An Absolute Phase Space for the Physicality of Matter

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Abstract. We define an abstract and absolute phase space ("APS") for sub-quantum intrinsic wave states, in three axes, each mapping directly to a duality having fundamental ontological basis. Many aspects of quantum physics emerge from the interaction algebra and a model deduced from principles of 'unique solvability' and 'identifiable entity', and we reconstruct previously abstract fundamental principles and phenomena from these new foundations. The physical model defines bosons as virtual continuous waves pairs in the APS, and fermions as real self-quantizing snapshots of those waves when simple conditions are met. The abstraction and physical model define a template for the constitution of all fermions, a template for all the standard fundamental bosons and their local interactions, in a common framework and compactified phase space for all forms of real matter and virtual vacuum energy, and a distinct algebra for observables and unobservables. To illustrate our scheme's potential, we provide examples of slit experiment variations (where the model finds theoretical basis for interference only occurring between two final sources), QCD (where we may model most attributes known to QCD, and a new view on entanglement), and we suggest approaches for other varied applications. We believe this is a viable candidate for further exploration as a foundational proposition for physics.

Keywords: phase space, physicality, matter, fermion, constitution, algebra, boson, wavefunction, symmetry, duality, vacuum, quark, hadronisation, hadron decay, weak interaction, strong force, quantization, coherence, neutrino oscillation.


1 BACKGROUND AND INTRODUCTION

Our aim is to devise a new foundational basis for physical reality that solves current contentious problems, with the eventual aim of allowing new discoveries and further predictions. We are using this paper to further develop “Algebra of a Three-fold Symmetry for Fundamental Physics”[4], to more clearly describe the algebra and model for a physical reality, and to publish the basic ideas, upon which specialized publications may be based. Although this paper does not present a complete physical theory, it is positioned within a suitable modular framework that allows for the modular design of abstraction, physicality, and background. In this work we emphasize physicality and abstraction, so we will not cover all aspects in detail, but will refer to readily-available workings where appropriate.

1.1 Concepts

We start with the proposition that all matter and energy in the universe is waves. Every compound wave is described mathematically as a set of three waves, each wave mapping to a one-parameter unitary group \( a, b, \) or \( c \), having cyclic phase \( 0..2\pi \) and sinusoidal value range \( \pm 1 \) with phase. These three axes each represent a pair of dual properties and respective anti-properties that are important to physics in a fundamental way[1,2,3,4]. The three property duals are orthogonal, are non-mixing, and have the same (absolute) meaning for every wave. We call this range of values in \( \{a, b, c\} \) the Absolute Phase Space, or just “APS”, not to be confused with “algebra of physical space”.

For these waves to conserve their information, they must exist in bound pairs as fundamental bosons (3.1.2). This structure has many consequences, providing an origin for latency, and an existential and causal perspective on how instances of matter can unambiguously exist and propagate, including a derivation of the Exclusion Principle[4] (3.1.3). Two bosons, each having a wave in conserved phase \( -b \), may combine to form a fermion event that exists only instantaneously before radiating away again as bosons. Bosons do not have definite position; they exist only as
a phase offset from a fermion event, so any propagating matter must re-constitute itself as a sequence of similar fermion events via the process of boson propagation.

We started with the $b$ wave to denote a ‘conservation’ duality, which when taken in the physical context, is a quantization algebra that creates the basic structure of a quantized matter network of point-like fermions and wave-like bosons. We can obtain a surprising amount of pertinent structure from just one APS axis in context of the physical model without declaring any background dimensions, other than the ability to separately resolve many events uniquely using only a phase operator; e.g. quantum mechanics, -dynamics and -computation, slit experiments and their variations, can be reasonably qualitatively explained without using contentious concepts.

Unfortunately, this one primary axis, conservation, alone does not convey the dimensionally rich information that we need to quantify observables, nor does it produce the background spaces associated with the secondary phase space. To extend the abstraction from just the $b$ element, we build an implicit secondary, dimensionally-rich structure by adding orthogonal waves to the compactified primary phase space. Two more waves complete the APS: again each corresponds to a foundational duality, and in these cases the $\{a,c\}$ waves on axes representing real/imaginary and dimensional/nondimensional properties create a geometric algebra, corresponding to the full Clifford Algebra ($\mathbb{C}l_{3,1}$). This method of combinatorially creating higher dimensionality is well-known, and is described in sufficient detail in Hestenes’ 1986 introductory paper on geometric algebra\textsuperscript{5}. The $\{a,c\}$ states at a fermion event form the basis of our observables algebra, describing more of the quantitative aspects of physics, and may be transformed into terms of the Dirac Equation or a nilpotent formulation. Taken as an operative sequence, each introduction of a new axis to the APS creates a new dual for the existing set, creating new number types that conjugate the existing number types in some fundamental way: a new symmetry for the reality, and a doubling of the algebra. Rather than continue adding axes to achieve a ‘monster group’ from which we could draw almost any arbitrary conclusions, we limit the APS to just three axes, because we believe this is all we need to concisely represent physics in terms of observables and (most interestingly) the behind-the-scenes unobservables that contribute to physicality.

Perhaps the most controversial and unique aspect of our work is the proposition that fermions do not themselves propagate, and that all propagation is by bosons. This creates a structure and ‘network’ for matter and its background spaces, providing a self-generating context for the instantiation, constitution, and re-encoding of matter. From this, we can reconstruct quantum physical phenomena, and form a view on many established techniques.

### 1.2 Origination, and Comparisons with Other Authors’ Approaches

Our project is a different take on the early (1991) work of Peter Rowlands\textsuperscript{1}. Our first efforts (1991) were an attempt to deduce the seemingly missing combinatorial trivector states from the three dualities; only four out of a possible eight (Table 2) were named, and at ANPA\textsuperscript{6} we attempted to frame the question and approach the answers\textsuperscript{1}, along with a way of forming simple closed systems using discrete phase operators\textsuperscript{3}. In recent private communications with Rowlands\textsuperscript{5}, the terms again defied satisfactory definition, but it was noted that they could exist as conjugate aspects to the named terms, and the argument can be repositioned as epistemological rather than solely ontological: they are components of the nilpotent formulation, rather than physical components in their own right.

After these relatively unproductive lines of enquiry, we think our more recent (2006) direction produces more useful work. We have taken those three important duals of physics, applied them directly as a phase space (extending the previous ‘discrete closure’ into a continuous space), and created a minimal model for physicality while including some basic fundamental requirements. Many aspects of both bodies of work (Rowlands, Valentine) agree, but have been reached via different approaches and reasoning. We believe this bodes well for the foundational ideas expressed by Rowlands (pre-1991), from the perspective of authors from different backgrounds being able to access similar conclusions by different logical deductions.

#### 1.2.1 Rowlands’ Nilpotent Rewrite Formulation and its Associated Algebra

The formulation proposed by Rowlands\textsuperscript{3} builds its algebra from a nilpotent universal computational rewrite system, which uses a simple symbol as both a state and an operator, that can either conserve itself or generate a new

\footnote{This initial effort was not successful, because the states defied definition because the context and language to describe them was not available, and the common fundamental abstractions used in physics failed to slot neatly into the available places.}
symbol. Meanings for the next new symbols are also proposed, which act as ‘complexify’ and ‘dimensionalize’ operators. In common with a group inverse operation, re-application of the latter two symbols reverses their respective effects, and re-use of the first symbol instantiates new entities.

Although we have not assumed any ‘creation roots’ from which a universe may emerge from self-rewrite, we have instead deduced a physical model and phase space from the requirement to resolve all other interacting objects uniquely from any given object. This resulted in our use of unique relative phases for resolved boson waves (like their \( e^{-i(p - q)} \) to close the nilpotent), and our use of an absolute reference phase \(-b\), to give ‘wave phase’ an absolute meaning and physical symmetry, and also to provide a trivial physical structural means for fermions to re-instantiate themselves in causal sequence from the minimal amount of information encoded in the bosons. We give the Rowlands symbolic abstraction an underlying physical context in the form of our matter network (3.1.1).

The key difference in our approaches, is that we have concentrated on the (self-) process and model to derive qualitative results from the physical structure of matter, using only one of the fundamental dualities, and have only outlined the full geometric algebra of a fermion event, achievable from \( \{a, c\} \), leaving its detail (e.g. groups, algebraic equivalence, spin formulation) to others [Clifford, Hamilton, Lie, Hestenes[5], Rowlands[3], Almeida[9]] as ‘standard texts’. In comparison, Rowlands has specialized on the algebraic structure of what we call the ‘fermion event’, using the nilpotent formulation, to give quantitative results and expression in many scientific disciplines. We think the most noteworthy point of the rewrite system is the use of three the dualities to create a full algebra (and by “full”, we mean that it retains the information that many other physical theories accidentally discard by omission); our \( \{b\} \) duality find expression as a dual algebra for the vacuum in their work, providing an immediately-accessible conjugation from conserved sources to their respective nonconserved bosons, fields, and quantum potentials, to form a full picture of possible states that an entity might assume.

1.2.2 Marcer’s Reference Wave

Likewise, our physicality has analogues with Peter Marcer’s notion[10] of states relative to an [absolute] reference wave. We derive our observables from the \( \{a, c\} \) elements of the APS, rather than from the \( \{b\} \) reference wave, because the \( \{b\} \) wave cannot itself be measured (in common with Marcer’s method), because it determines the points at which fermion events may form, which are the only points at which reality can be measured; we cannot arbitrarily measure bosons where \( \{b\} \) phases do not meet the criteria required for a fermion event.

Although different language is used in respective works, our interpretations on degeneracy and coherence as phase offset from the reference wave state \(-b\) are similar. The idea of co-homology is the same in both cases; any differences are solely because of our respective interpretations of matter constitution, rather than any difference in our respective derivations of the principles and self-processes of quantum computation.

1.3 Fundamental Properties

The \( \{b\} \) property is most interesting from the ontological perspective, because at the point where two overlapping waves have a value \(-b\), they represent a conserved matter state and may become a physical entity, but at any other value they represent divergences: a nonconserved state. Divergences may be viewed as or unresolved quantities requiring statistical evaluation in a solution space (standard quantum mechanics: the Copenhagen Interpretation), or as being realized at events on a mutually-shared world-line (predeterministic). Both of these states, conserved and nonconserved, have many meanings in physics (3.2). In terms of quantum computation, we regard fermions in conserved phase as sharp, and bosons in nonconserved phases as multiverse, and our physical model finds new perspectives on the (re)constitution of fermionic matter from bosons.

With regard to the interface between quantum and classical physics (3.3), there is a clear difference between the intrinsic phase states in the APS that are point-specific and relate to a quantum interaction, and the macroscopic quantities that are the accumulated results of many quantum interactions. We may interface the fundamental and quantum aspects to background in a macroscopic representation, projected through fundamental APS vector of conservation, dimensionality and sign, as combinatorially constructed in Geometric Algebras (\( \mathcal{Cl}_{4,1} \)), i.e. the nonconserved aspects of a fermion state drop into the dimensionally-rich background with every re-constitution.

The \( \{c\} \) property determines whether the APS state or unit vector is dimensional, or nondimensional. Again, these definitions have equivalent meanings, e.g. nondimensional implies continuity, indivisibility, irreversibility, and scalar value; dimensional implies their respective duals: discontinuity, divisibility, reversibility, 3-vector value.
**Rotation symmetry** and **translation symmetry** apply only to non-conserved dimensional states\[^{1,3}\].

The \{a\} property determines whether the APS state or unit vector is real, or imaginary. When applied to physical source terms, this property determines whether their forces are only attractive (real), or repulsive when like-signed terms are combined (imaginary).

Combining the \{a, c\} properties, we generate the bases known to geometric algebra\[^{5,4}\], for deriving the axes and number types that we use to represent the physical quantities. The mathematics of our simple phase algebra (2.1) are similar to GA, and when used in the context of our physical model, are compatible with many aspects of quantum mechanics (sections 3, 5).

A fascinating aspect of the APS is that its physical model unifies the fermions and bosons as being different views of the same waves, as well as describing the origins of many principles that are important to physics; such conventional and abstract phenomena may be described using more fundamental terms from this representation. It does this while having many desirable features of a good fundamental theory, and for this reason, we think it can be developed into a worthwhile theory of foundational physics.

## 2 APS: PRIMARY AND SECONDARY PHASE SPACES

We define the primary phase space from three fundamental properties, each having two opposite-valued meanings (\(a\): real or imaginary, \(b\): conserved or non-conserved, and \(c\): dimensional or non-dimensional\[^{1,3}\]) to represent the important fundamental aspects of physics. These form the three orthogonal bases of our **primary phase space**, where \(a \cdot b = a \cdot c = b \cdot c = 0\), which expands combinatorially to eight trivectors, each having sub-physical meaning.

As mentioned (1.1), waves operate independently on each axis of the primary phase space.

### 2.1 Number types: Secondary Phase Space

For general use, we use projections of real and imaginary elements having dimensionality or non/one-dimensionality, which we take from Hestenes’ geometric algebra construction\[^{5}\] (Table 1), to create the **secondary phase space**\[^{4}\]. These \(e_n\) bases specify the available axes of a quantifiable APS state, and the above table has conserved and nonconserved forms which are shown in Table 2. Names for primary APS trivector states provided by Rowlands\[^{1}\].

<table>
<thead>
<tr>
<th>Grade</th>
<th>(+a): Real</th>
<th>(-a): Imaginary</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-c): 1D (Scalar)</td>
<td>0 Unitary Real Scalare</td>
<td>3 Trivector (volume)</td>
</tr>
<tr>
<td>(+c): 3D (Vector)</td>
<td>1 Vector (of lengths)</td>
<td>2 Bivector (of areas)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary APS State</th>
<th>({b}) Conserved?</th>
<th>GA Grade</th>
<th>({a, c}) Elemental Value Representation</th>
<th>Secondary Unit Bases and Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>No</td>
<td>0</td>
<td>Real scalar</td>
<td>(x = g)</td>
</tr>
<tr>
<td>B</td>
<td>Yes</td>
<td>1</td>
<td>Real 3-vector</td>
<td>(x = s, y = s, z = s)</td>
</tr>
<tr>
<td>C</td>
<td>No</td>
<td>2</td>
<td>Imaginary 3-vector</td>
<td>(i = C, j = C, k = C)</td>
</tr>
<tr>
<td>D</td>
<td>Yes</td>
<td>3</td>
<td>Imaginary scalar</td>
<td>(i = t)</td>
</tr>
<tr>
<td>mass</td>
<td>Yes</td>
<td>0</td>
<td>Real scalar</td>
<td>(x = m)</td>
</tr>
<tr>
<td>charge</td>
<td>Yes</td>
<td>1</td>
<td>Real 3-vector</td>
<td>(x = \rho, y = \rho, z = \rho)</td>
</tr>
</tbody>
</table>

\(i = Q, j = Q, k = Q\)  
\(i = \phi\)

We adopt the standard GA notation for quantifying values on basis axes (a complete charge vector may be written as \(0i + 1j + 0k\), and of writing successive operators from right to left. Imaginary unitary values have negative
norm or signature, so square to –1, and real unitary values have positive norm or signature, so square to 1. It is worth noting the dimensional geometric equivalence of each basis element, e.g. each axis of charge is an area (Table 1: grade 2).

2.2 Phase Operator: Differences of State

All interactions of state vectors in the APS are phase operations:

\[ \phi_3 = \phi_1 \phi_2 \quad (1) \]

or

\[ e^{i\phi_3} = e^{i\phi_1} e^{i\phi_2} = e^{i(\phi_1 + \phi_2)} \quad (2) \]

Phase operations in any one of \( \{a, b, c\} \) bases operate in a one-parameter unitary group [Stone, Euler], having inverse phase \( \pm \pi \), and identity phase 0. Re-application of an inverting change returns to identity. From this simple binary-valued phase operation, we can recover:

Multiplication,

\[ +a^*a = -a^*a = -a, \quad (0 \text{ XOR } 1) = (1 \text{ XOR } 0) = 1, \]

binary exclusive-or logic,

\[ 0 \text{ XOR } 0 = (1 \text{ XOR } 1) = 0, \quad (0 \text{ XOR } 0) = (1 \text{ XOR } 1) = 0, \quad (3, 6) \quad (4) \]

relations from powers of \(-1\)

\[ (-1)^{\text{odd}}(-1)^{\text{even}} = (-1)^{\text{even}}(-1)^{\text{odd}} = -1, \]

\[ (-1)^{\text{odd}}(-1)^{\text{even}} = (-1)^{\text{even}}(-1)^{\text{even}} = +1, \quad (4) \quad (5) \]

to continuous waves

\[ (\forall \phi \geq 0) \in \mathbb{Z}, \quad -1^\phi = i^{2\phi} = \cos \pi \phi = e^{i(\pi/2)\phi} = e^{i\pi \phi}. \quad (4) \quad (6) \]

This describes samples from a unit circle \( \mathrm{U}(1) \), with the complete complex wave [Euler’s formula] preserving information with changing phase, by including components of a rotor of geometric full product:

\[ e^{i\phi} = \cos \phi + \sin \phi. \quad (4) \quad (7) \]

3 PHYSICALITY AND ONTOLOGY

3.1 Basic Phenomenology in a fundamental physical hierarchy

Some previously fundamental phenomena, thought to be abstract or fundamentally unexplained, may be redefined as being non-fundamental when derived in terms of our scheme. In Table 3, we list the major levels of abstraction, process and state that may be useful for placing physical or ontological phenomena. For example, the electron is a fermion, and therefore has an internal structure of four APS waves (4.2).

<table>
<thead>
<tr>
<th>Abstractions</th>
<th>States</th>
<th>Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duality</td>
<td>Property</td>
<td>Dimensionisation</td>
</tr>
<tr>
<td>Geometric Algebra</td>
<td>APS State Vector</td>
<td>Exclusion</td>
</tr>
<tr>
<td>Entity</td>
<td>Boson</td>
<td>Propagation</td>
</tr>
<tr>
<td>APS Wave</td>
<td>Fermion Event</td>
<td>Quantisation</td>
</tr>
<tr>
<td>Matter Network</td>
<td>Macroscopic Integration</td>
<td></td>
</tr>
<tr>
<td>Differentiable Manifolds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classical Approximation</td>
<td></td>
<td>Sensory Measurement</td>
</tr>
</tbody>
</table>
3.1.1 A Physical Reality of Fermions, Bosons, and their Interactions

We present a physical reality as follows:

3.1.1.1 A fermion event exists instantaneously at a point, and radiates away as fundamental bosons, leaving nothing behind;

3.1.1.2 A boson is a compound wave, comprising two waves that operate in the APS, i.e. a boson has six phase values: two state vectors in \( \{a, b, c\} \). A radiating boson has no position; just a nonconserved state having a phase offset from the fermion event;

3.1.1.3 When two bosons meet at a point where one wave from each boson has value \(-b\), then a new fermion event is formed.

This creates a network of fundamental fermion events with intrinsic values connected by fundamental bosons, which can reproduce the phenomena known to (quantum) physics. The remainder of this paper explores the implications of this description of physical reality, the rationale behind it, and its correlation with accepted theory.

3.1.2 Propagation by Bosons; No Propagation of Fermions

Rather than accepting that a fermion moves continuously away from a known point at \( t = 0 \), we propose that it disappears immediately after \( t = 0 \), and its constituent bosons move away from the fermion’s former position, finding a new position when another boson superimposes it to form a new conserved wave pair, i.e. a new fermion event (fig.1).

3.1.2.1 The fermion particle does not exist between fermion events.

Only at these fermion events may two waves ‘interact’, and this is done without interrupting the phase progression of the fundamental waves, which remain continuous through the interaction (figs.2a,9,10) without doing anything spontaneous. This offers: a quantum perspective using continuous waves, where continuous bosons may naturally create quantized events; and also a perspective from the discrete particles where two fermion events exist on the same continuous wave, with the boson expressing a latent phase offset that prevents two fermions having the same state at the same event (3.1.3). The radial generalization, time’s arrow, entropy, and the Second Law of Thermodynamics, all arise from a physically dimensional treatment of reconciling phase between fermion

![FIGURE 1. Quantum movement of a fermion: (a) a new fermion event; (b) propagating bosons and another new fermion event; (c) propagating bosons from two fermions; (d) and (e) new fermion event at “x”; (f) propagation. Note: some bosons not shown.](image1)

![FIGURE 2. (a) Four waves of a conserved fermion event; (b) Intermediate alternative to the Feynman diagram; (c) Diagram showing conservation state of waves in at fermions; (d) Zitterbewegung of possible fermion events from two waves.](image2)
3.1.3 Exclusion Principle and bosons

In our earlier work[4], we derived an Exclusion Principle from the two ideas:

3.1.3.1 A fermion event can only occur at the first unique solution of $-b$ for two bosons, and
3.1.3.2 Bosons resolve the existence of more than one instance of an energy state, and that a phase offset is the only way of separating similar states that would otherwise have violated 3.1.3.1 because a unique solution was not available.

3.1.4 Four-Wave Formulation of the Fermion

Rather than assuming propagating fermions at the lowest level, this interpretation of an interaction is unconventional because we use four contributing parts and assume that a fermion moves by repeated quantum propagation of its bosons. Our approach breaks previously fundamental fermions down into constituent parts, leading to a better understanding of interactions. We think of the fermion events as real particles, and the unrealized bosons as conventional virtual particles.

A simple diagram format illustrates this. Starting with a diagram of QCD from the perspective of one fermion $Z_n$ (fig. 2b), we show fermions as solid dots, and the resolved bosons $\phi_n$ as curly gluon lines.

This can be further developed, to reveal the internal structure of the bosons, and how they couple to the fermion events (fig. 2c). Conserved states are shown as connecting with the core, and nonconserved states connecting with the grey outer circle. A boson is shown as a pair of lines connecting two fermions, each line being a resolved APS wave with known limits. Note the lower view showing the continuous progress of one boson throughout a sequence of interactions. As with the Feynman diagram, we may, for example apply arrows and interpret an elastic electron/photon scattering in many ways. The algebra and model may describe accountable inelastic scattering using wave states in the primary phase space (2).

3.1.5 Finding solutions, splitting and re-emission

Simple quantized radial solutions in a 4D space-time for new fermion events are disproved by their topology; they fail for two reasons:

3.1.5.1 A quantized function of intersecting radial solutions is degenerate (non-unique), or
3.1.5.2 Unique points are improbable when the function on the conserved property is quantized, because the quantization phase does not coincide exactly with the unique radial solution.

To resolve this and other problems, we expect to find a field-modulating model for solving fermion events, but note that there are many approaches, depending on assumptions of background, and its correlation with phase progression.

3.1.5.3 The infinitesimal probability (of two instantaneous events being on the same world lines) is increased by phase modulation of $b$; modulating fields allow bosons to interact, which may be exploited to determine the likelihood of decoherence of a fermion’s constitution due to interaction with vacuum (3.3.3, fig.4).

We also require that the fermion event allows a proportion of the wave to be re-emitted from the fermion event’s point [Huygens-Fresnel], while the remainder continues radially. This is an incomplete coupling of the bosons to the fermion event, quantitatively set by the conservation phase of the nonconserved waves at the event, that is most likely to be a phase modulation.

Example candidate equations

For now, we use a placeholder phase operator $\phi_f$ as a modulator of the solution-finding function (eq.8), describing a single step of phase (approximately time-dependent) evolution, noting the use of $l$ to use the value of one wave to modulate the phase of the corresponding waves in its partner boson:

$$Z_{n+1} = \phi_f \phi_m Z_n$$

(8)
with, for example, 
\[ \varphi_f = f(\varphi, t) = e^{-itc}b(t, l) \]  
and 
\[ b(t, l) = v(S[l, h, m]) \]  
where, \( v \) is the value of \( S[l, h, m] \), using axis \( x \) on the APS vector of wave \( m \) of boson \( l \) at fermion \( S \), with mixing factor \( c \). Unit scaling factors have been omitted. As a physical consequence, a phase-modulated nonconserved wave will become part of a fermion event earlier or later during its propagation, depending on the sign of the modulation. [NB: The event will occur on the zero-thickness propagating boson shell, but it will not cause a solution to occur ahead or behind the wave’s shell.] This is therefore an action function: it moves the future occurrence of fermionic matter based on ‘order’ field values.

3.1.5.4 For \( 0 < c \leq 1 \), this creates a convergent series to a phase difference of \( \varphi/4 \), which diminishes the modulation, and eventually results in a phase operator of no effect.

3.1.5.5 Where \( c = 0.5 \), the result is an impulsive merging of the fields to mean-average value, and a merging of the two bosons to a single boson.

This process is reversible, in that it allows both merging and splitting of bosonic waves. We should make clear that eqs.8–10 are simply illustrative ‘placeholder’ equations that fulfill our modeling requirements, but have no direct fundamental basis, and lack the elegance of other parts of this work. We will direct future work towards quantitatively reconciling a splitting model with current phenomenology (6.2.1.2).

3.1.6 The particle life: creation, idempotent propagation, and collapse

Persistence (or propagation) of a particle state is best illustrated as idempotency (3.2). We distinguish here between two common definitions of propagation, and here we concentrate on the latter of: (a) Realization of a fermion event: the collapse of virtual particles to form real particles, which in our model is the formation of a fermion event; (b) Particle propagation: the sustained re-formation of a self-similar fermion event, or a pattern of events that looks like a composite particle.

3.1.6.1 Sustainable matter is a sequence of fermion events, from idempotent conditions (eq. may cover more than one span between events), enabling the realized wave states to propagate in a cyclic manner until point-local conditions change for the sequence of events, preventing further propagation in the same state.

3.1.6.2 The absolute value of ‘external’ influences on the sequence does not determine whether the state is sustainable: some sequences require external fields to continue; sequences will be initiated or terminated by a change of external fields, e.g. a QCD color singlet might need an external residual field to remain sustainable.

3.1.6.3 In our picture, nonconserved bosons transmitted from elsewhere may have influence on conserved solutions [more than two waves in nonconserved phase may exist at the fermion event, allowing the change of conditions that facilitate conventional creation or collapse of the idempotent condition]; In describing a creation event, it necessary for more than two bosons be involved:

3.1.6.4 The General Exclusion Principle\(^{[4]} \) (3.1.3) employs the bosonic phase to allow states >2 to exist elsewhere in a conserved state. This prevents ambiguity when resolving more than two states at a point.

3.1.6.5 When resolved into macroscopic potentials, matter created from a point would fall back into vacuum (not be resolved into a fermion event) without an additional field, generated by a further fermion event on the world lines of the event under consideration.*

The collapse of a sequence is just like the creation of a sequence, again involving a change of field states. Throughout the life cycle of a ‘particle’, the fundamental quantum processes are the same, and we do not need special rules to give pre-composite or posts-composite waves a different treatment than those forming the propagating idempotent particle; the process is constitution-symmetric.

3.2 The Meaning of Nilpotent Factors: Noether’s Theorem and Conservation Laws

In previous papers\(^{[2,4]} \), in supporting Noether’s theorem I\(^{[8]} \), we proposed that:

3.2.1.1 Conserved terms are: inner product, trace, source terms, fixed, identifiable, absolute phase value, and invariant.
3.2.1.2 Nonconserved terms are: outer product, bosonic, fields, latent, unidentifiable, relative, intrinsic quantum potential, and divergent.

3.2.1.3 Divergence pairs (or their expansions) lead to respective conservation laws: where there is no change in a property in the ‘divergent loop’, then there is a symmetry in that property, and that aspect of the system is invariant and therefore conserved while the other aspects (divergences) may change. This happens because APS ‘channels’ \{a, b, c\} are non-mixing.

Conventionally, the term nilpotent is given to any form whose powers (above 1) may evaluate to zero. Here, we use it to describe a scenario where the values at a fermion event are factors of zero product. Open systems (unsolved divergences, entropic, or vacuum-coupled) have non-zero solutions, and are merely closed systems with any number of factors (eigenvalues) extracted from the closed system value of zero.

3.2.1.4 Open solutions need not relate to just one specific external entity: they can be expanded to represent any closed loop or coupled sub-system, and thus may represent the vacuum energy, or fields imposed remotely upon an event by the rest of the universe. An idempotent operation is one that imposes no net change on a given state, i.e. any phase operator having ‘integer cycles’ phase value. We also use this informally to mean any particle that conserves its approximate state over time through many quantum interactions.

### 3.2.2 Value and potency: an informal guide

A boson wave has no potency when its two elements are a different by a quarter-cycle, which causes the partner of a conserved wave to have value 0\(b\) (fig.3). We contrast this with a pair of waves having conjugate phases, which will have a maximum field. Applying this to transient waves in background, we find that such waves, when generating a fermion event with one of its own waves at \(-b\) (rather than participating as a field in another wave’s fermions), it will generate no fields by itself; any fields at the event will be the result of vacuum.

This requires the two waves to have a phase difference of a quarter-cycle. If two such waves should meet in free space, they would generate no field, and any field at the (ineffective) fermion event would be from vacuum, i.e. the minor bosons can only be transformed by additional bosons/fields. This implies that the neutrinos, or a sea of massless bosonic waves, would usually be undetectable in free space, but would create opportunities for interactions when fields are present.

3.2.2.1 Minor bosons are a bound wave pair, with one wave having almost \((0,0)\) value in \{\(a, c\}\) when the other wave has significant \{\(a, c\}\} value at conserved phase \(-b\).

3.2.2.2 Major bosons are a bound wave pair, with one wave having significant nonconserved value in \{\(a, c\}\} when the other wave has significant \{\(a, c\}\} value at conserved phase \(-b\). This requires the two waves to have a phase difference approaching half a cycle.

Although there is no absolute distinction between ‘minor’ and ‘major’ bosons, this does help us to understand some phenomenology, giving us an insight into how matter behaves, in that fermions having a major boson will remain mostly impervious to the jostling of minor bosons: leptons seem to move around because the major bosons carry the significant value, which find solution at short distance because many minor bosons exist to impose the \(-b\) quantization condition. It might help the reader to think of Brownian motion, where large particles are jostled by smaller particles (5.4).

It may also provide a cosmological perspective on the origins of matter: if we can quantify the ratios and values of major/minor necessary to describe our universe, we can then posit models for their origin.

**Figure 3.** Partner waves in typical bosons.

**Figure 4.** PDFs for concurrent boson collapse. No field gives sharp peak at P(1); increasing random fields spread the PDF.
The model provides the means for successive fermion states to remain mostly stable, just as they are in the human environment, and it also allows for those states to be changed in extreme conditions, like those in theorized early-universe or high-energy scenarios.

### 3.3 Quantum and classical interpretations

#### 3.3.1 Correspondence Principle

To explain classical movement of a conserved entity in fundamental terms, we have proposed (3.1.2, 3.1.6) that matter moves by finding complete discrete and *conserved* solutions to bosonic wave propagation. For there to be any macroscopic movement of the composite particle, there must be an overall directional aspect to a succession of solution events (3.1.1).

This description of fundamental mechanics gives us a choice of two levels for abstract modeling:

- **3.3.1.1** A *quantum sequence* of many low-level linear segments from the constituent bosons.
- **3.3.1.2** A classical or high-level polynomial *approximation*, which fails on closer inspection, because it is a linear approximation of the non-linear total of the quantum picture.

Thus, a composite particle may be classically stationary despite the fundamental bosons being emitted at ‘light speed’ to create fermion events in repeating geometric patterns of positions previously occupied.

- **3.3.1.3** At small linear latencies, the classical limit is exposed (*Correspondence Principle*), and the Schrödinger picture also becomes inaccurate (3.3.5). This is because a classical path is not arbitrarily differentiable in a quantum representation while retaining relevance to the meaning of reality at the arbitrary limiting points.

In terms of experimental detection, it is only at the fermion events that we may ‘sample’ the bosons, and unfortunately the most fundamental abstraction levels are not directly observable (4.3); they are only deducible from higher-level physical measurement and sensing (Table 3). Historically, it is not surprising that we started with the classical, and are now progressing towards the most fundamental, via quantum physics.

#### 3.3.2 EPR Paradox

Our model uses a different picture of reality than is assumed in the EPR Paradox. Here, definite states exist and spin or phase correlation originates from the entanglement of two bosonic waves at source, and we do not require the (Bell) states to be indeterminate.

Component bosons may realize different paths, and they may be collapsed independently (fig.5), which means that the collapse of the first boson does not necessarily pass information to its partner boson nor does it causally collapse it, and effects like those observed in slit experiments (5.1) can easily be explained. For the purposes of these thought experiments, we may substitute a pair of coherent photons, to behave like the two bosons that leave a fermion event.

#### 3.3.3 Quantum bits (Qubits) in Quantum Theory (QT)

The implications for conventional quantum theory could be profound. With this model, although basic QT and
the use of its abstractions is not challenged, we redefine its conceptual reality, in that we do not need to assume a (static) multiverse, nor many possible realizable (dynamic) futures, nor non-locality (3.3.2), nor an observer and back-propagation to decide what actually happened.

3.3.3.1 The notion of observables and their eigenstates are actually less stable than QT expects, because the constitution of the object changes while QT expects it to remain invariant.

Physically, a fermion may seem to be a simple system, but because a fermion is radiated as two bosons and might not necessarily re-assemble using the same bosons (fig.6), we say that its constitution might change even when we expect the fermion to be the same fermion in legacy QT. This introduces decoherence (uncontrolled variables from the environment surrounding the system), effectively a “randomness from vacuum”, and when boson substitution occurs, such an observable change is a question of whether a state is to occur.

We can achieve a spectrum for qubits from each of the bosons that comprise a fermion; not from the multiverse. Pairs of bosons can each both physically realize alternative eigenstates, so we now express a Boolean multiverse as “a pair of simultaneously realizable options in nonconserved (virtual) phase”, and each bosonic divergence from a fermion may be ‘roots of NOT’.

3.3.3.2 Each non-mixing ‘channel’ of the APS \{a, b, c\} gives the opportunity of a foundational qubit and its corresponding observables.

3.3.3.3 Physical qubits comprise two single waves, one from each of two coupled bosons.

3.3.3.4 \(n\) external wave pairs introduce \(2^n\) more qubits, increasing the dimension of the observables matrices by factor \(2^n\). The simplest seemingly idempotent step for a fermion introduces external qubits, and therefore requires tensor products (one for each boson), just as any 2-qubit description in QT is represented by tensor products and algebra.

3.3.3.5 The Heisenberg picture is suited to qualitative questions of ‘whether’ and ‘how’ (quantized solutions of whether a specific coupling interaction occurs), and the Schrödinger picture is suited to quantitative questions of ‘how much’ or ‘how far’ (when we measure the dynamic time evolution of a system having fixed constitution).

3.3.4 Macroscopic action, intrinsic mass-energy, and inertial mass

A particle structure’s (non-linear) resistance to changes of velocity can help us understand possible origins of the laws of motion on hadronic matter, including concepts of mass, inertia, movement, acceleration, and momentum. We understand that composite particles, like hadrons, have a stable repeating structure (3.1.6), and it uses quantum potential (3.1.2) to distort that structure to take different-sized quantum steps to change the classical direction of movement. In the presence of a field, the quarks will re-form in a slightly different place than if there was no field, distorting the structure, and contributing to the classical macroscopic (statistical) momentum (or velocity) vector of the composite. The direction of the classical impulsive acceleration will depend on the orientations of the nonconserved fields with respect to the state vectors of the conserved matter. As the classical velocity approaches light speed, the structure of hadrons must stretch in the direction of momentum, whereas the structure of strong-residual-interacting hadrons must flatten so that its normal (in terms of its plane) corresponds to its momentum vector, which would make a hadron’s shape in space-time conform to ‘helixes on a cylinder’, and correspondingly direct the residual fields. We therefore equate inertial mass to the effect that a given phase operator (field) will have on the particle under consideration, and we equate the intrinsic mass-energy to the nonconserved phases (quantum phase potential) at the conserved phase of a fermion event (3.3.5, 3.2.2).

3.3.5 Higgs mechanism

Assuming non-modulated phase progression, a boson’s wave will be at conserved state again at phase \(+2\pi\), which defines the position(s) that require least energy (nonconserved modulation) to occupy. If the position of a solution is modulated by gauge fields (nonconserved terms), then the target fermion is in a higher energy state relative to a fermion formed at phase \(+\pi/2\) (which has zero rest mass), and the new position adopts an ‘excited’ state. QCD has higher-energy fermions, occupying positions at fractional phase relative to each other, thereby giving the composite a rest mass.

The simplest Higgs-like mechanism in this model is as follows: At near-zero phase offset, it is very unlikely that a fermion’s bosons will contribute to another fermion event (3.3.1.3, in contrast to the continuous Schrödinger
picture), because it will create a higher-energy state relative to the positions further out – the exception being condensates. We can show a natural asymptotic freedom from this, and the field modulation model. All four component waves from a fermion are subject to this condition, and in particular the waves having conserved state at the fermion event. We predict there is no Higgs particle, but note that all gauge bosons are compacted into APS phase progression, so are subject to the Higgs Mechanism.

### 3.3.6 Confinement and Asymptotic freedom

We offer the natural quantization of fermion events as a picture for the confining peculiarities of the strong force (QCD), where the requirement of an exact phase results in a ‘quantum sifting’ of the action or positional function, having short-ranging optimum solutions and unfeasible longer-range solutions. Using principles of ‘first unique radial solution’, we have found that free particle pairs will naturally find solutions at successively shorter intervals, until they settle at finding solutions spanning less than one wave cycle. However, our universe does not allow such freedoms because it has a ‘busy vacuum’, and hadronisation is much less likely to occur in sparse situations.

### 4 ALGEBRA OF THE FERMION EVENT

#### 4.1 Conserved State, Field State, Background

Recall (3.1.1) that our bosons are bound wave pairs, and a fermion event has both nonconserved (field) states and conserved states. For the ‘free nilpotent’ interaction, where two boson states are represented together as four state vectors \([Y_1, Z_1], [Y_2, Z_2]\) (fig. 7), states

\[ Y_1 Z_1 Y_2 Z_2 = 0 \] (11)

We may show this relationship as bosons linking phase difference \(\phi\) between two fermion events \(XW\) and \(ZY\) (eq.12). As an equation, only the phase operators are necessary; we show the ‘limiting’ fermion states \(XW\) and \(ZY\) for convenience only:

\[(XW\phi ZY)_1 (XW\phi ZY)_2 = 0\] (12)

This bosonic phase difference is in the nonconserved light cone, which includes not just spacetime, but all nonconserved states in the APS: space \(S\), time \(N\), gravity \(A\), and \(C\), compacted into a unified field covered by \(\{a, c\}\). More precisely, bosons span the real and imaginary macroscopic nonconserved open path integrals. Simplistically, the macroscopic nonconserved distance \(P\) between two entities (comprising a closed system) is equivalent to the summed history of nonconserved quantum phase actions between the conserved states, where some terms may be destructive.

\[ P_m = \sum_{n=1}^{m} \phi_n \] (13)

It describes our universe as a sea of bosons meeting to form matter at interaction events, in a way that mostly preserves (3.3.3.1) the idempotent ‘particulate’ matter that we observe, where \(\phi_n\) (eqs. 13, 14) is the total influence between any \(Z\) and its pattern-cyclic successor:

\[ \phi_n Z_n = Z_{n+1} \] (14)

The field states \(Y\) can be considered to be the influence that the rest of the universe has on the point (vacuum, FIGURE 7. Wave states in the APS at a fermion event.
3.1.2), limited to its nonconserved world-lines. We may choose any arbitrary point and calculate the field states because the waves are continuous, but the usefulness of such points is limited, and we question whether a physical point can exist outside a fermion event. These fermion events are point-local, such that ‘sub-physical’ interactions need have no notion of the conserved entities occupying the external (physical) space, other than through the nonconserved field state at that point. The basic model therefore does not include terms for non-local couplings.

The macroscopic effects of these interactions can only be seen when we accumulate the nonconserved expressions of the sub-physical interactions. Thus, we have a clear distinction between a sub-physical representation (a single interaction), and a macroscopic expression (an open path integral). This distinction is important for understanding the nature of the quantum and macroscopic viewpoints, and we feel that this approach successfully unites the two. This picture assumes that the macroscopic spaces are complete Hilbert spaces, which incidentally weakens the proposition for background-independent representations. Using this model, we aim to understand particle physics through an understanding of the mechanics of the single boson, and the implications of the interaction of two bosons at the fermion event.

4.2 Observables: Mapping the Algebras of Hestenes, Clifford and Dirac

Where two bosons are represented by four state vectors \([Y_1, Z_1], [Y_2, Z_2]\) at the same event (fig.7), we require that \(Z\) terms are conserved at the event, and \(Y\) terms are the nonconserved fields at the event. These \(Y\) states have potential to form a conserved solution at other events. At an event, we compute the relevant quantities as follows:

4.2.1.1 Combine the nonconserved \(Y\) states into the field state.
4.2.1.2 Combine the conserved \(Z\) states into a fermion state.

For \(b\)-conjugated waves, this eliminates the \(b\) property from the equation, and we are left with terms in properties \(a\) and \(c\), to create the paravector, which is given geometric relevance by Hestenes among others (Table 2) as components of Clifford algebra, including \(\mathcal{Cl}_{3,1}\). Starting with a closed system (nilpotent, eq.15), we rewrite \([Z_1, Y_1, Z_2, Y_2]\) as rows in APS \([a, b, c]\) with index values to identify the waves. With the assumption of \(b\)-conjugate wave states, we may simplify four terms into two by using indices \([1, 2]\) with relative sign ± and \(\mp\):

\[
Y_1 Z_1 Y_2 Z_2 = 0 = \begin{bmatrix}
\mp a_1 & \pm a_1 \\
+ b_1 & - b_1 \\
\mp c_1 & \pm c_1
\end{bmatrix}
\begin{bmatrix}
\mp a_2 & \pm a_2 \\
+ b_2 & - b_2 \\
\mp c_2 & \pm c_2
\end{bmatrix}
\]  
(15)

4.2.1.3 If we assign the conserved state \(Z\) to be the absolute state (fixed term), and nonconserved state \(Y\) to be the relative state (an divergence to be solved), we resolve the ordering problems of commutation typically associated with phase operators of seemingly equal status: we let \(Y\) operate on \(Z\).

Pairing the states (4.2.1.1, 4.2.1.2) produces paravecors, representing conjugate divergences at the point. We adopt the convention of writing relative operators to the left of absolute states:

\[
YZ = 0 = \begin{bmatrix}
\pm a_1 & \pm a_2 \\
\mp a_1 & \mp a_2 \\
\pm c_1 & \pm c_2 \\
\mp c_1 & \mp c_2
\end{bmatrix}
\]  
(16)

In losing the \(b\) terms, we discarded the non-observables, losing some information about the bosons’ coupling to the fermion event (3.1.5). However, we have all parts of the full products in the Clifford\(_{3,1}\) algebra (or GA), where we may extract scalar, vector, bivector and trivector parts. We may treat it as a Hamiltonian that summarizes all the fundamental observables, or make a direct number-type-compatible substitution\(^{[4]}\) into the Rowlands nilpotent representation for the Dirac equation\(^{[9]}\), by taking the states of all waves at an event (eq.16), as \(Z\) and \(Y\) (4.2.1.3), which correspond to tensor constructions in \([a, c]\) that are the four ‘Dirac images’ of a fermion. From fermion state \(Z\), we find the pentad from a re-compactified expansion from basis \(e_{0,3}\). Almeida\(^{[9]}\) provides further insights into the equivalence of other 5-dimensional GA representations in this context, in particular \(\mathcal{Cl}_{4,1}\). See below (5.3) for a description of the duality of the \(Z\) and \(Y\) states within the fermion event.

4.3 Hidden value, geometric product, and physical expressions

To achieve a model of observational truth, the scientific method attempts to uncover hidden truths about nature, and
tests a model by attempting to measure converted aspects of it. In doing so, we invent abstract concepts about these hidden aspects, and relate them to what we observe. In making a quantifiable observation, it must always relate to a spatial offset, but (without restricting the scope for physics), the measurable physical aspect is:

4.3.1.1 A privileged subset of the possible wave operations within the APS, and
4.3.1.2 A presentation layer based on the measuring interaction.

Given a sufficiently fundamental understanding of an interaction, we will be able to ‘unify’ all types of physical expressions, rather than applying different conversion rules at higher levels of the hierarchy. In defining the APS and its physical model, a more useful unification is achieved.

Geometric algebra is powerful in this respect: it allows two interacting vectors to be expressed in terms of the full product, without losing information:

\[ ab = a \cdot b + a \wedge b \] (17)

4.4 Uncertainty and projections on divergence

Given our assignment of divergences to outer products, and couplings to inner products (see also 4.5), we already have the tools needed to losslessly map dimensional values (covered by the unit basis elements of Table 2) to any phase in the APS. When deducing hidden structure, we must be careful to understand when we are reading the underlying APS state, and when we are reading the residuals of a fermion state. We regard the conserved state to be of absolute value, and the nonconserved state to be relative, so ordering the anti-commuting terms (4.2). Heisenberg’s Uncertainty Principle tells us that anti-commuting terms cannot be measured simultaneously, but we can explain further.

4.4.1.1 Knowing that the uncertainty-paired terms have different basis axes (Table 2), we cannot obtain a full inner product on both terms’ axes with one single measurement; we would need two separate projections to gain a full-value readings of both, but the first measurement would corrupt the quantum state before we could make the second.

Anti-commutation is not itself the reason for Uncertainty; a more fundamental explanation, rooted in the basic algebra, is that:

4.4.1.2 Any difference in APS phase between a state vector and a projector means that we cannot fully measure the state vector, so when a pair of state vectors is presented for measurement, then at least one of the two cannot be measured fully.

So where we stated that terms with differing \( b \) (conservation) properties anti-commute, we were only stating a small part of the uncertainty relation: properties \( a \) and \( c \) also imply uncertainty.

4.4.1.3 The (nonconserved) bosonic offsets, equivalent to a latent phase change in the wave, or phase difference from the fermion state, respond as a compact unified field. Measurement interactions may act from any projection on this unified field, and the uncertainty-paired terms (inner and outer products) correspond to conserved and divergent relations [Noether] at the measurement event (3.1.2).

We note (from 4.4.1.1) that there are other problems in measuring a complete quantum state:

4.4.1.4 Likewise, attempting more than one measurement, as is required to gain a more complete picture when there are discarded products, will necessarily sample different (event-sequenced) states of the target, rather than measuring the state at one event.

4.4.1.5 It should be possible to obtain a more complete quantum image of the target’s state using a probe having two orthogonal-phase waves (QM: so an expectation value is at one extreme of the spectrum; outer products are off-diagonal in matrices), but then (a) choosing the correct probe needs knowledge of the target state, and (b) that image would be subject to the same uncertainty restrictions as the original target, and be equally impenetrable [No-clone Theorem].

4.5 Preserving information: bosons and fundamental angular momentum

In building a boson from two waves (3.1.1.1), we can maintain dimensional (vector) information throughout a boson’s wave cycle, even when its state vector appears to be in scalar phase (where vectors have no meaning), and
we can manage exposure of *nonconserved* values from *conserved* quantities, e.g. fields from their sources. A continuous rotation transformation is needed to traverse phase in any of the properties \{a, b, c\}, for which we can use the magnitude-preserving (geometric algebra) rotor,
\[
V = (W \cdot c) \cos \theta + (X \cdot c) \sin \theta
\]
(18)
where \(W\) is the initial state, and \(X\) is the orthogonal final state. We may interpolate phase \(\theta\) of the transformation from \(W\) to \(X\), for \(\theta = 0..2\pi\), to give the interpolated state \(V\). This may be applied for any or all APS phases \{a, b, c\} simultaneously, to transform the expanded dimensional terms (Table 2), and combines into a single continuously differentiable expression.

4.5.1.1 The property \(a\), between real and imaginary. This is readily available as a multiplication by \(i = e^{\pi i/2}\), as typified in complex rotations. Interpolating or extrapolating the phase value of this rotation loses no information. Note that a complete phase cycle in \(a\) spans only half of one rotation on the Argand diagram.

4.5.1.2 Property \(b\) works similarly to property \(a\), but with no change of number type.

4.5.1.3 For the \(c\) axis, we should be able to express the *nondimensional* side as a direct scalar equivalent of the *dimensional* 3D values (the GA grades have the same ‘evenness’). Doing this should be a simple process of 4D rotation from vector into scalar, with phase determined by the position in \(c\) in the APS.

Rotations in properties \(a\) and \(c\) have the same form as those of GA constructions of \(\mathbb{E}_{3,1}\), and so provide the same algebraic origins for half-integer spin.

4.5.1.4 A boson is the minimum physical structure that can sustainably conserve information.

**Affinity of Waves at a Fermion Event**

At the fermion event, we have at least four waves, two of which will be at conserved phase: 2 *conserved*, and 2+ *nonconserved*: each *conserved* wave is bound to a *nonconserved* wave, and any remaining waves are *nonconserved*. Without even considering orientation to macroscopic background (space), the intrinsic angular momentum of a boson at a fermion event may appear to have one of two directions, determined by the slope of *nonconserved* order waves. If we take the two individual waves that are at *conserved* phase \(b\), they will have identical value in all orders of \(b\). One would think that this makes them interchangeable so that the set of *conserved* waves could somehow select their *nonconserved* partner, but this possibility is eliminated because it would violate angular momentum in axes \{a, c\}. One cannot argue that they would be interchangeable if the \{a, c\} terms were identical, because that would violate the Exclusion Principle, and the fermion event being discussed could not be constituted.

This leaves the *nonconserved* waves that have no *conserved* partner: these are the hypothesized incidental bosons, where both waves are *nonconserved*. These may couple with the fermion event, and be split or merged, according to the splitting and mixing formula (3.1.2).

**Conserving dimensional elemental value by order**

3D vector information would not be lost at phase \(\theta = \pi/2\) when the vector is fully rotated to a scalar, because of the internal housekeeping process of fundamental angular momentum in the boson, which mediates the phase change between its two waves. In doing so, it also mediates the *dimensional* values as a second-order differential term, which would otherwise have been lost by a single wave at scalar phase. Rather than it being a symmetry that must somehow be spontaneously broken to invoke causality, we view the simple four-order differential cycle,
\[
\ldots = -d^n \cos \theta = -d^{n+1} \sin \theta = d^{n+2} \cos \theta = d^{n+3} \sin \theta = -d^{n+4} \cos \theta = \ldots
\]
(19)
(domain omitted) as being a relation between the *conserved* state and ideally ordered fields, as found at a fermion event in a predetermined spacetime matter network. It allows latent bosons to avoid self-exclusion and conserve themselves by propagation into implicit macroscopic *nonconserved* domains. This may be re-written as an ‘elliptical’ (rather than circular) relation by treating axes \{a, b, c\} independently.

We are as yet uncertain whether adjacent-order differentials of sin \(\theta\) are intrinsic to the wave (which would imply new detail not yet described here), or to the boson; we expect the latter.
Applications and Further Work

5.1 Double-slit experiment, and variations

Using the four-wave formulation for the fermion (3.1.4), we apply those principles to slit experiments, and find that we can reproduce the expected results. At the source, a ‘particle’ $S$ is emitted as two bosons $S_1$ and $S_2$, which are independently propagated through latent space (3.1.2). Each boson has two waves, e.g. $S_1$ has waves $S_{1A}$ and $S_{1B}$.

Even when we factor in a positional randomness of the target positions that is greater in magnitude than the wavelength of the quantizing wave, the image formed at the target may then show an interference pattern, or not, depending on the apparatus between the source and the target (3.1.5). If there is a choice of paths, with no confinement to one path on any two consecutive screens, then an interference pattern may be present if the bosons are coherent at the target. With two paths and one common target fermion, the two bosons’ phases will be synchronized with respect to their paths, whereas with two targets, the source bosons may be incoherent with respect to any other bosons, implying no interference pattern at the target.

We admit that the following outcomes (fig. 8) are possible for the fermion $S$, where its two parts $S_1$ and $S_2$ may:

5.1.1.1 Each couple with a boson from separate fermions in the target (we’ll call those fermions $U$ and $V$, which each have two boson parts), so an interaction might look like “$S_{1A}$ to $U_{1A}$, $S_{1B}$ to $U_{2A}$, with the implied $S_{2A}$ to $V_{1A}$, and $S_{2B}$ to $V_{2A}$” with the bosons $U_{1B}$, $U_{2B}$, $V_{1B}$, and $V_{2B}$ coupling with other bosons from the target area. We call this diffuse propagation. It does not produce an interference pattern (unless its component waves form at the targets with other waves that are coherent with it); or

5.1.1.2 Taking the diffuse propagation (5.1.1.1) in reverse, we have converging propagation, which has an interference pattern if the two sources’ emission phases are synchronized (i.e. if they previously came from the same fermion); or

5.1.1.3 Both couple as one new fermion $S$, from the same waves that made up fermion $S$. The fermions at the target contribute only nonconserved values to the solution. We call this conserved propagation, which is the same as “diffuse + converging”. This has an interference pattern only if $S_1$ and $S_2$ are coherent and converge at $T$ via different paths; or

5.1.1.4 As a variation on 5.1.1.3, both couple with the bosons from fermion $T$ at the target, to make two new fermions $U$ and $V$. An interaction might look like “$S_{1A}$ to $T_{1A}$, $S_{1B}$ to $T_{2A}$, with the implied $S_{2A}$ to $T_{1B}$, and $S_{2B}$ to $T_{2B}$”. The two fermions form: $U$ where $T_1$, and $V$ where $T_2$ are in conserved phase, and has an interference pattern only if $S_1$ and $S_2$ arrived via different paths. We call this separating propagation, which is the same as “diffuse – converging”.

A slit provides the distinguishable location that seems to be a new source. It does this, not necessarily because the slit provides a break in the screen, but because of the matter around the slit re-encodes the source wave as a multi-source wave packet (this causes fringing, because we are effectively providing more than one point of

<table>
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<th>Slit sequence</th>
<th>Independent paths</th>
<th>Interference observed?</th>
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<tr>
<td>(No slits)</td>
<td>Infinite</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Diffraction fringing only</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Diffraction fringing only</td>
</tr>
<tr>
<td>1, 2</td>
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<tr>
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<td>Diffraction fringing only</td>
</tr>
<tr>
<td>1, 2, 2</td>
<td>4</td>
<td>(half will interfere)*</td>
</tr>
<tr>
<td>1, 2, 1</td>
<td></td>
<td>No*</td>
</tr>
</tbody>
</table>

**FIGURE 8.** Outcomes for source bosons forming at a target.
emission, which again behaves like two slits). This re-encoding depends on the wave splitting (3.1.5; merely assigning a proportion of the wave to a new source position, while the remainder continues). Experimental scenarios are tabulated in Table 4, and we predict that all slit experiments will behave as if two actual paths are always formed.

As well as fermions, we can show the same results for source bosons (photons), provided they are from a coherent source such as a laser, which can provide phase-correlated (non-random) waves. This confirms what standard quantum physics tells us, but by other means: that waves will pass through both slits in the ‘multiverse’, if they are presented as classically alternative options. Our four-part fermion construction, being a snapshot of two independent bosons, allows a determinate solution to the problem by allowing two waves to start with coherent phase, each wave having option of a different path (by first unique solution), re-propagating at slits as wave packets, to finally re-combine at the target plane.

5.2 Hadron Structure

Using our description of fermions and bosons, we may describe stable hadrons as repeating sequences of fermion events, and for each fermion event, its bosons are realized at two different fermions in the future. An ideal baryon is composite of three continuous bosons (six APS waves), tightly confined by the quarks (fermion events). We propose that two quarks each emit bosons at phase 0/3 and 1/3 respectively, and these bosons interact to form the state at phase 2/3. When the composite is not accelerating, the quark at phase 3/3 is identical to the quark at phase 0/3, and the process continues, with each quark disappearing when it emits a boson, and re-appearing when bosons coincide in conserved phase. Assuming it can remain stable, a two-quark hadron (meson) may propagate similarly in alternating two-phase.

We may generalize a trivial entangled baryon pattern (fig.9):

\[ NP_m = \varphi_{1..6}, \]  
(20)

and

\[ X_1 \ldots P_m \ldots X_2 = 0 \]  
(21)

with fermions indexed \( Z_{m=0..2} \) and bosons (gluons) indexed \( \varphi_{1..6} \), \( X \) terms representing full creation and annihilation operator sets, \( P_m \) as the nonconserved action (eq.13), and \( N \) normalizes the total phase progression to equal the composite’s displacement (parallelism in the networks). Note that eqs.22–29 assume phase modulo \( 2\pi \):

At rest,

\[ P_m = 0, \]  
(22)

**FIGURE 9.** Three structures for continuous bosons in baryons: (a) simplest structure, (b) one segment \([Z_1 \text{ to closest } Z_2]\) is too distant to be linked by a boson, (c) two segments are too distant. Note that residuals are omitted.
and with uniform external fields, i.e. non-accelerating,

\[ \phi_1 \phi_3 \phi_5 = \phi_6 \phi_4 \phi_2 = 0. \]  \hspace{1cm} (23)

At any given instant in time, a whole hadron does not exist in a fermionic state; rather you would find only bosons-in-transit (conventionally termed ‘virtual particles’), which are re-propagated, ready to produce instantaneous fermion events in the future. The Standard Model’s values for the charge of quarks are merely a probabilistic averaging the three available ‘valence’ phase values, none of which actually realizes a fractional charge when using a deterministic approach.

In all hadrons, we have two bosons meeting at a fermion event, and then bosons are emitted to the next event, and so on. From the perspective of quark \( Z_n \), we see two bosons entering the fermion event, and two bosons leaving the fermion event (fig.9).

\[ \phi_4 Z_{n-2} = Z_n; \quad \phi_5 Z_{n-1} = Z_n; \quad \phi_1 Z_n = Z_{n+1}; \quad \phi_2 Z_n = Z_{n+2}. \]  \hspace{1cm} (24)

and

\[ \phi_4 \phi_5 \phi_1 \phi_2 = 0. \]  \hspace{1cm} (25)

To signify RGB colors of Standard Model QCD, we may assign color operators to phase terms that sum to one complete phase revolution, like three nodes on a unit circle. We note that eq.20 contains three sets of colors and anti-colors,

\[ \phi_a = \text{red}, \quad \phi_{a+2} = \text{green}, \quad \phi_{a+4} = \text{blue}, \]  \hspace{1cm} (26)

\[ \phi_a \phi_{a+3} = 0, \]  \hspace{1cm} (27)

and

\[ \phi_{a+3} = \text{anti-red}, \quad \phi_{a+5} = \text{anti-green}, \quad \phi_{a+1} = \text{anti-blue}. \]  \hspace{1cm} (28)

Co-homology (alternative routes from start to end points, admitting entanglement) has the forms:

for even \( n \),

\[ \phi_n = \phi_{n+5} \phi_{n+1}, \quad (\text{or} \quad \phi_n = \phi_{n+5} \phi_{n+4}), \]  \hspace{1cm} (29)

and for odd \( n \),

\[ \phi_n = \phi_{n+1} \phi_{n+5}, \quad (\text{or} \quad \phi_n = \phi_{n+1} \phi_{n+2}). \]  \hspace{1cm} (29)

All the above still applies when \( \phi_n \neq \phi_{n+2} \neq \phi_{n+4} \); if we assume equal frequencies for all waves in property \( b \), then phase values for the color bosons need not be equal for there to be a sustainable composite particle state. Fig.9 shows the fermion/boson network of a baryon from the perspective of the bosons. Each horizontal line is a continuous and repeating wave that crosses fermion events in conserved phase (shown as filled circles) and in nonconserved phase as fields (shown as slashes). Consistent with our previous principles, each of the \( \phi \) phase segments represents a boson and its limits. Each boson comprises two APS waves that are labeled A and B, and two \( \phi \) phase operators \( \phi_a, \phi_{a+3} \) (color and anti-color) cover a full phase cycle (eq.27). From this, we see precisely how the four bosons’ component APS waves interact at fermions \( Z_0, Z_2 \), without breaking phase continuity.

In terms of degeneracy or ambiguity, the two conserved wave states at any fermion event are not arbitrarily interchangeable, because to conserve intrinsic angular momentum in other elements \( \{ a, c \} \), the bosons’ waves must resolve themselves to a continuous sequence (see examples, fig.9). The seemingly inseparable pair of conserved wave values implied by quantization of the physical model (e.g. in fig.9a, waves 1B and 3A at fermion event \( Z_i \)) will each resolve their quantum potential when they form new separate fermion events at \( Z_0 \) and \( Z_2 \) respectively (figs.9,10).

This approach gives us some clues about the specific values that quarks and their gluons may assume, and their inter-relationships (we are particularly fascinated by the quarks sharing each others’ constitutions). However, we cannot simply assume that, for example, all instances of ‘up’ quark will have consistent intrinsic APS (or elemental) values; the phase positions of the fermions (valence quarks) may move around the phase span, and the limits of the bosons will accordingly change. Our future analysis will therefore focus on the gluons themselves, and the totality of the composite, which should reconcile with current experimental deductions.

### 5.3 Super-symmetry and duality

We do not subscribe to super-symmetry as-is; instead we describe conserved and nonconserved states as being dual (1.1, fig.10). A fermion event includes a conservation duality, of conserved states, and of nonconserved states describing the fields, relative operators, and gauge generators (all of these are the same underlying phenomenon).
Inverting the phase of $b$ for all waves would not be symmetric with the original system, because the fermion events would then form in different places, with different \{$a, c\}$ values. Thus, fermions and bosons are not directly interchangeable entities, but we have instead unified the more fundamental aspects of fields and particles, so that we can describe them all in terms of the same type of wave.

### 5.3.1 Zitterbewegung and Weak Interactions

A structural weak interaction can be produced by swapping adjacent $Z$ fermions (fig.9) via an external boson, to change the relative ordering of waves in a boson (fig.3), and change the structure and mass of the composite. This also can be done for long-range interactions (like neutrino flavor oscillation) via zitterbewegung (fig.2d shows all four possible fermion events from two bosons).

### 5.4 Emergent aether-like medium of fermions

Fundamentally, we assume that there is no aether. However, because all fermions radiate themselves as bosons, and the conditions for further fermions can occur in the intermediate space, we can show that an aether-like sea of fermion events could form if there is sufficient surrounding matter and time for its bosons to propagate and intersect (fig.11a). We call this a secondary aether. This is not a continuous background aether, is not fundamental, and may seem random if there is no knowledge of the specific boson sources. The individual fermions will be instantaneous like all other fermions, and will not propagate as idempotents, so they will not be seen to form and move around. Instead, they act as interaction points for fields to influence idempotent fermions or composites.

If we apply this idea to dark matter and dark energy, where the dark energy corresponds to propagating bosons, and dark matter corresponds to the aether-like fermions, we immediately find that there is a measurement problem when we consider that fermions are instantaneous: it is not possible to measure the ratio of fermions to bosons at any given instant (the fermion count diminishes to zero). Instead, we must adopt reference frames and the idea of simultaneity, and use a time interval or field modulation (3.1.2, fig.11b) to count the fermions and bosons in a modeled scenario. Indeed, the ratio doesn’t make much sense in this context, and neither do the ‘missing mass’ or ‘missing energy’ anomalies described by contemporary physics, for the same reasons.

### 5.5 QED: moving the electron

We may use the same four-part fermion model with QED. A fermion emits itself as bosons, with the dominant (idempotent) boson waves then interacting with another boson at a new fermion event. Electromagnetic fields find projection in the APS, and are realized in the fermion events (5.4) in the space surrounding their source charges.
5.6 Inverse proportionality

Being a pure phase interaction, there should be no magnitude fall-off with distance. This seems to be at odds with our current understanding of Coulombic forces and inverse-proportionality laws, but following on from 5.4, we propose that inverse proportionality can be explained as secondary effects of the dissipation caused by aether-like fermion events in a busy universe. This dissipation is well-known in computer modeling, and has been shown in the author’s own ‘adjacency lattice’ computer simulations (1993) having one axis of freedom (fig. 11c). It is a simple derivation of the second law of thermodynamics; dimensionality is essential in its construction (3.1.2).

5.7 Black holes: event horizon and information paradox

We propose that information may escape a black hole if fermion event solutions are allowed to occur consistently in the outward direction, rather than the inward direction. Conditions are such that gravity causes solutions to be strongly inwardly oriented, so the fundamental signature of any radiation would be quite specific, as follows. The unitary phase operation implies that no quantum field value may exceed unity, and the scenario of a fermion outwardly crossing the event horizon is possible: a fermion near the event horizon must have an environment that allows an approximately idempotent fermion state (to continue the outward momentum), and must have a counteracting field value closer to unity than the field imposed by the inner gravitational mass. We look to imaginary sources (like charge), and find that they can provide the necessary force (phase modulation), and note that charges tend to cancel out over distance if both signs are present, so escape sites are likely to have a concentration of one polarity over the other.

We may resolve the information paradox by suggesting that the ‘event horizon’ is not a strict barrier but a probabilistic one, and we suggest conditions whereby all bosons may eventually traverse the event horizon, in a different ‘encoding’ than the matter that entered the body, by re-combination of the component waves into radiation that does not form matter on an inward vector, nor does it find proximate solutions that would easily return inwards. Our physical model allows one half of the fermion’s waves to be separated from the other, so allowing entangled states (or eigenstates of a trapped fermion event) to exist on both sides of the event horizon, or to be transformed into radiation that may escape; this separation becomes viable because the phase of each component in the wave pair (fig.10) becomes critical to its chance of escaping. Notably, being a quantum process, it does not conform to a continuous function with radius, and conventional rigidity of Schwarzschild solutions is probabilistically avoided.

5.8 Other phenomena with reasonable description

5.8.1.1 Condensates and Cooper Pairs, from the assumption that fermion events do not dictate where other fermion events form if their conserved waves are not shared.

5.8.1.2 Quantum nature of matter: We can use the four-part fermion formulation, and its realization in physical form as a ‘matter network’ to provide satisfactory pictures for slit experiments and Aharanov-Bohm Effect experiments, where a fermion’s constituent parts may take different virtual paths (i.e. influenced by fields within the unrealized radius), and combine at the target, either as a reconstituted conserved particle, or as a random matching with other parts of a coherent source (5.1).

5.8.1.3 Quantum entanglement, where terms are phase-correlated from a fermion event or coherent source. For a ‘comparative circuit’, co-homology presents two paths to a final event, via an intermediate stage that is a destructive integration in one nonconserved term, while being a constructive integration in another (e.g. space). We may also calculate results of particle pair experiments designed to test Bell’s Theorem, using ‘diffuse propagation’ (5.1.1.1).

5.8.1.4 Dark energy and dark matter, using bosons in transit as dark energy, and the secondary aether (5.4) as the dark matter [Speculative].

5.8.1.5 CMBR, as second-generation radiation returning from distantly-formed fermion events (5.4), and there would be a very weak action of similar returning radiation on disparate matter, possibly a contributor to the Cosmological Constant. An alternative derivation of the cosmological constant is that field modulation only modulates values where a solution may occur, resulting in a bias towards expansion that is significant (as a proportion of distance) the very smallest scales (fig.4), which is evident at large scales.
6 SUMMARY

For brevity, we only outline key features, predictions and where we believe further work will be fruitful.

6.1 Basic Conclusions

6.1.1 Unification: We can show how all matter may exist as sequences of continuous waves and particle events. The fermion (3.1.1) is a snapshot of the component bosonic waves at a point, when specific simple conditions are met: two bosons each having a wave element in conserved phase. This unifies the traditional categories of ‘wave’ and ‘particle’, and provides satisfactory answers to wave-particle duality, including double-slit experiments. The fermion event description also includes a unified field that encapsulates known forces, both as intrinsic quantum potentials and their integrable macroscopic expressions.

6.1.2 Correspondence Principle: Our model derives both quantum and classical mechanics using the same picture and hierarchy (3.3), along with reasons for classical limits.

6.1.3 New fundamentals: Quarks and leptons are no longer fundamental, existing only instantaneously before being radiated away as bosons again (3.1.2). We have a minimal description of real and virtual parameters at a fermion event, and the compactified form is a referencing projection to source terms like charge and mass.

6.1.4 Exclusion and Latency: The boson structure and its phase mechanism provide the means for two distant fermion states to become part of the same continuous wave, with many physical consequences (4.5): conservation of source information during propagation, the latency of all nonconserved terms, fundamental angular momentum, causality (quantum sequence), wave propagation, and the origins of nonconserved (gauge) fields and integrable macroscopic domains and potentials.

6.1.5 Confinement: With phase operators and self-quantizing matter in a predeterministic model, some infinities and discontinuities are avoided. Fundamental fields have no fall off, and have unitary source value.

6.1.6 Relativity and Inertial Mass: A change of velocity of a composite particle requires a distortion of the ‘macroscopic positional structure’ of the sequence of fermion events (3.3). We believe that this would demonstrate length contraction, and the model as a whole can demonstrate both Special Relativity and General Relativity at the abstraction level where macroscopic physics is emergent.

6.2 Predictions and further work

We have made predictions and identified many objectives for further works, beyond the scope of this short paper:

6.2.1 Create a computer simulation, using the model. Reconcile ratios of energies, masses, or other characterizing measure of entity, with those of the Standard Model. Formally unify those entities, and demonstrate their equivalence without privileging the processes. Reconcile values of important constants, and conditions that generate entities known to the Standard Model.

6.2.2 Find a sufficiently fundamental model for splitting of bosons, and a means of finding ‘unique first solutions’ for field-modulated radial bosons (3.1.5).

6.2.3 Split bosons (3.1.5) should be visible as a wave packet when the radiated bosons are viewed off-axis from the line between the originating fermion and the fermion where the splitting occurs. This could have applications in sensing.

6.2.4 Apply the principles to QED (5.5).

6.2.5 Calculate the vacuum energy density of transient bosons and their ‘aether-like fermions’, and whether they give expected values for dark energy and dark matter respectively (5.8.1.4).

6.2.6 Derive current 5D algebraic representations[^9] from the APS, and give them deeper physical meaning with the fundamental origins implied by the APS.

6.2.7 Establish whether the APS and physical model outlined in this paper can be a useful basis for a quantum theory for gravity (Table 2: state A, 4.1, 4.4.1.3).

6.2.8 Understand the physical meaning of all differential orders of a boson (4.5).
6.2.1.9 Analyze ‘uncertainty pairings’ by the ‘projectors’ rule (4.4.1.2), to see if new relations can be discovered.

6.2.1.10 Prediction: Our description of stable hadrons allows for the signature of residuals to be predicted, and vice versa. Residual fields should be directionally polarized because of the spatial reformation pattern (5.2), appearing as a strong force ‘multi-pole’ source residuals (or multiple monopoles) approximated by unitary groups. This, along with relativistic changes to the composite particle, should be confirmable by experiment.

6.2.1.11 Prediction: There is no Higgs boson (3.3.5), but the Higgs mechanism is inherent in the propagating APS phase of the two bosons (four waves) leaving a fermion event, each wave has the freedom of the APS, and is therefore a compacted form of all four SM gauge bosons (4.4.1.3).

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8 REFERENCES

7. P. Rowlands, (private communication) “four from eight”, (20 February 2009).