Outer boundary of the expanding cosmos: Discrete fields and implications for the holographic principle

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Abstract

A physical interpretation of the holographic principle is derived, using a specific non-local hidden-variable theory called the Cordus conjecture. We start by developing an explanation for the vacuum, and differentiate this from the void into which the universe expands. In this theory the vacuum comprises a fabric of discrete field elements generated by matter particules. The outside void into which the universe expands is identified as lacking a fabric, and also being without time. From this perspective the cosmological boundary is therefore the expanding surface where the fabric colonises the void. Thus the cosmological boundary is proposed to contain the discrete field elements of all the primal particules within the universe, and therefore contains information about the attributes of those particules at genesis. Inner shells then code for the changed locations of those particules and any new, or annihilated, particules. Regarding the notion of holographic control of inner contents of the universe from the outer surface, this theory identifies the infeasibility of placing a physical Agent at the boundary of the universe, and also predicts there is no practical way to control the universe from its outer boundary as the holographic principle suggests. It also rejects the notion that the boundary contains information about the future and past, or about all possible universes. The Cordus model suggests that there is no causality from the boundary of the universe to its inner contents.

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1 Introduction

The holographic principle is that the information content of all the matter that has fallen into a black hole can be represented by fluctuations in the surface of the event horizon [1]. Extending this to the universe as a whole, the principle suggests that the two-dimensional (2-D) information on the outside surface of the universe, the cosmological boundary, encodes for the whole three-dimensional (3-D) content of the universe within [2-3]. The concept is typically identified with string theory [2] and information

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theory [4]. The holographic principle implies that everything that we perceive as physical and real in the universe, even life, is merely a hologram projected in from the cosmological boundary. The true reality would be on that 2-D surface on the edge of the universe. This concept has significant philosophical implications for what we construe as reality. In the present context the term 'cosmological boundary' refers to the physical extent of the entire universe, not merely that component visible to us. The latter is the *observable universe* or *particle horizon*, sometimes rather confusingly referred to as the *cosmological horizon*. However we use the term *cosmos* to refer to the entire universe, whether or not this is observable.

In this paper we show that it is possible to provide a physical interpretation of the holographic principle using a specific non-local hidden-variable theory called the Cordus conjecture. We start by developing an explanation for the vacuum. The second stage is to explain how the cosmological boundary concept works within this framework. We also include considerations of the observable universe. We then close by discussing the implications.

2 The vacuum problem

There is no universally accepted interpretation of the composition of the vacuum or explanation of its mechanics. Electromagnetic (EM) wave theory models the vacuum as consisting of nothing at all, but yet paradoxically having finite electric and magnetic constants. The existence of these constants (which are presumed to be universally constant) and the fine-structure constant alpha, is difficult to explain from within classical EM theory. Nor is it possible from EM theory to explain why the constants take the values they do.

Another concept for the vacuum is available in General Relativity (GR), which includes a space-time medium [5]. It describes gravitation well, but not the structure of matter or the other forces. It also does not describe the composition of space-time. Furthermore it assume space-time is smooth, which makes for difficulties integrating this concept with other theories.

The main theory for the composition of the vacuum is undoubtedly quantum mechanics (QM). According to the Standard model, the vacuum contains *virtual-particles*, which are short-lived transient particles that are believed to exist temporarily due to the Heisenberg uncertainty principle, and which cannot be observed – though they are believed to be the carrier for interactions (forces) and a variety of particle decay processes. According to quantum field theory the vacuum state |0> contains no physical matter, but is the ground state (zero average energy) of the quantised electromagnetic field, for which the photon is the gauge boson in the Standard Model. Generally the vacuum state has, by definition, zero usable energy. However it still has vacuum fluctuations, and thus it has zero-point energy, since its variance is not zero even if the mean is. This is believed to be the explanation for a non-zero cosmological constant. Quantum electrodynamics (QED) [6], models the vacuum as consisting of temporary energetic particles, but no average substance. These are proposed to come in and out of existence via a pair-production > annihilation process. The presence of the temporary particles thus give substance to the vacuum. The corollary is that the vacuum is never empty, even in the ground state. QM therefore does not differentiate between a region within the universe that is current free of such particles, and a region outside and beyond the current expansion limits of the universe. Coupled with this, QM has no model for time; at least not one that scales to the macroscopic level, though loop quantum gravity pursues that goal.[2]

While these diverse concepts for the vacuum are individually adequate for their respective physics, the overall situation is ontologically problematic. For one, the existing theories conflict in their explanations. The integration is poor, the mismatch over gravitation being a case in point. Also, these theories find the idea of a matter-based aether unacceptable, yet ironically all include something that looks conceptually much like a medium.

None of these theories describe what it is that the universe is expanding into. For the sake of discussion, call that outer region the *void.* Conventional physics has no way of differentiating the vacuum/void concepts, and consequently tends to a single interpretation of vacuum that is applied to both regions. If these are the same thing then there is an issue of how the same vacuum that fills a finite universe, also extends to the region beyond the universe, and whether that outer region is infinite or bounded in some further way. However, if the vacuum and void are not the same, then how to differentiate them?

3 Purpose

There is a need to better understand what the vacuum is within the universe, what it is that the universe expands into, and whether the holographic principle is a valid concept. The primary purpose of this paper is to attempt to explain the vacuum and cosmological frontier effects, through the lens of the Cordus conjecture. This is worth doing for the potential to add new perspectives to the debate on this important cosmological subject. In this specific area it provides, as will be shown, novel explanations for the vacuum and holographic principle.

A secondary purpose is to test the logic of the conjecture. Does it have sufficient conceptual coherence to withstand an extension of its principles to the area under examination, or does it reduce to absurdity?[3]

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[2] Loop quantum gravity is based on a network of loops (hence the name) that quantise geometry and are represented mathematically in a 'spin foam'. In the Cordus conjecture use is also made of the term 'fabric', but the idea is something quite different as it refers instead to a network of interconnected discrete field elements, and is given a physical rather than mathematical meaning. The Cordus concept of fabric also provides for the interconnectedness of space (c.f. the relativity of simultaneity) and thus a discrete model for both time and gravitation.

[3] It is difficult for theories developed for fundamental physics to scale up to the cosmological level. This is evident in the difficulty achieving a gravitation theory from quantum mechanics. Likewise the de Broglie Bohm hidden-variable solution

The Cordus conjecture is a non-local hidden-variable (NLHV) solution [7]. The core ideas are 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. A fibril joins the reactive ends and is a persistent and dynamic structure but does not interact with matter. Each reactive end of the particule is energised in turn at the frequency of that particule (which is dependent on its energy). It emits a discrete force element when it is energised. These pulses are connected in a flux line called a hyperfine-fibril (hyff) that is emitted into the external environment. Each reactive end of the particule emits three such orthogonal hyff, at least in the near-field. These directions are termed hyperfine-fibril emission directions (HEDs). The aggregation of hyff from multiple particules creates a discrete field. The discrete force element is a 3-D composite structure. The direct lineal effect of the discrete force element provides the electrostatic interaction, the bending of the hyff 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 discrete force element as it propagates outwards on the hyff flux. See Appendix A for a fuller description.

4 Approach

The Cordus conjecture was created with a systems design methodology, i.e. we anticipate a set of internal and field structures for particules¸ sufficient to explain the observed functionality (physical phenomena). We continue this logical approach.

First we determine the composition of the vacuum under the assumptions of the Cordus conjecture. This composition we call the fabric [8], and we propose it contains discrete fields. From this we infer the composition of the void beyond the universe, by negation of the vacuum contents. It helps that we have separately developed a model for time [9] within the same Cordus theory: this is useful because it shows that time too is an emergent property of the fabric. We infer that a region that has no fabric, i.e. the void, is also timeless. We then show that the cosmological boundary can be given a physical explanation in terms of the Cordus differentiation between the vacuum within the universe and the void into which it expands. From this are extracted implications for the holographic principle.

We represent this theory as a causal model, using the systems engineering modelling notation of integration definition zero (IDEF0) [10].[4] The IDEF0 model represents the proposed relationships of causality,

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has little to say at the cosmological level. We are therefore interested in testing the Cordus conjecture at this level, and seeing if it has anything meaningful to contribute to the debate at the cosmological level.

[4]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.

and thus serves the same purpose as mathematical formalism does in conventional physics.

Any particular assumptions required, are noted as lemmas in Appendix B. The lemmas represent the proposed Cordus mechanics, and are a mechanism to ensure logical consistency within the wider theory.

5 Results: A cosmological boundary to the vacuum

The Cordus conjecture is a non-local hidden-variable (NLHV) solution [7]. The core ideas are 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. A fibril joins the reactive ends and is a persistent and dynamic structure but does not interact with matter. Each reactive end of the particule is energised in turn at the frequency of that particule (which is dependent on its energy). It emits a discrete force element when it is energised. These pulses are connected in a flux line called a hyperfine-fibril (hyff) that is emitted into the external environment. Each reactive end of the particule emits three such orthogonal hyff, at least in the near-field. These directions are termed hyperfine-fibril emission directions (HEDs). The aggregation of hyff from multiple particules creates a discrete field. The discrete force element is a 3-D composite structure. The direct lineal effect of the discrete force element provides the electrostatic interaction, the bending of the hyff 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 discrete force element as it propagates outwards on the hyff flux. See Appendix A for a fuller description.

5.1 System model

A cosmological framework

We start the explanation with an overview model, shown in Figure 1 (CM-07). This provides the wider context in which to understand the boundary effect. This is necessary because the cosmological boundary is part of a broader set of cosmological processes. This part of the model is represented in IDEF0 system modelling notation and should be understood as a set of proposed causal relationships. At this level we identify several main activities.

The first is a set of genesis production processes (1), whereby a pair of photons are converted into the first atoms. This is followed by a rapid expansion (2), which is the inflation of the universe. In the Cordus theory, the inflation is driven by repulsion between the particules, in turn because of the synchronous Interaction (strong force) [11].[5] The inflation results in

[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

an expanding universe, where the matter content of universe moves outward. Those matter particules generates discrete fields (3), the aggregation of which creates a fabric (4). The combination of fabric and expansion creates the cosmological boundary (6).

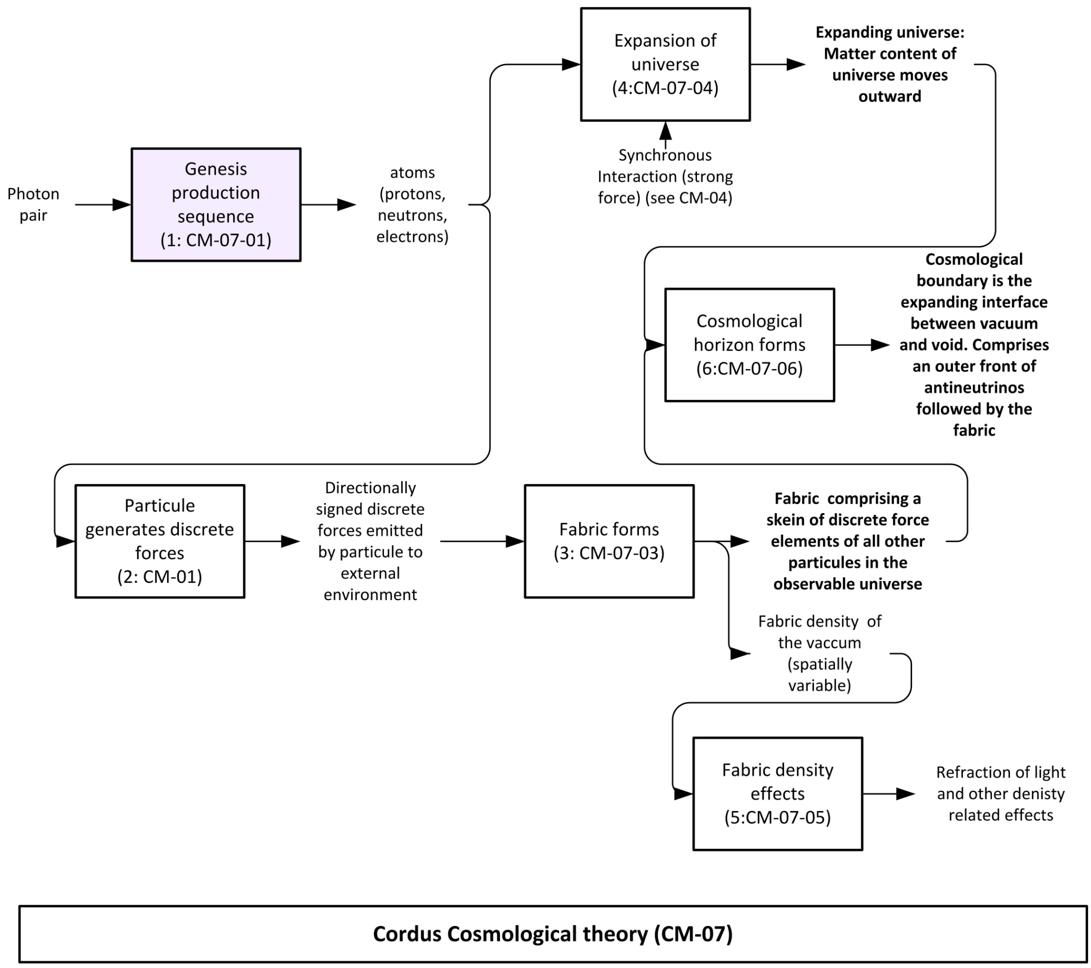

Figure 1: The cosmological boundary is explained within the broader Cordus cosmological theory, which is represented by this system model.

Genesis production sequence

More details about the genesis production sequence are shown in Figure 2 (CM-07-01). It involves Pair Production (1) to produce electrons, Asymmetrical baryogenesis (2) to produce protons, Beta+ decay (3) to produce neutrons. Hence provision of all the subcomponents for the assembly to simple atoms (4). This represents the sequence as it is commonly accepted, and is not in contention. However the details of several stages in the process are incompletely understood in modern physics. In particular the mechanics whereby photons convert to an

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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.

electron and positron (pair production) are uncertain, and the asymmetrical baryogenesis process is completely unknown, likewise the asymmetrical leptogenesis. Where the Cordus theory is different is in providing an integrated solution to all these sub-problems. Specifically, there are detailed Cordus explanations for the mechanics of pair production and asymmetrical genesis [12], the nucleon decay processes [13-14], and the strong interaction [11] for assembling the atom. The Cordus theory for the cosmological boundary is consistent with these proposed underlying mechanics.

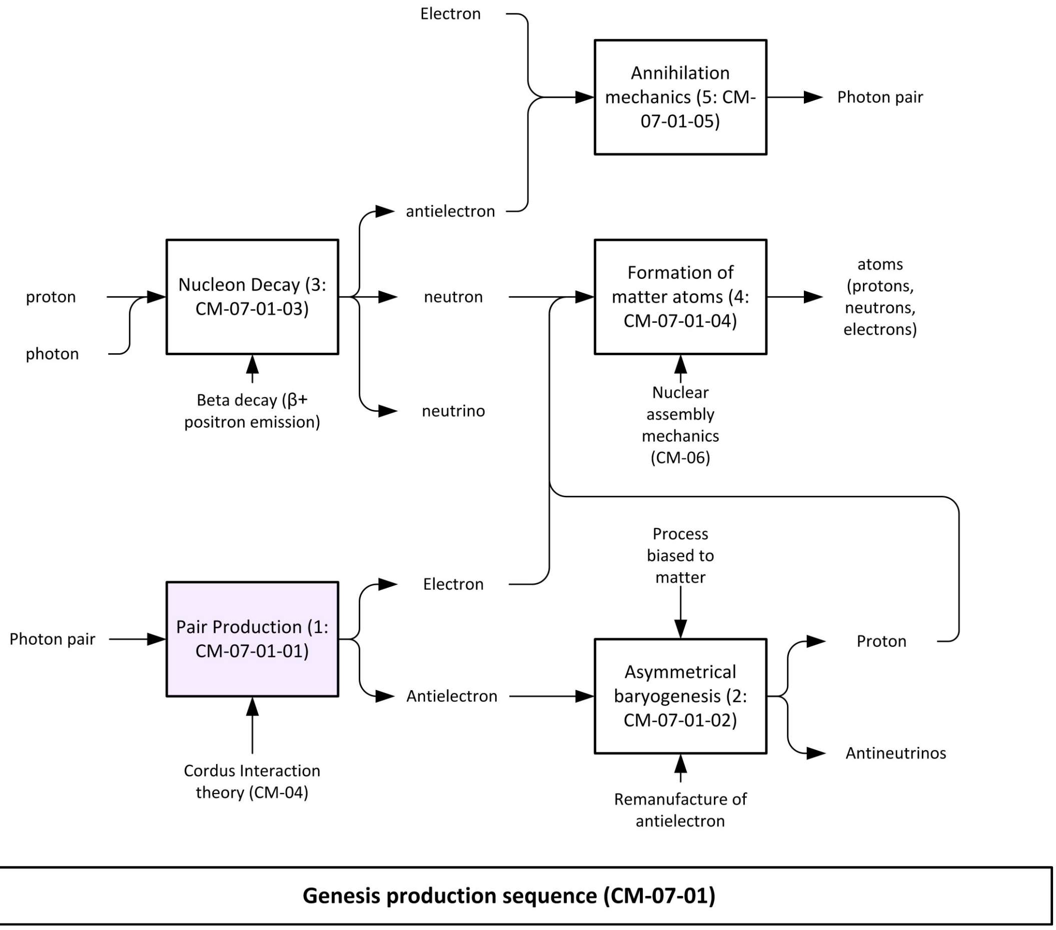


Figure 2: The Cordus genesis production sequence (CM-07-01).

Of relevance to what comes later is the prediction of specific roles for the neutrino and antineutrino in the genesis sequence. The existence of neutrinos from β+ decay is a known fact, which is accommodated and its mechanisms further explained in the Cordus theory [15]. The Cordus theory predicts the antineutrinos are waste products of the remanufacturing process at asymmetrical genesis, and have a crucial role in that process. They are also important in the later explanations for the boundary.

5.2 Formation of the fabric

The next part of the theory describes the fabric, and how it is formed. This has important implications for the differentiation between the vacuum and the void.

The fabric comprises a *skein* of discrete field elements, which are generated by all the particules in the accessible universe. The way this arises is briefly described, with reference to the system model in Figure 3. First, the individual particules generate discrete fields (1). These interact with the reactive ends of other particules in the electro-magnetic-gravitational-synchronous (EMGS) interactions (2). These displacements of reactive ends are proposed for what we more commonly perceive as force. Fields (3) result as an aggregation of the individual discrete field elements. The Cordus theory suggests that that discrete fields are not consumed or changed in these interactions (4) (in contrast to the colour change of QCD or the virtual bosons of QED), but instead continue to propagate away from their basal particule. At the same time, the basal particule continues to emit more discrete fields (5) each time its reactive ends energise. The overall result is that the space between matter particules is filled with these discrete field elements (6), and this is the Cordus fabric.

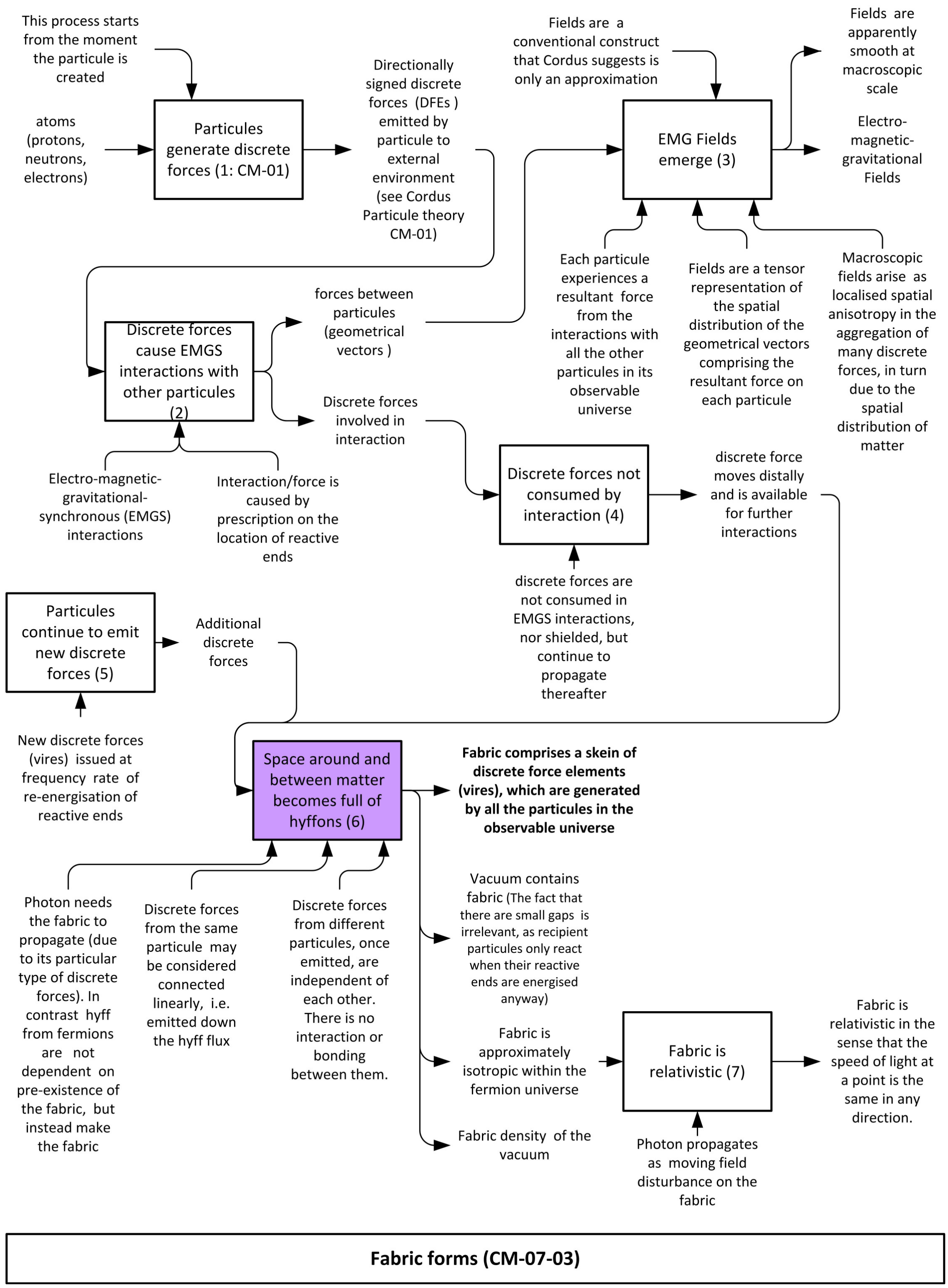


Figure 3: The Cordus fabric (CM-07-03).

It is worth noting that in this Cordus fabric theory, the photon needs the fabric to propagate, due to its particular type of discrete field arrangements [16]. In contrast the hyff from fermions are not dependent on pre-existence of the fabric, but instead make the fabric, and are able to propagate even in the absence of other discrete fields. This becomes relevant when considering the cosmological frontier. Thus the vacuum within the bounds of the universe contains a fabric of discrete fields, and the density thereof depends on the local abundance of matter.

Note also that the Cordus fabric is relativistic, in that for an isotropic fabric the propagation speed of the photon is the same in any direction, regardless of the motion of the body emitting the photon. Thus the Cordus theory supports relativity in this aspect. The Cordus theory also predicts that the speed of light depends on the fabric density, being slower in more dense regions. This also explains the electric and magnetic constants, and gives a physical interpretation of the fine structure constant α as a measure of the transmission efficacy of the fabric [8]. While the Cordus fabric concept is similar to the space-time of general relativity [5], there are important differences. In the Cordus theory the fabric is discrete and therefore only approximately smooth and continuous. Nor does the Cordus fabric carry a time dimension, though it does have an important role in the Cordus theory for time and the coordination underpinning the relativity of simultaneity [9].

Vacuum vs. Void

The Cordus theory of the fabric readily permits a definition of the vacuum, and that of the void into which the universe expands.

- **Vacuum: that part of the universe and its surrounds that have a non-zero fabric density.**
- **Void: that region beyond the outer boundary of the cosmos, and is characterised by having neither fabric nor time.**

Cordus thus distinguishes between the fabric that makes up the vacuum of space, as opposed to the void beyond the universe. The next stage in the logical development of this subject is to consider the behaviour of the outer boundary of the universe as it expands into the void.

5.3 Cosmological boundary forms

The model now is that the universe forms a fabric (vacuum), and as the universe expands outwards so the fabric colonises the void. This is represented diagrammatically in Figure 4. As a consequence of the progressive nature of the genesis production sequence, and its subsequent quiescence, a shell structure is predicted to develop for the universe. The outer boundary of this is the cosmological boundary, and represents the expanding interface between vacuum and void. The prime candidates for composition of the boundary are the antineutrinos that Cordus suggests are produced as a by-product of asymmetrical genesis [12], and the discrete forces from those particules and the matter baryons and leptons within the universe. We tentatively assume a propagation mechanism: that the discrete forces that make up the fabric propagate outwards along the hyff flux in increments of one span-length (of the base particule) at each frequency cycle.

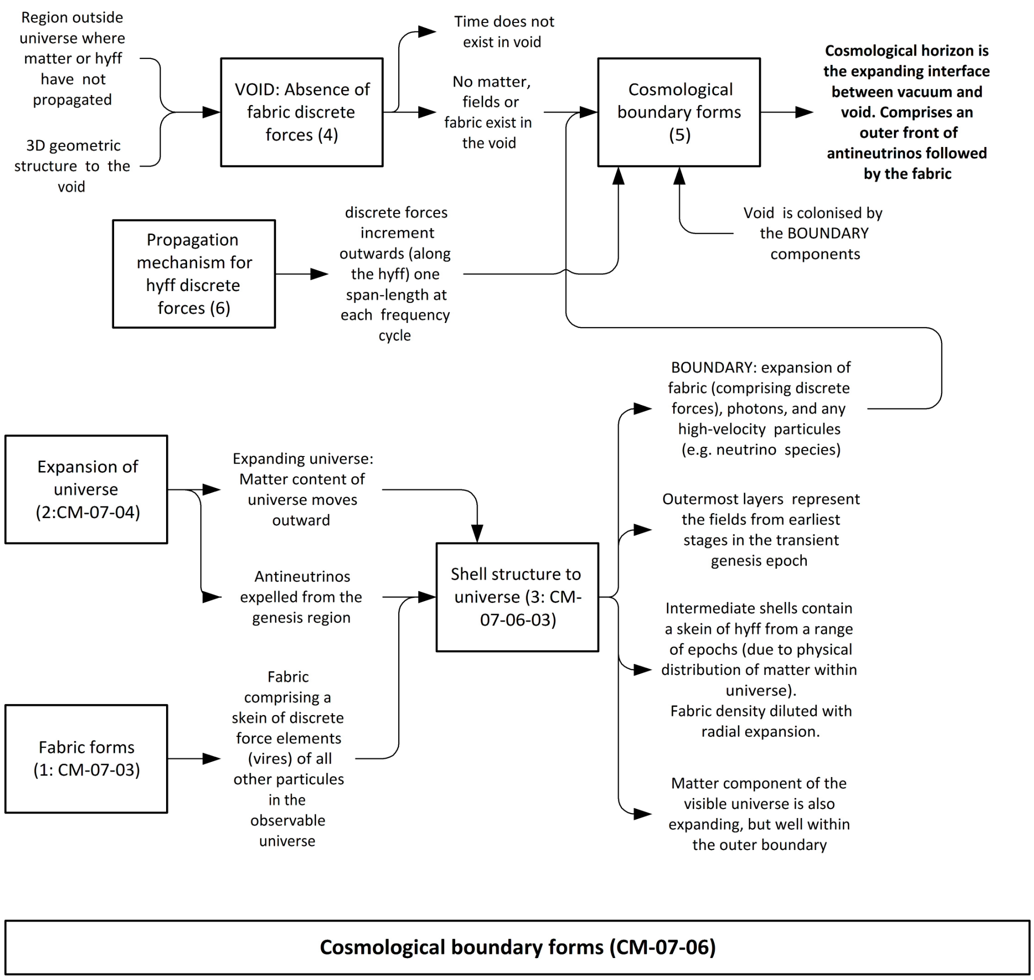
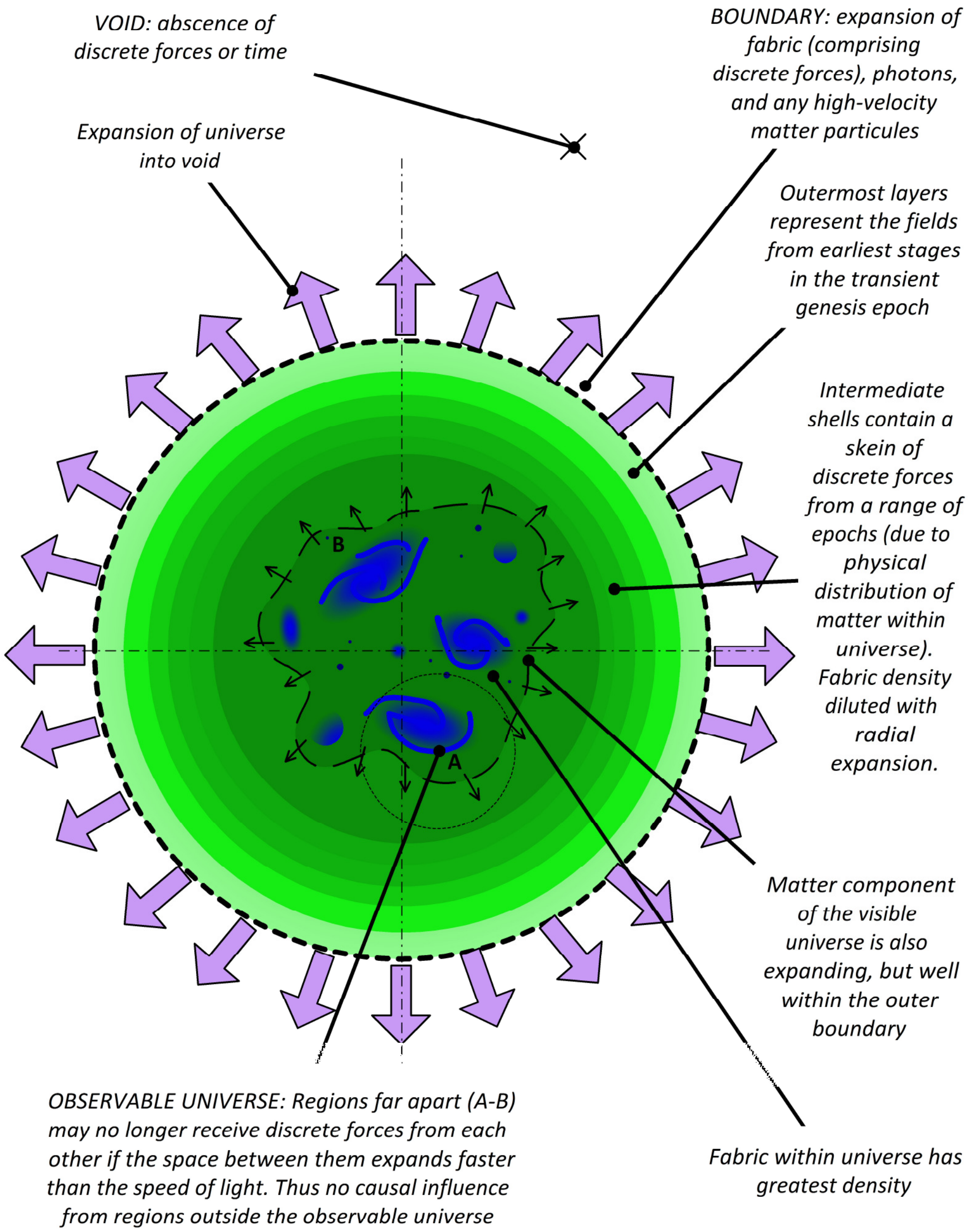


Figure 4: The cosmological boundary (CM-07-06) forms as an expansion of the universe into the void.

Shell structure

So, from the cordus perspective, the cosmological boundary of the universe contains the discrete fields of only the primal particules within the universe. These represent the classical electro-magnetic-gravitational (EMG) fields. A shell structure emerges, with intermediate shells containing discrete fields from later epochs of the universe, see Figure 5.

During these later epochs the original particules will generally have moved to new locations, and this information is carried out by the hyff at the local speed of light, and therefore reaches outer shells much later. In addition, particules that are created ex photons long after the start of the universe, e.g. via pair production, will only start emitting discrete fields from their moment of creation, and propagate them out at the speed of light. Therefore their discrete fields will not be represented at the cosmological boundary, but only on inner shells. Furthermore, any one intermediate shell contains discrete fields from a range of epochs, since the spatial spread of matter ensures that some bodies are closer and others further from any one point on the shell. In the limit this reduces to an observable universe, i.e. a volume of space which has had sufficient time to send its discrete fields to the location under examination.



Shell structure to universe (CM-07-06-03)

Figure 5: The Cordus model for the boundary of the cosmos. At the outer frontier the expanding universe colonises the void. This boundary only codes for the very first fields created at the genesis event. Inner shells code for the later states of the universe.

The Cordus boundary is therefore broadly consistent with the cosmological boundary and holographic principle of string theory. Both agree that the properties on the boundary code for matter on the inside.

6 Discussion

6.1 Comparison of the models

Despite the similarities, the Cordus theory identifies additional characteristics of the boundary that make it different to the holographic construct.

First, the Cordus interpretation is that the coding is only for the particules as they once were, not for their present position within the universe nor even for their existence. If they have subsequently been annihilated their hyff (discrete flux lines) collapse outward only at the speed of light. Thus Cordus predicts that the boundary will not be an up-to-date representation of the state of the universe. It is a hologram, a 3D picture, but one of the deep past.

Second, Cordus predicts that particules emit their discrete fields in a directional manner, the hyff emission directions, and therefore any one particule within the universe will display its fields at only specific locations on the boundary. This is contrary to the conventional model of fields being propagated in all directions. Thus access to any one region of the boundary would not allow reconstruction of the contents of the whole universe. To do that for all particules would require access to the whole boundary.

Third, Cordus does not support the idea that a single cosmological boundary completely codes for up-to-date information on every particule in the universe. It also rejects the idea that 'All of the possible histories of the universe, past and future, are encoded on the apparent horizon of the universe' [3], and instead suggests that the outer boundary only contains information about the genesis epoch, with successively concentric inner boundaries coding for the state of the universe at later times.

Fourth, Cordus does not support the idea that the inner volume of the universe can be controlled from the outside surface, for reasons more fully explored below.

6.2 Implications

Can the universe be controlled from outside?

The explicit implication of the conventional idea of the cosmological horizon is that the inner universe of 3D matter could be controlled from outside, by an intelligent Agent that could access the outer 2D horizon [17]. This thought-provoking idea has significant existential implications for reality. Cordus rejects this as a fanciful notion, for the following reasons.

First, as already noted, the Agent would need to control the whole entire horizon simultaneously (as opposed to only one patch). This task is physically infeasible, given the size of the universe, and the necessary coordinated control would need to be instantaneous to have any useful control purpose. This excludes any physical Agent.

Second, a physical Agent is further excluded because such an Agent, positioned around the cosmological boundary, would therefore become part of the process whereby the void is colonised by matter and its fields. Thus the Agent would become part of the system being measured and controlled, and the unidirectional causality could not be maintained. It is therefore not possible, according to the Cordus theory, to have an independent physical Agent, observer, or inanimate instrumentation at the boundary.[6]

The third objection is that there is, according to the Cordus theory, no bidirectional causality between the 2D surface and the inner 3D volume. Even if there was a non-physical (metaphysical) Agent at the boundary, one nonetheless able to meddle with the boundary hyff, a frontier interaction does nothing to change the emitting particule. This interpretation arises because the Cordus theory suggests that discrete fields are unilateral interactions with mono-directional causality. Hyff are not a conduit for bi-directional force transfer.[7] Consequently, the discrete field pulses that are received at any inspection point remote from the emitting body are a force on any matter at that inspection point, and have no reciprocal effect back on the emitting body.

The only way for an Agent on the boundary to change the particules inside the universe is for the Agent to emit its own discrete fields back into the universe to target those particules. However this would require a physical agent (which we already exclude) to generate the discrete fields. This is because discrete fields are a feature of matter, and do not have an independent pre-existence. There is a further obstacle too: even if it were somehow possible to generate discrete fields without matter, these would take time to arrive at their target, thereby adding a practical limitation to the efficacy of the control.

So there are three objections to the control idea, the most fundamental of which is that simply intercepting the discrete fields of the original emitting

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[6] Elsewhere the Cordus theory shows that the act of observation changes the system, i.e. observation is necessarily contextual. This applies to photons in double-slit and interferometer apparatus. In the case of the cosmological boundary there is a similar principle, except here the addition of the Agent adds to the system under observation.

[7] The idea that forces like gravitation are bidirectional is a tacit assumption in classical mechanics. The relation for gravitation, $F = G\ m_a\ m_b\ /r^2$ specifically identifies that the force depends on both masses, not one. The Cordus theory accepts this at the macroscopic level, but suggests that the effect is not a bidirectional force conduit between the two masses, but rather two independent effects that are aggregated. More specifically, that discrete fields emitted from source A cause their recipient target B to experience prescribed constraints on the re-energisation location of its reactive ends, and this is what we perceive as force. The recipient body B also sends out its own discrete fields, some of which are intercepted by A, and the mutual attraction/repulsion of the EMG forces arises by a combination of the individual unilateral effects. Simple passive access of field information does not necessitate control of the emitting source, according to the Cordus theory.

particule is insufficient for controlling that particule. The universe can therefore not be controlled from its boundary. For all these reasons, the Cordus model excludes the possibility of placing a physical Agent at the boundary of the universe, and also shows there is no practical way to control the universe from the outside. The *control* aspects of the holographic principle are therefore rejected. We have not excluded the possibility that a metaphysical Being may be able to achieve this, but for such considerations one must look to theology not physics.

Implications for cosmological principle

The Cordus theory proposes that the fabric is approximately homogeneous and isotropic within the matter compartment of the universe. However, both those fail in the outer shells where the fabric density is lower and increasingly directionally. Thus the Cordus theory proposes that the cosmological principle of homogeneity and isotropy of the universe is only approximately true, and only for the central part of the universe. Consequently the concept of comoving distance (distance between objects, corrected for expansion of the universe), which is based on the isotropic assumption, also becomes unreliable in the Cordus theory. Furthermore the Cordus theory for time [9] proposes that there is no universal cosmological time, and so even proper distance becomes time-dependent (even without an expanding universe).

Implications for event horizons and black holes

Regarding the implications for the event horizon of a black hole, the Cordus model acknowledges that it is conceivable to position a physical Agent outside that horizon (unlike the case of the universe), but asserts that would still not give any control of the inner workings of the black hole, for the reasons already given.

What has been achieved?

This paper makes several novel contributions. The first is that it shows that it is possible for a non-local hidden-variable theory to provide an interpretation of the cosmological boundary. This is unusual since NLHV solutions, typified by the de Broglie-Bohm pilot wave theory [18-20], are focussed on the sub-atomic scale and usually have little to say about cosmological effects. A second contribution is the provision of an alternative explanation for the boundary and a dismissal of the control elements of the holographic principle. The contribution here is not so much the provision of a more valid competing theory, since neither explanation can at this time be validated, but rather the provision of new considerations to enrich the debate. A third contribution is the provision of a new theoretical model for the composition of the vacuum. This explanation is integrated with a theory for discrete field elements and hence also gravitation.

Falsifiable predictions

Making falsifiable predictions about the cosmological boundary is difficult, since it is inconceivable that anyone could be in that location of space to put them to the test. Nonetheless there are some subsidiary effects that are perhaps testable. The main one is the Cordus prediction regarding the unilateral causality of gravitation at the smallest scales. According to this perspective, a body A emits discrete gravitational fields, some of which are intercepted by remote body B. The Cordus theory predicts that such an interaction only changes B. The corollary is that B can only change A by sending discrete fields to A. It is not inconceivable that this might be testable by using pair-production or annihilation to abruptly bring the two bodies into/out of existence, and thereby test whether or not the presence of both is required for the arousal of the gravitation force. While we have couched this test in terms of gravitation, Cordus predicts the same should apply to the electrostatic force, and this might be easier to arrange into an experiment.

Implications for the Cordus conjecture, and future research questions

This paper has provided an explanation for the cosmological boundary. Since the validity of this is unknown, the result is not suggested to be evidence confirming the Cordus conjecture. Nonetheless it does expand the range of phenomena for which the conjecture has an explanation, i.e. it expands the fitness (as opposed to the validity) of the solution. The Cordus theory can now offer a logically consistent theory for a wide range of effects. These include wave-particle duality, Brewsters' angle, force unification, asymmetrical baryogenesis, and now some cosmological implications. That coverage is more extensive than competing theories, even though some, like QM, have greater detail and quantitative formulism.

Future research questions along the Cordus line would be the expansion mechanism and composition of the fabric at the outer boundary. In particular, it cannot be determined from this model whether the process of colonising the void is done by the fabric discrete fields, or by outward motion of massy particules with the fabric following (or both). Also, we note that the theory requires the void to have a three dimensional geometry which is ready for colonisation, and so a deeper ontological question arises of why the void should have a latent three dimensional structure.

There are many other related cosmological questions, e.g. how time works, anomalous gravitation (dark matter), accelerating expansion (dark energy), early inflation, asymmetrical baryogenesis etc. This integration has not been achieved with either relativity, quantum mechanics, or string theory. Obviously it is desirable that any theory of physics should explain all these too. Currently the Cordus theory can explain time, inflation, and asymmetrical genesis, so there is more work to be done.

7 Conclusions

We have shown that the cosmological frontier has a physical representation in the Cordus theory. However the principles are transformed and the implications are different. The Cordus theory proposes that the outer boundary contains information about the location of the primal particules at genesis, and the inner shells code for the changed locations of those particules and any new (or annihilated) particules since. This conceptual model arises from a consideration of the

Cordus theories for the discrete field structure of particules (a NLHV solution), and the composition of the fabric of the vacuum.

The Cordus boundary model rejects several of the implications of the conventional holographic models. In particular it suggests that the universe cannot be controlled from its outer boundary. This is for two main reasons. The first is the impossibility of locating a physical agent there to do the controlling. The second is that there is predicted to be no causality from the boundary of the universe to its inner contents, so accessing the fields on the boundary would not provide any control of the particules inside the universe. Also rejected are the notions that the boundary contains information about both the future and past, or about all possible universes.

END OF MAIN PAPER [21]

A Appendix: Cordus theory

A.1 Cordus conjecture

What is the Cordus conjecture?

The Cordus conjecture is a non-local hidden-variable (NLHV) solution. It has been applied to explain entanglement and wave-particle duality [7]. The conjecture starts by questioning the premise of particles being zero-dimensional (0-D) points [22], then infers what functionality is required, and then anticipates through design an internal and external structure sufficient to deliver that functionality. This structure is called the cordus particule. The term 'particule' is used in contrast to the conventional zero-dimensional 'particle'. Abandoning the premise of zero-dimensional particles is a profound conceptual change that unlocks a world of new solution possibilities. The Cordus conjecture infers the attributes (functionality, dimensions/variables, properties, causal mechanics) of the particules in this new framework.

The Cordus theory has been developed by application of system design principles. The initial concept has been further refined by checking the theory against a variety of phenomena, and designing new features and properties on the basis of requisite variability.[8] The resulting theory has

[8] Design is particularly good at this activity of inferring the necessary internal structure from the functionality required. In typical applications of new product development (NPD), the design process is applied to the future functionality, e.g. the specification desired by a customer. The outcomes of a design process, at least in NPD, are specifications of the physical geometry, materials, operating system, and manufacturing structure of an engineered product. Design is particularly effective at inferring geometry for a requisite functionality, hence often expressed in drawings, but is capable of defining internal structure in other ways too, including principles of operation and assembly. There may be more than one design solution. The design methodology is also valuable when the problem is

high fitness to explain many phenomena in physics, within one logically consistent conceptual framework.

A.2 Cordus 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 [23]. 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 cordus is affected by more than the fields at its nominal centre point [24]. The reactive ends are energised (typically in turn) at a frequency [25].

External structure: Cordus discrete field structures

When the reactive end is energised it emits discrete force elements in up to three orthogonal directions.[9] Within our model we refer to these discrete force pulses as *vires.* 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 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 discrete prescribed displacements acting on the particules. Force becomes coercive displacement. See Figure A.1 for examples of the Cordus structure and principles.

Each reactive end of the particule is energised at the frequency of that particule (which is dependent on its energy). It emits a discrete force element (vis, vires: L., 'force') when it is energised, and the Cordus theory requires a continuity between these pulses. Conceptually they are strung together in a flux line. We refer to this linear structure as a hyperfine-fibril (hyff). Each reactive end of the particule emits three such orthogonal hyff, at least in the near-field. These directions are termed hyperfine-fibril emission directions (HEDs). Particules at close-range interact by

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over-constrained or the requirements are conflicting. In these cases it tends to offer a range of solutions, which differ by the criteria they preferentially satisfy. One particular design solution may satisfy more of the constraints than other solutions, and is then considered to have higher fitness. In this case we apply the design methodology, but the functionality that we seek to support is the observed behaviours of physics. The outcome we get is a design for the physical features and operating principles of particles. In other words, if particles were to have these features then we can explain the (observed) functionality.

[9] Nominally the directions are designated radial (r), axial (a), and tangential (t). This differentiation is useful for the photon, which has a direction of motion, though less applicable to stationary particules. Earlier papers used the term 'hyffon' for the discrete force element (DFE). 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'.

negotiating complementary HEDs and synchronising the emission frequencies of their discrete force elements, and hence bonding arises. The aggregation of hyff from multiple particules creates a discrete field.

In this theory electric charge is carried at 1/3 charge per hyff, with the sign of the charge being determined by the direction of the discrete force element. So the number and nature of energised HEDs determines the overall electric charge of the particule. For example, the electron is proposed to have three discrete field elements. Neutral structures are accommodated, but incompletely filled HEDs are proposed as the reason for instability [14]. A HED notation has been derived to represent these proposed discrete force structures [26]. 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.

The discrete force element is a 3-D composite structure, with a hand defined by the energisation sequence between the axes. In the Cordus theory this hand provides the matter/anti-matter species differentiation [27]. The direct lineal effect of the discrete force element provides the electrostatic interaction, the bending of the hyff provides magnetism, and the torsion of the DFE composite provides the gravitation interaction [28-29]. These are all carried simultaneously by the discrete force element as it propagates outwards on the hyff line.

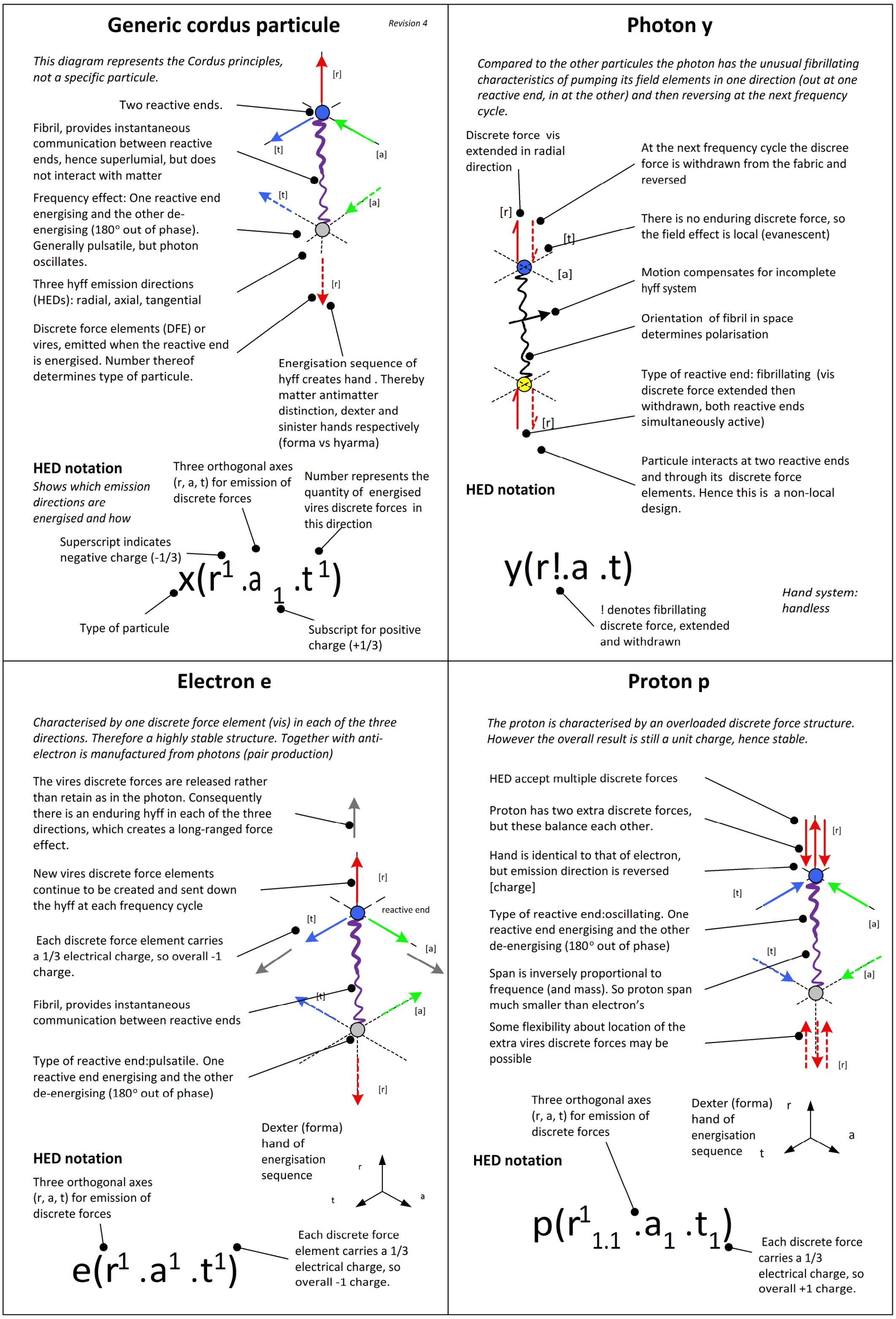

Figure A.1: Cordus models for the proposed structure of several particules. The basic structure includes reactive ends, fibril, and discrete force elements. It is the number and nature of the discrete forces that determines the externalised behaviour of the particule.

The Cordus theory provides that the discrete field structures (hyff) around 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, and this synchronicity is proposed as the mechanism for the strong force [11]. 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. Consequently the theory rejects the conventional idea of the Standard Model that every force has a different messenger particle, thus specifically rejecting the concepts of QM gauge bosons and QCD gluon colour particles.

In the Cordus theory the photon is required to have a single radial discrete force element which it periodically extends and withdraws. By comparison all massy particules have permanent discrete forces that they continue to generate (at the frequency of the particule) and propagate out into space. This includes neutral particules like the neutron. The difference in field structures between the photon and electron, then explains [30] why the photon generates an evanescent field that decays exponentially whereas the electrostatic field of electron decays at $1\backslash r^2$.

A.3 Contrasts

While such a solution may seem precluded by the Bell-type inequalities [31-32] there is reason to believe those constraints are questionable [33-34] and we propose that the Cordus model falsifies them [22]. The Cordus idea goes beyond conventional NLHV solutions, such as the de Broglie-Bohm model [18], by offering a solution not only for the inner contents of a particle, the hidden variables, but also predicts how its discrete fields operate.

The Cordus theory competes with QM, and makes specific assertions of the deficiencies of QM and the bounds of applicability of that mechanics [35]. Thus it is proposed that QM is only a statistical approximation to a deeper and faster phenomenon that it cannot track. Nonetheless Cordus theory accommodates QM as an adequate approximation for specific situations. It likewise accommodates elements of general relativity [9]. Furthermore the Cordus theory provides a physically natural explanation as a counter-point to the abstraction of string theory [36].

A.4 Applications

The Cordus particule theory is characterised by two tightly-integrated designs. One covers the proposed internal structure of the particule, specifically the two reactive ends and fibril. The other describes the discrete force structures and the hyff emission directions (HEDs). These two designs are linked by the logical necessity for the reactive ends to emit the discrete fields. The Cordus conjecture shows that if matter and photons had the proposed structures, then a large number of fundamental phenomena in physics can be explained within a logically consistent framework.

It is the conceptual coupling between the discrete fields and the internal structures that gives the Cordus theory the power to offer explanations to a wide range of phenomena and several enigmatic problems of fundamental physics and cosmology.

The Cordus theory provides explanations for the following phenomena:

- Collapse of photon to specific location (e.g. double slit and interferometers) [37] [38].
- Derivation of basic optical laws for reflection and refraction [7].
- Superposition [7] [39].
- Frequency [40] [25].
- Entanglement and the superluminal transport of information [24].
- Electro-magnetic-gravitational fields [28-29] [41-42], Strong force [43] [11], unification of forces [42].
- Matter particules [41] [43].
- Fabric and vacuum [8].
- Coherence [37] [35], irreversibility and decoherence [35, 44], entropy [45],
- Superconductors, superfluids and quantum vortices [39].
- Differentiation of matter and antimatter species [27].
- Annihilation process [46].
- Parity violation [12].
- Neutrino behaviour [15].
- Neutron decay [14].
- Pair production and asymmetrical baryogenesis [12].

B 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-07-03 Fabric hyff Lemma

.1 Each reactive end of the particule, when energised, emits discrete force element(s) (vis, vires: Latin, 'force').

.2 There is only one type of discrete force element (vis) which on its own is fundamentally electrical in nature, being created by charged particules.

.3 Electric charge is carried at 1/3 charge per discrete force element (vis).

.4 The sign of the charge is determined by the direction of the discrete force element (vis). Outwards is taken as negative (a sign convention).

.5 The number and nature of energised HEDs determines the overall electric charge of the particule. Neutral particules arise from balanced discrete force elements. The opposition here is in direction, not hand.

.6 For any one particule there is a continuity between these pulses. Conceptually they are strung together like pulses down a line. We refer to this linear structure as a hyperfine-fibril (hyff) or flux line.

.7 Each reactive end of a massy particule emits three such orthogonal hyff, at least in the near-field. These directions are called hyperfine-fibril emission directions (HEDs).

.8 The discrete force element is a 3-D composite structure, with a hand defined by the energisation sequence between the axes. This hand provides the matter/anti-matter species differentiation.

.9 All of the electric, magnetic, gravitational, and strong (synchronous) forces (EMGS) are carried by the discrete force complex. These are all carried simultaneously by the discrete force element (vires) as it propagates outwards on the hyff flux line.

.9.1 The direct lineal effect of the discrete force element provides the electrostatic interaction.

.9.2 The bending of the hyff provides magnetism.

.9.3 The torsion of the discrete force composite provides the gravitation interaction.

.9.4 Particules at close-range interact by negotiating complementary HEDs and synchronising the emission frequencies of their discrete fields, and hence strong force and bonding arises.

.10 The photon has a single radial discrete force element which it periodically extends and withdraws. By comparison all massy particules have permanent discrete forces that they continue to generate (at the frequency of the particule) and propagate out into space. The photon can alternatively be considered a transient on the fabric hyff.

.11 The aggregation of discrete force elements in hyff, from many particules, creates a discrete field.

.12 The fabric of the universe is made of the hyff of all the massy particules in the observable universe.

.13 The frequency of the particule emitting the discrete force elements determines the spacing thereof. Therefore the frequency of the hyff field line varies for different types of particules.

.14 The density of the hyff in the vacuum determines the temporal capacitance and therefore the propagation speed of light through the vacuum.

.15 Propagation of light through matter, e.g. glass, involves additional hyff generated by the matter of the medium. This increases the hyff density and lowers the speed of light. Hence also refractive index.

CM-07-06 The cosmological boundary lemmas

.1 Vacuum and Void: The vacuum is that part of the universe and its surrounds that have a non-zero fabric density. The void is that region beyond the outer boundary of the cosmos, and is characterised by having neither fabric nor time.

.2 The cosmological boundary forms where the fabric (vacuum) expands outwards and colonises the void.

.3 The candidates for composition of the boundary are antineutrinos produced as a by-product of asymmetrical genesis, and the discrete force elements (vires) from particules within the universe.

.4 The discrete forces that make up the fabric propagate outwards (along the hyff) in increments of one span-length of their originating particule at each frequency cycle. They can do this in the absence of other hyff.

.5 The cosmological boundary contains the discrete electro-magnetic-gravitational (EMG) fields of only the primal particules within the universe.

.5.1 The coding is only for the particules at the genesis epoch, not for their present position within the universe nor even for their ongoing existence.

.6 A shell structure is predicted to develop for the universe, with intermediate shells containing discrete fields from later epochs of the universe.

.6.1 Information about changed attributes of particules is carried out by the hyff at the local speed of light, and therefore reaches outer shells much later.

.6.2 Any one intermediate shell contains discrete fields from a range of epochs, since the spatial spread of matter ensures that some bodies are closer and others further from any one point on the shell. In the limit this reduces to an observable universe, i.e. a volume of space which has had sufficient time to send its discrete fields to the location under examination.

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