Speed of light dependency on fabric density

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Abstract

The invariance of the in-vacuo speed of light is a premise of general relativity and all the cosmological models built thereon. There is also good empirical reason to believe it constant in the situations that we can measure. Nonetheless it is still possible that the empirical evidence could be explained by a variable speed of light (VSL) theory. In this paper we develop such a theory from the basis of the Cordus conjecture, which is a non-local hidden-variable (NLHV) solution. The theory proposes that all particules of matter emit discrete fields, which aggregate to create an electro-magneto-gravitational (EMG) fabric. Consequently, the fabric density at a location is variable, being determined by the proximity and local spatial distribution of matter. It is proposed that the discrete fields of the photon interact dynamically with each discrete field of the fabric. Thus frequency cycles of the photon are consumed with fabric interactions, and hence time also is consumed. Therefore we propose a time dilation effect whereby the photon takes longer time (shorter time) to cross a unit distance when in a fabric that is denser (sparser) than the Observer's frame of reference. The outcome is that the Cordus theory predicts that the speed of light depends on the fabric density, which in turn depends on the proximity and spatial distribution of matter. Consequently the Cordus theory denies the universal applicability of the cosmological principle of homogeneity and isotropy of the universe, and instead proposes that these principles are only approximately true.

Keywords: Cordus conjecture; observer; non-local hidden-variable solution; variable speed of light; cosmological principle

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1 Introduction

The constancy of the speed of light in the vacuum was the central insight in Einstein's work on general and special relativity [1]. We are inclined to accept this as true, and it forms the foundation of much of current cosmology. In addition, there has not been any empirical evidence that convincingly shows the speed of light to be variable *in-vacuo*. Nonetheless, from a theoretical perspective the invariance is an assumption, and it is possible that the empirical evidence could be explained by a different theory. In this paper we develop such a theory. We argue, from the basis of the Cordus conjecture, which is a non-local hidden-variable (NLHV) solution, that the speed of light could be variable.

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2 Background

Invariance of the speed of light

The aberration of light, whereby the location of stars appears to change depending on the velocity of Earth in its orbit, was an early indication that light had a finite speed [2]. In the late 1800s the propagation of light was believed to be through a medium called the luminiferous ether. One of these theories, the undulatory theory of de Broglie, Fresnel, Schrödinger and others [3, 4], proposed that the ether was generally at rest, except in transparent bodies where it caused refraction. The Michelson-Morley experiment [5] directly tested the idea of Earth moving through a stationary ether, by looking for differences in the speed of light in orthogonal directions, and found no evidence to support such a theory.

Einstein subsequently built special relativity [1] on the insightful premise that the speed of light is the same for all inertial reference frames. Specifically, that the speed of light is invariant under any velocity or orientation of the inertial frame of observation (Lorentz transformation). Yet the constancy of the speed of light is nonetheless an assumption: Einstein guessed rather than proved it, and designed it into special relativity (SR). The invariance is therefore no proof of the validity of SR. However what is more convincing is that the effects SR predicts, including time dilation and the relativity of simultaneity, do appear to be real and therefore provide secondary support for the invariance premise underlying SR. Furthermore, a string of subsequent measurements have supported the constancy of the speed of light. The most recent [6] set a lower limit on any local anisotropy Δc of the speed of light c as $\Delta c/c \sim 1\times10^{-17}$ (over one year, in a block of fused silica).

Variable speed of light models

Thus the constancy of the *in-vacuo* speed of light, at least on Earth, is well-established, as are the effects of SR. Nonetheless there has been ongoing interest in whether the speed of light really is invariant. The primary purpose of these endeavours is to explore for new physics at deeper levels, with a particular interest in quantum-gravity. One line of attack has been to look for violation of Lorentz invariance in other settings [7]. For example, it may be that the invariance of c breaks down at very small scales, or for photons of different energy. However such searches have typically (so far) been unsuccessful [8].

Another approach is cosmological, in that assuming a variable speed of light can solve certain problems. Thus explanatory advantages are had if there were a faster c in the early universe, i.e. a time-varying speed of light. Specifically, it has been proposed that the horizon, inflation and flatness problems can be resolved this way [9]. There are several other applications of variable speed of light (VSL) theories [9, 10] including branes [11] and particle creation [12]. Another focus has been to use VSL to explain the Pioneer anomaly [13], e.g. using power law fitting [14].

In all these theories the difficulty is providing reasons for why c should vary with time or scale. They require the speed of light to be different at

genesis, and then somehow change slowly or suddenly switch over at some time or event.

4 Purpose and Approach

The purpose here is to explore the implications of the Cordus conjecture for the speed of light. Our approach is to use a logical method based on systems design. Specifically we start with the Cordus conjecture [15], and its theories for time [16], and for the fabric of discrete forces that it proposes as the content of the vacuum [17]. From this we identify the causes of variability in the fabric density, and then why the speed of light would depend on this density.

Our approach is a conceptual one, and we represent this theory as a causal model, using the systems engineering modelling notation of integration definition zero (IDEF0) [18].[2] The IDEF0 model represents the proposed relationships of causality, and thus serves the same purpose as mathematical formalism does in conventional physics. Any particular assumptions required, are noted as lemmas in Appendix A. The lemmas represent the proposed Cordus mechanics, and are a mechanism to ensure logical consistency within the wider theory.

5 Results

5.1 Cordus theory for particules

Inner structure of the Cordus particule

The basic idea is that every particule has two reactive ends, which are a small finite distance apart (span), and each behave like a particle in their interaction with the external environment [19]. A fibril joins the reactive ends and is a persistent and dynamic structure but does not interact with matter. It provides instantaneous connectivity and synchronicity between the two reactive ends. Hence it is a non-local solution: the particule is affected by more than the fields at its nominal centre point [20].

Each reactive end of the particule is energised in turn at the frequency of that particule (which is dependent on its energy). The reactive ends are energised together for the photon, and in turn for matter particules. The frequency corresponds to the de Broglie frequency. The span of the particule shortens as the frequency increases, i.e. greater internal energy is associated with faster re-energisation sequence (hence also faster emission of discrete force –see next section- and thus greater mass).

[2]Legend: With IDEF0 the object types are inputs, controls, outputs, and mechanisms (ICOM) and are distinguished by placement relative to the box, with inputs always entering on the left, controls above, outputs on the right, and mechanisms below.

External structure: Cordus discrete field structures

When the reactive end is energised it emits discrete forces in up to three orthogonal directions.[3] The quantity and direction of these are characteristic of the type of particule (photon, electron, proton, etc.), and the differences in these signatures is what differentiates the particules from each other. [4] Although for convenience we use the term discrete *force* for these pulses, the Cordus theory requires them to have specific attributes that are better described as *latent discrete prescribed displacements*. This is because a second particule that subsequently receives one is prescribed to energise its reactive end in a location that is slightly displaced from where it would otherwise position itself. Thus in the Cordus theory, that which we perceive as force is fundamentally the effect of many discrete prescribed displacements acting on the particules. Force becomes coercive displacement.

These discrete forces are connected in a flux line that is emitted into the external environment. (In the Cordus theory this is called a hyperfine-fibril, or hyff). Each reactive end of the particule emits three such orthogonal hyff, at least in the near-field. The exception is the photon, which only emits radially. These directions are relative to the orientation of the span, and the velocity of the particule, and termed hyperfine-fibril emission directions (HEDs). The axes are named [r] radial outwards co-linear with the span, [a] and [t] perpendicular to the span and to each other [21]. These are so-named for consistency with our previous nomenclature for the photon, but when applied to massy particules do not necessarily imply motion. It is proposed that the quarks and other leptons follow the same pattern, though in the case of the quarks not all the hyff emission directions [r,a,t] are filled (hence their fractional charge). These principles and their application to the photon, are shown in Figure 1.

[3] We acknowledge that we have not described what these discrete field pulses comprise. Instead, the Cordus conjecture simply shows that having such elements is a logical necessity for this solution.

[4] Within our model we refer to these discrete force pulses as *vires.* Earlier papers used the term 'hyffon' for the discrete force. We have changed the terminology to avoid the implication that these elements are 0-D particles. The terms *vis* (singular) and *vires* (plural) are Latin for *force*.

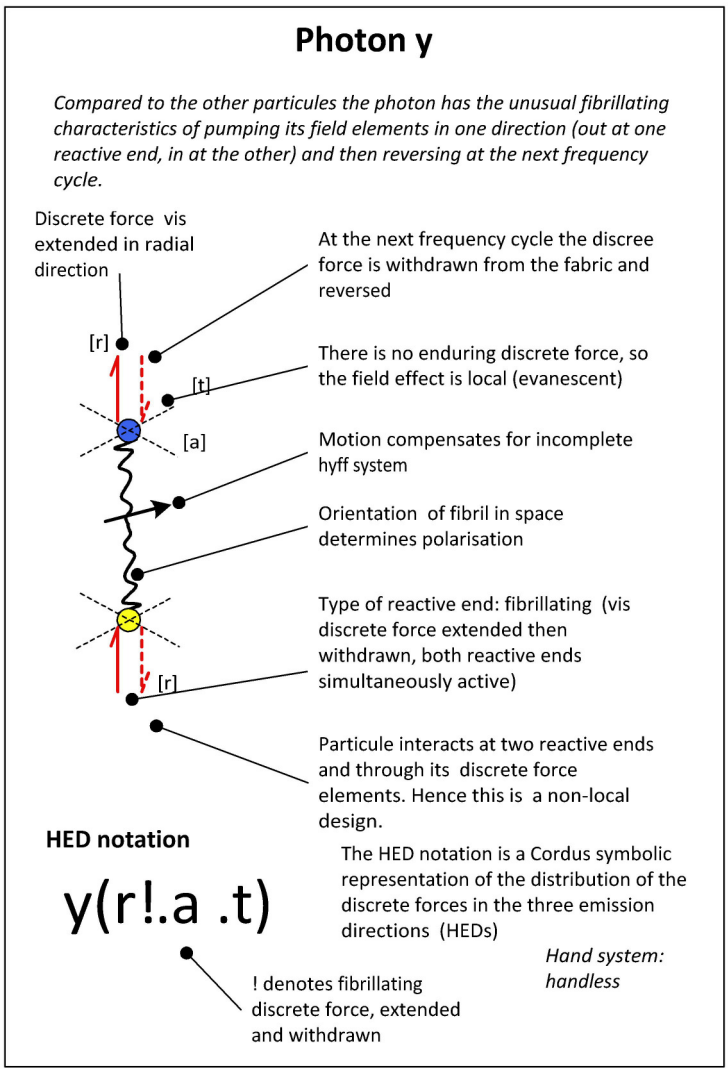

Figure 1: The Cordus theory proposes that particules have an internal structure and emit a signature of discrete external forces. This diagram shows the Cordus model for the photon structures.

The aggregation of discrete forces from multiple particules creates the EMG fields, which are thus discrete. The combined emission discrete forces makes up a 3-D composite structure. The direct lineal effect of the discrete force provides the electrostatic interaction, the bending of the hyff flux line provides magnetism, the torsion provides gravitation interaction, and the synchronicity between discrete force elements of neighbouring particules provides the strong force. These are all carried simultaneously by the composite discrete force element as it propagates outwards on the hyff flux.

Assembled massy particules compete spatially for emission directions, and may synchronise their emissions to access those spaces. Thus there is mutual negotiation in the near-field between interacting particules, based on shared geometric timing constraints. These particules interact by negotiating complementary HEDs and synchronising the emission frequencies of their discrete force elements. This synchronicity is proposed as the mechanism for the strong force [22] and for coherent assemblies. The same mechanism, acting through coherent assemblies of electrons,

explains molecular bonding. Thus the Cordus theory provides force unification by providing a model for electro-magnetic-gravitational-synchronous (EMGS) interactions as consequences of lineal, bending, torsion, and synchronicity effects respectively. The discrete force element is a 3-D composite structure, with a hand defined by the energisation sequence between the axes, and hence the matter/anti-matter species differentiation.

5.2 System model

A cosmological framework

There are several other elements of the Cordus theory with cosmological reference. In particular, there are theories in place for the processes of pair production and asymmetrical genesis (baryogenesis and leptogenesis) [23], nucleon decay and formation of neutrons [24], strong force and the simple hydrogen nuclide [22]. The inflationary expansion of the universe is also explained by the strong force: in the Cordus theory the strong force is explained as a synchronous interaction [22], [5] and the inflation is simply the natural result of desynchronisation between the discrete forces produced by particules, with a consequence repulsion. The cosmological boundary has also been explained [17], and an interpretation given for the holographic principle - not all of which is accepted in the Cordus theory. These basic principles of the Cordus theory are represented in Figure 2 (CM-07).

Part of the Cordus conjecture is an internal-variable solution, and the other part is a model for the outward propagation of discrete forces, with the two models being tightly linked. By contrast other NLHV solutions, like the de Broglie-Bohm [3], tend to only address the inner part of the problem. The Cordus theory therefore provides a mechanism whereby matter particules generate discrete fields, the aggregation of which creates a fabric that pervades all space within the universe.

[5] The Cordus theory for the strong force proposes that it is a synchronous interaction between discrete fields, as opposed to the conventional interpretation that the force changes its nature with distance to become attractive-repulsive (doi:http://vixra.org/abs/1208.0030). Thus in the Cordus model the synchronous interaction prescribes displacements to pull the particules together at one reactive end (or push them apart). Specifically, it is proposed that inflation arises from a competition for field emission directions that cannot be satisfied under the extreme constraints at genesis, so the reactive ends of the particules escape by reenergising at more distal locations, hence outward velocity. The synchronous interaction has a short range, hence limiting the scope of the inflation.

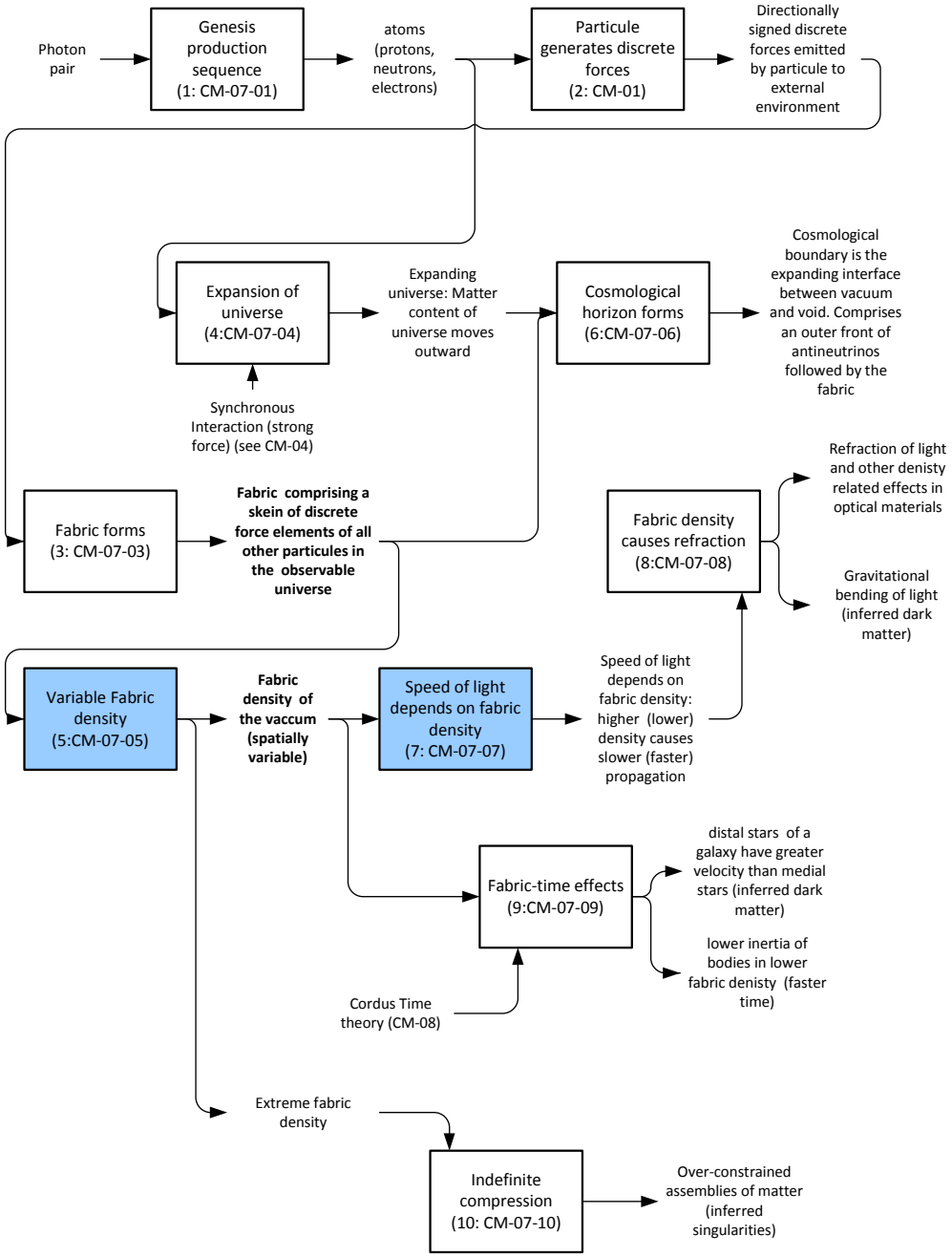

Figure 2: The broader Cordus cosmological theory includes proposals for the genesis processes, including the asymmetry thereof, and the subsequent expansion of the universe. These are represented in this system model. Our interest in this paper is in two subcomponents of this model, namely the variable fabric density and the speed of light (highlighted boxes).

5.3 Variable fabric density

In the Cordus theory all particules of matter have two reactive ends separated by a span, and these ends are energised in turn at a frequency. The energisation results in the reactive end emitting discrete force elements in three orthogonal directions (HEDs), and these discrete forces are propagated out into the external environment surrounding the particule. The particule continues to emit more discrete forces each time its reactive ends energise. The discrete forces are not consumed by interactions with other particules, but instead continue to travel away from the particule that emitted them. The aggregation of many such discrete forces from many neighbouring particules creates the electro-magnetic-gravitational (EMG) fields. Consequently these discrete forces can also be considered discrete field elements.[6] The overall result is that the space in and between matter particules is filled with these discrete field elements, and this is the Cordus fabric [17]. The fabric therefore corresponds in the first instance to the gravitational field, but is a discrete version thereof and carries more than just that single field. Furthermore, the fabric density at a location is variable, being determined by the proximity and local spatial distribution of matter, and in this regard is no different to the variability of EMG field strength. The system model for this is shown in Figure 3 (CM-07-05).

Thus in the Cordus theory the fabric comprises the moving discrete field elements generated by matter particules within the observable universe [17]. In this way the Cordus theory differentiates between the vacuum within the universe and the outside void into which the universe expands. The void is identified as lacking a fabric, and also being without time.

The immediate consequence is that the fabric density of the vacuum is spatially variable, being denser nearer to matter. This also implies that the fabric density will be constrained by the observable universe. Thus matter that is too far away might be unable to send its discrete forces to a specific location of interest, and therefore does not contribute to the fabric density at that point. The complementary principle is that the fabric density is diluted by an expanding universe.

Furthermore, this means that the fabric will be anisotropic, since it depends on the spatial distribution of matter. It may be locally isotropic where the matter is uniformly distributed. However the Cordus theory predicts that the fabric will be highly anisotropic out towards the boundary of the cosmos.

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[6] The Cordus theory proposes that the electrostatic, magnetic, and gravitational fields are each separate attributes of a single deeper phenomenon based in discrete forces. The theory also accommodates the known attributes of the forces/interactions/fields. Thus the $1/r^2$ decrease of the EMG fields is explained as arising from the dilution of the discrete forces across an expanding spherical area; the attractive-indent-repulsive nature of the strong force is explained as a synchronisation of discrete forces; the evanescent field of the photon with its exponential decrease with distance is explained as a consequence of that particule recycling its discrete forces (as opposed to releasing them) and thereby recruiting a volume of material rather than merely a front.

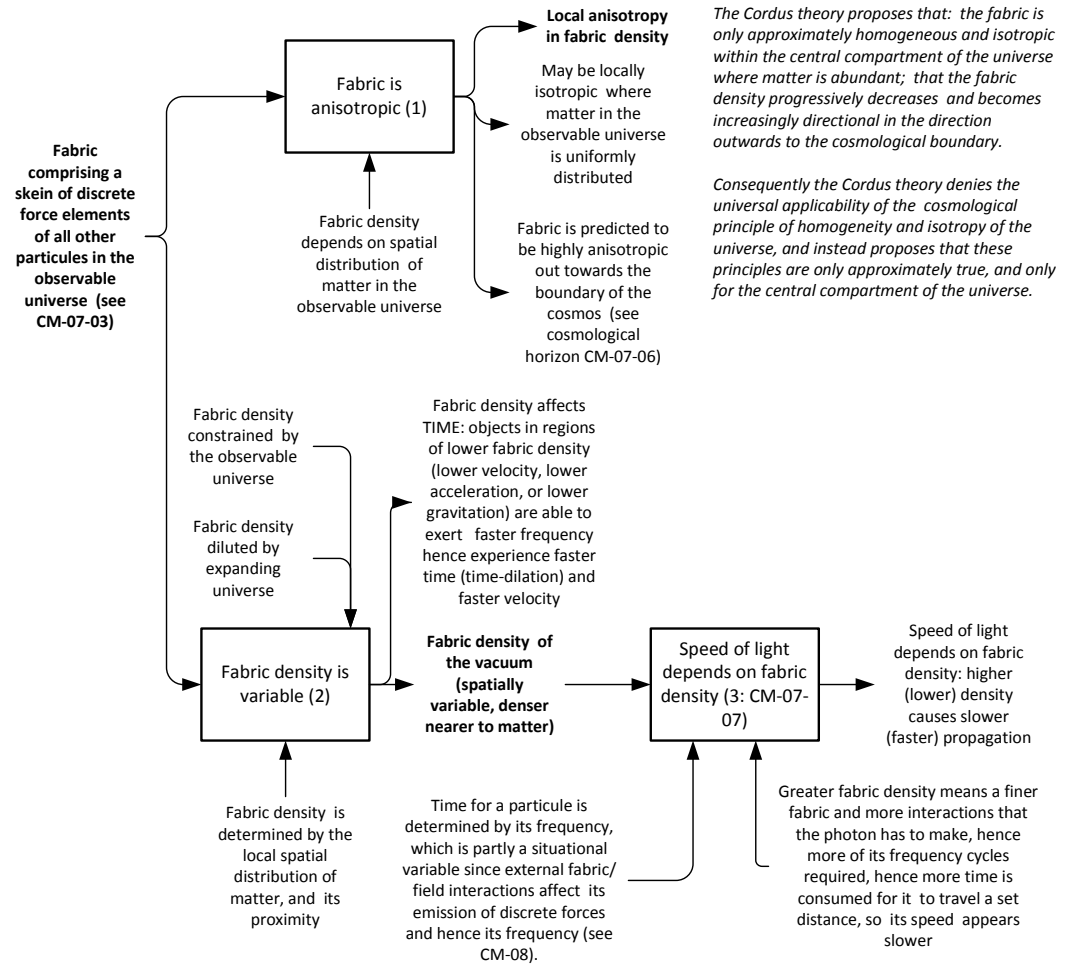

Figure 3: The fabric is proposed to have a variable density, due to the spatial distribution of matter within the universe. Consequently there are two effects to consider, the anisotropy and density of the fabric. It is the density effects that are of particularly interest here, because of the implications for the speed of light.

Thus this part of the Cordus theory proposes that: (1) the fabric is only approximately homogeneous and isotropic within the central compartment of the universe where matter is abundant; (2) that the fabric density progressively decreases and becomes increasingly directional in the direction outwards to the cosmological boundary. Consequently the Cordus theory denies the universal applicability of the cosmological principle of homogeneity and isotropy of the universe, and instead proposes that these principles are only approximately true. Nonetheless, for privileged situations within the universe, such as inside galaxies or far from any galaxy, the night sky is approximately homogenous, and therefore the fabric density is also approximately isotropic and apparently constant.

Having proposed a means whereby the fabric may be inhomogeneous, we now consider the implications for the speed of light.

5.4 Dependency of speed of light on fabric density

Propagation of the photon in the fabric of the vacuum

The Cordus theory proposes that the photon is different to other massy particules in that its discrete forces are emitted and withdrawn, as opposed to being released. The discrete forces of the photon can alternatively be considered to involve energy that is borrowed from the fabric.[7] We take this idea further in proposing, as a lemma or assumption of this part of theory, that the discrete fields of the photon are transients in the discrete forces of the fabric. This explains why many photons can share the same space: one photon imposes a distortion on the discrete forces of the fabric, and the distortions of multiple co-located photons are cumulative.

Thus we propose that: the photon interacts dynamically with the fabric > each interaction requires a frequency cycle of the photon (since the photon's discrete forces are only generated when the it re-energises) > that frequency cycles of the photon are consumed with fabric interactions > hence denser fabric requires more frequency cycles of the photon per distance traversed (and less dense fabric requires fewer photon frequency cycles).

At this point we bring in the Cordus theory for time [16], which proposes that time at the fundamental level consists of the frequency oscillations of the particules concerned.[8] Consequently the traverse time of the photon depends on the fabric density. This is because greater fabric density means more interactions that the photon has to make, hence more of its frequency cycles required, hence time runs slower for the photon relative to a frame of reference with sparser fabric. Thus we are proposing a time dilation effect whereby the photon takes longer time (shorter time) to cross a unit distance when in a fabric that is denser (sparser) than the Observer's frame of reference. This conclusion also relies on another lemma, that it is meaningful to consider a unit distance being the same whatever the fabric density.[9]

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[7] Consequently the photon can also be considered a type of electromagnetic transient within the fabric. This is consistent with electromagnetic (EM) wave theory, though the Cordus theory makes it a dipole arrangement rather than a point, and discrete forces rather than continuous EM fields.

[8] Thus time is locally generated and a property of particules (matter and photons), which consistent with the perspective of quantum mechanics. At the next level up, that of the assembly of matter particles via bonds and fields, the interconnectedness of that assembly creates a patchwork of temporal cause-and-effect, and hence a coarser time. Hence a phenomenon that occurs in one body is communicated via photons, or massy particules, or fields, to other matter around it. Thus time at the macroscopic level is also universal and relative, which consistent with the perspective of general relativity.

[9] This does not involve the Lorentz length contraction because that is a kinematic effect associated with the time-dilation and the relativity of simultaneity rather than fabric density.

The outcome is that the Cordus theory predicts that the speed of light depends on the fabric density, which in turn depends on the proximity and spatial distribution of matter. Higher (lower) fabric density is expected to cause slower (faster) photon propagation. The system model for this is shown in Figure 4 (CM-07-07).

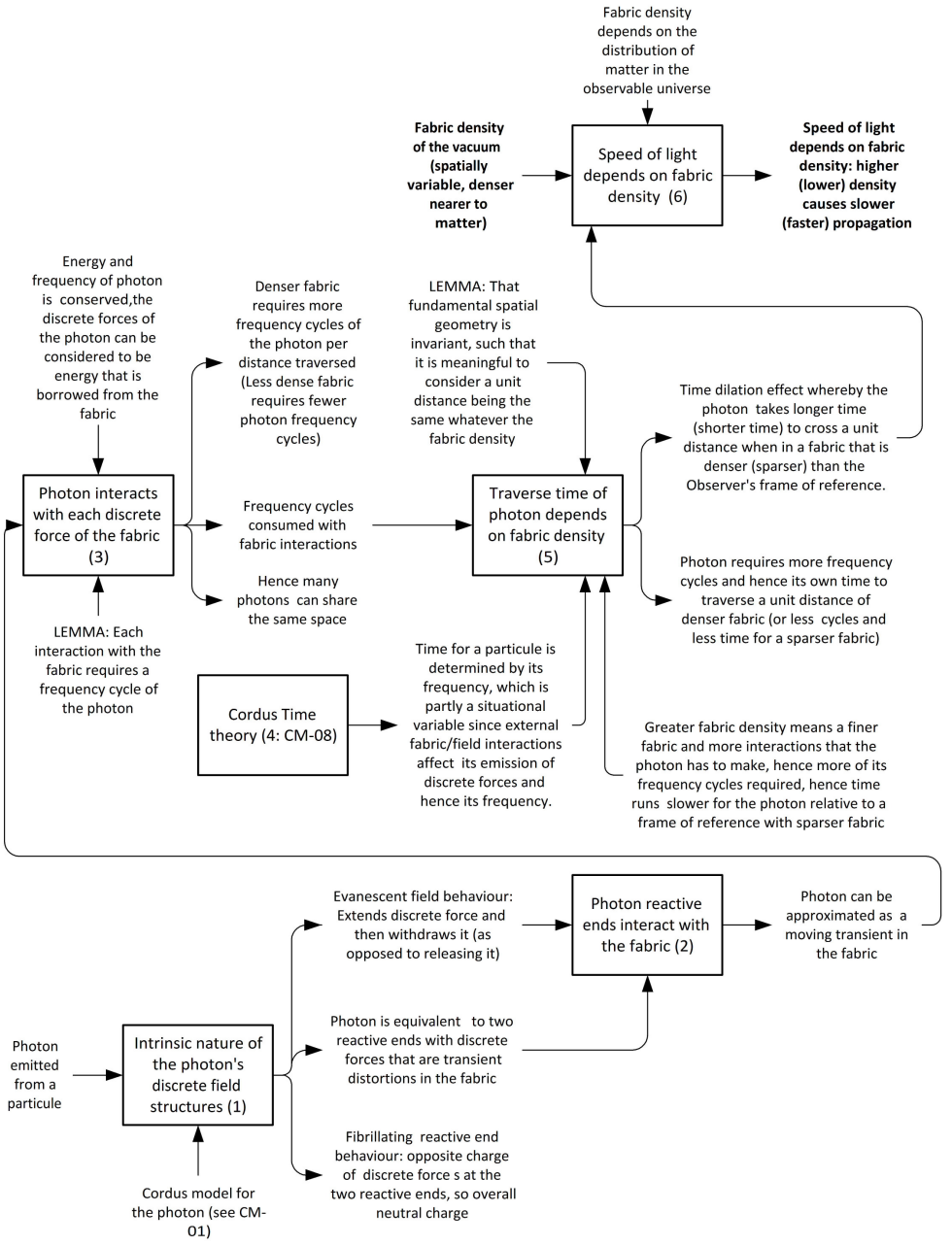

Figure 4: The Cordus theory predicts that the speed of light depends on the fabric density, which in turn depends on the proximity and spatial distribution of matter. Higher (lower) fabric density is expected to cause slower (faster) photon propagation.

6 Discussion

6.1 Outcomes

This analysis shows the logical feasibility of a variable speed of light, starting from a NLHV design. The argument starts with some basic assumptions that are reasonable in themselves, and provide a systematic grounding for a variable speed of light theory. This is a novel outcome of itself, since it provides a more systematic basis than most other VSL theories (which tend to simply take VSL as a premise). A second contribution is the specific identification of fabric density as the dependent variable. In contrast, other VSL models propose that *c* varies with time or some geometric-like scale, and then struggle to provide naturally plausible reasons why *c* should depend on that variable. The Cordus theory is unique in proposing fabric density as the variable. Compared to other VSL theories, the Cordus theory differs in that it does not require an abrupt switch in *c* (as do some theories).

A third contribution is that this theory offers a conceptually simply way to reconcile the refraction of light in *ALL* settings, vacuum and optical materials. Optics already accepts that the speed of light is variable in any matter-based medium. Furthermore it is a general principle of optics that the refractive index increases with the mass density of the medium. The Cordus theory explains this as the fabric within a glass object being denser, due to the proximity of the massy glass molecules, than the vacuum. Thus it is proposed that the fabric of the vacuum extends into and through all massy objects, and those objects densify it locally. Thus the Cordus theory provides a parsimonious way to reconcile the phenomenon of the speed of light varying with refractive index, and the *in-vacuo* behaviour of light.

A fourth contribution is that the Cordus theory reconciles many of the existing theories of light, despite their differences. Thus it accepts, albeit as approximations, the ideas from electromagnetic wave about light being an electromagnetic wave, that the vacuum is a medium, that the photon is a transient in the medium. It likewise accepts the quantum mechanics ideas of photons being individual items rather than waves. It also accepts, with caveats, the special relativity assumption that the speed of light is constant in the space around earth. However the Cordus theory also proposes that the behaviour of light is more than any of these theories on their own.

Falsifiable predictions

The Cordus theory is a conceptual work, built on a starting conjecture for the structure of matter. Falsifiable feature of the theory are:

1. That speed of light depends on fabric density. This feature alone is sufficient to differentiate the Cordus theory from all conventional and other VSL models.
2. Another falsifiable prediction is that the speed of light is *variant to this day.* By comparison, some of the other VSL models that are time-based propose that the speed of light is now invariant.

6.2 Implications

The outcome is that the Cordus theory rejects the concept of the invariance of the *in-vacuo* speed of light. Consequently this theory is contrary to special and general relativity. Nonetheless the theory accepts relativity as valid concept where the fabric density is sufficiently constant. Consequently the Cordus theory denies the universal applicability of the cosmological principle of homogeneity and isotropy of the universe, and instead proposes that these principles are only approximately true. The Cordus theory accepts the existing mathematical formulism of relativity and quantum mechanics as useful approximations in certain well-defined situations, and therefore a wider integration is feasible. If this theory is true then the many applications in cosmology that assume invariance of *c* would need to be revisited. We develop these ideas further in additional works.

7 Conclusions

The Cordus theory rejects the concept of the invariance of the *in-vacuo* speed of light, and instead proposes that the speed depends on the fabric density. The theory also provides a description of the composition of that fabric. This is in terms of an aggregation of discrete forces from many neighbouring particules to create an electro-magnetogravitational (EMG) fabric.

There are several key concepts that differentiate this Cordus theory from other VSL theories. The first is the provision of a NLHV structure, the discrete force concept, and the idea that the fabric density at a location is variable being determined by the proximity and local spatial distribution of matter. The second is the idea that the discrete fields of the photon interact dynamically with each discrete force of the fabric and therefore consume frequency cycles of the photon. The third is that frequency cycles correspond to elapsed time, and therefore the traverse time of the photon depends on the fabric density. Thus we are proposing a time dilation effect whereby the photon takes longer time (shorter time) to cross a unit distance when in a fabric that is denser (sparser) than the Observer's frame of reference.

A Appendix: Lemmas

The following assumptions are built into or emerge from this Cordus theory, and expressed as lemmas. The lemmas represent the Cordus mechanics, and are a mechanism to ensure logical consistency within the theory.

CM-07-07 Speed of light Lemma

.1 Each interaction with the fabric requires a frequency cycle of the photon

.2 That fundamental spatial geometry is invariant, such that it is meaningful to consider a unit distance being the same whatever the fabric density.

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