Cordus Conjecture: Overview

Dirk J. Pons, [1] Arion D. Pons, Ariel M. Pons, Aiden J. Pons.

Abstract
The Cordus conjecture suggests there is a deeper, simpler, deterministic, and more elegant reality beneath quantum mechanics and wave theory.

Revision 1
Document: Cordus_0Summary_E1.04.doc

1 Introduction to cordus

The Cordus conjecture is that all 'particles', e.g. photons of light, electrons, and the protons in the nucleus of the atom, have a specific internal structure. This structure is a 'cordus': two reactive ends that each behave like a particle, with a fibril joining them. The reactive ends are energised at a frequency, and emit a force line called a hyff that makes up the field, see Figure 1.

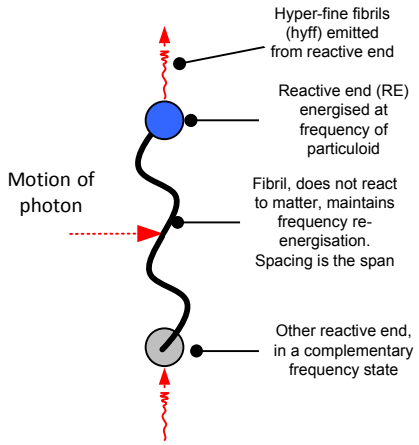

Figure 1: Cordus model of the photon

The idea of a cordus allows many puzzling phenomena to be explained at a conceptual level. For example, light seems to behave either as a wave or a particle in the double slit experiment, and cordus explains this wave-particle duality. Curiously, the same cordus concept flows across as an explanation for many other baffling effects in fundamental physics. It therefore provides an explanation that is logically consistent across a wide range of effects.

---

[1] For commentary, discussion and feedback, please see http://cordus.wordpress.com. Please address correspondence to Dr Dirk Pons, Department of Mechanical Engineering, University of Canterbury, Private Bag 4800, Christchurch 8020, New Zealand, Email: dirk.pons@canterbury.ac.nz.

As the term ‘conjecture’ shows, it is a guess based on intuition. It is a conceptual and descriptive model. There is no guarantee that the cordus conjecture is correct. It is a thought-experiment rather than a fully worked-out or validated theory. Some or all of it may be entirely wrong.

Cordus is an audacious idea, and it produces a radical re-conceptualisation of fundamental physics. It is an unorthodox idea, one that cuts across conventional physics and challenges the premises on which those theories have been built. It is likely to be controversial. However it is not deliberately confrontational: it is simply a process of taking a creative idea and running it through to its logical conclusions.

It is in those conclusions that, if cordus is correct, there are causalities for existing principles of conventional physics. For example, cordus invalidates the ‘particle’ premise of quantum mechanics, refutes superposition, redefines the principle of locality, denies the existence of ‘virtual particles’, refutes the concept of interference of light, asserts that Bell’s theorem is wrong, re-introduces a modified concept of the aether, and reconceptualises the fundamental forces. Cordus explains why Quantum mechanics, which *seems* to apply at the level of individual particles, does not scale up to macroscopic bodies: something that QM itself has been unable to explain. Furthermore, cordus proposes a set of new principles for the next deeper level of physics.

Cordus is a wild idea, in that it is totally different to conventional physics, and is based on conjecture and intuition with all the attached subjectivity. It is not an incremental extension of existing theories, but a disruptive new idea and a drastically different way of thinking. That does not necessarily make it valid, but it is beautiful albeit in a different way to the usual standard of beauty in physics or mathematics. Cordus has a beauty in its coherence: it provides logically consistent explanations across a broad range of physical effects. It does so without the weirdness that is so typical of the conventional explanations. It is also beautiful in the way it unexpectedly shows that the next deeper layer of reality is deterministic, not probabilistic as usually thought. There are many surprises in the cordus conjecture.

There is, as we have taken care to point out, no certainty that this thought-experiment is really valid. Nonetheless, if it were to be true, then the implications are that there is a deeper mechanics beneath the conventional theories of quantum mechanics (QM) and electromagnetic wave theory (WT). Both QM and WT emerge as outward, and in the case of QM only approximate, mathematical representations of a deeper behaviour within particuloids. The extreme predictions of cordus also encompass general relativity (GR).

2 Integration problems in conventional physics

The dominant existing frameworks for fundamental theoretical physics are Quantum mechanics (QM) for particles, Electromagnetic wave theory (WT) for light, electrostatics and magnetism, and General relativity (GR) for gravitation. While those conventional theories are generally accepted as valid in their particular areas, there is the unfortunate problem that they do not integrate well. Furthermore, they sometimes give weird explanations to simple phenomena, this being particularly the case with QM. Also, there are many areas that they simply do not explain at all, or give conflicting interpretations.

A case in point is wave-particle duality. For example in the double-slit experiment, light apparently sometimes behaves like a wave, and sometimes like a particle, depending on how it is observed. WT and QM adequately describe the fringe and particle behaviours respectively, but their explanations do not overlap. Thus there is no single integrated explanation for wave-particle duality. Furthermore, while QM has exquisite mathematical models for the particle behaviour, the physical interpretation of those models results in really strange predictions of reality e.g. superposition, and some explanations that are beyond physics, e.g. virtual particles and parallel universes. That in itself would not be a problem except that we do not actually see reality behaving the way QM predicts, especially not at the macroscopic scale.

All these issues suggest that there might be a deeper physics, a better theoretical foundation that provides a coherent explanation across the many phenomena. However, if there is a deeper theory, one that subsumes both wave and particle perspectives, it is not obvious what that might be. Also, there is reason to believe, per Bell's theorem, that no theory of internal (or hidden) variables is possible for the photon and particles generally. Thus the problem of wave-particle duality may be fundamentally unsolvable. The null explanation is then to simply accept the paradoxes and consider the matter intractable.

3 Approach taken

The Cordus conjecture started as an attempt to create a more rational explanation for wave-particle duality of the photon in the double-slit device. The method did not follow the conventional method of physics, which relies on derivation of beautiful mathematics and subsequent extrapolation to explanation, but rather used the logic of creating a system model by reverse-engineering known phenomena, adding conjectures and intuitive material, and noting the necessary assumptions along the way. Thus the central strand in the Cordus conjecture is a set of lemmas, and these we do not attempt to prove. The resulting Cordus model is primarily conceptual and descriptive, rather than mathematical, at least at this point in time. It is likely that much of the mathematics of conventional physics can be adapted and re-contextualised for a Cordus Mechanics, because

the issues are not with the mathematics but the explanations of conventional physics.

Quis es tu, cordus?

Cordus asserts there is no such thing as a 'particle'. Instead the basic structure for a photon, electron, proton etc., is a cordus with two reactive ends, with a physical gap between them, held together with a fibril. The reactive ends may be energised to various degrees, and in turn consist of hyff force lines. The energy shuttles between the ends, and this also means that the particuloid does not exist continuously at one location, but at two, and oscillates between them at a frequency. Consequently, cordus suggests that all the principles of physics that are built on a 'particle' premise are of dubious validity, especially at the finer scales.

Outcomes

The idea of a 'cordus' was first created to explain photon path dilemmas in the double-slit, and then extended to explain fringes too. This provided a conceptual resolution of wave-particle duality. The principle was then extended to optical effects of reflection and refraction. The next step was application to matter effects, particularly the electron and special states of matter. It is here that the contrast between Cordus and Quantum mechanics is most evident. Thereafter the cordus principle was pushed to the extremities, out of curiosity. This last set of papers is therefore the most radical – and the least likely to be correct but the most disruptive to conventional theories of physics if true. It provides a new perspective on fields, unifies gravitation with electromagnetism, and infers the structure of quarks.

A major benefit of the Cordus conjecture is that it provides a conceptual framework that is coherent across many physical phenomena. The effects explained include:

- Internal structure of the photon
- Path dilemmas of the photon in the double-slit device and Mach-Zehnder interferometer
- Wave-particle duality of the photon, electron, and matter waves
- Fringes in gaps, apertures, and double slit, diffraction of single photons and beams
- Near field
- Beam divergence
- Frequency of photon, electron and matter generally
- Zeno effect
- Heisenberg uncertainty principle
- Entanglement
- Aharonov-Bohm effect
- Electron orbital shape
- Spin angular momentum
- Pauli exclusion principle
- Atomic bonding
- Entropy
- Superfluidity including quantum vortices and heat conduction
- Superconductivity including Meissner effect
- Josephson effect
- Coherence

- Quantum mechanic's scaling problem: why does QM not apply at macroscopic levels?
- Casimir effect
- Tunnelling
- Reflection including derivation of critical angle from a particuloid perspective
- Refraction and Snell's law derived
- Brewster's angle derived
- Polarisation
- Electrostatic field and granulation [quantisation] thereof
- Magnetism
- Gravitation and mass
- Spacetime, but not time as 4^{th} dimension
- Lorentz
- Relativistic nature of the vacuum
- Finite speed of light in vacuum
- Colour of quarks
- Charge of quarks in 1/3 units
- Mass excess in the atom
- Parity violation

The implications of cordus are that several existing principles of conventional physics may need to be revised or abandoned:

- Particle: invalidated, does not exist as QM assumes, replaced with 'cordus particuloid'
- Virtual particle: invalidated, unnecessary and confounded concept, replaced with 'hyff'
- Many-worlds interpretation: irrelevant
- Interference of light: refuted, does not occur as Wave Theory describes. Useful mathematical concept, worth keeping if limitations respected.
- Locality: invalidated, replaced with new 'Principle of Wider locality'
- Power of Observer choice to change outcomes: invalidated, instead the way the Observer sets up the experiment determines the behaviour the photon will evidence
- Heisenberg uncertainty principle: minor adjustment
- Bell's Theorem: refuted
- Beam splitter: reconceptualised
- Superposition: refuted as a physical effect, but useful as a rough statistical approximation
- Coherence: reconceptualised, limitations applied
- Schrodinger's Cat: irrelevant as based on flawed premises
- Quantum mechanics: only applicable on average over many 'particles', and only at a level where things look like 1D points
- Copenhagen interpretation: a mathematical simplification of deeper effects, is not the reality
- Wave theory: validity limited primarily to light en-masse
- Fundamental forces limited to electrostatic, magnetism, and gravitation. Common unified underlying mechanism provided. Abandon strong and weak interactions – nothing specially fundamental about them.
- Invariance of the speed of light in the vacuum: not supported, instead is variable depending on fabric.
- Aether re-introduced in modified form, but not a matter or particle based one.

The cordus conjecture also introduces some new concepts that do not exist in conventional physics:

- Cordus structure and mechanics
- Complementary frequency state synchronisation (COFS) as the underlying mechanism for electron orbitals, Pauli exclusion principle, entanglement, internal structure of proton, atomic structure, atomic bonding, strong force
- Principle of wider locality
- Internal structure of the photon
- structure of quarks
- Internal structure of the proton and neutron
- Electric field and granulation thereof
- Electric field cannot be shielded
- Magnetism: new concept
- Gravitation: new concept, integrated with electromagnetism, granulation
- Fabric of the Universe
- Mass: new concept of underlying mechanism, granulation and transient nature
- Time: new concept, and how atomic time aggregates to personal sense of time
- Vacuum: new concept of what it contains, fabric hyff, differentiation from 'void'
- Strong force (interaction): not a fundamental force but a COFS effect
- Weak interaction: not a fundamental force or interaction but same class of interactions as photon emission
- Level of assembly: new concept for understanding why smaller particuloids are heavier (explains mass excess)
- Conservation of mass: reformulated
- Synchronous hyff emission direction (SHED) as mechanism for strong interaction holding quarks together

As the method explains, the treatment of these matters is by logical inference, and the results are primarily conceptual. The validity of the results is uncertain and it is to be expected that some or all of the model may be wrong or require revision. Nonetheless, the ideas build a novel conceptual framework for fundamental physics. This framework is coherent in its ability to explain a wide range of phenomena in a physically descriptive way.

4 Cordus mechanics

The following is a summary of the cordus conjecture and its mechanics. Each of the parts is a paper on its own.

4.1 Cordus Conjecture

Cordus Conjecture: Part 1.1 Quis es tu photon?

This paper introduces the core idea: a new conceptual model is proposed for the internal structure of the photon, and the mechanics thereof. This internal structure is called a cordus. The cordus consists of two reactive ends (RE) connected together with a fibril. The fibril connecting the two reactive ends does not interact with other matter. Each of the two reactive

ends behaves like a whole photon in its ability to interact with other matter, including reflection, transmission, and the ability to take two paths, though it collapses to only one location. The reactive ends emit hyperfine fibrils (hyff) which are force lines. The cordus structure is neither a particle nor a wave, though can appear as either in certain circumstances. (Pons, Pons, Pons, & Pons, 2011a)

Cordus Conjecture: Part 1.2 Quo vadis, photon?

Photon path dilemmas are a difficult area for conventional physics. Typical situations are the double-slit device and interferometers. The problem manifests as an apparent ability of the photon to simultaneously take all paths through the device, but eventually only appear at one. Neither Electromagnetic wave theory nor Quantum mechanics provides a fully coherent explanation for the behaviour of light in the double-slit device, and the integration of 'wave-particle duality' is poor. It is shown that a cordus structure is conceptually able to resolve the path dilemmas in wave-particle duality. Explanations are given for the double-slit device and interferometers. The Cordus conjecture implies there is a deeper, simpler, deterministic, and more elegant reality beneath quantum mechanics and wave theory. (Pons, Pons, Pons, & Pons, 2011b)

Cordus Conjecture: Part 1.3 Explanation of fringes

The cordus concept is shown to be able to explain wave behaviour in gaps, and fringes in the double slit device. This is useful because one of the enigmas of the double-slit device is that single photons form fringe patterns. Cordus explains fringes in terms of force lines called hyperfine fibrils (hyff) and their interaction with the edges of the light path. This also explains beam divergence and near-field effects. The significance of this is that it shows it is conceptually possible to create a solution for fringes based on a particuloid interpretation of light, without using the concept of interference. This means that the Cordus solution has coherence over a wider range than simply the path-ambiguity problems. (Pons, Pons, Pons, & Pons, 2011c)

The biggest difference between Wave theory and the cordus explanation is their interpretation of the mechanism for fringes. Wave theory explains fringes as 'interference': two separate waves of light differing by full (half) fractions of wavelengths and thus constructively (destructively) interfering. From the Cordus perspective photons do not actually interfere or add together, and 'interference' is only a convenient analogy. The Cordus explanation is that fringes are caused instead by interaction of the photon hyff with opaque edges.

Comments on the bracket of 'Cordus Conjecture' papers as a whole

Wave theory and quantum mechanics are functionally adequate theories on their own, and powerful in their ability to predict how beams of light and individual photons, respectively, will behave in a given situation. However, despite their mathematical sophistication, they are incongruous explanations of reality when wave and particle behaviours occur in the same situation, e.g. the double-slit device. In these situations their

explanations are weird, which suggests that the models of causality are incomplete. The problem has been that wave theory and quantum mechanics are just so good, that it has been difficult to see what the deeper mechanics could be, especially as Bell's theorem seems to prohibit solutions with hidden variables.

How do Quantum mechanics and Wave theory fit in?

From the cordus perspective both conventional theories, quantum mechanics and wave theory, are mathematical simplifications of a deeper mechanics. Those theories represent the *output behaviour* of the inner system. The weirdness of conventional wave-particle duality is not because the photon is fundamentally weird, but because the existing conceptual frameworks are inadequate: their mathematics are sufficient for forward propagation of effect (prediction), but give unreliable results when used for backward inference of causality (explanation).

Resolution of wave-particle duality

The Cordus conjecture does away with much of the weirdness of wave-particle duality: there is no need for virtual particles, superposition, observer dilemmas, pilot waves, intelligent photons, or parallel universes. A simple deterministic, unintelligent photon with a dual existence is all that is required.

From this perspective wave and particle behaviours are simply the different output behaviours that the internal system shows depending on how it is measured. The duality and the apparent incongruity of Quantum mechanics and Wave theory is resolved: the conflict no longer exists at the deeper level.

Thus Cordus offers a deeper mechanics that subsumes both quantum mechanics and wave theory. This bracket shows how it resolves wave-particle duality, and other papers extend it to other enigmatic effects, as well as the mundane. Perhaps surprisingly, Cordus is also simpler and more coherent across a wider range of phenomena than quantum mechanics or wave theory on their own. Even more surprising, and unexpectedly contrary to the prevailing probabilistic paradigm of Quantum mechanics, Cordus suggests that the next deeper level of reality is deterministic.

4.2 Cordus optics

Cordus optics: Frequency (Part 2.1)

Conventional particle and wave theories struggle to explain the frequency of photons and matter in a coherent manner using natural physics. This paper applies the cordus conjecture to develop a model for frequency of the photon. The interpretation is that there really is a part of the photon cordus that moves with a frequency. The working model is for a reciprocal motion: the energy alternates between the two reactive ends across the span of the cordus, and the hyff represent the observable electric field. This cordus model for frequency readily explains polarisation

and tunnelling, and the concept is fundamental to other developments of the cordus mechanics including the reflection and refraction of particuloids. The implications are that frequency is not just an intrinsic variable, but a physical effect within the photon. The cordus frequency is a fundamental conceptual building-block in creating an integrated solution that unifies wave and particle behaviour. It is a powerful concept that is coherent across many other phenomena too, including matter particuloids and it contributes subsequently to the cordus model for granular fields. (Pons, Pons, Pons, & Pons, 2011m)

Cordus optics: Surface interactions (Part 2.2)

Optical effects such as reflection and refraction are conventionally best described by Electromagnetic Wave theory, at least when they involve beams of light. However that theory does not explain why single photons should also show such behaviour. This paper shows that optical effects can also be explained from a cordus particuloid perspective. Several principles are proposed for the interaction of a cordus photon with an optical surface, and these are used to explain reflection and refraction. The formulae for critical angle, Snell's law, and Brewster's angle are derived from a particuloid basis. The cordus and wave theory perspectives are compared and contrasted. The significance of this work is that the cordus mechanics explains the reflection and refraction behaviour of both single photons as well as beams of light, so it is a more universal explanation. (Pons, Pons, Pons, & Pons, 2011n)

4.3 Cordus matter

Matter is conventionally thought to consist of particles, and quantum mechanics (QM) is the dominant, and apparently mostly sufficient, theory for this area. The application of cordus concepts to the particle world of quantum mechanics consequently has some surprises.

Cordus matter: Part 3.1 Wider Locality

Quantum mechanics does a good job of providing mathematical descriptions of particle effects, and the fact that it can do so is usually taken as circumstantial evidence that QM must be correct. Unlike other areas, such as wave-particle duality, there is no major competing interpretation to QM in the area of sub-atomic particles. All the same, QM is not particularly effective at providing a qualitative *description* of the effects, and this makes it complex and difficult to understand at an intuitive level, and consequently people generally, though perhaps not physicists specifically, perceive QM as strange. Maybe the effects really are intrinsically complex, and the mathematical formulations are the reality: the simplest possible way to express the underlying mechanisms of causality. (Pons, Pons, Pons, & Pons, 2011h)

Einstein called entanglement 'spooky action at a distance' and it continues to sit uneasily within physics since a qualitative explanation is lacking even though the reality is accepted. It is contrary to relativity, and to the *principle of locality*. Nor can entanglement satisfactorily be explained with

existing hidden-variable theories. However it is consistent with quantum mechanics. The principle of locality is that an object is only affected by its immediate surrounding. Entanglement appears to require the principle to be violated: twin particles may be linked, such that changing the state of one instantly changes the other, even if they are separated by macroscopic distances. The mechanisms are incompletely understood in conventional physics. (Pons, et al., 2011h)

This particular paper shows how entanglement is readily explained as a natural consequence of the cordus. This obviates the need for the usual spooky and metaphysical interpretations. The paper also introduces the principle of complementary frequency state synchronisation (CoFS). This is an important concept in that later papers show how it underpins the Pauli exclusion principle, coherence, and the strong interaction.

More radically, Cordus suggests that Bell's Theorem is only applicable to 1D point particles, and is thus generally irrelevant. It is an artefact of the flawed 1D particle premise of conventional physics, and is not an obstacle to models of hidden variables. Another radical suggestion from Cordus is that the principle of locality is not viable in its present form and needs to be widened.

These are unorthodox predictions. The implications are that the 'particle' conceptual foundation of Quantum mechanics is invalid. QM only applies at the level at which small pieces of matter look like point particles, and is invalid at smaller scales.

Cordus matter: Part 3.2 Matter particuloids

While matter forms the tangible substance of our world, our understanding of it at the atomic level is far from complete. Some of the most enigmatic effects in the physics of electrons are its wave-particle duality and the Aharonov-Bohm and Casimir effects. Even relatively core concepts of atomic physics, like spin and the Pauli exclusion principle, lack satisfactory descriptive explanations. This paper shows that application of the cordus principle can explain these effects in a coherent manner. (Pons, Pons, Pons, & Pons, 2011i)

Cordus matter: Part 3.3 Energy cycles within matter

The interaction of light with electrons is one of the fundamental perceptual realities of what we see. Yet that interaction is only partly understood. Cordus concepts are applied to develop a descriptive model of the mechanisms whereby photons are absorbed into electrons and emitted. From the Cordus perspective, the temperature of a body is primarily a measure of its phonons (lattice-vibrations). Cordus shows why entropy occurs, despite the individual mechanisms being reversible. An understanding of the mechanisms for entropy is relevant to the understanding of coherence, superfluidity and superconductivity. Cordus suggests that a failure to adequately conceptualise entropy leads to misapplication of coherence and ultimately to unreliability in the premise of superposition. (Pons, Pons, Pons, & Pons, 2011j)

The cordus re-conceptualisation of entropy might seem basic and almost self-evident in hindsight, but it is a core concept in understanding why QM does not scale up to the macroscopic world. Entropy is the Achilles heel of Quantum mechanics.

Cordus matter: Part 3.4 Special states of matter

The Cordus principle of complementary frequency states (CoFS) is used to develop a novel descriptive model for the mechanisms underlying superfluidity and superconductivity. In both cases Cordus explains the effects as synchronisation of forces between electrons and atoms. Several associated effects are likewise explained, including quantum vortices, heat conduction in superfluids, and the Meissner effect in superconductors. Cordus also asserts that superposition does not exist, at least not the way QM conceptualises it. In particular, that the mathematics of superposition and the wavefunction are not the reality, only mathematical approximations of deeper effects, and are unreliable qualitative descriptors of those underlying mechanisms. (Pons, Pons, Pons, & Pons, 2011k)

Cordus makes the unorthodox assertion that superposition does not exist, at least not the way QM conceives of a whole particle or body being fully in two places at once. Cordus provides for positional variability: the two reactive ends of a cordus are in different places, and extends that to larger assemblies of matter only if such objects can be placed in full body-coherence (which is rare). However Cordus rejects the QM superposition concept of causal variability: the idea that the *whole* particle or body is simultaneously in both and neither positions and therefore has two futures before it, which can diverge.

Cordus asserts that QM is only approximately accurate at the sub-atomic scale because of the problem with superposition, and not at all at the large scale. Briefly, the reason is that large bodies have too much internal entropy (disorder) to have the necessary coherence to appear in more than one location. Even if they did have body-coherence the results would be minuscule (small span) and not as dramatic as popularly imagined. The mathematics of QM are premised on coherence, and thus the explanations of QM are unreliable where body-coherence fails. In most room-temperature applications this is the atomic level. Quantum mechanics therefore does not practically apply to large bodies, living creatures, or the universe as a whole.

Cordus re-conceptualises, or at least conceptually clarifies the concept of ‘coherence’, and describes why that state cannot be readily achieved. Thus Cordus predicts what size bodies should and realistically cannot be made into matter-waves. Thus the concept of large macroscopic objects, such as motor-cars, being able to go through a double slit, is proposed to be a fallacy. This also allows Cordus to explain why Quantum mechanics, which *seems* to apply at the level of individual particles, does not scale up to macroscopic bodies: something that QM itself has been unable to explain.

Cordus matter: Part 3.5 Schrodinger's Cat reconceptualised

Quantum mechanics is the dominant conceptual foundation for fundamental physics. Nonetheless there are effects that it does not explain, or explains only by reference to metaphysical effects. While many have wondered whether there could be a more-complete explanation, the solution has been elusive. Cordus suggests that the necessary deeper mechanics is only accessible by abandoning the premise of 'particle', and shows how to achieve this. The resulting Cordus mechanics provides a new way of thinking and a radically different conceptual foundation. This paper primarily contrasts Quantum and Cordus mechanics. In the process, Cordus re-conceptualises Heisenberg's uncertainty principle. It also provides an explanation for the paradox of Schrödinger's Cat, and shows it to be based on unrealistic and unattainable premises. (Pons, Pons, Pons, & Pons, 2011l)

Cordus does not support the idea of virtual particles, nor the interference thereof, nor the collapse of the wavefunction. For Cordus the particuloid is neither a wave nor a particle but behaves as either depending on the measuring method. The measurement method unavoidably changes how the particle behaves, and this is particularly pronounced with the photon. The Experimenter's choice of method therefore limits the type of results that will be observed. Wave and particle duality are only measuring artefacts, not the reality.

4.4 Cordus in extremis

The Cordus concept as a whole is conjectural, and the previous papers have taken care to ground the concepts by comparing them against well-known physical phenomena. The present bracket of papers is less cautious. The purpose here is to audaciously push the cordus concept to see if it has novel suggestions about deeper mechanisms, particularly the propagation of light and fields in general. As always, we are not saying that the results are necessarily valid, only that they are logical and curious. *In extremis* therefore refers both to the subject of fields and the cosmos, and the conceptual extrapolation of doubtful validity.

Cordus in extremis: Part 4.1 Electromagnetism

The Cordus conjecture is extended to create a conceptual model for electromagnetic fields. The resulting model shows how a cordus particuloid generates small transient units of force at the sub-atomic level, thereby creating the apparently smooth and continuous electric field that we more commonly perceive. The starting premise is that all fields are hyff, of one sort or another. 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). Thus fields consist of a rapid sequence of discrete impulses of transient force, radiating out from a cordus at the centre. However we do not see this granularity at our level of perception. Instead we perceive fields to be smooth, continuous, and uniform in all directions. This is because of the en-masse effect of many particuloids being involved.

Cordus also reconceptualises how magnetism is generated at the sub-atomic level, and likewise explains how the granularity arises. From the Cordus perspective, a static charge only generates an electrostatic force, without magnetism, because the hyff are straight outwards. However a moving charge *causes* bending of the e-hyff, and this is what we perceive as magnetism. Any moving mass generates curvature of the hyff, and these generate the magnetic field, except that neutral-charge mass has no observable magnetic field because it emits positive and negative hyff. Thus electrostatic forces are a position effect, while magnetism is a velocity effect. However the same basic structure, the hyff, is responsible for both.

Cordus electromagnetism is applied to explain the electric field surrounding a wire carrying current, the locus of moving test charges in a magnetic field, and the mechanism for how force arises in permanent magnets. The contribution made by this paper is a description of electromagnetism that goes to the next deeper level: it explains the underlying mechanisms for how the forces arise. Also, it provides a mechanism for fields to be granular and directional at the small scale, but smooth and continuous at larger scale. (Pons, Pons, Pons, & Pons, 2011d)

The cordus explanation for electromagnetism is unorthodox in several areas. First, it dispenses with the need for additional particles, and conventional references to 'virtual particles' of any kind are thus re-interpreted as a hyff effect. Second, conventional theories tend to portray electric fields and magnetic fields with equal standing: they are interchangeable concepts. By contrast, Cordus suggests that the electric field is the fundamental effect, and the magnetic field is a derivative. Thus electrostatics is a reactive end position effect, magnetism a RE-movement phenomenon, and (yet to be shown) gravitation a RE-acceleration effect. Third, Cordus is unconventional in asserting that the electric field cannot be shielded, and that what looks like shielding is only localised neutralisation.

The results show that the Cordus conjecture can be extended to electromagnetic fields. Doing so permits novel re-conceptualisation of some fundamental paradigms of conventional physics, and lays the foundation for the next ideas.

Cordus in extremis: Part 4.2 Fabric of the universe

The concept of the vacuum is problematic for conventional physics. Electromagnetic wave theory models it as consisting of nothing at all, but yet paradoxically having finite electric and magnetic constants. Quantum mechanics models it as consisting of temporary particles, but no average substance. General Relativity theory includes a spacetime medium, without describing the composition. In all cases the underlying physical mechanisms are obscure. Furthermore, these existing perspectives conflict in their expectations, so the integration is poor. The treatment is not always logical either: conventional theories find the idea of the matter-based aether thoroughly unacceptable, yet ironically all include something that looks conceptually much like a medium. The Cordus conjecture

provides a conceptual solution for the composition of the vacuum: it provides a fabric that is granular (similar to quantised) at the smallest scale, scales up to a continuum, provides a medium for propagation of disturbances and waves, provides a medium for electromagnetism and gravitation, is relativistic, is not a matter aether, and includes a time signal. In the cordus solution the vacuum is made of tangled hyff (force lines) from all the surrounding matter particuloids. This cordus fabric concept also provides a descriptive explanation as to why the speed of light is a finite value. The fine structure constant is given a physical interpretation, as a measure of the transmission efficacy of the fabric. Cordus also distinguishes between the fabric that makes up the vacuum of space, as opposed to the void which has neither fabric nor time as we perceive it. This model is radically unorthodox in suggesting that the speed of light is relativistic but not invariant; that it depends fundamentally on the fabric density and hence the accessible mass density of the universe at that locality. (Pons, Pons, Pons, & Pons, 2011e)

Cordus in extremis: Part 4.3 Gravitation, Mass and Time

Gravitation is conceptually problematic to General Relativity and Quantum mechanics in that the fundamental mechanisms are unknown to both, and the theories have different requirements that are difficult to reconcile into a single model. Cordus gravitation offers a solution to the problem. It provides a mechanism whereby gravitation is not continuous but in discrete force (or displacement) increments similar to quanta (but not uniform increments). Also, 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, and in this regard Cordus is consistent with General relativity. Both QM and Cordus agree that gravitation is quantised. 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 that ensures the reactive end re-energises on-time and in-place; particuloids like nucleons have mass to the extent that they have frequency. Furthermore, 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 Cordus offers a radically new way of thinking about the problem of gravitation, mass and time that is quite unlike conventional physics, yet includes concepts that might be recognisable to those other physics. (Pons, Pons, Pons, & Pons, 2011f)

Cordus in extremis: Part 4.4 Quarks

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. (Pons, Pons, Pons, & Pons, 2011g)

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.

5 Conclusions

The cordus concept was originally created to explain wave-particle duality of the photon. It turns out to be much more adaptable and powerful, in a descriptive way, than simply a solution for the photon. Cordus is a conceptual solution that shows it is possible to conceive of fundamental physics in a radically different way.

Cordus challenges the conventional idea of 1D points, and the whole conceptual edifice of quantum mechanics built thereon. The concept that emerges here is that 'particles' are not actually 1D points, neither are they waves. Instead 'waves' and 'particles' are simply the external manifestations of hidden internal structures. Thus Cordus offers a deeper mechanics that subsumes both quantum mechanics and wave theory, and thereby resolves wave-particle duality and several other enigmas. Perhaps surprisingly, Cordus is also simpler and more coherent across a wider range of phenomena than quantum mechanics or wave theory on their own. Radically and contrary to the prevailing probabilistic paradigm of quantum mechanics, Cordus suggests that the next deeper level of reality is deterministic.

Cordus is a thought-experiment. The treatment is primarily conceptual and descriptive, and the cordus mechanics only lightly sketched out. It is a conceptual model, not so much a full theory with all the details worked out. While it has been thought-tested against many physical phenomena, it has not been checked against all. Furthermore, it is based on intuition and conjecture, and makes many assumptions (lemmas) that have yet to be tested. Thus the validity is uncertain. Nevertheless, Cordus is a purposely audacious idea: it explores new ways of thinking, and therefore

deliberately puts forward tentative explanations. We don't believe the particular design variant developed in this set of papers is necessarily the only or the final solution, and we are open to the possibility that it could be totally wrong. Thus the cordus concept and the specific working models presented here are simply concepts to be critically evaluated.

The conceptual contribution of this work is the demonstration that it is indeed possible to create hidden-variable models, and that Bell's theorem is not a limitation. It shows that the application of logic and semantic inference to existing experimental observations can give interesting new insights. The beauty of the Cordus Conjecture is that it provides an explanation that is coherent across wave and particle effects, photons and matter, 'particles' and macroscopic bodies.

Thus 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. Therefore 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 their weirdness. Even if Cordus is not the deeper mechanics, there can now be no doubt that a deeper mechanics does exist. Perhaps the biggest contribution is simply the intellectual stimulus to think creatively and more deeply intuitively about topics that we thought we already understood.

Acknowledgement
The authors wish to thank the staff of New Scientist for their interesting and thought-provoking journalism. Those articles ignited the curiosity and launched the cordus thought experiment.

References

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011a). *Cordus Conjecture: Part 1.1 Quis es tu photon?* .

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011b). *Cordus Conjecture: Part 1.2 Quo vadis, photon?*

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011c). *Cordus Conjecture: Part 1.3 Explanation of fringes*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011d). *Cordus in extremis: Part 4.1 Electromagnetism*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011e). *Cordus in extremis: Part 4.2 Fabric of the universe*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011f). *Cordus in extremis: Part 4.3 Gravitation, Mass and Time*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011g). *Cordus in extremis: Part 4.4 Quarks*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011h). *Cordus matter: Part 3.1 Wider Locality*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011i). *Cordus matter: Part 3.2 Matter particuloids*.

Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011j). *Cordus matter: Part 3.3 Energy cycles within matter*.
Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011k). *Cordus matter: Part 3.4 Special states of matter*.
Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011l). *Cordus matter: Part 3.5 Schrodinger's Cat reconceptualised*.
Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011m). *Cordus optics: Part 2.1 Frequency*
Pons, D. J., Pons, A. D., Pons, A. M., & Pons, A. J. (2011n). *Cordus optics: Part 2.2 Surface interactions*.