Chapter 1

Vacuum, Gravitation, and Standard Model Structure from Deterministic Mechanics

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We use mechanics from Valentine that describe the quantum propagation of modified qubits or oscillators, with emergent physicality as self-collapsing networks. We detail Standard Model phenomena at all energies, vacuum structure and its effects on matter, accountable spontaneous symmetry breaking with the weak interaction, intrinsic Higgs mechanism, asymptotic freedom, charge, fermion flavors and their decays, gravitation, matter-antimatter asymmetry, and a basis for classical observation. In simulation, we demonstrate gravitation as a statistic of vacuum interactions. We describe simulation methodology, initial results, and expectations for further development.

1. Introduction

In earlier work,[1] we proposed foundations for deterministic mechanics for physics at all energies, inferred useful emergent behaviors of physical systems, and proposed[2] new descriptions of challenging phenomena like the black hole life cycle, asymptotic limits, dark matter, redshift, and antimatter asymmetry. Here, we summarise the mechanism in context of the Standard Model, and create a determininstic simulation.

1.1. *Review: Deterministic rules*

We'll refer to these deterministic rules:[1]

(1) Waves are bound in pairs as oscillators or qubits.

(2) Waves propagate radially, as light speed bosons, having equivalence of phase, distance, and time:

$$d\phi = ds = dt \tag{1}$$

(3) Nonunique waves, having the same phase and source, are excluded from interactions.

(4) An oscillator's mass is a function of its wave phases:

$$\rho = e^{-i(\phi_B - \phi_A)} \tag{2}$$

(5) ρ modulates phase ϕ of other overlapping waves.

(6) Two waves, from different fermions, with $\phi = 0$ at a unique point, collapse their bosons into a fermion.

2. Fermion propagation

2.1. *Quantum information, propagation, entanglement*

The wave pairs (rule 1) resemble *oscillators* or *qubits*, with an elliptical skew (rule 4) to encode *mass*. The basis of the waves is real-valued.

There is no continuous classical movement of the fermion. Rather, it's a quantum collapse or teleportation to a new point. For example, for a conserved fermion cycle **A** $\rightarrow$ **D** (fig.1), two oscillators from fermion **A** each collapse in events **B** or **C** respectively, then they in turn collapse to a new fermion solution **D** on the shells from **B** and **C**.

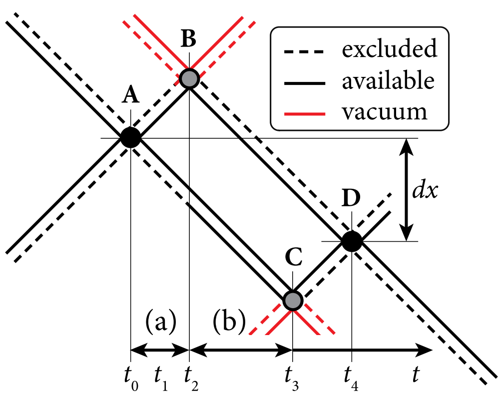

Fig. 1. The propagation of a conserved fermion from **A** to **D**. Each line is a wave; each pair of lines is a boson.

If lengths **A** $\rightarrow$ **B** and **A** $\rightarrow$ **C** differ, spatial displacement results. Propagation is light-speed, and indirect walks aggregate as slower classical propagation.

A *shell* is the time, distance, or phase offset from a fermion event; they're all equivalent (rule 2), like a sphere expanding from a point in space and time. All waves on the shell are *entangled*, share the same spatial identity (2.2), and are indistinguishable from each other unless they are unique in phase. This is how we derive *exclusion* (rule 3). All shells are bosonic (3.1).

2.2. *Fermions as unique collapse conditions, exclusion*

Fermions are a special condition on the continuous journeys of oscillators. Their uniqueness properties change through the ferion event (table 1).

Table 1. Uniqueness-related properties before, during, and after fermion solutions.

Property	Bosons to collapse	Fermion	Emitted Waves
Position	Ambiguous (many shells)	Unique	Ambiguous (on-shell)
Origin	Multiple points	Collapse point	Common point
Wave phase (collapsing)	Proximate	Identical	Excluded
Wave phase (partner)	Distinct	Unique	Available
Entanglement	Not entangled	Coupled	Entangled

2.3. *Only fermion events are observable*

Observations are only possible at fermion collapse events, but not for the intermediate sub-physical propagation. Indirect observation of fermion events is possible through a network of fermion events. For example, if the oscillators of a fermion are wholly conserved and confined over its propagation sequence $\mathbf{A} \to \mathbf{D}$ (fig.1), then any external sensing oscillators are interacting with the virtual antiparticles at **B** or **C**, or other wrappers of confined 'layers', rather than the fermion itself at **A** or **D**.

Observed properties (or net cross sections) may vary according to the combinations of possible collapse sequences in the network, especially with 2nd and 3rd generation fermions (3.10).

2.4. *Observation follows the mass, not the vacuum*

As classical observers, we commonly privilege the more massive oscillators because we can follow them, and it's experimentally challenging to follow the lesser-mass vacuum oscillators. This is like observing the Brownian motion of a pollen grain in a fluid.

In this representation, neither mass is more fundamental than the other, and all oscillators are conserved while fermions are created and annihilated.

An observed 'free fermion' is likely an oscillator with high mass. As it propagates over many collapse events, it shares its shell with many low-mass oscillators in turn, likely from vacuum, that enabled its collapse.

3. Standard phenomena

3.1. *Vacuum*

Immediately after a fermion event, the fermion exists not as a point, but as a radiating shell of oscillators (rule 2). We structure the vacuum as many such oscillators that radiated from previous fermions. These instances of discrete 'vacuum energy' have the same structure as the objective fermions of interest.

3.2. *Weak interaction*

Rather than considering the weak interaction as a distinct field, we identify it as the possible changes in the potential of the expanding shell. Component waves of Z and W bosons are spread over all oscillators in the shell, and the waves may collapse independently to change the potential (3.6.1).

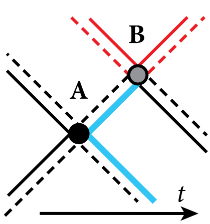

Fig. 2. $W^{\pm}$ boson: solid lines from **A**.

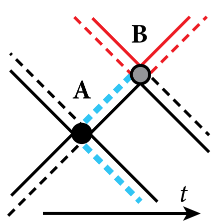

Fig. 3. Z boson: dashed lines from **A**.

- The $W^{\pm}$ *bosons* are the two available waves from fermion **A**, with non-identical phases, and mass that induces interactions with other oscillators.

- The Z *boson* is the excluded output of fermion **A**. By rule 3, “waves having the same phase and source are excluded from interactions”, which screens the Z boson until fermion **B** at t_2, which is a vacuum interaction with a non-excluded wave from fermion **A**. After **B**, the remaining oscillator from **A** is available as a superposition of two entangled waves expressing conjugate masses, like a Majorana particle.
- The *Goldstone boson* (fig.4) is all waves output from a fermion. For example, for first-generation fermions, two of the four waves are non-excluded at any given time, until both its oscillators are collapsed, resembling the doublet of the scalar Higgs field.

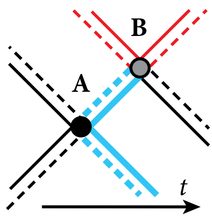

Fig. 4. Goldstone boson: all lines from **A**.

3.2.1. *Reinterpreting ‘spontaneous’*

If we were to regard vacuum as ‘background’ or a field, and ignore its discrete nature, then we could only interpret vacuum interactions as spontaneous and random. However, with our mechanism, the vacuum is accountable, we can trace instances, and oscillators are classically attributable. We find a unified mechanism, but not a unified field, for gravitation and interactions of the standard model.[2] With some compromises, we can convert their statistics into fields.

3.3. *Bosons*

Shells are always *bosonic*, having an even number of non-excluded waves available for interaction at any given time:

- *Weak-broken* (3.2) shells have two waves as one oscillator. Neither wave is excluded unless is shares the same phase with another wave on the shell (2.1).

- Unbroken shells have one non-excluded wave from each of two oscillators on the shell. Oscillators may collapse independently, and when one does, any co-excluded waves in other oscillators are weak-broken and become available for interaction.

3.4. *Higgs boson*

Mass generation (rule 4) and the modulating effect of mass (rule 5), are intrinsic to the structure of every oscillator, and the mass propagates with every oscillator collapse. We avoid extrinsic bosons and couplings.

3.5. *Virtual particles*

For a 'free' fermion **A** to reconstitute as fermion **D** (fig.1), vacuum instances pair with components of **A** to create intermediate 'virtual particle' antifermions at **B** and **C**. On leaving **A**, the waves that collapsed the fermion are excluded because they have identical phase and source (rule 3). Only after **B** and **C** are those waves again available to collapse to **D**, a similar fermion to **A**.

Another example of a virtual particle is vacuum self-interaction. A vacuum oscillator may interact with another vacuum oscillator to create a fermion. This can be conserved, or it more likely radiates to vacuum.[3]

3.6. *Particle size*

A conserved free fermion interacts with vacuum to reconstitute around the same area in space (3.5). We derive the 'size' of this fermion from the mass of the vacuum instances and the mass encoded in the fermion's shell.

The probability $P_H(r)$ of an expanding single-oscillator shell interacting with vacuum having uniform mass and phase distribution, where p is the proportion of the phase cycle available for interaction due to mass ρ,

$$P_H(r) = p^r(1 - (1-p)^{\frac{dV(r)}{dr}}), \tag{3}$$

integrates to a 50$^{\text{th}}$ percentile Compton radius,

$$r = \frac{\ln 2}{\rho}, \tag{4}$$

for non-overlapping phases of a shell.[1]

The profile of this interaction (fig.5) is asymptote-free, and contrasts with the standard inverse-power profile of charge and gravitation. This asymptotic freedom is distinct from the screening provided by exclusion.

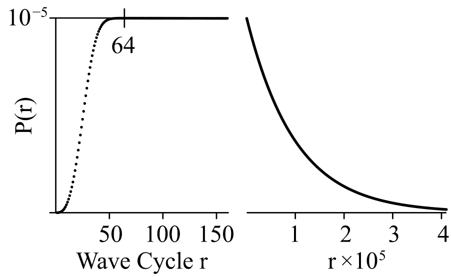

Fig. 5. Plot of eq.3, for $p = 10^{-5}$.

Our profile removes the ghost bosons required to explain deviations from singularities and asymptotes. Without vacuum, an oscillator would propagate radially at light speed, and the probability of interaction with anything else does not diminish with radius. With vacuum, or any other trigger for wave collapse, the probability falls off with radius.

The asymptote-free profile also infers wells of 'lowest potential' for various phases, energies, and distributions of matter and flux. We can use these distances to infer parameters for our wave phases.

3.6.1. *Composite collapse functions, SSB*

Modulation acts independently for each wave, so mass values are non-associative, and cannot be accumulated nor canceled.

For homogeneous weak-broken *vacuum* oscillators, we can assume positive and negative mass magnitudes are identical. The pre–weak-broken function is

$$[-\rho_1, -\rho_2][+\rho_{\text{vac}}, -\rho_{\text{vac}}], \tag{5}$$

and the post–weak-broken function is either

$$[+\rho_2, -\rho_2][+\rho_{\text{vac}}, -\rho_{\text{vac}}], \tag{6}$$

or

$$[+\rho_1, -\rho_1][+\rho_{\text{vac}}, -\rho_{\text{vac}}]. \tag{7}$$

Table 2 summarizes these by boson and wave elements. Doublet techniques for degeneracy and spontaneous symmetry breaking are useful here.

Table 2. On-shell mass ρ, to modulate other bosons.

Oscillator	Wave	Emitted	Weak-broken option 1	Weak-broken option 2
1	1	excluded	off-shell	$+\rho_1$
	2	$-\rho_1$	off-shell	$-\rho_1$
2	1	excluded	$+\rho_2$	off-shell
	2	$-\rho_2$	$-\rho_2$	off-shell

3.7. *Electromagnetism*

An external boson may pass through the propagation sequence on path **AB**, **AC**, **BD**, or **CD** (fig.1), and the flux enables a spatial displacement from **A** to **D**, as an exception to the uniform directionality of vacuum displacements. This is how we represent charge, electromagnetism, and electrodynamics.

3.8. *Coherence*

Plasma is the state where matter fails to reconstitute consistently, and fermions have no continued identity.

For oscillators of high mass, in a vacuum of low mass oscillators, we picture a conserved fermion having Brownian-like motion while it retains its full identity with confined component oscillators.

An electromagnetic interaction has decoherence with the interchange of oscillators, but we can 'watch' the oscillator with high mass and think of it as conserved because we observe its propagation.

If we then consider a confined composite, say of quarks, their interaction radius (eq.4) will be small, compared that of oscillators from the environmental vacuum. Increasing numbers of environmental oscillators or the input of high-mass oscillators, increases the probability of the composite structure becoming decoherent.

Where there is no recurring composite structure, and we can identify two masses of components, we regard the oscillators as a plasma. With the lighter components as a flux for the heavier components, the plasma has electromagnetic charged interactions.

3.9. ***Matter and antimatter***

An oscillator has two waves, separated by $(0.25 + \rho)$ cycles. At a fermion event:

- For matter, partner waves lag by ≈ 0.25 cycles.
- For antimatter, partner waves lead by ≈ 0.25 cycles.

Treating this as an oscillator, the collapse-triggering wave is the reference wave, with the partner wave as the order term. This determines the sign of both its phase modulation and angular momentum.

Because the waves having $\phi = 0$ are excluded after the fermion event, its first oscillator may collapse (as the weak interaction) with opposite-signed mass and modulation direction. This typically leads to a repeating sequence,

$$\mathbf{A} \to \mathbf{BC} \to (\mathbf{D} = \mathbf{A})... \tag{8}$$

of alternating matter and antimatter (fig.1), noting that antimatter-matter-... sequences are an equally valid perspective.

Mass ρ (eq.2) modulates the phases of other overlapping waves (rule 5), allowing a oscillator with mass to collapse other oscillators having non-excluded waves with a phase between $-\rho$ and 0 at the point oscillators overlap. We call this a *phase window*.

Positive and negative mass therefore have access to different phase windows of vacuum energy or confined flux. After a weak interaction (3.2) on a shell, both waves of the remaining oscillator are non-excluded, so it carries both signs of phase modulation, for a phase window twice as wide as a single non-excluded wave. This availability enables vacuum flux to flow through fermion networks (3.7) without the need for intermediate fermions of opposite sign.

3.9.1. *Matter-antimatter asymmetry*

- Matter interacts near 0 cycles, and relatively,
- Antimatter interacts near 0.25 cycles.

Their partner waves are near 0.25 cycles for matter, and near 0.75 cycles for antimatter.

This results in a different collapse radius for each wave of an oscillator, which affects all interactions. This is most significant at the smallest distances $l_P/4$ and highest energies, and the imbalance lessens at large distances and lower energies as the probabilities even out. This violates matter-antimatter symmetry,[2] making vacuum polarization more probable at high energies, like big bang fermiogenesis.

3.9.2. *Matter-antimatter labeling*

It might be misleading to classify the *fermion* with a matter or antimatter status, when *oscillators* carry the sign information and mediate the charge-like behaviors. It's possible to label fermions with matter/anti-matter labels because we privilege oscillators of higher mass as representing the fermions, and thus attribute the matter/anti-matter label to the fermion.

3.10. ***Generations, flavors, strong force***

3.10.1. *Fermion types and generations*

The fermion types (quark, electron, neutrino) are combinations of oscillators with high mass A and low mass B (6.1.1).

We define generations by the number of oscillators with non-excluded waves that interact at the fermion event. For example:

- A first-generation fermion event collapses non-excluded waves from two shells, one oscillator on each shell, like fermion event **A** (fig.6).
- A second-generation fermion event has 3 collapsing oscillators, as one shell of two oscillators, and one shell of one oscillator, like fermion event **E**.
- A third-generation fermion event has 4 collapsing oscillators, as two shells of two oscillators each, like fermion event **D**. This implies that none of the shells are yet weak-broken.

3.10.2. *Fermion flavor up-type, down-type*

Propagating quarks or leptons have the expected W boson decays:

- *Up-type* as before the weak interaction.
- *Down-type* as after the weak interaction. The down-type shell has one fewer propagating oscillators than the up-type shell.

We represent decay modes as changes of oscillator count, between one instance of a fermion and its next reconstitution, via two anti-fermions.

Table 3. Properties for fermion generations 1, 2, and 3.

Entity Generation:	3rd	2nd	1st
Quark (A, A)	b, t	s, c	d, u
Lepton (B, A), (A, B)	τ	μ	e
Neutrino (B, B)	ν_τ	ν_μ	ν_e
Collapses oscillators[a]	4	3	2
Collapses non-excluded waves[a]	4–8	3–6	2–4
Collapses oscillators of shell 1[a]	2	2	1
Collapses oscillators of shell 2[a]	2	1	1
Collapses weak-broken oscillators[a]	0	1–2	0–2

[a] "Collapses..." numbers are counts.

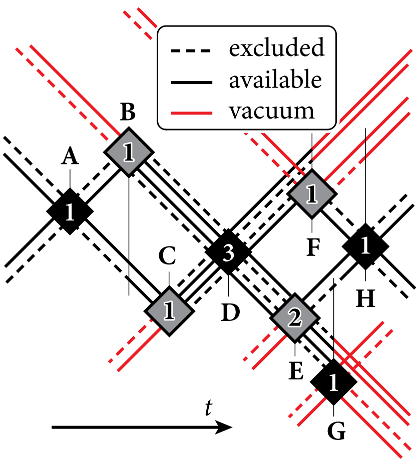

Fig. 6. Example decay of a 3rd generation fermion **D**. Numbers show generation.

CKM matrices encode both the common up/down flavor changes, and the decays over the sequence **A** $\rightarrow$ **D** (fig.1).

For example, to decay **D** (fig.6), via each anti-fermion **E** (2nd generation) and **F** (1st generation), a vacuum oscillator collapses an oscillator from **D** in a weak interaction, which removes the exclusion constraint for the remaining waves on the **D** shell. We show them here radiating to vacuum. The confined products of **E** and **F** can then combine as a 1st generation fermion **H**.

3.10.3. *Strong force*

We expect A (3.10.1) to be around $10^{-19}\ l_P$, for a 50th percentile quark collapse at around 1fm. Quark pair production is possible with electron-type (A, B) input, to provide another A with enough mass to compete with the coherence of existing quarks, like a plasma state (3.8).

3.11. *Photons*

We represent *photons* as paired oscillator impulses, which can be received by structures similar to their sources, having a frequency that may be derived from a sparse sampling of impulses;[1] compatible with creation and annihilation operators of quantum harmonic oscillators.

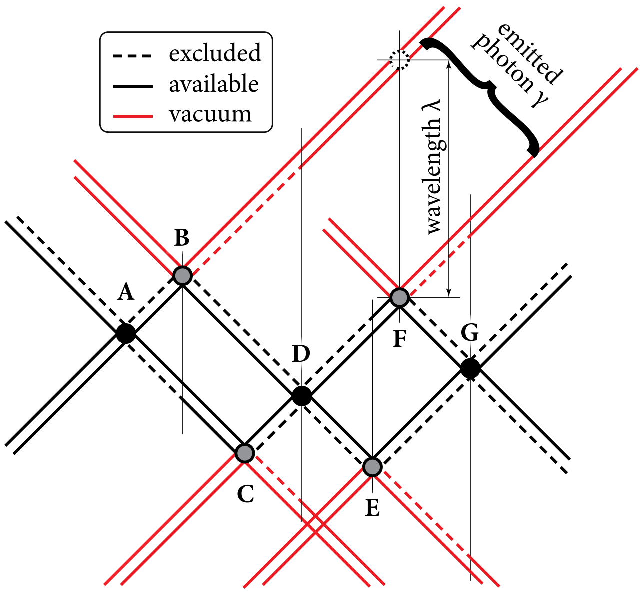

Fig. 7. Emission of a photon.

3.12. *Gravitation*

As with charge-based interactions, we represent gravitation as an attribution of flux origin, rather than a fundamental force. A large classical body collapses and re-radiates vacuum oscillators, which may in turn collapse fermions some distance from the body. As with all collapse events, the positional solution of collapse is directly between the respective points of origin (fig.8).

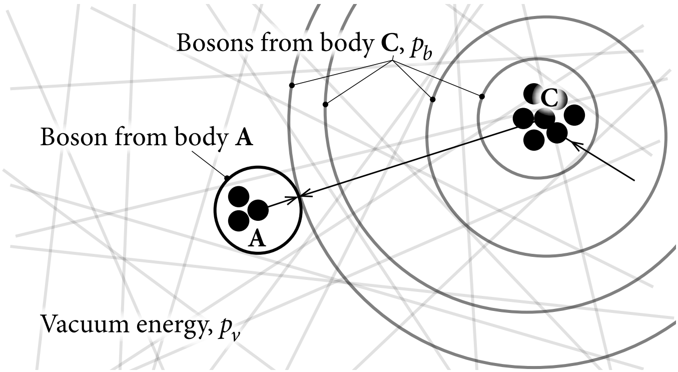

Fig. 8. Emission of a photon.

Negative mass does not infer repulsion. Instead, it changes the absolute phase where , and also changes the sign of phase modulation imparted to other overlapping oscillators (3.9).

4. Category theory

We can express the mechanism using category theory, with functors at abstract levels of the hierarchy. In each object, we identify inputs, intrinsic properties, functors, and outputs.

4.1. *Object hierarchy*

- *Oscillator* (skewed qubit), with two waves, mass generation as a function of the wave phases, and continuous propagation of phase with time.
- *Shell*, of propagating entangled oscillators. In a spatial context, shells radiate spherically.
- *Fermion event*, with collapse and re-radiation. Fermions are composable in time via intermediate shells, and in space as multiple instances.
- *Conserved fermion*, as a pattern for propagation over the idempotent sequence $\mathbf{A} \to \mathbf{D}$ (fig.1), as context-dependent expressions of collapse. **A** and **D** have the same total identity, composable in chains, but a looser definition can permit interchange of vacuum components.

- *Composite particle*, as a confined network of oscillators, with optional vacuum interactions. Sub-types of composite particles: bosons, hadrons, nucleons, atoms, and so on.
- *Vacuum*, as a collection of propagating shells, external to, or mediating, fermions or composites. In context of an arbitrary point in space, vacuum has flux statistics: a phase spectrum and a mass spectrum.
- *Classical body*, as a network of fermions, composites, and their flux. Aggregated objects at a larger scale are more difficult to represent, because systems are chaotic, and the boundaries between them are fuzzy.
- *System* or *Universe*, as the totality of all objects.

4.2. *Other emergent effects*

The *weak interaction* is a collapse that leaves an oscillator on the shell. We interpret this as an effect because it changes the availability of waves for collapse, and therefore the potential for further interaction. However, this is already covered in the object hierarchy.

Within the conserved fermion pattern, we have intermediate stages of fermion propagation: *decoherence*, *conservation* of separate parts with virtual antiparticles, and options of *decay* or *reconstitution* as a conserved fermion.[1]

5. Simulation methodology

We define the scene in flat $(3^+, 1^-)$ metric, and encode (fig.9) entities as fermions with the position and time of their collapse event (rule 6).

For each fermion, we list its bosons, and each boson has two wave phases (rules 1 and 4). From this data, we can infer:

- Exclusion from wave phases (rule 3).
- Mass of each boson, and its modulation signs.
- The radius of a shell of bosons at any given simulation time, from its fermion event time.

We test for collapse where spheres meet from different fermions (rule 6), and also test for the modulation condition (rule 5). Interactions are an n-body problem, which we're not optimizing yet. The steps are:

(1) Seed the scene with fermion events.

```
fermions: [
  {
    position: [-7.5651, 16.3342, -26.5382],
    time: -30.0,
    bosons: [
      {
        waves: [
          { phase: 0.0000 }
          { phase: 0.2501 }
        ]
      }, {
        waves: [
          { phase: 0.0000 }
          { phase: 0.2500 }
        ]
      }, // ...more bosons
    ]
  }, // ...more fermions
]
```

Fig. 9. Minimal data structure for simulating the mechanism, omitting id properties, and cached mass and exclusion.

(2) Test all combinations of fermions for events where spheres touch. We calculate the position and time of the interactions, regardless of current simulation time. We select events after the current simulation time.
(3) Order the events by their time of interaction.
(4) Commit only the first interaction to occur after the current simulation time, and repeat from step 2 as necessary.

At setup, and as the simulation runs, we continuously seed the scene with a history of distant fermion events, which then sweep over the experimental area of the scene as vacuum flux, to the required flux density and mass profile.

This simulation methodology does not need time-step processing, except to seed the vacuum flux, but can instead skip directly to the next fermion event, regardless of time or distance. We can currently process the simulation with a variety of exit or pause conditions.

5.1. *Initial results*

We recently reproduced emergent gravitation in an uncalibrated simulation (5), and results are available online.[4] The simulation view (fig.10) shades boson spheres by their on-shell mass. The fermions with large on-shell mass are at the centres of the sites of the two concentric boson re-emissions. In the dynamic simulation, the massive fermions demonstrated attraction and jittery orbits, mediated by the re-radiated vacuum flux. There are also instances of vacuum fermions collapsing in quantum fluctuations, shown in the figure as smaller circles in the surrounding space.

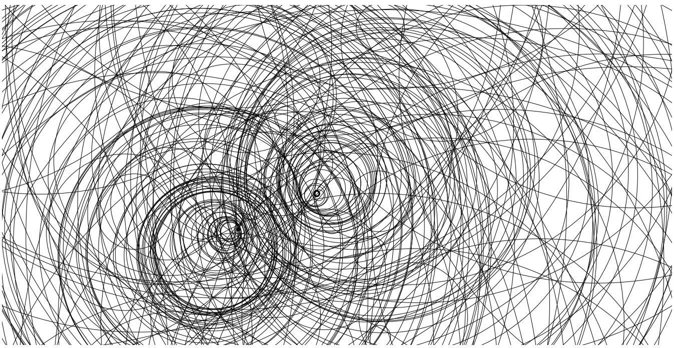

Fig. 10. SVG export of spherical bosons in simulation, displayed as a 2D projection of the 3D space. Line thickness represents on-shell mass.

5.2. *Analysis methods*

We are developing a task interface with JavaScript (interoperably a NodeJS worker or browser application) to build and run scenes with vacuum configurations and a hierarchy of matter systems. Analysis methods are:

- Single pass, intended for interactive viewing.
- Multi-pass PDF, with tracing criteria.
- Multi-pass trial, with Boolean criteria.
- Goal seek, to find input variables that meet criteria.

The simulation design includes global tracing, tagged tracing, text log, and event logs. The simulation viewer has timeline simulation and review, tracing interface and overlays, events and logs, and exports.

We'd like to use the exports in interactive web timelines and simulations, to demonstrate our work.

5.3. *Expectations from simulation*

We'd like to explore and demonstrate many aspects of physics, including:

(1) How the classical identity of fermions is associated with the larger mass oscillator, and how the full identity changes with charge interactions.
(2) Classical attribution of force carriers, and the quantum encoding of gauge fields.
(3) The effect of vacuum energy density on matter and its electrons (3.6).
(4) Structural coherence life cycles: fermions, composites, plasmas, and black holes.
(5) Classical dynamics.
(6) Relativistic dilation effects.
(7) Derive quark masses from the (A, B) parameter set (3.10) of mass values.
(8) Analytics on quark decay modes (3.10), to derive CKM and PMNS matrices from mass parameters.
(9) Strong force $q\bar{q}$ pair production.
(10) Trivially simulate a hydrogen atom, and more complicated structures, in a vacuum flux.
(11) Nuclear stability.
(12) Matter-antimatter vacuum polarization from unpolarized plasma soup (3.9.1).
(13) The exacting requirements for creating stable particles, in context of the opportunities on cosmological timescales.
(14) Vacuum statistics, as a variable for large-scale cosmological evolution and structure.

6. Unknowns

We need to find answers for the unknown aspects of our representation:

- Free parameters.
- Arbitrary design decisions or behaviors.
- Information incompleteness.

6.1. *Free parameters*

Our representation has just three free parameters:

- The two phase offset values for partner waves, which give mass values A and B (3.10).
- The fundamental wavelength of all oscillators.

6.1.1. *Mass parameters*

Ideally, we'd derive mass values for oscillators (3.10) A and B from geometric principles. Alternatively, we can constrain A and B if we take typical scales of interaction for baryons, electrons, and neutrinos, and apply eq.4,

$$A < 4.0 \times 10^{-18} \tag{9}$$

$$B < 2.9 \times 10^{-37} \tag{10}$$

The isolated values of A and B are lower than these constraints, because the typical scales of interaction include the vacuum that helps oscillators collapse. We need to recompute them using a flux approximation of vacuum.

6.1.2. *Are oscillators all Planck oscillators?*

Throughout, we assume that all waves have a fixed wavelength identical to the Planck length. This has implications for the precision of numbers needed for computation and simulation (6.2.5). We cannot arbitrarily scale the simulation without also changing quantized results.

6.2. *Design decisions*

6.2.1. *Mass modulation function*

We have no fundamental basis for how mass modulates phase (rule 5), with two undisproved options, depending on units used and shaping:

$$\rho = \phi_B - \phi_A - 0.25 \tag{11}$$

$$\rho = \cos 2\pi(\phi_B - \phi_A) \tag{12}$$

6.2.2. *Positive and negative mass modulation*

We chose to evaluate each wave separately rather than accumulate all values, or accumulate all values of sign. This allows an oscillator to collapse only the qualifying oscillators on another shell.

6.2.3. *Commit modulated phase at collapse*

Does fermion collapse (rule 6) commit modulated phase to actual phase?

There is also a sub-choice of whether to commit one or both waves. Speculatively, oscillators could then drift through phase with each collapse.

This would lessen universal synchronicity for a more relativistic view, allow dark matter in unobserved phases bands, and allow more quantum tunneling. Given that mass values are tiny (6.2.5), we think phase drift would annihilate or tunnel too many fermions, unless phase drift was self-correcting in larger systems.

6.2.4. *Homogeneous vacuum phase distribution*

Are the fermion events of vacuum flux homogeneous over the whole phase range, or is it localized around phases where matter collapses?

6.2.5. *Numeric precision*

Eq.4 shows an inverse proportionality between the phase window of an oscillator and its expected interaction distance, centered around '1' being Planck length.

The numeric precision required to cover this range is not supported by double-precision [IEEE-754] commonly used in computer hardware.

We need precision of at least $2u + v + w$ significant figures, or $(2u + v + w)(\ln 10)/(\ln 2)$ bits for mantissa, where $v = 12$ significant decimal figures at both the 50th percentile radius of interaction $10^{u} l_P$, and at its reciprocal phase value $10^{-u} l_P$, with $w = 10$ more digits beyond 50th percentile.

BigNumber libraries like decimal.js[5] can compute with arbitrary precision, with code written differently, and slow execution.

Table 4. Numerical precision required to simulate energies at scale $10^{u} l_P$.

Scenario, Radius	u	digits_{10}	bits_2
Planck scale	1	24	80
Weak itneraction	18	58	194
Strong force	19	60	200
Naive atom	24	70	233
Human scale, 1 mm	31	84	280
Human scale, 1 m	35	92	306
Observable universe	60	142	472

6.3. *Information incompleteness*

Our mechanism (1.1) conserves all oscillators, while creating and annihilating fermions using those oscillators as components. It does not address how all the oscillators of the universe originated.

We could conjecture to modify the modulation function (rule 5, 6.2.3), to split off any modulated value into new units, and destroy units when values cancel, conserving mass.

Fundamentally, interacting systems need only have two states and a means for them to couple.[6] Our oscillators couple unique states by continuously changing phase over emergent space. We do not explain how:

- Phase emerges into a manifold with a flat metric, aside from geometric algebra inferring dimensionality of only 3 or 1.
- The universe is a set of oscillating information units.

Other authors have described how to create a universe of discrete units. For example, Bastin, Kilminster, Noyes, Etter, Manthey explored a 'bit-bang' hypothesis.[7] Rowlands explored a 'rewrite system' as a fundamental basis for a single unit to self-replicate.[11]

Our single algebraic basis for waves evolved as follows: We explored geometric algebra,[8] to transform closed and open terms in 16-dimensional expansions symmetric in dihedral bases $3 \times \mathrm{D}_2$,[9] then as oscillators in continuous bases $3 \times \mathrm{C}_2$,[10] and finally using just one of the C_2 bases to provide a physical context for information.

As-is, our mechanism offers insights into all but the first phases of the 'big bang' hypothesis, but we're not committed to big bang as a satisfactory explanation.

7. Conclusions

Our representation encodes phenomena of the standard model, and gravitation, in a single uniform mechanism. It does not describe a unified field, because that would summarize the discrete interactions as statistics, losing vital information at high energies, along with complications with the uncertainty principle.

We eagerly anticipate simulation results, and to offer values for parameters, or insights into mechanics, that are difficult to discover by other means.

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