle perspective, using a non-local hidden-variable solution (Cordus theory).* ***APPROACH:*** *The theory assumes a flux tube of discrete force emissions, and this property is exploited to derive the Lorentz transformation. Then this is generalised to a formalism for time dilation, and the relativistic Doppler relationship.* ***FINDINGS:*** *We show it is straightforward to derive the Lorentz and relativistic Doppler from a particle perspective. However the equations are found to contain an additional term relating to the difference in fabric density between situations. For a homogenous fabric - which is the assumption of general relativity - the conventional formulations are recovered.* ***ORIGINALITY:*** *Deriving the Lorentz and relativistic Doppler from a particle theory is novel. Also novel is the proposition that fabric density is a covert variable. The implication is that inertial frames of reference are only situationally equivalent if they also have the same fabric density, and this has further implications for interpreting cosmological redshifts.*

Keywords: gravitation; special relativity; Cordus theory; non-local hidden-variable;

1 Introduction

General and special relativity are well-established from a continuum perspective, but not from a particle basis. Relativity provides the formulations for how an observer in one frame of reference perceives motion in another [1]. A number of phenomena are involved, including time dilation and the Doppler effect. This paper demonstrates the feasibility of deriving relativity formulations from a particle mechanics, specifically a non-local hidden-variable (NLHV) design for the sub-particle structure. The underlying theory is provided by the Cordus NLHV theory. We provide a derivation for the Lorentz transformation – significantly this is in terms of a particle physics and the explanation is grounded in physical realism. The results also lead to the finding that there is an additional covert variable in the Lorentz, which is the fabric density.

2 Existing approaches

The Lorentz transformation is conventionally explained from the continuum perspective of relativity [1]. There is a long history of derivations from various perspectives [2], with equifinality in outcomes. Different derivations vary in their complexity [3]. All are based on a number of postulates about the nature of measurement [4] and by implication that space-time is a continuum [5]. However, particle theories have fared poorly at relativity. It is not possible to derive the Lorentz transformation from first principles using quantum mechanics (QM), nor from string theory, nor using historical NLHV theories such as the de Broglie-Bohm [6, 7]. There are also problems with cosmology in the form of the intractableness of the composition of dark matter and of the process for asymmetrical genesis. These are indicative of inadequacies with one or both of particle physics and general relativity [8].

From the perspective of physical realism there should exist a physics that unifies particle and gravitational effects. However this will not necessarily be an extension of quantum mechanics [9] or of general relativity. I While alternative or new theories of physics do exist, none offer a derivation to recover that key feature of relativity, the Lorentz transformation. Consequently an important test of validity for a more-complete particle physics, quantum mechanics or alternative, is to derive the Lorentz or offer an equivalent formulation. QM has not achieved this, nor have competing theories, so this remains an open question.

3 Approach

Purpose

Previous work has identified a candidate new particle physics in the Cordus theory [10]. This proposes that there is structure at the sub-particle level, and the theory makes specific predictions for the identity of these structures and their mechanics, hence this is a type of NLHV theory with discrete fields. The purpose of the present work was to test whether this theory could recover the Lorentz. Doing this could unify aspects of particle behaviour and relativity. Furthermore, since the Cordus theory is based on physical realism, a successful derivation could provide an explanation of relativistic motion and time dilation that was also grounded in physical realism. Physical realism is a premise about causality: that physical phenomena have deeper causal mechanics involving parameters that exist objectively.

Approach

The approach involves taking elements of the existing theory and extending them to the case of relativistic velocity. Prior work established that under this theory the vacuum speed of light [11] and the rate of time [12] are inversely related to fabric density (described below) which in turn is an emergent property of the spatial distribution of matter, hence varies with location in space.

In the present work we extend this concept to derive the Lorentz transformation. We show that a specific property of the Cordus sub-particle structure, namely the flux tube of discrete force emissions (described below), allows a novel and direct way to achieve this. The theory also predicts that the Lorentz formulation is modified by the fabric density. This requires the conventional concept of an inertial frame of reference to be extended to include the effect of fabric density. We then determine the implications for time dilation for relative motion, by building on prior qualitative work [12] which we extend to a quantitative formulation. The final stage is to derive the relativistic Doppler relationship for this particle theory. This is important because the transverse Doppler Effect is a unique prediction of relativity. We show that this prediction is also achievable from a particle perspective, which is original.

Conceptual underpinnings

The Cordus theory is a NLHV design with discrete fields [10]. The theory proposes that particles are not zero-dimensional points, but instead have a specific internal structure. This comprises two reactive ends some geometric separation apart, somewhat like a dipole. These ends are proposed to be connected by a fibril. The ends are energised in turn at the de Broglie frequency, and in doing so they emit discrete forces at each cycle [10]. These discrete forces are connected in a flux tube. The structure of the electron per the Cordus theory is shown in Figure 1. The frequency mechanism described therein is important for the present analysis, because it involves discrete forces connected in a flux tube. As will be shown, it is the stretch of this flux tube that explains the Lorentz. The other internal structures, such as the span (separation between the two reactive ends), are immaterial for the present gravitational analysis.

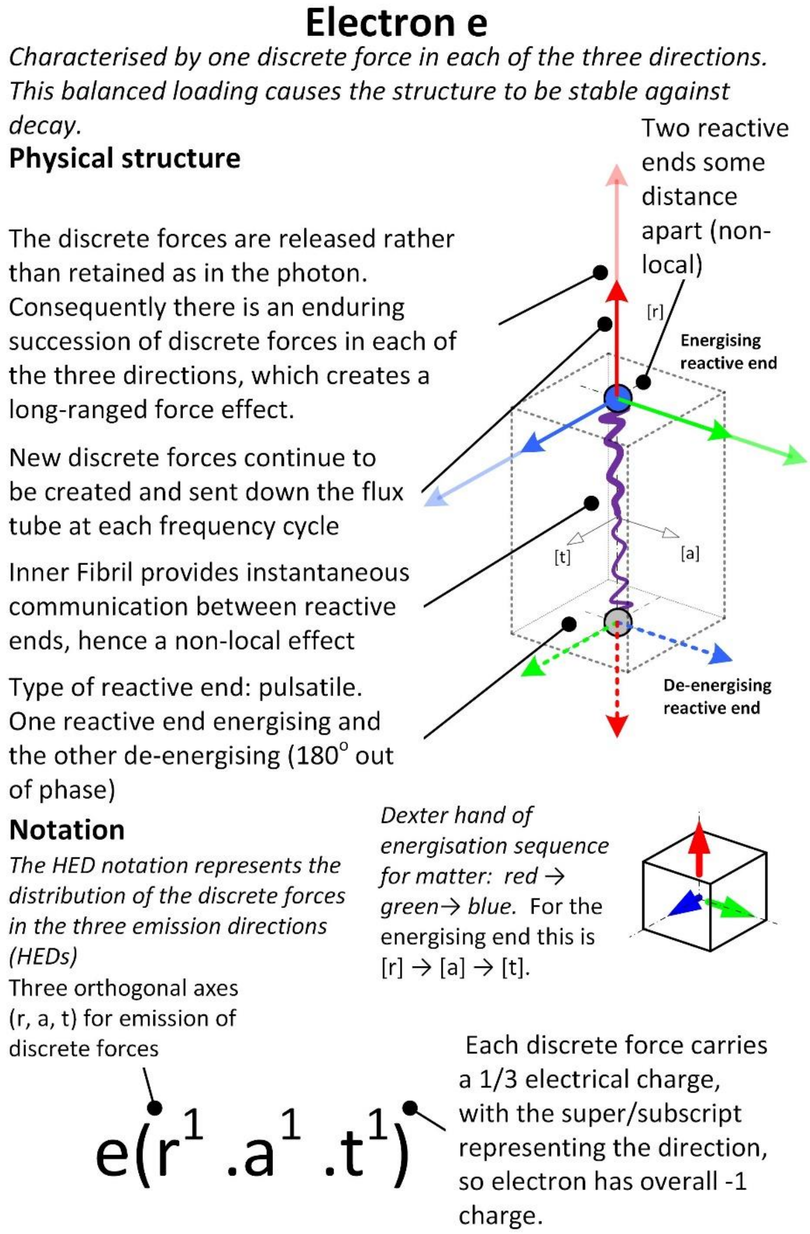

Figure 1: The representation of the electron's internal and external structures. It is proposed that the particle has three orthogonal discrete forces, energised in turn at each reactive end. Adapted from [13].

This structure is termed a *particule* to distinguish it from the zero-dimensional point *particle* of quantum mechanics. This structure explains multiple phenomena, primarily in the area of particle interactions. Examples are the decay processes [14, 15], neutrino selective spin [14], annihilation [16], pair production [17], photon emission [18], and the stability of nuclides [19, 20]. It has also been applied to cosmological problems, such as asymmetrical baryogenesis [21], time dilation [12], and the nature of the vacuum and of the cosmological horizon [22].

4 Results

4.1 Derivation of the Lorentz transformation

Assumptions

Consider massy particule B with a Cordus structure (e.g. an electron) travelling at constant velocity v_B along the x-axis, see Figure 2. Let B emit discrete fields at a frequency, assume these propagate out radially at the local propagation speed, and assume this to be the speed of light c.

Derivation of Lorentz from geometric considerations

The derivation of the Lorentz transformation is achieved by geometric considerations of the effect of movement on the flux tube of discrete forces. Particule B passes point O at time t_0 and emits a discrete field at this moment. After time t_1 this field emission moves out radially on the y-axis a distance $c.t_1$ to point Q. In this same time B moves a distance $v_B.t_1$ to point R on the x-axis. B continues its field emission during this process. Were B to have been stationary at R instead, its emission would have reached point P in the same time. Note that the speed of propagation c is finite.

The emission from B as it moves from O to R must have continuity of the flux tube rather than be broken. Hence the emission from location R is not absent at Q, but is instead stretched, hence redshifted.

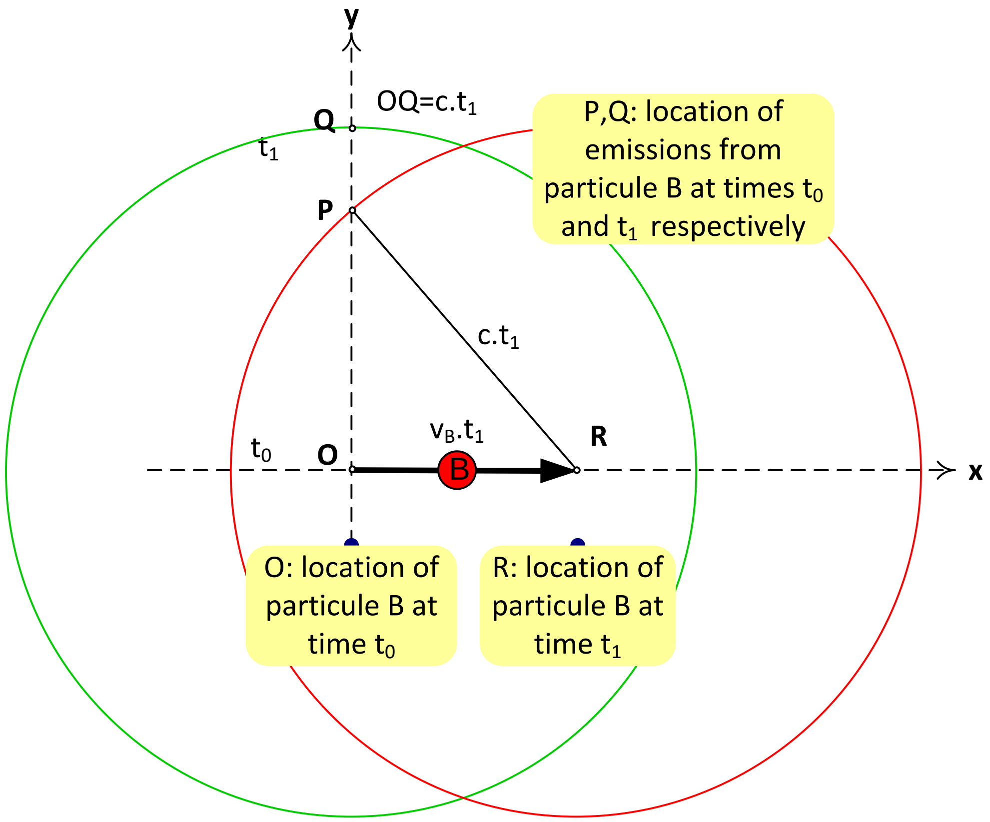

Figure 2: Geometric construction for Lorentz derivation

Then by geometric considerations:

$$\overline{RP}^2 = \overline{OR}^2 + \overline{OP}^2 \tag{1.1}$$

Hence

$$\overline{OP} = \sqrt{(ct_1)^2 - (v_B t_1)^2} = ct_1\sqrt{1 - \left(\frac{v_B}{c}\right)^2} \tag{1.2}$$

The extent of stretch is how far the emission from R has reached towards Q, i.e. distance OP, relative to where the emission from O has reached, i.e. distance OQ. Hence:

$$\frac{\overline{OQ}}{\overline{OP}} = \frac{ct_1}{ct_1\sqrt{1 - \left(\frac{v_B}{c}\right)^2}} = \frac{1}{\sqrt{1 - \frac{{v_B}^2}{c^2}}} = \gamma \tag{1.3}$$

This is the Lorentz. This equation is consistent with the conventional expression of the Lorentz. This completes the first objective, which was to derive the Lorentz from a particule perspective. Note that the derivation is based on physical realism, and plausible assumptions of the continuity of the flux tube.

Interpretation

Thus as velocity increases closer to the speed of light, so γ becomes larger. Greater γ causes reduced apparent frequency of emissions of B as perceived at O, f_{BOb} compared to that at source f_B:

$$f_{BOb} = \frac{f_B}{\gamma} \tag{1.4}$$

Although the derivation considered the stretch in the y-axis, and assumed a time interval t_1, the size of the time interval is immaterial. In the limit as Q->O, i.e. for an Observer positioned at O, the frequency change still exists. Note also that the situation from which the Lorentz is observed is the stationary point O.

As OP ≤ OQ always, so OQ/OP ≥ 1 and the stretch gets larger as the velocity v increases. Hence redshift increases with velocity.

The relativistic time dilation may derived. In what follows the Observer Ob1 is positioned in situation 1. The Lorentz, as derived above, is an indication of the stretch of the Cordus flux tube, and this stretch is manifest as slowing of the frequency as observed by Ob1, giving:

$$f_{BOb1} = \frac{f_{B1}}{\gamma} \tag{1.5}$$

where f_{B1} is the native frequency of object B in situation 1. Frequency in the Cordus theory also corresponds to the rate of time passing for a particule [12]. Greater γ causes reduced frequency of emissions of B as perceived at O, i.e. the clock of moving B appears to be slower to Ob1. This is consistent with the conventional formulation of special relativity whereby a stationary observer perceives a moving clock to run slower.

Evaluation of assumptions

We have assumed that B is a Cordus particule, and emits a discrete field at a frequency. This frequency emission is intrinsically included in the Cordus theory. The theory proposes that particules emit discrete forces from one reactive end, and then from the other, with the emissions from any one reactive end connected to make a flux tube. This construct for frequency is important because it provides the rationale for the emissions from O and R to be synchronised. This supports the interpretation of *stretch* of the flux tube. To achieve something similar within the conventional framework of general relativity, one could assume B to emit pulses of light. However it then becomes difficult to explain why such pulses of light should have temporal continuity between them.

While the Cordus theory proposes that particule B has two reactive ends separated by a span, the above derivation takes the macroscopic perspective and assumes that the span is negligible. We have also assumed B to be a single particle rather than a macroscopic body of many particles. However this is only for convenience of explanation, because it means that only one field is emitted, rather than many. A macroscopic body simply emits many overlapping discrete fields. Each of these is individually subject to the same considerations given here. Thus the derivation applies to assemblies of multiple particles and macroscopic bodies whether coherent or decoherent.

Up to here it has been assumed that the speed of outward propagation of a field is the speed of light. This is consistent with conventional assumptions. The Cordus theory further explains that the finite propagation speed arises because the discrete fields are emitted into a fabric comprising the discrete fields of all other particles in the accessible universe [12]. The derivation shown here requires the speed of light to be locally constant, i.e. the same within the situation, but does not require this to be universally constant.

4.2 Time and fabric density

.1 Fabric

Fabric refers to the mesh of moving flux tubes that are postulated to exist in space [22]. These flux tubes comprise the discrete forces emitted by all particules in the accessible universe. In physical terms this refers to the magnitude of the gross (not the net) electric field in space, under the assumption that even neutral charges emit positive and negative fields. The fabric also distinguishes the vacuum within the universe from the void before genesis, and is proposed as the reason for the existence of electrical and magnetic constants of the vacuum. The density of the fabric ϕ determines those constants and gives the speed of light the value it has [23]. The speed of light arises as the ability of the photon to advance through the fabric. This act of locomotion is proposed to involve the evanescent field of the photon recruiting the fabric's discrete forces, hence creating a travelling disturbance in the fabric. The greater the fabric density the more discrete forces to disturb, and hence in a unit time the photon makes shorter incremental displacement along its locus, hence the slower light travels.[1] With this fabric *c* is locally invariant for isotropic ϕ, hence the speed of light is the same regardless of (a) the motion of the observer or light source, or (b) the direction of motion. However it also follows that under these assumptions the fabric density must generally be a variable, since it depends on the local distribution of mass, which is not homogenous. Consequently the theory predicts that ϕ varies with location in space. This also means that the speed of light is not strictly constant but is instead dependent on the spatial distribution of matter [23].

For this theory the single-body gravitational field approximates to the fabric density. In the more complex case of n-bodies then the mutual contributions increase ϕ but weaken the net gravitational field, so the correspondence is broken. Nonetheless the simple single-body case is useful for exploring the phenomena.

.2 Theory of Time

The Cordus theory proposes that time arises due to the frequency emissions of particles [12]. This may need some explanation as it is a different concept to that of general relativity where time is a dimension. The Cordus theory posits that time is the rate at which a particule is able to energise and emit discrete forces. These phases of energisation are also when the particule responds to the discrete forces of other particules. This is the only way the particule can interact with its surroundings. The particule only exhibits agency – the ability to interact with another particule or field– when it is energised.

Particules that are able to energise faster will achieve more of these interactions than identical particules elsewhere that energise at a slower frequency: the latter are time dilated. The phenomenon of time therefore arises at the sub-particule level, and via these interactions scales up the macroscopic level. Thus, for example, the mechanical process of the ticking of a clock is linked to the rate at which its atoms are able to respond to internal and contact forces, and these depend on the fundamental interactions. This means that the rate of time is local to the situation: there is no universal time, nor is time a dimension.

The frequency of the particule, hence its time rate, is affected by the ease with which the particule can emit its discrete fields into the fabric. This is affected

[1] In contrast a higher density of the medium results in faster speed for sound. However these have different underlying mechanisms. For light the disturbance in the fabric requires the recruitment of a lateral volume of medium, whereas for sound the disturbance involves compression-tension of the medium in the axial direction.

by: the background fabric density for that situation in space (which includes but is more than the gravitational field); the relativistic velocity (whereby forward emitted discrete forces locally densify the fabric); and any acceleration of the particule (which increases its rate of engagement with the fabric). The total fabric density relative to the particule is the sum of these. Thus increased fabric density may arise from either a more matter-rich region of space, or higher velocity, or acceleration, or a stronger gravitational field. These are predicted to cause the particule's own emissions of discrete forces to be retarded, hence its frequency to be slower. Thus also the rate of time is slower for the particule. The theory thus gives a qualitative explanation for the causality of time dilation at the particle level [12].

.3 Definition of situation

The fabric density ϕ is therefore a new variable to be included in the Lorentz formulation. This variable is not expressed in orthodox cosmology, which assumes that the vacuum properties are universally and temporally isotropic. The Cordus theory rejects this idea of cosmological homogeneity, and proposes instead that there is a gradient of fabric density across the universe due to the historic expansion thereof [22], and due to the non-homogenous spatial distribution of matter.

Whereas relativity assumes that two inertial frames of reference are equivalent, the Cordus theory instead proposes that equivalence only applies if the fabric densities are also the same. This cannot generally be accepted to be the same, at least not at cosmological scales or involving different epochs.

Consequently we introduce the term '*situation'* to describe an inertial frame of reference *with a specific fabric density*. Two situations are only similar if both their inertial kinematics and background fabric densities are the same.

Note that in the derivations so far the fabric density ϕ was assumed to be constant throughout. Thus particule B started and continued in the same fabric density, which was also the same at all points under consideration. In the more general case the particule B starts in situation 1 and subsequently moves into situation 2 of different fabric density. We derive this formulation next.

.4 Lorentz Fabric density transformations

The Cordus theory predicts that the frequency of a massy particule is inversely related to fabric density. We propose as a lemma that the relationship is one of inverse proportionality rather than any other function:

$$f \sim \frac{1}{\phi}$$

(2.1)

This leads to the following relationships of situational relativity.

Intrinsic Changes as the Observer moves into a different fabric density

In the general case consider massy particule B with non-relativistic velocity v_{B1} starting in situation 1 with fabric density ϕ_1 and frequency f_{B1}. It subsequently moves into situation 2 of different fabric density ϕ_2 where its velocity becomes v_{B2} and its frequency f_{B2} as measured by a co-moving observer Ob2 in situation 2. These are termed *intrinsic* changes because the properties of B change, even though the observer travelling with B does not notice them. In applying the intrinsic transformations, it is assumed that Object B was once in one situation and then moved to another.

Frequency of massy particule

The frequency of massy body B as measured in the new situation (i.e. the point of observation is co-moving with B) changes to:

$$f_{B2}\,\phi_2 = f_{B1}\,\phi_1$$

(2.2)

Frequency at the fundamental level is the rate at which time passes for the particule, according to this theory. If the Observer travelling with particule B moves into a situation ϕ_2 of *lower* fabric density, then the fabric resistance to the emission of discrete forces *reduces*, so the emission frequency *increases*. Consequently all processes are faster in situation 2, i.e. the time rate is faster. The particule has greater agency to interact with other particules. This also means that an observer Ob2 in situation 2 of lower fabric density is able to process information faster than an observer Ob1 in situation 1. Consequently Ob2 *does not* perceive self to be operating at faster time, but rather that Ob1 and objects in situation 1 have relatively slower rate of time. This applies to massy particules, including clocks, that travel with the Observer into situations of different ϕ

Velocity of massy particule

The velocity of B as measured in situation 2 becomes:

$$v_{B1}\,\phi_1 = v_{B2}\,\phi_2$$

(2.3)

Thus we are proposing that there is an *intrinsic* change in both frequency and velocity, i.e. that the particule really does change those properties. However to the particule itself, the change in its own frequency is not apparent. This is because its frequency also determines its rate of time. For example, velocity v_B *increases* when B moves into a situation of *lower* fabric density, but its frequency, and hence rate of time, also increases by the same proportion. So the co-moving distance travelled by B in a unit of own time is the same as before, though both the velocity and the unit of time have changed. As the intrinsic change in velocity is not perceived by co-moving Ob2, consequently there is predicted to be no perception of inertial acceleration. It is only by examining own progress relative to background objects in situation 1 that Ob2 can infer own velocity to have increased. Alternatively, Ob2 perceives objects in situation 1 to have length contraction.

Behaviour of light in changing fabric density
So far the focus has been on the behaviour of massy particules. The photon is predicted to behave differently. The speed of light *c* is the saturated speed of propagation of discrete forces. The Cordus theory predicts that *c* is inversely related to the fabric density [11]. The theory does not predict the form of this relationship, so we proceed on the assumption of a simple inverse proportionality with fabric density. Hence the speed of light as it moves from situation 1 to 2 is:

$$c_2\, \phi_2 = c_1\, \phi_1 \tag{2.4}$$

For example, if B moves into a situation ϕ_2 of *lower* fabric density, then the local speed of light c_2 increases, though it remains relativistic (is not affected by the velocity of the emitting particule) and is homogenous within that situation (providing there is no gradient to the fabric density). Consequently the Cordus theory is a variable speed of light (VSL) theory [23]. There are other VSL theories in physics, but the Cordus theory is unique in predicting that the variability originates with fabric density.

.5 Applications

Apparent Changes due to observation from a situation of different fabric density
The other transformation is when an object B in situation with ϕ_2 is remotely viewed by an Observer Ob1 *who remains* in situation 1 with fabric density ϕ_1. Ob1 may have no knowledge of the past history of B, or when in the past they inhabited a common situation, i.e. when their temporal-spatial trajectories last converged. Assume the velocities are non-relativistic.

Observer Ob1 observes the passage of B across a foreground of situation 1 marker objects of spacing L, and then uses the local time, i.e. frequency f_1, in situation 1 to infer the velocity of B:

$$v_{BOb1} = L f_1 \tag{2.5}$$

The fabric density effects are not dependent on velocity in the non-relativistic case, so the effect described here is not the same as Lorentz-Fitzgerald length contraction which is purely a velocity effect. Object B notes its own passage against the same marker objects, the spacing of which is also L. For explanation assume $\phi_2 < \phi_1$ hence frequency f_2 is faster in situation 2. Thus B assesses its own velocity v_{B2} as the distance travelled per (shorter) unit of time:

$$v_{B2} = L f_2 \tag{2.6}$$

This is higher than v_{BOb1} due the different rate of time caused by the ratio of fabric densities. We have thus:

$$\frac{v_{BOb1}}{f_1} = \frac{v_{B2}}{f_2} \tag{2.7}$$

Hence also:

$$v_{BOb1}\,\phi_1 = v_{B2}\,\phi_2 \tag{2.8}$$

This is the same general form as Eqn 2.3. This is a useful equation as it allows the velocity v_{B2} of B to be determined from its apparent value in another situation, providing the ratio of fabric densities is known. If there are no Doppler or relativistic velocities then the ratio may be determined by the observed frequencies of some characteristic electron/photon effect. If a time rate f_{B2} is observed from situation 1, then Eqn 2.2 applies.

Round trip

The transformations may be applied sequentially. Consider identical Objects A and B that initially share with Observer Ob1 a common situation 1 with ϕ_1. B has initial velocity v_{B1} and frequency f_{B1}, and the properties of A are initially the same as those of B. Object A remains moving in situation 1, but B moves into situation 2 with fabric density ϕ_2. Assume for explanation that $\phi_2 < \phi_1$. Then the velocity of B increases to $v_{B2} = v_{B1}\,\phi_1 / \phi_2$ per Eqn 2.3. Observer Ob1 remains in situation 1 and observes the passage of B against a foreground of situation 1 markers, and measures velocity v_{BOb1} using Ob1's (slower) rate of time.

Then the proper velocity of B is the distance as measured by Ob1 divided by the elapsed time as recorded by B. This may be inferred as $v_{BOb1} =$

$v_{B2}\ \phi_2/\ \phi_1$ per Eqn 2.8. Substitute v_{B2} from Eqn 2.3 hence $v_{BOb1} = v_{B1}$. Thus the proper velocity of B is the same as before. This is because the decrease in fabric density for B causes the intrinsic velocity of B to increase, but also increases the clock frequency of B by the same proportion. This is the combined effect of B *moving out* of situation-1 and then being observed *from* situation 1. Thus B will perceive that its speed is unchanged, whereas Ob1 will perceive B to be moving faster in the lower fabric density situation.

If B subsequently returns to situation 1, its velocity will decrease per Eqn 2.3 as it enters the higher fabric density ϕ_1, and the observational difference will collapse per Eqn 2.5, so it will once more take up velocity v_{B1} and in that respect be the same as Object A. There will no longer be any difference in simultaneity between A and B. However B will have accumulated more frequency cycles than A, per Eqn 2.2, and hence B will have aged more than A.

This explanation has been given in terms of fabric density. The general principles are proposed to apply also to gravitational fields, which are a proxy for ϕ. Thus if B moves with non-relativistic motion into a region of lower gravity, then conventional gravitational time dilation expects that B will experience faster time frequency. This is consistent with the Cordus explanation provided above. However the Cordus theory also predicts that B will move faster too, which is a new prediction. This has implications for the equivalence of gravitational and inertial mass, which we explore in a companion paper.

Gravitational time dilation for massy particules

Consider a massy particule B that moves away from a massive object, hence moving from a stronger gravitational field (situation 1) to a weaker field (situation 2). For the simple case of a single-body in the universe, the gravitational field corresponds to the fabric density. Hence this distal movement corresponds to a decrease from ϕ_1 to ϕ_2 and Eqn 2.2 predicts a corresponding increase in the intrinsic frequency of the particule. This results in a faster rate of time for the particule in situation 2 compared to one in a stronger field. Since a macroscopic body comprises many fundamental particules this means that the body ages faster in lower gravitational field. This is consistent with gravitational time dilation per general relativity. This finding is qualitatively consistent with the conventional gravitational time dilation effect. The formula considers an inertial frame relative to the gravitational body: such a frame must be moving with the escape velocity v_{esc} and per the Schwarzschild metric this is:

$$v_{esc} = \sqrt{\frac{2GM}{r}}$$

(2.9)

with *G* gravitational constant, *M* mass of the central body, *r* radial position of the Observer's location from the centre of the body. Hence per Eqn 1.3

$$\gamma = \frac{1}{\sqrt{1 - \frac{2GM}{rc^2}}}$$

(2.10)

which is the Lorentz gravitational transformation. However the present theory requires that neither G nor c be universal constants, hence the Schwarzschild formulation of gravitational time dilation is expected to be a simplification of a more complex formulation.

Gravitational redshift of photons
The previous case was for a massy particule experiencing a changing gravitational field: the frequency of the particule increases as it moves outward and this is evident in its changing rate of time. Different behaviour arises where the outward-moving particule is a photon, and in this case redshift occurs, for the following reasons.

When a photon moves outwards against a gravitational field, it moves from situation 1 with higher ϕ_1, into a situation 2 of lower ϕ_2 where Observer Ob2 is located. The conventional prediction is that the photon's frequency will reduce as it moves outwards, hence it will be red shifted. Our Eqn 2.2 appears to be contrary to this, as it predicts that the frequency will increase as viewed in the co-moving frame, but that equation only applies to massy particules. For a photon, the lower fabric density causes an increase in the velocity per Eqn 2.4, hence a stretch of the wavelength and a reduction in frequency. Thus the Cordus theory also predicts that the photon will display gravitational redshift, though attributes this to the change in fabric density rather than the gravitational field per se. Thus the Cordus theory makes the falsifiable prediction that the gravitational red-shift will depend not only on the gravitational potential but also on the background fabric density. For situations with higher background ϕ the extent of the redshift will be reduced.

4.3 Relativistic velocity with changing fabric density

Previous sections have separately derived the Lorentz velocity transformation and the fabric density transformations. Now these are combined.

Geometric considerations

Consider the arrangement per Figure 2, but now assume point R is in a situation of fabric density ϕ_2, whereas the observer Ob1 at O is in a situation with fabric density ϕ_1. Assume that the fabric density changes abruptly immediately outside point O. Then the field emission from object B travelling along RP will be subject to v_{B2} and c_2. Hence the propagation distance OP becomes:

$$\overline{OP} = \sqrt{(c_2 t_1)^2 - (v_{B2} t_1)^2} \tag{3.1}$$

Then substitute the fabric density transformations to refer c_2 to c_1 (Eqn 2.4) and v_{B2} to v_{B1} (Eqn 2.2):

$$\overline{OP} = \sqrt{\left(c_1 \frac{\phi_1}{\phi_2} t_1\right)^2 - \left(v_{B1} \frac{\phi_1}{\phi_2} t_1\right)^2}$$
$$= c_1 \frac{\phi_1}{\phi_2} t_1 \sqrt{1 - \frac{v_{B1}^2}{c_1^2}} \tag{3.2}$$

The speed of light at O determines the distance OQ:

$$\overline{OQ} = c_1 t_1 \tag{3.3}$$

So the Lorentz for variable fabric density, as perceived by Ob1 at point O, is:

$$\frac{\overline{OQ}}{\overline{OP}} = \gamma(\phi) = \frac{1}{\left(\frac{\phi_1}{\phi_2}\right)\sqrt{1 - \frac{{v_{B1}}^2}{c_1^2}}} \tag{3.4}$$

Thus this particle mechanics requires the relativistic Lorentz to have an additional factor included, which is the ratio of fabric density between the two situations. Thus as velocity increases closer to the speed of light, so $\gamma(\phi)$ becomes larger, as per the usual Lorenz effect. However, as the fabric density in the situation 2 decreases, so $\gamma(\phi)$ becomes smaller. The Lorentz $\gamma(\phi)$ is maximised by *higher velocity* and movement into *situations of higher fabric density*. In both cases the moving particule experiences the fabric at a greater rate. The implication is that the conventional Lorentz is an incomplete representation of relativistic phenomena, since it only includes the velocity component and omits the situational differences caused by fabric density. In the case where there is no difference in fabric density, then the conventional Lorenz is recovered. The novel prediction here is that the underlying causality for relativistic effects includes not only velocity, but also the fabric density. This is not anticipated by other theories, and is a falsifiable prediction of the Cordus theory.

4.4 Time dilation with relativistic velocity and variable fabric density

Previous work on the Cordus theory for time dilation has anticipated the effect of fabric density, but the treatment was primarily conceptually [12]. Now we develop a quantitative formalism. Consider an Observer Ob1 (in situation 1 with fabric density ϕ_1) who observes body B (in situation 2 with fabric density ϕ_2 and moving with velocity v_{B2} measured in 2, or v_{BOb1} measured in 1). Then the frequency (rate of time) of B as perceived remotely by Ob_1 is by substitution of Eqn 3.4 into Eqn 1.4:

$$f_{BOb1} = f_{B2}\ \frac{1}{\gamma(\phi)} = f_{B2}\left(\frac{\phi_1}{\phi_2}\right)\sqrt{1-\frac{{v_{B1}}^2}{c_1^2}} \tag{4.1}$$

This equation provides the mathematical formalism for the Cordus time-dilation concept.

The implications are that time dilation is determined by both velocity and fabric density. Note that fabric density is determined by the spatial distribution of matter in the accessible universe around the location under examination. Thus the fabric density is proposed to be the deeper causal mechanism that subsumes gravitational time dilation.

A remote clock B ticking at frequency f_{B2} and moving with velocity v_{B2} in situation 2, will be perceived by a remote observer to have a frequency f_{BOb1} that is determined not only by the Lorentz velocity factor, but also by the ratio of fabric density. The only variable that is unapparent from the perspective of Observer Ob1 is the remote fabric density ϕ_2. This is a covert variable.

Hence we make the novel and falsifiable prediction that there is a time dilation due to a change in fabric density alone, even for particles at rest. The formulation is obtained by putting $v_{B1} = 0$ in Eqn 4.1:

$$f_{BOb1} = \frac{f_{B2}}{\gamma} = f_{B2}\left(\frac{\phi_1}{\phi_2}\right) \tag{4.2}$$

for $v_{B1} \ll c_1$

This may also be recovered from combining Eqn 2.7 and 2.8. In the case where ϕ_2 is less than ϕ_1, then observer Ob1 will perceive B to have a greater frequency than if B was in the same situation as Ob1.

In these equations f refers to the energisation frequency of the single particule under consideration. A macroscopic body has many particules that energise at different frequencies, which all scale by the same factor $\gamma(\emptyset)$. The Cordus theory identifies that particules are only reactive when they energise, i.e. that the agency of a particule occurs at its frequency. Hence all interactions between particules in the body are scaled identically. These interactions include strain, kinematics, chemical reactions, field forces, and nuclear processes. Consequently the body as a whole experiences a change in its rate of time, and this applies whether or not the body has life. Thus the time interval Δt between two ticks of a clock depends on its internal interactions, regardless of whether the mechanism is mechanical, electrical or atomic.

Consider stationary body A in situation 1, and moving body B in situation 2. Both are equipped with identical clocks that according to A beat with intervals of $\Delta t_1 \propto 1/f_{A1}$. Since the clocks are identical A believes that $f_{B2} = f_{B1} = f_{A1}$. Then A will observe that the clock of B is time dilated to interval $\Delta t'$as follows. Per Eqn 4.1 put $\Delta t' = 1/f_{BOb1}$and $\Delta t_1 = 1/f_{B2}$hence we have:

$$\Delta t' = \Delta t_1 \frac{1}{\left(\frac{\phi_1}{\phi_2}\right)\sqrt{1-\frac{{v_{B1}}^2}{c_1^2}}} \tag{4.3}$$

Thus the moving clock B will be perceived to have a longer interval $\Delta t'$ if it moves faster (higher v_{B1}) or moves into a region of greater fabric density (greater ϕ_2). Note that v_{B1} is the proper motion of B in situation 2, from the perspective of an observer in situation 1. This recovers the conventional kinematic time-dilation formula, but with the addition of a fabric effect.

4.5 Doppler change in perceived frequency

The above formulations show how frequency is affected by relativistic velocity and fabric density together. However there is also the Doppler effect to include, since this also changes frequency. We start by showing how the conventional Doppler equation may be derived from the Cordus particule basis, and then progress to add the fabric density effect.

Derivation of conventional Doppler effect (no fabric gradient)

Consider all actions occurring in situation 2. Body B moves with constant velocity v_{B2}, and the frequency of its light is detected by an observer Ob2 from *within the same situation* (inertial frame of reference with constant fabric density). This motion results in a Doppler shift of the emitted frequency. Assume that the motion of B does not take it out of situation 2, i.e. B continues to experience the same background fabric density ϕ_2. The velocity v_{B2} may be resolved into a component in the line of sight of and towards the observer $v_{B2//}$, and a component transverse to the line of sight v_{B2T}.

Descriptive explanation
The change in frequency (e.g. increases for bodies with closing velocity) is a result of the Observer encountering more wavelength fronts in a given time. The wave source (or Observer) has time to move before the next wave is intercepted. If waves travelled instantly then the movement to a new emitting (or observing) location would make no difference to the receipt of the next wave since it would arrive instantly after it was emitted.

Then the Doppler shifted wavelength of light from B as perceived by Ob2, which is λ_{BOb2}, is the native wavelength λ_{B2} less that *reduced* by the ratio of the parallel velocity $v_{B2//}$ to the local speed of light c_2:

$$\lambda_{BOb2} = \lambda_{B2} - \frac{v_{B_2//}}{c_2}\lambda_{B2} = \lambda_{B2}\left(1 - \frac{v_{B_2//}}{c_2}\right) \tag{5.1}$$

Hence the apparent Doppler frequency of B as perceived by Ob2 is:

$$f_{BOb2} = \frac{c_2}{\lambda_{BOb2}} = \frac{c_2}{\lambda_{B2}\left(1 - \frac{v_{B_2//}}{c_2}\right)} = \frac{f_{B2}}{\left(1 - \frac{v_{B_2//}}{c_2}\right)} \tag{5.2}$$

This derives the *conventional Doppler equation*. The Doppler factor may be written as the ratio of the observed frequency f_{BOb2} to the emitted frequency at source f_{B2}.

4.6 Relativistic Doppler with fabric density

The next objective is to combine all three effects: Lorentz, Doppler, and fabric density.

.1 Doppler with time dilation

Consider object B moving with velocity v_{B2} in situation 2 of fabric density ϕ_2 and local speed of light c_2. Object B emits light at a native frequency f_{B2} or wavelength λ_{B2}, these being as measured by B itself. This emission is received by remote Observer Ob1 located in situation 1 having fabric density ϕ_1 and local speed of light c_1.

Approach
Construct the analysis by progressively changing the vantage point of the Observer, from Ob2 with the object in situation 2, to Ob1 in situation 1. Apply

the relevant transformations at each stage. Also introduce the concept of *expected* frequency.

Analysis of situation 2

Start with Doppler (Eqn 5.2), and consider an Observer Ob2 in situation 2. Note that f_{B2} is the emitted frequency at source. In this case, where there is no fabric gradient within the same situation, Ob2 has perfect knowledge about the expected value of frequency f_{B2} because this can be measured for an equivalent stationary object, providing the emission phenomenon can be replicated. Hence f_{B2} equals the value f_{BExp2} expected for the phenomenon by an Observer Ob2 in situation 2. In other words, the Observer has additional information about the 'true' nature of the emission at source. This assumption of universality is tacitly built into the conventional Doppler equation. We propose that no such truth is knowable unless the fabric densities are also known.

Note also that the velocity v_{B2} is as B perceives its own motion, e.g. against a backdrop of stationary marker objects in situation 2. This is also the velocity observed by co-moving Ob2, since there is no time dilation *within* this situation. Thus $v_{B2} = v_{BOb2}$. The Doppler Eqn 5.2 becomes:

$$f_{BOb2} = f_{BExp2} \frac{1}{\left(1 - \frac{v_{BOb2//}}{c_2}\right)} \tag{6.1}$$

.2 Equivalent values in situation 1

Now change the perspective and consider an Observer Ob1 in situation 1, who is looking at object B in situation 2. It is necessary to apply the Lorentz time dilation with fabric density, per Eqn 4.1. Note that $f_{B2} = f_{BOb2}$ for reasons above, and thus substitute Eqn 6.1 into Eqn 4.1. Hence:

$$f_{BOb1} = f_{BExp2} \frac{1}{\left(1 - \frac{v_{BOb2//}}{c_2}\right)} \left(\frac{\phi_1}{\phi_2}\right) \sqrt{1 - \frac{{v_{B1}}^2}{c_1^2}} \tag{6.2}$$

This is incomplete as it is still necessary to refer all situation 2 parameters back to the equivalents in situation 1 using the fabric density transformations (Eqn 2).

Expected frequency f_{BExp2}

A crucial component is the expected frequency and its dependency on fabric density. This frequency is based on a phenomenon, e.g. an electron energy change with a characteristic photon emission. The conventional assumption is that this frequency is universally the same at all sources, and hence that any observed differences may be attributed only to Doppler or relativistic effects hence to velocity difference. However the Cordus theory rejects that interpretation as simplistic, and instead predicts that frequency and the rate of time are dependent not only on velocity but also on background fabric density. For stationary Object B in situation with lower ϕ_2 the frequency of all interactions is higher, and thus the same physical emission phenomenon also occurs at a higher frequency. Hence f_{BExp2} in situation 2 is higher than the frequency f_{AExp1} of the same phenomenon in situation 1. The expected frequency of the phenomenon in situation 1 is therefore affected by the fabric density per intrinsic changes Eqn 2.2. Hence:

$$f_{BExp2} = f_{AExp1} \frac{\phi_1}{\phi_2} \tag{6.3}$$

This takes care of the static situation where there is a fabric difference between the situations, but no motion. The relativistic velocity effects are accommodated in the Lorentz.

Doppler velocity $v_{B2//}$

The observer Ob1 in ϕ_1 measures velocity $v_{B1//}$ rather than the native $v_{B2//}$ itself, and there are different way to reconcile this. We suggest the following. For the Doppler component, the shift is related to the velocity of B relative to the speed of light *in the same situation 2*, per Eqn 5.1. When deriving the Lorentz with fabric density at Eqn 3.2 we used the fabric density transformations to refer c_2 to c_1 (Eqn 2.4) and v_{B2} to v_{B1} (Eqn 2.3), thereby determining the equivalent velocities in situation 1. The same approach is applied here.

The ratio of fabric densities affects both v and c in the same way: both will be elevated by the same proportion if situation 2 has lower fabric density. Thus the fabric effect cancels. Thus we directly transfer the Doppler ratio for situation 2 into situation 1:

$$\frac{v_{BOb2//}}{c_2} = \frac{v_{BOb1//}}{c_1} \tag{6.4}$$

Velocity in situation 1

For the Lorentz component the observed speed is the same as used in Eqn 3.2 hence:

$$v_{BOb1} = v_{B1}$$

(6.5)

.3 Resulting formulation of observed frequency

To determine the observed frequency at Ob1, substitute Eqn 6.3-5 into Eqn 6.2:

$$f_{BOb1} = f_{AExp1} \frac{1}{\left(1 - \frac{v_{BOb1//}}{c_1}\right)} \left(\frac{\phi_1}{\phi_2}\right)^2 \sqrt{1 - \frac{{v_{BOb1}}^2}{c_1^2}}$$

(6.6)

This is the relativistic Doppler with fabric density. Note that this formulation predicts a squared dependency on the ratio of fabric density, which is original. In other respects the conventional relativistic Doppler is recovered when there is no gradient in fabric density ($\phi_1 = \phi_2$).

This also recovers the *transverse* relativistic Doppler, i.e. there is a Doppler effect even when there is no component of motion in the line of sight ($v_{BOb1//} = 0$). Eqn 6.6 gives the transverse redshift as observed by Ob1 watching object B. The light emitted by B *in its own situation* is blue shifted because B emitted the light before the point of closest approach (point O in Figure 2), and hence the flux tube is *compressed* rather than stretched per Eqn 1.3.

This equation accomplishes the purpose of this paper. It derives the Lorentz transformation, including the fabric density. This provides a formalism for relative velocity time dilation.

.4 Special case: motion in the line of sight

In the special case where the velocity of B is entirely in the line of sight, then $v_{BOb1//} = v_{BOb1}$, hence Eqn 6.6 becomes:

$$f_{BOb1} = f_{AExp1} \frac{1}{\sqrt{\left(1 - \frac{v_{BOb1}}{c_1}\right)^2}} \left(\frac{\phi_1}{\phi_2}\right)^2 \sqrt{1 - \frac{{v_{BOb1}}^2}{c_1^2}}$$

$$= f_{AExp1} \left(\frac{\phi_1}{\phi_2}\right)^2 \sqrt{\frac{1 + \frac{v_{BOb1}}{c_1}}{1 - \frac{v_{BOb1}}{c_1}}}$$

(6.7)

This also has implications for the red-shift, as shown next.

.5 Redshift

The conventional representation of the redshift may be recovered, by introducing simplified terminology to recast the equations into the conventional variables. Define:

$f_o = f_{BOb1}$

$f_{Exp} = f_{AExp1}$

$v = v_{BOb1}$

defined as positive *toward* Ob1.

$c = c_1$

$\beta = v/c$

If v is instead defined as positive *away* from Ob1 then the sign of β reverses.

Then Eqn 6.7 becomes:

$$f_O = f_{Exp}\left(\frac{\phi_1}{\phi_2}\right)^2 \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \tag{6.8}$$

Hence the red-shift (z) for the special case of motion in the line of sight is:

$$z(\phi) = \frac{f_{Exp} - f_O}{f_O} = \frac{f_{Exp}}{f_O} - 1 = \left[\left(\frac{\phi_2}{\phi_1}\right)^2 \sqrt{\frac{1-\frac{v}{c}}{1+\frac{v}{c}}}\right] - 1 = \left[\left(\frac{\phi_2}{\phi_1}\right)^2 \sqrt{\frac{1-\beta}{1+\beta}}\right] - 1 \tag{6.9}$$

Thus the red-shift is proposed to also depend on the fabric density ratio.

5 Discussion

Outcomes

We have shown that it is possible to derive the Lorentz transformations from the particle perspective of the Cordus theory.

This work makes several novel contributions. The first is deriving the Lorentz transformation from a particle perspective. The key differentiating factor in this explanation is the continuity of the proposed flux tube. The implication is that a simple physical explanation underpins the Lorentz effect. Providing an explanation for relativity based on physical realism is novel. A related contribution is deriving the equations for relativistic time dilation and Doppler too. This has not been achieved previously from a particle perspective, neither

QM nor string theory nor using other NLHV theories. It is also potentially significant that the theory encompasses aspects of both relativity and particle interactions (such as wave-particle duality, photon emission, and table of nuclides, see for example [17] [19]). An improved integration between particle physics and cosmology is an important priority for any new physics, and this theory evidences this attribute.

A third and more radical contribution is proposing a new cosmological variable of fabric density, and formulating it into relativity. This variable does not appear in other theories, and is a falsifiable prediction of the Cordus theory. This has important implications which are explored next.

Findings
We propose that the conventional formulation of the Lorentz transformation is incomplete and needs the inclusion of a fabric density variable. General relativity is premised on the speed of light in-vacuuo being universally constant. In turn that premise arose as a simple way to formulate the relativity of simultaneity, and as a consequence of rejection of the aether following the Michelson-Morley experiment [24]. In contrast our theory splits and treats separately the relativity of observation, versus the speed of light. It proposes that the fabric is relativistic in terms of exhibiting Lorentz effects, and that the speed of light is constant within an isotropic fabric, but proposes that the fabric density is anisotropic and affects the speed of light.

It is radical to propose fabric density as a new cosmological variable, but it is logically congruent with gravitational time-dilation. The implication is that general relativity is only applicable where the reference frames have the same fabric density, i.e. the *situations* are the same. This means that general relativity is expected to be accurate within the environs of the solar system, but not to intergalactic space. This has further implications for interpreting gravitational interactions at the galactic scale and larger.

We propose that it is necessary to abandon the cosmological principle with its assumption of homogeneity across the temporal phases and spatial dimensions of universe. In its place we propose the concept of variable fabric density. We have shown how the fabric density would affect the Lorentz transformation and we have provided a derivation from a particle basis. Fabric density is expected to show *temporal variation* with the evolution epoch of the universe, and *spatial variation* across aggregations of matter. Gravitational field strength is a proxy variable for fabric density.

If this is correct then several cosmological phenomena need reinterpretation. The fabric effect is covert in that it changes frequencies and velocities in ways that are non-obvious to observers. Consequently human observers attribute other mechanisms to effects that could be due to anisotropic fabric density. Many cosmological phenomena are formulated with the Lorentz or the conventional red-shift. These effects include the Hubble expansion, dark energy, galaxy rotation curves, dark matter. If the red-shift has a dependency on fabric density as we propose then a re-interpretation of these effects will be necessary.

The accelerating expansion of the universe is conventionally attributed to dark energy, the nature of which is unknown. In contrast our theory suggests the phenomenon is due to epochal changes in fabric density. Specifically that the fabric density was greater in the early epoch of the universe, assuming an explosive release of matter at baryogenesis. In later epochs such as ours, the dilution of matter across space caused a reduction fabric density, and this caused massy bodies to experience an intrinsic increase in their velocity (Eqn 2.3 applies).

Within any one epoch the fabric density also changes with spatial position in the universe, being greater at the centres of galaxies than in the disk. The Cordus theory predicts that the lower fabric density in the distal galactic regions causes these distal stars to experience an intrinsic increase in velocity per Eqn 2.3. The Cordus theory suggests that the gradient in fabric density contributes to the anomalous rotation curves of galaxies, such that dark matter may not be necessary in the quantities expected. Further work is required to quantify the effect of fabric density in rotation curves.

6 Conclusions

This work achieves a derivation of the Lorentz transformation from first principles from a particle perspective. While there are many other derivations of the Lorentz there is no particle derivation. Additional originality is that the derivation is from the non-local hidden-variable sector.

The findings are that the conventional Lorentz formulation is missing an important variable, the fabric density. Fabric refers to the aggregation in free space of discrete forces emitted from all the other particules in the vicinity. We propose a new formulation of the Lorentz that includes the relative difference in fabric density between source and observer. We derive a quantitative formulation for time dilation with relativistic velocity and variable fabric density. This complements earlier work that provided a qualitative description of time dilation [12]. The relativistic Doppler equation is also derived, which is likewise an original contribution since it is a key feature of general relativity that has not previously been demonstrated from a particle basis.

The implication is that the conventional Lorentz is an incomplete representation of relativistic phenomena, since it only includes the velocity component and omits the proposed situational differences caused by fabric density. In the case where there is no difference in fabric density, then the conventional Lorenz is recovered. Hence we make the new prediction that the underlying causality for relativistic effects includes not only velocity, but also the background fabric density. This is not anticipated by other theories, and is a falsifiable prediction. We propose that the concept of a 'reference frame' in conventional relativity needs to be replaced with that of a 'situation', which is an inertial frame of reference *with* fabric density. The wider implication of situational relativity is that velocity phenomena, such as cosmological expansion and galaxy rotation profiles, are at least partly artefacts of temporally and spatially variable fabric density respectively.

Author Contributions
All authors contributed to the creation of the underlying concept, development of the ideas, and editing of the paper.

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