Cordus in extremis: Part 4.4 Quarks

Pons, D.J. , [17] Pons, A.D., Pons, A.M., Pons, A.J.

Abstract
A conceptual model is created for the composition of quarks and the internal structure of the proton and neutron. In this model the charge of a quark indicates the number of hyff (force lines) it emits. Cordus also explains the colour and provides a mechanism for the strong interaction (both the attraction and repulsive components). The model also explains why parity violation occurs. A new concept of the 'level of assembly' is introduced and used to explain mass excess and why smaller particuloids have greater mass. Cordus also predicts non-conservation of mass.

Keywords: cordus; quark; colour; spin; proton; neutron; parity violation; strong interaction; weak interaction; fundamental forces; unification;

1 Introduction

It may seem strange to addresses the structure of quarks when describing fields and cosmological effects of the wider universe, but the two are linked. The connecting effect is the fabric (see part 4.2), because this determines the macroscopic features of the universe, as well as the locations at which the quarks can exist, and therefore the stability of matter. And in the reciprocal direction the existence of the quarks creates the fabric hyff. So the systems are co-determined.

This paper, which is fourth in a set that applies the Cordus concept to the extremes. The first paper covers the electric and magnetic fields and shows conceptually how they are formed by hyff from cordus particuloids. The cordus concept itself is described in a companion set of papers (ref. 'Cordus Conjecture', 'Cordus matter'). The second part creates a working model for the composition of the vacuum, and shows how this fabric is made of the hyff of all the other particuloids in the universe. It also shows how this fabric limits the speed of light to a finite value that is relativistic. The third paper creates a conceptual model for gravitation that is integrated with electromagnetism, and a model for time. The present paper applies elements of those previous concepts to predict the basic structure of the quarks within protons and neutrons, and creates a model for the strong interaction, thereby reconciling another of the fundamental interactions.

2 Existing interpretations for the strong interaction

[17] Please address correspondence to Dr Dirk Pons, University of Canterbury, Christchurch, New Zealand.

The nuclear force, or strong interaction, holds neutrons and protons together in the nucleus, overpowering the electrical repulsion. The nuclear force, by extending a short distance beyond the nucleus, is also understood to give rise to van der Waals forces. The same effect holds the quarks together within the proton and neutron.

The Quantum mechanics (QM) interpretation is that the force is transmitted by the exchange of particles called gluons between quarks. It is generally accepted that quarks attract each other (strong force): this creates the force binding quarks together inside the proton and neutron, and holds the protons in the nucleus despite their same electric charge.

Quarks have six types (flavours): down, strange and bottom; up, charm, and top, with the first three having -1/3 charge and the latter +2/3 charge. Of these, up (U) and down (D) are lightest and most stable, hence abundant. Quarks also have spin (+- ½) and colour charge (RBG). Quarks can transform into other types. Protons consist of UUD, and neutrons of UDD. It is believed that the strong interaction is repulsive at small separations, and that this maintains the spacing of protons and neutrons. QM does not provide physical explanations for these parameters: it portrays them as intrinsic variables devoid of physical meaning.

3 Cordus quark mechanics

The Cordus interpretation is that quarks are also cordi, not particles. It is then relatively easy to assign physical interpretations to the various properties. The spin refers to the frequency state: there are two reactive ends for each quark, only one is active at any one time, and two quarks may share space if their frequency states are opposite (+- ½), as per lemmas provided previously (ref. 'Cordus Matter'). Several additional assumptions, as follow, are required to build a working model for the quark.

E.6 Quark lemma

E.6.1 Quarks are cordi and alternately energise their reactive ends at the cordus frequency

E.6.2 The magnitude of the charge of a quark refers to the number of hyff emitted at a reactive end, out of three possible directions, i.e. the arrangement is 3D geometric.

E.6.2.1 We term these hyff emission directions (HEDs).

E.6.2.2 Particuloids with unit charge have one hyff in each of three orthogonal directions.

E.6.3 The colour (red, blue, green) refers to the arrangement of the hyff in the orthogonal 3 axes of the HEDs.

E.6.3.1 The axes are named (r) radial outwards co-linear with the span, (a) and (t) perpendicular to the span and to each other.

E.6.3.2 A single hyff (e.g. D -1/3) may be arranged in one of three ways: (a), (r), or (t).

E.6.3.3 A double hyff (e.g. U +2/3) may be arranged in one of three ways: (a, r), (a, t), (r, t)

E.6.4 The operative principle governing the sharing of spaces is Complementary frequency state synchronisation (CoFS). A maximum of all three directions (a, r, t) may be filled with hyff, i.e. a synchronous hyff emission direction structure (SHEDS) is created.

E.6.5 Opposed charge hyff may be considered to cancel each other's use of the hyff emission directions. However they do not cancel the contribution to the fabric.

E.6.6 A hyff can change to a different HED. This corresponds to a colour change.

E.6.7 Hyff come in pairs, one at each end of the span, and the emission directions at the two reactive ends are complementary (parallel but opposite directions).

E.6.7.1 The hand of the hyff at one RE is consistent with that at the other RE, i.e. colour is conserved across the span.

E.6.7.2 The span of the particuloid provides a small offset between the two hyff of any pair, i.e. the hyff are not co-linear. At higher frequencies the span decreases and this lack of parity also decreases.

E.6.8 Charge is reversed for antiquarks: hyff go in the opposite direction.

E.6.9 The HED alignment force locks hyff into synchronisation, and is also repulsive to intrusion.

E.6.10 A particuloid becomes unstable and decays to a photon or alternative structure when there is no place for its reactive end to form, i.e. the external constraints of the fabric and the hyff of the immediate environment dominate and preclude the emergence of the particuloids's hyff.

E.6.11 The nature of the SHED process within a nucleon creates the handedness of matter, e.g. the right-hand rule of the Lorentz magnetic force.

Note that the Pauli exclusion principle does not apply here. That principle applies only where the hyff emission directions are already all fully occupied, which happens in the electron. In the more general case of the quark there are three HEDS which may be filled in three ways. The more universal principle, that subsumes the Pauli principle and covers several other effects (see Cordus matter) is the complementary frequency state synchronisation (CoFS).

4 Quark structures

Thus Cordus proposes that quarks like D have a single hyff giving a -1/3 charge and three hyff emission directions available for that single hyff, hence three colours. Quarks like U have two hyff, energised in turn at each of two reactive ends. There are three ways of arranging these hyff across three HEDs. The conceptual layout for an isolated U quark is shown in Figure 1.

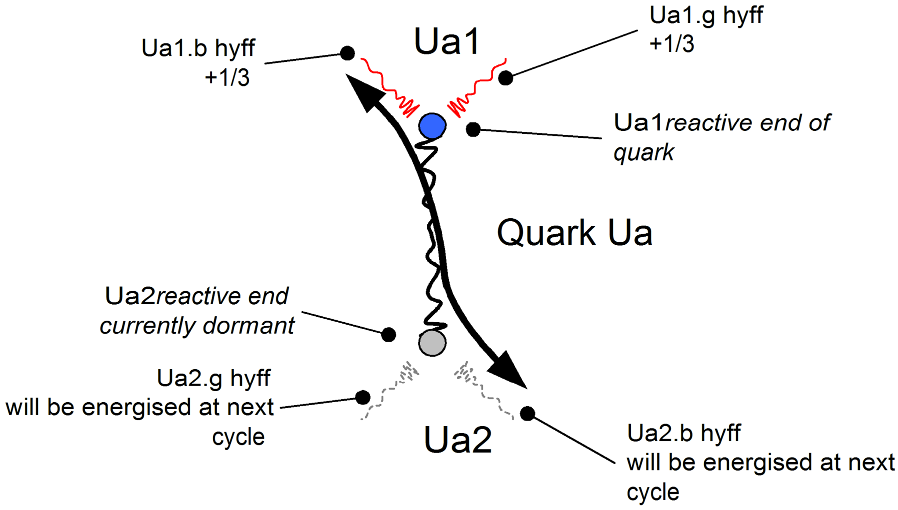

Figure 1: Hyff arrangement for a U quark, with +2/3 charge. The reactive ends are Ua1 and Ua2, and the former is energised in this diagram. The arrow shows that the hand is consistent across the span (E.6.7). The hyff emission directions are presumed to be orthogonal.

The implication of this lemma is that while the current working model for the photon has only one hyff at each reactive-end, in the (r) axis, this is not a universal limitation. Thus the quark lemma provides for the proton, and by implication probably also the electron, to have three pairs of hyff, one in each HED. The corollary is that that the fundamental electric charge of -1 for the electron is actually not the base unit of charge: instead that is a single hyff of -1/3 (except that separate quarks do not exist naturally). Note that whereas the photon emits and recalls its hyff, the quarks have permanent hyff.

Internal structure of the proton

A proton and neutron each have three quarks: UUD and UDD respectively. This gives +1 charge to the proton and nil charge to the neutron. It is now straightforward to propose a model for the internal quark structure of the proton for example. Each subatomic baryon particuloid is known to have three quarks. Cordus requires that these must be arranged without their hyff being superimposed so that slots in all axes are filled: the E.6.4 CoFS exclusion principle, with the E.6.5 concession. This means that the *local* axes of some the quarks will have to rotate relative to the others (change colour), thereby accessing the slots in 3D. Three colours (RBG) for three rotations.

The previous figure showed what a single free quark might look like. However, when the quarks condense into the proton, their hyff mutually influence each other to rotate, synchronise, and snap into the available emission directions, i.e. SHEDS. Once they are in, they are locked in by the high degree of CoFS.[18] Thus the arrangement of the quarks inside the proton is proposed as per Figure 2.

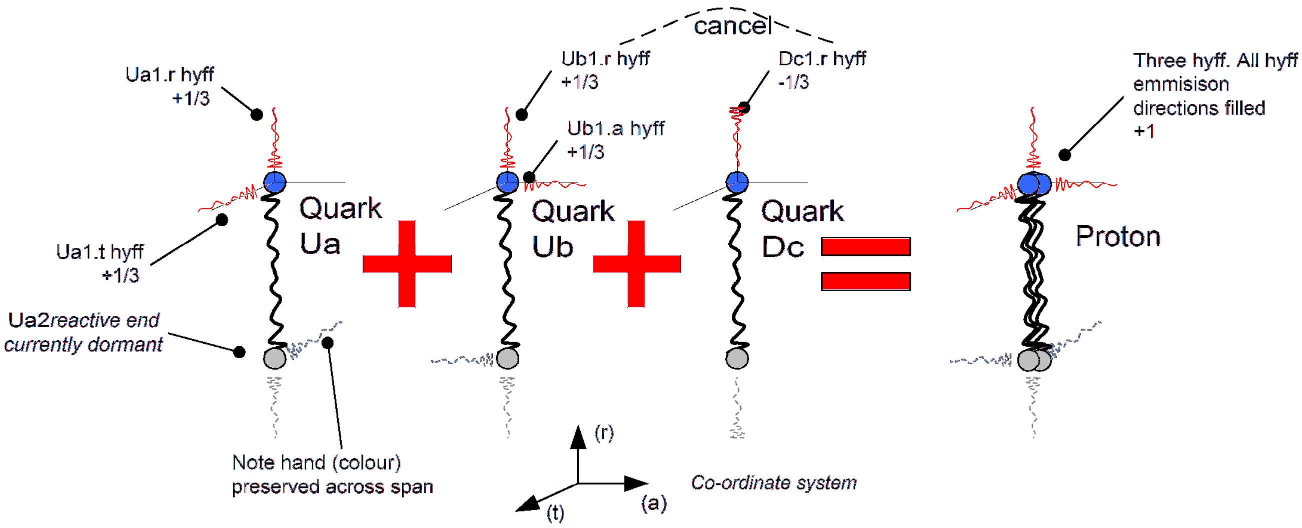

Figure 2: Proposed components of the proton. Two up quarks (U) and a down (D) quark align themselves to fill all three orthogonal hyff emission directions. They also synchronise their three frequencies, polarisations of their spans, and phases of their frequencies. This high degree of complementary frequency state synchronisation gives the assembly high stability against perturbations in the fabric.

All the above comments apply also to the neutron, and the structure of that particuloid is a simple adaptation of the proton but with a UDD structure such that all the hyff are cancelled out, so there is no net electric charge. However, that does not mean that there are no hyff emitted, only that they are balanced (E.6.5).

Stability through SHEDS

An individual quark is known to be unstable. Cordus suggests the reason is the fabric locally disrupts the hyff differently at the two reactive ends, so that the hand or colour cannot be conserved across the span (E.6.7), hence instability of the RE. The quark may be *intrinsically* stable, but no quark exists in a void of its own. The combination of three quarks creates a structure that also has *external* stability. The hyff of the three quarks guide each other to persistently stable locations (hence emission directions). This is consistent with the QM perspective that quarks of different colour are 'attracted' to each other. The whole structure is in a CoFs state. The hyff support each other, and this reduces their vulnerability to the fabric variability, and hence increases stability. Presumably if the localised

[18] One could say that there is a high degree of 'coherence' across the structure. However we avoid that term, because it is so mixed up with multiple other meanings in QM, that it is a cognitively ambiguous concept and therefore semantically unreliable. We deliberately use 'CoFS' because it does not come with prior connotations.

gradients in the fabric were too high, then the proton structure could disintegrate.

Decay model

We anticipate a general mechanism for decay in E.6.10. A particuloid becomes unstable and decays when there is no place for its reactive end to form, i.e. the external constraints of the fabric and the hyff of the immediate environment dominate and preclude the emergence of the particuloids's hyff. This prevents re-energisation of the RE. We further speculate that the particuloid escapes this untenable situation by converting to a photon and transmitting away, and/or changing its internal structure and level of assembly.

Parity violation

The reason parity is not conserved by quark interactions is a geometric consequence of E.6.7: that the arrangement of the hyff is conserved across the span, *but* the span is a finite length of separation. Therefore the particuloid has an orientation of its span, and is *not a simple 1D point.* Thus a mirror image of quark Ub in the above figure is not identical to Ub itself, about every mirror plane. If quarks were points, which is the conventional QM paradigm, then they would be. At a high enough level of abstraction the cordi can effectively be considered particles, hence parity violation only occurs at small scales.

Comparison with QM

What then of QM's gluons? Cordus suggests there are no such 1D particles, but that instead the interaction is mediated by the CoFS interlocking of hyff. The nearest match to a 'gluon' is therefore a single hyff, or perhaps the hyff renewal pulses (hyffons), but this is not a particularly apt or useful concept. Cordus suggests it is better to abandon the 'particle' view altogether, and not try to translate the concepts back into Quantum mechanics. The glue is in the SHEDS, not the particles.

What is the strong interaction (force)?

If this *in extremis* Cordus extrapolation is true, then the strong interaction is simply an application of the CoFS principle to three axes. Thus the force that bonds quarks together is the positional convenience of their interlocked hyff, i.e. SHEDS. The hyff themselves are the same as those that create the electrostatic force, but it is not electrostatic attraction that does the bonding in this case. Thus the 'strong' force is not a fundamental force, but rather an interaction. It is the same class of effect as electron orbitals and bonds between atoms.

What is the weak interaction (force)?

The 'weak' interaction is the activity whereby quarks can change flavour and emit/absorb electrons. It apparently involves short-lived particles, the W and Z bosons, that carry away charge, spin, or momentum etc., and thereby change the properties of quarks, before decaying into a conventional particle and a photon. Cordus suggests the weak interaction is not a fundamental force either, but rather an effect: a transitory form in the decay of matter. It is the same class of effect as electrons emitting/absorbing photons to change energy shells. From a Cordus perspective it is likely that there are still deeper internal variables driving those behaviours, but it is not a different category of *force.*

Fundamental forces

Thus, from the Cordus perspective, there are only three fundamental forces: electrostatics, magnetism, and gravitation. There are also several different ways that hyff interact, including electron orbitals and a predicted synchronous hyff emission for the quark.

5 Level of assembly

The concept of mass developed above (part 4.3) is not what it seems at the everyday level of our existence. Mass is not a permanent property of matter, but a dynamic consequence of the frequency of the cordus, and the interaction thereof with the fabric (part 2). If true, this has some interesting implications regarding the absoluteness of mass.

The atom is known to have a 'mass excess', whereby the assembled nucleus is lighter than the individual masses of the protons and neutrons. From the Cordus perspective the reason is that smaller-span cordi have greater frequency. This means, in a counter-intuitive way, that smaller-span particuloids have more mass. By implication any particuloids that exist within the quarks will have shorter span and hence greater mass: at least for particuloids that are isolated. However the distinction between assembled and isolated particuloids is an important one. The process of aggregating particuloids into a higher assembly results in *less* mass than the separate particuloids. This means that mass is not conserved at assembly/disassembly. The Cordus explanation is the spans of the assembled particuloids are *longer* than their free spans, and therefore their frequencies are *higher* and their mass *lighter*.

When particuloids are assembled into CoFS states, e.g. the SHEDS of the quarks in the proton and neutron, then their spans are stretched to accommodate the standard gauge of the assembly. Thus the span of the assembly determines the mass of the assembled particuloid, not the masses of the individual parts. This applies within the nucleons, within the nucleus, within atoms, and within molecules.

Conservation of mass – or not

Why then is there a conservation of mass in physics and mechanics? Cordus suggests that the conservation exists in our everyday living, because the interactions of matter generally do not deconstruct the body very much. However, when the interaction has sufficient energy to break the protons apart, then the fragments have the potential to have greater mass than the assembly.

The conventional interpretation is that the energy is converted into mass, i.e. $E = mc^2$ mass–energy equivalence. Cordus does not disagree with that, but merely shows there is another way to look at it: that mass depends on the *level of assembly*. Thus changing the level of assembly exposes or incorporates more mass. It involves energy to change the assembly level. So mass is the dependent variable: $m = E/c^2$.

Also, the assembly concept suggests that at smaller scales the relationship between mass and energy is not smooth but becomes granular as whole assemblies are changed. This applies also to electron bonding, and the effects are visible even at room temperature, e.g. the specific heat capacity of matter and latent heat.

Thus matter does not have an invariant mass: it depends on the level of assembly. Conservation of mass therefore only applies when the masses do not change assembly level. Even then the conservation is only approximate, because even changes to electron bonds change the mass of the assembly, albeit small.

Another implication concerns the binding energy required to disassemble a molecule or atom. Cordus interprets a positive energy as meaning that the span of the assembly is *greater* than the parts. This is somewhat counter intuitive as we tend to think of molecular assemblies as bonds that pull the atoms *closer.*

Mass, span and Level of Assembly are related
Thus the mass of a particuloid depends on the span that the external environment requires it to adopt. For a quark in a proton, that constraint on span is determined by the other quarks in the assembly in a negotiation process of exchanged constraints (see below). For an electron in a bond, the constraint on span is determined by the joint structures of the two atoms. For a free electron in space, the span-constraint arises from the fabric.

Coupling between mass and field

That suggests another interesting conceptual development. The Cordus mechanics already provides that the hyff and the fibril are coupled. So if a free cordus particuloid, say a free electron, is forced by the fabric to take a different span, say shorter, and therefore increase its frequency, then there is a consequence for the hyff (read 'field' in conventional physics). The increase in frequency causes the mass of the electron to increase too. In conventional physics this would be called the mass of the 'shell', but of course Cordus does not hold with that notion of spherical particles. If the situation is adiabatic, i.e. the electron has not been given additional energy or absorbed a photon, and assuming conservation of energy, then by implication the electron has to withdraw energy from the hyff system to support the increase in its mass.

It is to be expected that the hyff system will resist this. Consequently there will an element of stability for the cordus system as a whole (fibril, span, frequency generator, reactive-ends, hyff, hyffons). Thus the cordus particuloid can adjust its frequency and span in response to sufficiently strong external demand, but it has internal stability mechanisms that moderate the changes.

It may be that this is what the photon is doing. In other words, this might explain why the photon emits and withdraws its hyff, a feature of Cordus that has been commented on above.

Singularities

One of the problems in conventional physics including quantum field theory is the singularities that arise when diameters of 'particles' are condensed to zero. The resulting infinities have to be treated with 'renormalisation' processes which seem to work even if of dubious fundamental validity.

Cordus offers a totally different way to view the problem: matter is not points in the first place, and the smallest size of a particuloid is not zero but the span of its cordus. The inertia of an electron is not infinite, because it never is a point. Nor do interactions become infinitely strong at shorter distances: the particuloid is not always energised to be able to react. There are no actual singularities: those only appear in physics as artefacts of the 1D point premise. Thus the appearance of a singularity in physics implies that the mechanics and its mathematics are deficient and unable to be applied to the next level down: they only apply on-average to the next higher level of assembly. That is why quantum mechanics is only applicable, and only on-average, to larger aggregates of particuloids, and starts to break down at the level of the double-slit device where individual particuloids become involved. Cordus thus asserts that we cannot complacently accept 'renormalisation' as a self-consistent process, but instead need to recognise it as a warning sign that the limits of validity for that theory have been reached and that a fundamental re-conceptualisation may be required in that area, with a switch to a deeper mechanics with a different mathematics, if the next deeper level of reality is to be accessed.

Nucleon masses

The interconnectedness of mass, span and Level of Assembly also allows an explanation of the mass difference between the proton and neutron. The neutron is known to be heavier. The Cordus explanation is that the natural span of the D quark is smaller than that of U, for reasons uncertain.[19] Thus a proton of UUD causes the D to be stretched, hence lowering its mass, because the UU dominate the outcome. The neutron of UDD causes the U span to be compressed, increasing its mass. True, the DD will be stretched slightly, decreasing their mass, but there are two of them so the effect is disproportionally smaller. The overall effect is that the neutron is slightly heavier.

Thus considerations of cordus span and frequency could be useful in understanding the mass differences in other sub-atomic assemblies.

[19] Probably the U quark is an assembly of smaller cordi, and the assembly gauge is thus stretched (E.7.3).

Cordus suggests that mass is determined by the frequency of the assembly. We summarise the above with the following lemma.

E.7 Level-of-assembly lemma

E.7.1 Higher frequency (smaller) particuloids have more mass.

E.7.2 Mass is not conserved at assembly/disassembly.

E.7.3 Particuloids that have their span stretched at assembly into atomic structures reduce mass, and the converse.

E.7.4 The span of the assembly as a whole (assembly gauge) determines the mass of the assembled particuloid, not the masses of the individual parts.

E.7.5 Matter does not have an invariant mass: it depends on the level of assembly.

E.7.6 Span (assembly gauge) tends to increase at higher levels of assembly. Hence higher levels of assembly are lighter.

E.7.8 In adiabatic conditions a conservation of energy applies between the fibril energy and the hyff energy of a cordus matter particuloid. Thus the emission of a hyffon momentarily extracts energy from the fibril, which causes the span to increase (reactive end to move radially outward).

Atoms in SHEDS

Previously, in 'Cordus Matter', it was suggested that the electron in a shell was influenced by the hyff arrangements of the inner shells, and those inner shells in turn by the outer shells. Presumably something similar applies to the nucleus. The hyff that protrude from the three quarks inside the proton will interact with those from other protons and neutrons.

The whole nucleus is therefore an extended SHED structure. The protons and neutrons have to fit their hyff around each other. The electrons also: they cannot simply go anywhere, but have to fit around the hyff from the nucleus and the other electrons, hence the orbitals. The addition of more electrons neutralises some of the proton hyff, and thus allows more protons to be added to the assembly. The whole atom is therefore very much more than simply an electrostatic interaction between electrons and protons.

Thus we have provided a model for the inside of a proton, and conceptually identified the possible structural principle for the larger nucleus and the atom itself, but the details remain an open question. This might be a good place for a mathematically based optimisation method to make a contribution, because intuitive the structure of a large atom is going to be complex and beyond the power of the simple logically descriptive method used here.

6 Conclusions

By pushing Cordus to the extremes, a conceptual model has been created for quarks and the internal structure of the proton and neutron. In this model the charge of a quark indicates the number of hyff (force lines) it emits. Cordus also explains the colour and provides a mechanism for the strong interaction (both the attraction and repulsive components). The model also explains why parity violation occurs. A new concept of the 'level of assembly' is introduced and used to explain mass excess and why smaller particuloids have greater mass. Cordus also makes some more radical predictions, such as non-conservation of mass.

Fundamental forces

In this extrapolation of the Cordus conjecture, gravitation is caused by acceleration of the basal cordus particuloid, magnetism by velocity of the reactive ends, and electrostatic force by position thereof. These are the only three fundamental forces: the strong and the weak 'forces' are aptly named 'interactions' and in the same categories as orbitals and photon emission respectively, i.e. not fundamental forces.

The important concept here is that one mechanism, the emission of hyff, provides the underlying mechanism for electrostatics, magnetism, and gravitation. These forces are intrinsically unified. In contrast, QM perceives these forces, together with the strong and weak nuclear interactions, as mediated by virtual particles and tries to unify them on that basis. Cordus suggests the so called virtual particles are simply different measurement artefacts of the hyff, not the real interactions.

Comment

The macroscopic world is very beautiful. Despite the large gaps at the sub-atomic level, and the dynamic turmoil within even the simplest atom, the overall effect at our level of being is of a reliable, smooth, persistent world. The paint on the aircraft is durable and behaves the same, day after day, despite what is happening in its sub-atomic structure. The macroscopic stability of matter is all the more surprising. It is also beautiful because it creates the world in which our bodies can exist.

7 Closing summary

This series of papers is an extrapolation of the basic Cordus concept to the extremes. We are not saying that the resulting concepts are necessarily true, only that they are challenging ideas that are worth considering.

What has been achieved here?

Cordus *in extremis* offers novel concepts for several effects, starting with fields. It proposes a mechanism for granular field-forces that aggregate to the apparently smooth field at our level of everyday perception. The hyff carries a transient quantum of force ('hyffon') directed back down the hyff towards its origin. Each re-energisation of the reactive end sends another renewal-pulse of force down the hyff. Therefore hyff are directional force lines that extend out into space from their basal particuloid, and where the force appears in pulses that travel outwards along the line (hyffons). For a test charge in an electric field, the overall effect is a steady rain of hyffons that are individually small transient units of force. The overall effect is a smooth force.

Cordus proposes that the electric field cannot actually be shielded, only locally neutralised, and it provides a new way to conceive of the connection between electrostatics and magnetism. Cordus does not consider electromagnetism as equivalent concepts, but suggests they are quite different physical effects and that electrostatics is the more fundamental and magnetism the derivative.

Unconventionally, Cordus predicts a fabric to the universe: a type of massless relativistic aether, but made of tangled hyff force lines not particles. The fabric is made of the hyff of all the other massy particuloids in the accessible universe. This fabric limits the speed of light to a finite value. An even more drastic proposal is that the speed of light is not invariant, even if it is relativistic.

Another radical outcome is that Cordus proposes an integration with gravitation through the same hyff mechanism underlying electrostatics and magnetism. The important concept here is that one mechanism, the emission of hyff, provides the underlying mechanism for electrostatics, magnetism, and gravitation. It is proposed that these are the only fundamental forces and are intrinsically unified. The hyff provide a mechanism whereby gravitation is not continuous but in discrete force (or displacement) increments, and the closing force between two masses is transient. In this idea, gravitation, and therefore also mass, is a discontinuous property: i.e. a particuloid emits gravity (has mass) at some moments but not others. Thus gravitation is an effect that a mass does to the whole universe, not to targeted other bodies. Cordus conceptually integrates the different effects of mass: Gravitation is a particuloid contributing hyff to the fabric; Newtonian mass is resistance of the reactive ends to unexpected displacement; Relativistic mass is decreasing efficacy of hyff engagement with the fabric as velocity of the reactive end increases; Momentum is a frequency mechanism (as yet incompletely described) that ensures the reactive end re-energises on-time and in-place; particuloids have mass to the extent that they have frequency.

Less radical, but nonetheless a useful integration, Cordus offers an explanation of how time arises at a sub-atomic level by the cordus frequency, and how this aggregates to the sense of time that we perceive biologically. Thus time is carried in the fabric, and this is a similar concept to spacetime in General relativity, though Cordus does not see time as a fourth dimension.

The fabric itself is proposed to be made from the hyff of sub-atomic particles, including the quarks. Cordus goes on to suggest a composition for quarks, and the structure of the proton and neutron. The fractional charge of the quark is explained in terms of hyff, and the colour by the combinations of hyff emission directions. The strong interaction then emerges as a hyff interaction effect, not a fundamental force as such. Cordus suggests the weak interaction is not a fundamental force either, but rather an effect: a transitory form in the decay of matter. Thus Cordus proposes that there are only three fundamental forces: electrostatics, magnetism, and gravitation, and they are all carried by the same hyff. Those same hyff also contribute to the fabric and to time, so the concepts are interlinked. As a by-product, an explanation emerges for why parity is violated by quark interactions: this is explained as a geometric consequence the cordus having a finite span.

Cordus is unconventional in suggesting that mass is not generally. Instead it is proposed that matter does not have an invariant mass. Mass depends on the level of assembly of the particuloid into sub-atomic, atomic and molecular structures. It predicts that mass is determined by frequency, which in turn is related to cordus span, hence size of particuloid and the way it is bonded into other assemblies.

Thus Cordus *in extremis* provides a coherent explanation across a wide variety of phenomena that otherwise are only partially explained by conventional theories of physics, see Figure 3. Compared to the conventional theories, Cordus offers greater explanatory power, greater coherence with less reliance on metaphysical explanations, and greater integration across a broader range of phenomena. This is particularly evident when considering the effects also described in the companion papers, which resolve many of the paradoxes of wave-particle duality and provide explanations where conventional theories are limited to abstract mathematical interpretations or reliant on metaphysical effects.

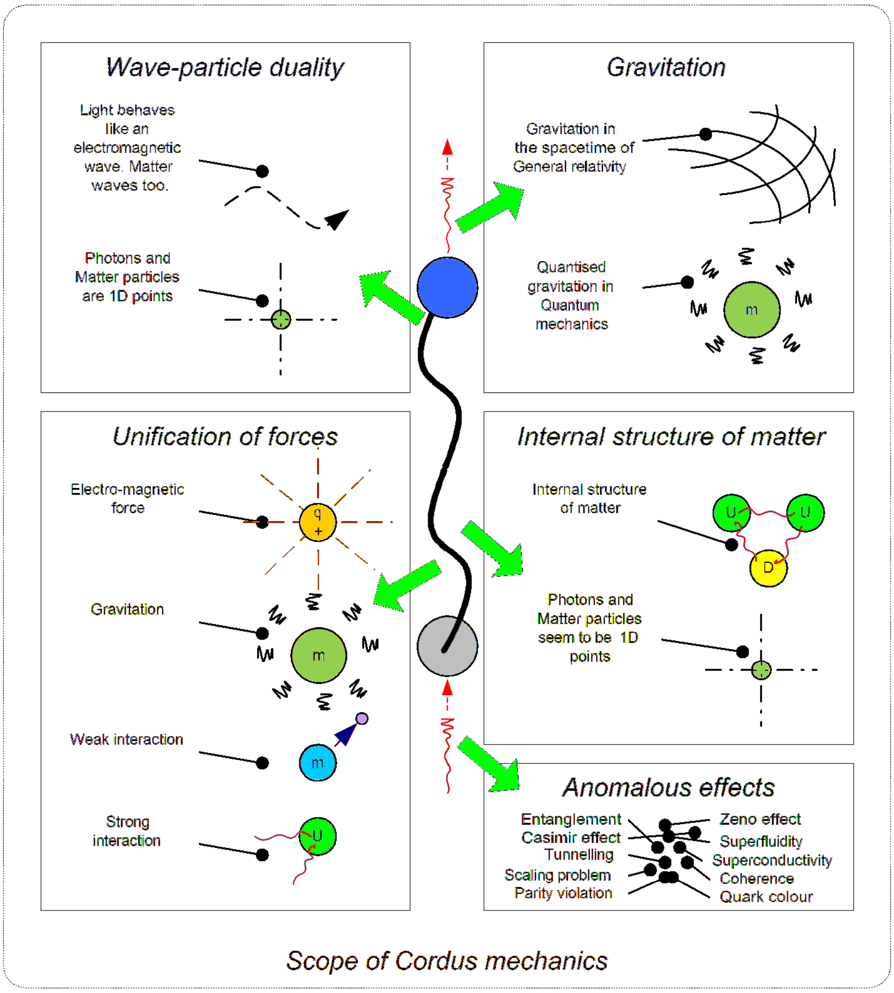

Figure 3: The core idea of the cordus conjecture is that all 'particles' have a two-ended cordus structure. This basic idea may be extended to create a conceptual framework that provides a logically consistent description across a variety of effects. The result is a high-level descriptive integration across fundamental physics, and the emergence of a deeper mechanics.

The purpose of this paper was to push the Cordus mechanics into extreme predictions, out of curiosity for any new concepts that it might suggest. The original Cordus concept was created to explain wave-particle duality of the photon in the double-slit device. When applied to the extremes, the concept has yielded unexpected new insights, novel re-thinking of things we thought we already knew, explanations for things that were paradoxes, and some unconventional contrary predictions. Cordus provides a radical re-conceptualisation of several areas of fundamental physics.

Cordus is fundamentally different to conventional thinking. It departs radically from both quantum mechanics and general relativity in its suggestions of the underlying mechanisms. Yet in many cases it offers concepts that will be recognisable to those other areas.

The primary contribution of the Cordus work as a whole is that it provides a new conceptual framework for thinking about fundamental physics.

Cordus may or may not be a robust solution, but it does show that there are other ways of thinking about the issues, and we do not need to be discouraged by the staleness of the debates about wave-particle duality, nor stuck in the fixed paradigms of existing theories, nor perplexed by the weirdness of quantum mechanics. Even if Cordus is not the deeper mechanics, there can now be no doubt that a deeper mechanics does exist.