Cordus Conjecture: Part 1.1 Quis es tu photon?

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Abstract
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.

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1 Introduction: Wave-particle duality

Wave-particle duality is a mostly-sufficient explanation of the behaviour of light, but fundamentally incomplete because of its lack of an integrated theoretical foundation or a coherent explanation that is consistent with reality. It gives rise to sometimes weird explanations, 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.

The Wave theory (WT) part of the duality perceives light as electromagnetic (EM) waves, and uses this to explain various optical effects. From this perspective light is a temporally continuous beam. Thus the light going *into* an object, e.g. a mirror or a double-slit device, exists at the same time as it *exits* and can therefore interfere with *itself*. Interference is therefore a core concept throughout the WT perspective. WT is an effective predictor of large scale optical effects and fringes. However WT is incapable of dealing with individual photons, and therefore with certain classes of effects, such as single photons into the double-slit device with a blocked slit.

The other part of the duality is Quantum mechanics (QM). It takes the particle perspective and treats light as a series of photons. It can thus

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explain effects involving single photons, e.g. the photo-electric effect, that WT cannot. QM states that the photon's particle properties are described by a probabilistic wave-function, and that superposition applies, so that its location is indeterminate while it is flight: the wave-function supposedly collapses only when it is observed. QM is an excellent predictor of how particles will behave, though WT is better for beams of light. However QM is a mathematical and statistical solution that suffers from poor physically meaningfulness: 'mechanics' is not particularly apt. It is good at providing a quantitative prediction of *what* can happen, but weak at giving a qualitative description of *how* the causal mechanisms operate.

Wave theory and Quantum mathematics accurately *predict* physical outcomes, but neither is completely sufficient as an *explanation* of reality, and they do not integrate well. 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. 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.

Is there a way to integrate wave and particle views? Is there a deeper mechanics, one wherein the paradoxes dissolve? Yes, we think so. This paper introduces a novel concept, the Cordus conjecture, and shows how it can resolve elements of wave-particle duality. This primary paper conceptually sketches out the underlying mechanics, and anticipates the internal structure of the photon. Companion papers extend the concept to explain the optics of light beams, matter, and fields. Taken together, the papers sketch out a conceptual foundation for a proposed cordus mechanics: a candidate for a deeper mechanics beneath both quantum mechanics and wave theory.

This paper is part 1 in a bracket of three. The first part describes the fundamental cordus concepts. i.e. the proposed internal structure of the photon. The second part solves the apparent path-dilemmas in the double-slit device, and also interferometers. The third develops a novel mechanism for the formation of fringes. Other brackets of papers apply the Cordus concept to optical effects (ref. 'Cordus Optics'), matter (ref. 'Cordus matter'), and fields (ref. 'Cordus in extremis'), and each of those have several parts.

2 Method

The objective was to identify, at a conceptual level, whether there could be internal structures and properties to the photon that could explain its observed behaviour.

The approach taken was a logical rather than mathematical one: by knowing the behaviour of the photon in various experimental situations, infer the possible internal variables that could give rise to this behaviour.

This is a typical system-thinking approach to reverse-engineering a product or process. It is a process of working out what the black box might contain by observing its outputs in different situations. The process is necessarily conjectural, and is more a thought-experiment with demonstrations than a conclusive proof.

Existing photon effects are accepted as *veritas*, including the wave and particle outcomes in the double-slit experiment: an interference pattern is created even from single photons (eventually, given enough photons). A new structure for the photon was then conjectured. This is a conceptual model of what the mechanisms might be within the photon that could give rise to those observable effects. The concept was then tested against various other optical and quantum phenomena. It was deliberately tested in areas of theoretical incongruence and discontinuous output behaviours, because these are potentially where the system variables are most exposed. Also, such cases are opportunities to think of radically new concepts, less cognitively encumbered by existing theories.

Then additional *lemmas* (premises, assumptions) were added to the basic cordus concept to explain these other situations. This process further defined, constrained, and developed the concept in a process of synthesis to match the *veritas*. New variables were added parsimoniously where necessary for requisite variability.

Cordus is intended to be a thought-experiment rather than a proof, and therefore seeks to create coherent conceptual links between topics. Consequently it offers *explanations* rather than mathematical proofs. Tentative explanations are put forward, and even speculative extrapolations. The latter are labelled '*in extremis*' to show they are secondary explanations and not core requirements.

The cordus concept is a class of solutions that permits several design variants. Where necessary we selected a particular variant, referred to as the *working model*. The result is a type of 'hidden-variable' solution, that identifies internal variables within the photon and shows how they cause the external behaviour.

3 Cordus conjecture

The cordus conjecture proposes a radically different structure for the photon. It is a structure that is neither a particle nor a wave, though can appear as either in certain circumstances. Instead it is proposed that the photon consists of a cordus: 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. Applying some assumptions about the basic sub-structure of this cord, permits the concept to be expanded and used to explain a variety of effects.

3.1 Cordus model of the photon

The starting concept is that the photon *does* pass through both slots in the double slit experiment, and therefore has two ends that are in communication. This is called a 'cordus': two reactive ends (RE) connected together with a fibril, see Figure 1.

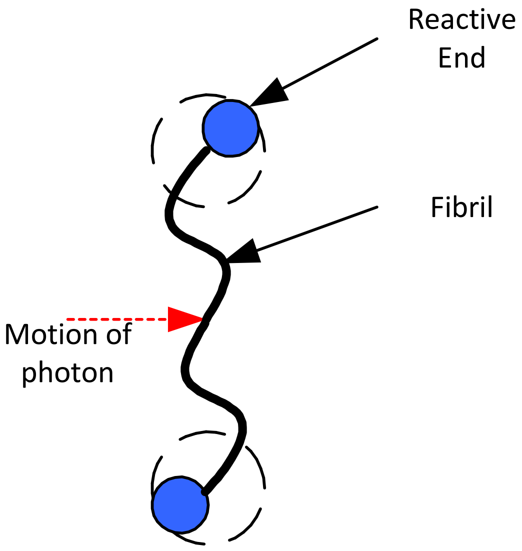

Figure 1: The cordus consists of two reactive ends, functionally connected by a fibril. The effective mean centre of the photon is at the midpoint, but the statistical modes are at the REs, i.e. the photon is only every found at the ends.

This is a *functional* concept. Exactly what geometry or physical sub-structure creates this cordus functionality is not prescribed at this point. It is necessary to add further assumptions (*lemmas)* to construct a workable model, Hence the following additional*.* The first focuses on the path-ambiguity behaviour, and others follow to address fringes.

Lemma L.1 Behaviour of the cordus

L.1.1 Each of the two REs behaves like a whole photon in its ability to interact with other matter, including reflection, transmission, and absorption.

L.1.2 The fibril connecting the two reactive ends does not interact with other matter.

L.1.3 The REs may take different paths to each other: spatially distinct; angularly distinct; reflect off different surfaces.

See *Causa 1* for a working model of the possible underlying explanations.

Causa 1 Cordus underlying mechanisms

Several possible underlying mechanisms may be anticipated. Note that these are simply a selection of design variants to consider. The cordus (see Figure 2) may consist of:

C.1.1 Two particle-like reactive ends with a fibril connecting them ('bola-fibril')

C.1.2 Fibril with reactive ends ('open-fibril')

C.1.3 Fibril that vibrates, where the vibrations create the functionality of reflect/transmit/collapse, only appears when the energy is in the condensed state at the reactive ends.

C.1.5 Fibril where the energy reciprocates and there is a field effect at reactive ends, i.e. it is the vibration that interacts ('reactive') with other structures ('thick-fibril')

C.1.4 Fibril where the energy reciprocates from one side to the other. The reactive end appears momentarily as a 'particle' when the energy is in its arrested or condensed state before deconstructing and changing direction again ('teleport fibril'). Several sub-versions might include a single 'particle' that traverses the entire span, i.e. the cordus has two ends but only one is active at a time ('full-span shuttle'); two 'particles' each reciprocating between the centre and an end ('twin half-span shuttle'); two particles of which one is a different type and reciprocating over the full or half span ('anti-particle shuttle'). In all cases the energy is non-reactive to other matter while in transit, and the particle nature, e.g. the ability to the ends (hyff model, see later). The energy appears at one end while the other is dormant, and then withdraws and changes to the other end. At any one moment only one end is active.

C.1.6 In this variant the energy retracts at one end (C+) and extends at the other (C-), before reversing. There is only an instant when a reactive end is neither C+ nor C-, unlike the C.1.5 model where one end is dormant for a full half cycle.

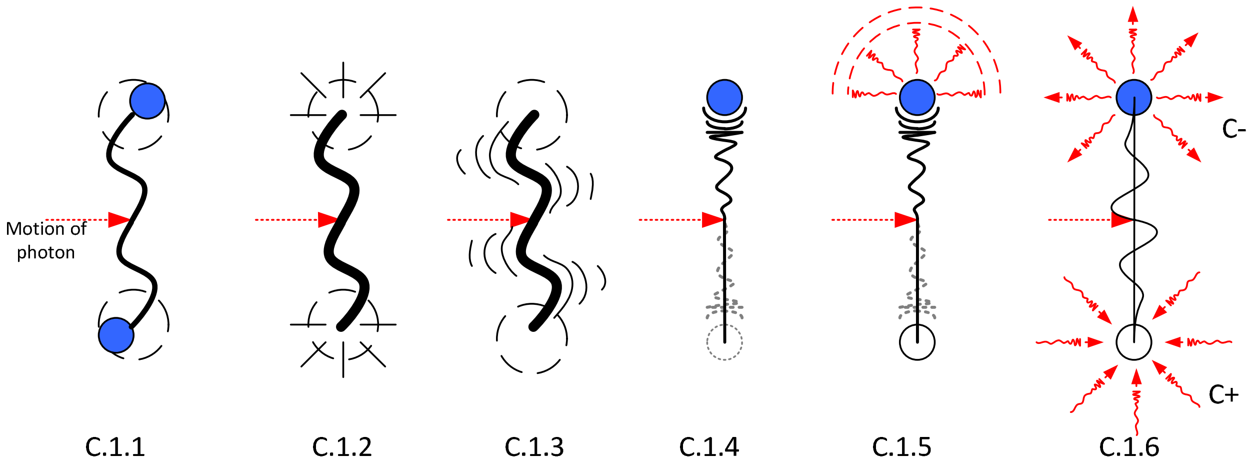

Figure 2: Several different design variants for the cordus structure, by way of illustration of the concept. No specific variant is preferred or necessary at this stage. The dashed lines represent the frequency component.

The preferred design variant is C.1.6, though this only emerges subsequently as the bigger picture is built up.

The concept now is that the photon does actually pass through both slits in double-slit experiment, i.e. that the observed behaviour is the reality. However additional lemmas are required to explain the selective appearance of the photon.

Lemma L.2 Collapse of the cordus

L.2.1 When one reactive end touches a material that absorbs photons (i.e. an opaque material) then that RE is 'grounded'.

L.2.2 Once one RE grounds, the cordus collapses.
One design variant is that the fibril withdraws the other reactive end and collapses the cordus to the location of the grounded RE. However the preferred explanation using C.1.6 is as follows:

L.2.2.1 Only an energised reactive end can ground.

L.2.2.2 At the time of grounding, the other (free) reactive end ceases to exist at the next frequency cycle.

L.2.3 Once grounded, the photon appears as a stationary point, and an injection of energy into the lattice of the material.

L.2.4 The first RE to be grounded collapses the cordus. This corresponds to the shorter of the two temporal optical paths.

L.2.5 The (statistical) mode of the collapse location is not the mean photon location. Mode is determined by the location of the two reactive ends, and this is where grounding occurs, whereas Mean is optical centre line and the geometric centre of the fibril.

The mode of the collapse location is therefore not precisely on the optical centreline of the photon, but will instead be at one of the reactive ends. The non-grounded reactive end simply ceases to exist at the next frequency reversal. Therefore the reactive end does not need to be dragged through the material, so the optical properties of the intervening material is of no consequence at collapse.

With Lemma 2 it is now possible to explain the quantum behaviour of the double-slit experiment, as will be shown. However to resolve the observer paradoxes requires another related lemma on detection.

Lemma L.3 Detection and Observers

L.3.1 Detecting the position of a photon requires arresting the cordus entirely. Detecting the photon's position is *intrusive* observation as it collapses the cordus. Intrusive observation may be used to detect the position of a single photon or beam of photons.

L.3.2 The cordus is not collapsed, nor the position of the photon detected, by transparent media or reflective surfaces.

L.3.3 *Passive* observation is simply looking at the experiment and not interfering with the cordus. Passive observation is inconsequential for the photon.

L.3.4 *Passing* observation is detecting that a photon has passed a point, e.g. by detecting its effect on other material or fields, without collapsing the cordus.

L.3.5 The internal variables of the photon are bi-directionally linked (coupled) to the external electromagnetic (EM) fields that it generates, see also C.6 hyff lemmas.

L.3.5.1 Passing observation can add or subtract energy from the photon, via the coupling.

L.3.5.2 Passing detection alters the state of the photon.

L.3.4.3 Passing observation cannot determine location of the photon.

Thus Cordus differentiates between types of Observers: *passive, passing,* and *intrusive*. Lemma 3 states that detecting a photon's position corresponds to *intrusively* collapsing the cordus entirely, whereas reflection and transmission through a transparent material do not. Whether the reactive end strikes an opaque material, absorbing detector, or the eye of an Observer is all the same: the cordus collapses. It is analogous to measuring the speed of a small moving motor-car by placing a loaded shipping container in front of it: the car is arrested and smashed in the process and its previous functional capability is destroyed. Observation of a photon's position collapses the cordus and destroys its functionally expanded state.

However passing observation is unreliable for measuring properties of a single photon, since the process of measurement changes other properties of the photon. However it can be more reliably applied to beams of multiple photons, where the sacrifice of a few is immaterial. Depending on the measurement, it may unduly preserve the configuration of the photon, or attract/push it into a different state, transferring energy.

The different types of observation have implications for the detection of position and velocity, as the next section shows.

3.2 Application to quantum measurement effects

Heisenberg's Uncertainty Principle

The Heisenberg Uncertainty Principle states that it is impossible to simultaneously know the position and momentum of a photon. Further, that the effect arises because it is fundamentally unknowable, not from limited precision of measurement. The Cordus Conjecture is consistent with this Principle, and suggests that the explanation is that the momentum and position are measurements of different states of the photon: in flight vs. arrested. Measure it in flight and only the presence of the photon can be inferred, using passing observation (L.3.4). The dynamic and twin-headed nature of the photon in flight means that it fundamentally has no physically measurable centroid, even if it has modes. Measuring its location can be done but requires intrusive detection, which collapses the cordus and destroys the kinetic state. Thus the choice of measurement constrains the behaviour of the photon and thus the measured outcome. The flight and static states of the photon are physically mutually exclusive: so too are the measurements thereof.

Zeno effect

The Zeno effect is that observation of a quantum state can preserve the configuration or hasten its change, depending on how the measurement is made. The cordus explanation is that these measurements are of the *passing* type, and therefore add or subtract energy from the photon (Lemma 3.4), thus constraining the photon's configuration.

4 Conclusions

Wave-particle duality, which has been enigmatic to conventional physics, is shown to be conceptually solvable by a new way of thinking about the photon. A particular internal structure, called a cordus, is proposed for the photon, and the underlying mechanics sketched out. In subsequent papers it is shown that a cordus structure is conceptually able to resolve wave-particle duality, i.e. explain both wave and particle effects.