Cordus process diagrams: Symbolic representation of annihilation mechanics

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Abstract

We introduce a new system-modelling representation for the interaction of particules with internal structures (hidden variable solutions). This is an improvement on Feynman diagrams that only represent points and limited information about state. The notation is able to represent key variables describing the internal states, such as phase and the three dimensional discrete field structures. The latter include the cordus hyff emission directions (HEDs). With this method it is possible to model the different stages in an interaction processes. It is applied to the cordus annihilation mechanics, and the resulting models qualitatively distinguish between the parapositronium and orthopositronium annihilation phenomena.

Keywords: annihilation, fundamental physics, orthopositronium, parapositronium, alternative representation, notation, IDEF0, Feynman diagram

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1 Introduction

This paper describes a method for representing the interaction process between particules, and applies it to electron-antielectron (positronium) annihilation. We have separately established a cordus model [1] for matter (M) and antimatter (aM), that distinguishes the two species primarily by their ma hand. We have also described the annihilation process itself at the level of the internal structures of the two cordus particules, and set out the lemmas for the mechanics [2].

Feynman diagrams

The best current representation of particle interaction is Feynman diagrams. These represent the inputs and outputs of particle interactions, especially the transformation to different particles, such as annihilation, weak processes, impact, and decay. They represent the main phases (or stages) in the process. For an example, see Figure 1.

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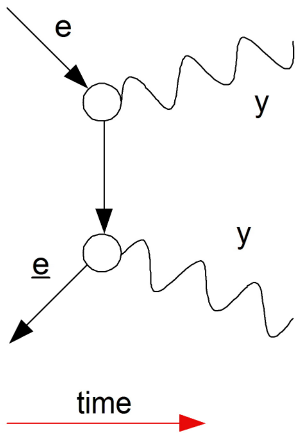

Figure 1: Feynman diagram for electron-antielectron annihilation to two gamma photons. The inputs are on the left and comprise an electron e and an antielectron e (with reversed arrow). These two interact to produce two output photons y. Conventional physics does not explain how *that interaction occurs, but cordus does.*

As a graphical representation, Feynman diagrams have the disadvantage of variable notation, particularly the meaning assigned to the direction of arrows. Specifically, some of the notations encourage the idea that antiparticles travel back in time, which adds mystery more than meaning.

Feynman diagrams do not represent the underlying mechanisms at the deeper level, nor all the intermediate structures. This is not a criticism of the diagrams, but simply a statement of the inability of conventional physics to provide a physical explanation for the mathematical models. The diagrams are consistent with empirical observed tracks where certain intermediates are not detected until a transformation to another particle occurs, i.e. there are gaps in the tracks. The diagrams encapsulate the idea that these unobservable structures are 'virtual' particles. Thus we have various virtual bosons identified as part of the deconstruction process, and even the photon is repurposed as a virtual photon for the electromagnetic effect.

The physics way of thinking (Kuhn's 'paradigm' [3]) is to preferentially interpret subatomic entities as 'particles'. These particles have no internal structure, except sometimes other more fundamental particles, and are thus zero dimensional regarding structure. However, they have other directional attributes of spin and momentum, and indeed several other properties or 'intrinsic variables' and thus we refer to this as a *one-dimensional construct*. This is evident in the Feynman diagrams, which show 0-D points with direction. The paradigm is also seen in the prevalence to interpret anything whatsoever that happens in a high energy physics impact, observed or theorised, as a particle, hence the W and Z bosons, gluons, Higgs, etc. From the cordus perspective this is a very limiting paradigm, and cordus specifically refutes the point particle construct that underpins much of it [4].

The cordus conjecture offers a solution where the subatomic entities have internal structure. A specific structure, called a cordus, is proposed [5].[2] This is used to produce a coherent set of explanations for a wide variety of enigmatic effects in fundamental physics, including wave-particle duality. Cordus identifies internal structures, and the states thereof, as being important in the annihilation process [2]. For example, the different outcomes for para- and ortho-positronium are shown to depend on the relative phase difference of the input particules. Thus it is important to have a representation, like Feynman diagrams but better, that can represent how the internal structures affect the outcomes.

Needed, a finer-scaled representation

There is nothing fundamentally *wrong* with Feynman diagrams, other than disputable treatment of antiparticles, but they just don't have the necessary power to represent the new processes suggested by the cordus mechanics. At the other extreme are the cordus diagrams showing the detail of the interaction, but these are too cumbersome for general use. We seek something in between: a notation that represents the detail of the cordus annihilation mechanics but retains at least some of the simplicity of the Feynman diagrams.

2 Approach

Process diagrams are common in production engineering, because the nature of that discipline is to manage processes. We thus apply production engineering thinking to create a diagrammatic representation and a short-hand notation.

2.1 Process diagram

The first thing we do is simplify the Feynman diagram, for example that for electron-antielectron annihilation, to produce Figure 2.

[2] The cordus conjecture is that all 'particles', e.g. photons and electrons, have a specific internal structure of a *cordus,* comprising two *reactive ends*, with a *fibril* joining them. The reactive ends are a small finite *span* apart, and energised (typically in turn) at a frequency, at which time they behave like a particle. When energised they emit a transient force pulse along a line called a *hyperfine fibril (hyff),* and this makes up the field. We call this a cordus 'particule', and stress it is very different to the zero-dimensional point assumed by conventional physics.

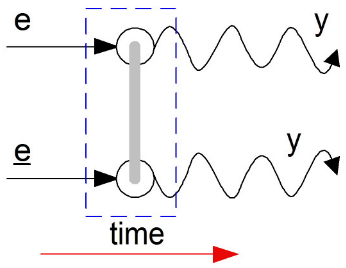

Figure 2: Cordus process diagram for electron-antielectron annihilation to two gamma photons. The inputs are on the left and comprise an electron e and an antielectron e (no reversal of arrow) as we do not accept the Feynman concept that an antielectron travels backwards in time. The activity of interaction is represented by the rectangle. At this point we retain the circles (nodes) of the Feynman diagram and the interlinking bar, but this is simply for explanatory continuity and later we omit these. The output is two photons y.

Next, we need to diagrammatically represent the perspective that these are not 0-D points, but rather cordus particules. First, we define some convenient symbols, wherein the frequency state is represented, see Figure 3.

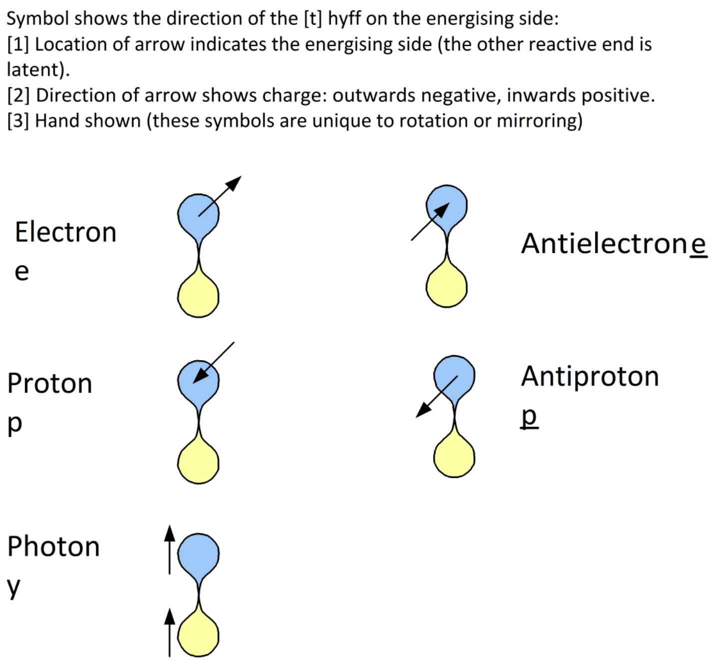

Figure 3: Symbolic representation of charged particules. These symbols capture the variables of phase, charge, and ma hand (matter vs. antimatter).

At the same time we adopt a process formalism, i.e. a diagrammatic notation. Since the choice of notation always limits what can be represented, and perhaps even conceived, with any diagram, we need to adopt a relatively powerful system modelling approach to this problem. We elect to use what we term 'dynamic process analysis' as it is designed to capture changeable effects (or multiple pathways of activity) under high epistemic uncertainty. In turn, it is expressed graphically as a flowchart using the integration definition zero (IDEF0) notation [6, 7], see legend in Figure 4.

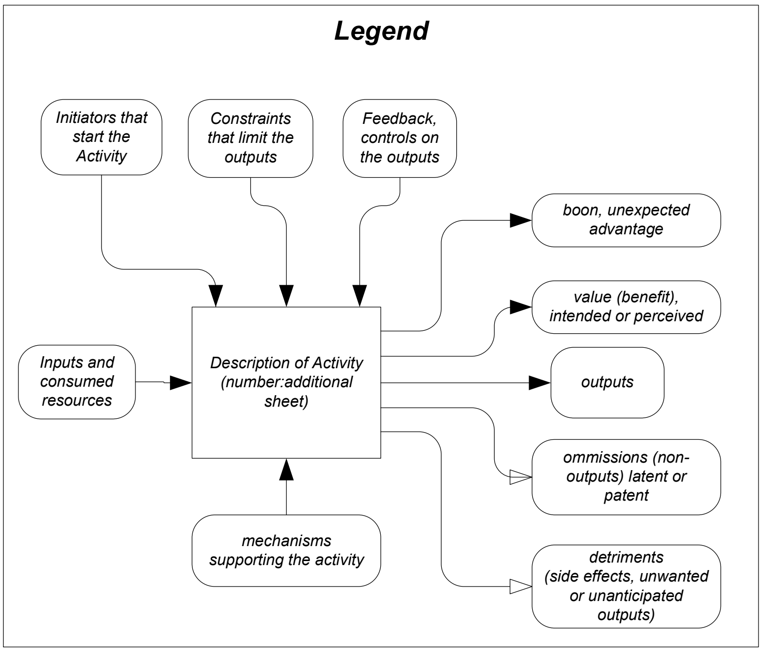

Figure 4: Notation for IDEF0. The object types are inputs, controls, outputs, and mechanisms (ICOM), and are distinguished by placement relative to the box, with inputs always entering on the left, controls above, outputs on the right, and mechanisms below. The box itself describes a function (or activity), and the arc (line arrow) describes an object.

IDEF0 is more powerful than we currently need, but we are only dealing with the relatively simple case of electron-antielectron annihilation here, whereas there are more complex interactions to be considered for the future.

We also need an abbreviated notation to complement the diagrams, as simple expressions like e + $\underline{e}$ -> 2y are inadequate when representing internal structures. Hence the following complementary notation.

2.2 HED notation

In the cordus concept, a particule consists of two reactive ends geometrically separated from each other, and connected instantaneously by a fibril [5]. A core concept is that the reactive ends, at least of massy particules, emit field structures (hyffons) in three orthogonal directions. These are called hyff emission directions (HEDs), and implicated in the strong interaction and indeed all bonding [8].

The three HEDs are named radial [r], axial [a], and tangential [t], and their orientation is relative to the fibril and the motion or spin of the particule. Two hands are possible for this co-ordinate system, and these are termed forma and hyarma, and proposed as the structural difference between matter and antimatter respectively [9].

Electric charge is identified as the direction of propagation of the hyffon (field pulses) along the hyff emission directions. Negative charge is nominally an outward propagating hyffon, and positive is inward (this is merely a sign convention). Each hyffon corresponds to a fundamental charge of 1/3. So an electron has one of these in each of three HEDs, hence an overall charge of -1. Charges of quarks (+2/3 and -1/3) are readily accommodated as partially filled HEDs.

The previous work on the internal processes of annihilation [2] shows that it is the field structures, collectively the hyff, hyffons, & HEDs, that are remanufactured when an electron meets an antielectron. Therefore we need a diagrammatic short-hand way to represent the state of these HEDs.

We use a simple notation, which we call HED notation. Basically, for each particule it shows the three HEDS, and how they are filled with hyffons, see Figure 5.

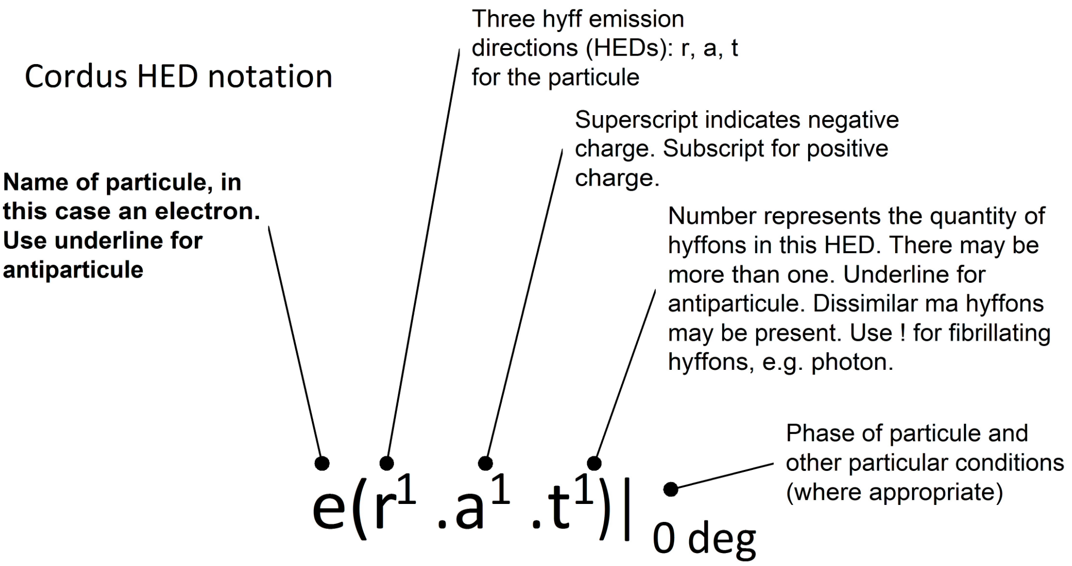

Figure 5: HED Notation, showing usage of the various components. The example is for an electron, and shows the arrangement of its field components.

The HED notations for several common particules are given below.

Electron $e(r^1 .a^1 .t^1)$

Antielectron $\underline{e}(r_{\underline{1}} .a_{\underline{1}} .t_{\underline{1}})$

Photon $y(r!\ .a\ .t)$ *See note 1.*

U Quark $u(r_1\ .a_1\ .t)$

D Quark $d(r^1\ .a\ .t)$

Proton $p(r_{1.1}\ .a_1^{1}\ .t_1)$ *See note 2.*

Antiproton $\underline{p}(r^{\underline{1.1}}\ .a_{\underline{1}}^{\underline{1}}\ .t^{\underline{1}})$ *See note 2.*

Neutron $n(r_1^{1}\ .a_1^{1}\ .t)$ *See note 2, 3.*

Antineutron $\underline{n}(r_{\underline{1}}^{\underline{1}}\ .a_{\underline{1}}^{\underline{1}}\ .t)$ *See note 2, 3.*

[Note 1] The photon is a fibrillating hyff pump in that it does not release its hyffons, but instead immediately recalls them [10]. By contrast all other massy particules release their hyffons, then switch over to the opposite reactive end and release a hyffon from there.

[Note 2] The cordus models for the proton and neutron internal-structures & quarks have been previously identified [8]. These are assembly structures. The examples given here show the current working model for the allocation of hyffons to the HEDs and we acknowledge that several other combinations are possible. These internal arrangements are believed to correspond to quark colour.

[Note 3] The difference between the neutron and antineutron is the ma hand: the charges themselves are neutral in both cases, though the process of obtaining that neutrality is different. The HED notation shows this difference in hand.

We now have three representations for the interaction of particules: (1) the detailed cordus models of the 3D structures, though these are too cumbersome for general use, (2) the process diagrams, and (3) the HED notation. We refer to the latter two as cordus process diagrams. We can now use these to represent the annihilation processes.

3 Positronium annihilation

Regarding annihilation, the main difference between matter and antimatter (M-aM), according to cordus [9], is that the ma hand of the hyff is inverted. Separately we have developed a candidate model for the annihilation process between an electron and antielectron (positron) [2]. This explains the process in terms of the ma handedness of matter and antimatter, the interaction of the two particules as they approach, the collapse of their hyff structures and their reformation into photon hyff.

We now represent the mechanics with cordus process diagrams. The specific focus area is positronium: the temporary bound states of electron-antielectron. Two states are known: parapositronium (life of about 125E-12 s), and orthopositronium (life 142E-9 s). Positronium has been relatively well studied e.g. [11] and production channels modelled mathematically [12-14]. Positronium has the known behaviour of producing two photons when the electron and positron have antiparallel spins (parapositronium), and three photons for parallel spins (orthopositronium). However, spin is ill-defined in quantum theory, because QM denies that there is any internal structure. Instead QM considers spin to be merely an intrinsic variable. Only with a hidden-variable theory, like cordus, can a physical interpretation be gives for the many intrinsic 'quantum numbers' that QM relies on but cannot explain. In this particular case, cordus explains 'spin' as the frequency phase of the particules. Once this concept is adopted, then it becomes possible to explain the different behaviours of positronium in a natural way.

3.1 Parapositronium

It is known that in parapositronium the two particles have antiparallel spins. The life before annihilation is the shorter of the two forms. Annihilation is known to produce two photons, or less often 4 or 6 etc.

The cordus explanation for the annihilation process itself, including the production of two photons, is described in the companion paper [2]. Here we focus on representing it diagrammatically, see Figure 6.

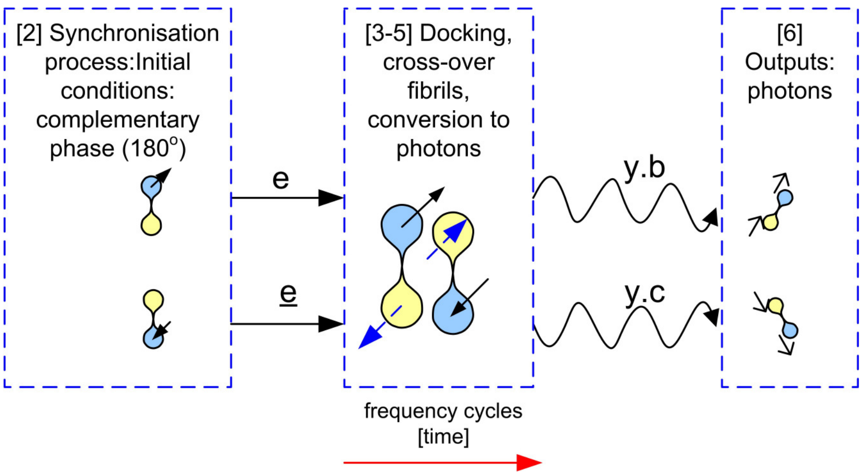

Figure 6: Cordus process diagram for annihilation of electron and antielectron, where they are initially out of phase with each other. This is the parapositronium state.

The numbers in the figure correspond to the stages in the detailed model [2]. According to the cordus interpretation, parapositronium already has the electron and antielectron in the correct 'complementary' phase of 180^{o} phase difference (hence opposite 'spin'), so the synchronisation (stage #2) is pre-arranged. The process therefore proceeds directly to docking, cross-over fibrils, and conversion to photons (stages 3-5).

The diagram itself is an elaboration of the simple cordus process diagram of Figure 2. Note the inclusion of additional activity boxes. Each of these can be further decomposed, which is achieved in the detailed model [2].

Note the diagram also includes the symbolic cordus particule that represents the ma hand state *and* the relative phase. These are two variables that are important in the process, and therefore need to be represented at this level. The output photons also have a cordus particule structure, which is shown in the output activity (stage #6). While we retain the wave symbol for ease of comprehension and compatibility with Feynman diagrams, the photon is not fundamentally either a wave nor a particle, but instead another cordus particule.

In some ways the complementary phase of parapositronium state looks like bonding or entanglement, and cordus states that those effect do indeed all use the same underlying mechanism of CoFS [15].

Note that in the process diagram the horizontal axis is time. More specifically, cordus identifies that time at the deeper level corresponds to the re-energisation frequency cycles of the particules [16]. Thus particules need cycles to accomplish the process activities.

The short-hand representation of this in the HED notation is:

$$e(r^{1} .a^{1} .t^{1})|_{0\ deg} + \underline{e}(r_{\underline{1}} .a_{\underline{1}} .t_{\underline{1}})|_{180\ deg}$$
$$=> o(r^{1}_{\underline{1}} .a^{1}_{\underline{1}} .t^{1}_{\underline{1}})$$
$$=> y.b(r! .a .t)|_{0\ deg} + y.c(r! .a .t)|_{180\ deg}$$
$$=> y.b + y.c$$

where 'o' represents a transitional state. In this particular case, this can be identified as parapositronium. We note that the structure $o(r^{1}_{\underline{1}} .a^{1}_{\underline{1}} .t^{1}_{\underline{1}})$ is capable of reforming to two photons, having previously demonstrated the mechanics [2], and therefore note this as a core annihilation process in lemma Ma.4.2.

In the reduced format without the HED details:

$$e + \underline{e} => 2y$$

which is what the Feynman diagram states. Thus an electron and antielectron in parapositronium annihilate to two photons.

Obviously these models do not represent the full details of the remanufacture of the hyff into photons. For that see the detailed model [2]. Instead all we seek to achieve here is a representation of the overall process, so that we can compare different processes. The next case, orthopositronium, starts to show the power of the method to differentiate similar cases.

3.2 Orthopositronium

Orthopositronium is the other temporary association of an electron and antielectron, and has the longer life before annihilation, though still short. It is known that the two particles have parallel spins. Annihilation is known to produce three photons, less often five.

The cordus explanation for the annihilation process, including the production of three photons, has been described [2]. The process diagram is shown in Figure 7.

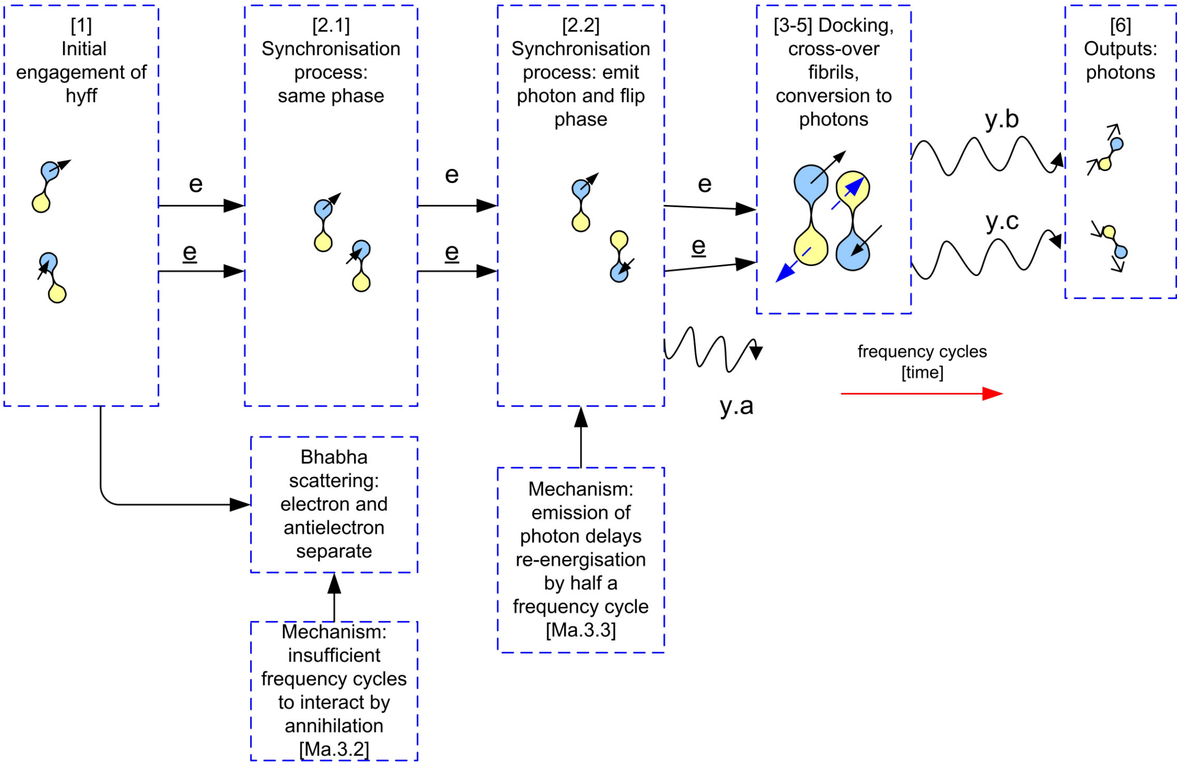

Figure 7: Cordus process diagram for annihilation of electron and antielectron, where they are initially in phase with each other. This is the orthopositronium state.

This diagram is more complex than the previous one. This is because orthopositronium has additional activities required before the main annihilation process can get underway. Thus the particules are in-phase (0^o offset between re-energisation) (stage 2.1), and one of them needs to emit photon y.a to change phase (stage 2.2). We also know the mechanism for this, or at least can identify part of it as lemma Ma.3.3. Note that the mechanism is shown *under* the activity block, this being the IDEF0 notation. The diagram identifies that photon y.a is emitted at stage 2.2.

Thereafter the assembly is effectively parapositronium, and proceeds to conversion to an additional two photons y.b and y.c (stages 3-6).

The short-hand representation of this in the HED notation is:

$e(r^1 .a^1 .t^1)|_{0\ deg} + \underline{e}(r_{\underline{1}} .a_{\underline{1}} .t_{\underline{1}})|_{0\ deg}$

$=> y.a(r! .a .t) + e(r^1 .a^1 .t^1)|_{0\ deg} + \underline{e}(r_{\underline{1}} .a_{\underline{1}} .t_{\underline{1}})|_{180\ deg}$

$=> y.a + o(r^1_{\underline{1}} .a^1_{\underline{1}} .t^1_{\underline{1}})$

$=> y.a + y.b(r! .a .t)|_{0\ deg} + y.c(r! .a .t)|_{180\ deg}$

$=> y.a + y.b + y.c$

Or in the reduced format:

$e + \underline{e} => 3y$

Thus an electron and antielectron in orthopositronium annihilate to three photons.

3.3 Comparison: parapositronium vs. orthopositronium

Cordus predicts that the two- and three-photon production processes for para- and ortho-positronium are very different: the third photon is *not* merely one of three, but has a different causality and comes out at a different part of the process. Both forms of positronium use the same *core* annihilation process (stages 3-6) for the production of the paired photons.

The reason orthopositronium cannot emit only two photons is conventionally explained as a consequence of charge conjugation invariance.[3] From the cordus perspective the reason is instead that one photon is required to change the state into the antiparallel state (as per Ma.3.3) and the conservation of hyff required that two photons be produced (Ma.3.8).

Cordus offers a qualitative explanation of why the lifetime for parapositronium is so much less than orthopositronium: the latter has further processes to undergo, and these take time. Parapositronium is a preassembly that is already in the docked state (stage 3), and therefore proceeds directly to stages 4-5 and hence to photons. By comparison orthopositronium is in stage 2 and first has to emit a photon before it can continue.

If this interpretation is correct, then we can make another inference: that the time taken to get the particules into the correct geometric position (Ma.3.2) is much the greater contributor to the decay time than the annihilation process to photons. We noted this as lemma Ma.3.9 [2].

[3] Charge conjugation invariance is the expectation that process, such as the emission of photons, are the same -hence invariant- if all the particles are replaced with antiparticles. Cordus rejects the implication that antiparticles are simply opposite charge.

The cordus explanations for the production of two and three photons is thus consistent with known behaviour of positronium. Cordus also independently derives the spin requirement, and the direction thereof. Cordus also goes further in making the ‘spin’ tangible, which is otherwise only an intrinsic variable to quantum mechanics. In the orthopositronium case one of the photons may be of a different energy [17], and cordus accommodates this too.

3.4 Scattering

The impact of moving particles does not necessarily cause deconstruction. Particles are known to recoil elastically from the impact, and this is termed scattering. The cordus interpretation is that the particuloids interact through their hyff as they approach each other. The hyff have to negotiate mutual emission directions (HEDs) and thus exert force on each other’s particuloid before the reactive ends actually coincide. So the effect happens at a small distance away from the reactive: see also the cordus Principle of Wider Locality [18]. According to the cordus mechanics, the scattering outcome ultimately depends on the frequency & phase. Thus it depends on which reactive ends are energised at the time, what their relative frequency states are, and which way their hyff are directed. The latter depends on the velocities of the particuloids, since cordus identifies that the orientation of the hyff is aligned to the direction of motion. Furthermore the orientation of the hyff is determined by the species: matter and antimatter differing by the ma hand of their hyff.

One form of scattering is particularly associated with electron-antielectron interaction, and is discussed next.

Bhabha scattering

The system model of Figure 7 also includes Bhabha scattering. In this effect an electron and antielectron recoil from impact. This is anomalous given that matter and antimatter more generally annihilate. Cordus explains the scattering as caused by two factors: the two particules have phases that are too close, and therefore the SHEDs principle [8] causes repulsion, and the momentum is such that the particules do not have enough frequency cycles (‘time’) to get into a complementary phase state. The latter is covered in lemma Ma.3.2 [2].

3.5 Lemma

The following lemmas summarise the additional assumptions made here.

Ma.4 HED principles

Ma.4.1 Principle of conservation of hyff. The total number of active hyff, i.e. hyffons, owned by input particules is conserved across the output particules, unless annihilation occurs. See also Ma.3.8.

Ma.4.2 A core annihilation process: A fully HED-complementary structure, i.e. $o(r^1_{\underline{1}}\ .a^1_{\underline{1}}\ .t^1_{\underline{1}})$, collapses to two photons 2y(r!.a.t).

4 Conclusion

What we have achieved is a new system-modelling representation for the interaction of particules. The notation is able to represent the different stages in the interaction processes.

The advantage of the HED notation is that it permits the intermediate structures to be worked out. Thus it is able to represent different states of particules, including their key internal structures. This is an advance on Feynman diagrams. We have applied this method to the cordus annihilation mechanics, and have shown how to develop models that can distinguish between the parapositronium and orthopositronium annihilation phenomena.

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