Global symmetries recovering

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Abstract

A new charge is postulated in a finite, closed, Euclidean discrete space to restore all fundamental symmetries on a global level. Gravity emerges as a residual effect of the electromagnetic force in this scenario, resulting in a deterministic toy universe driven by a single input parameter. This is not an interpretation of Quantum Mechanics, but a deeper attempt to describe nature.

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1 Introduction

Wheeler [1] coined the aphorism 'it from bit'. With this, he meant that anything physical, any *it*, derives its existence from discrete binary choices, or *bits*. This gives support to the notion that information has an ontological nature. The concept implies that physics, particularly quantum physics, isn't really about reality, but just our best description of what we observe.

In this regard, cellular automata (CAs) are mathematical idealizations of physical systems in which space and time, an evolution parameter, are discrete. Their attractiveness comes from the notion that simple rules can lead to very complex behavior, tending to long and interesting evolutions.

An alternative representation of the universe is developed in this work using the cellular automaton paradigm. The theme has been explored for a long time (see [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12] for example). However, these studies generally remain in the abstract realm or present very limited models. Here, a full **4+1** core specification is posited. Although it is a qualitative analysis for the time being, the model is amenable to immediate computational investigation.

Just classical logic and plain integer math, along with a hint of topology, are used in the dynamics.

It will be clear that foundationally this is not an interpretation of Quantum Mechanics, but a deeper attempt to describe nature.

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2 Space and time

A collection of $2L$ coexisting $SIDE^3$-sized Euclidean lattices each, closed on themselves as three-dimensional tori, represents an absolute inertial reference frame. Each cell contains an equal amount of information (a *register*) and are synchronized by a common time $t \in \mathbb{N}$, exchanging information with its nine neighbors only (six in dimensions xyz, two in dimension u and one in dimension v). This exchange is done alternately, so time homogeneity is recovered at each two clock ticks, configuring a *cellular automaton.*

The single input parameter $SIDE$ was estimated from the size of the observable universe at a fraction $(1/8)$[1] of the Planck scale as

$$\begin{aligned} SIDE &= 2^{order}, \\ &\approx 6.582 \times 10^{63}, \end{aligned}$$

where $order = 212$. The arithmetic uses $SIDE$ as module.

The torus is the simplest topological structure capable of holding a 3D universe and charge quantization. The finitude of the universe is a necessary condition to reach this quantization (Smith [13]). Cosmological observations favor a multi-connected rather than a simply connected universe (see Lachieze-Rey and Luminet [14]).

3 Bubbles

Each register contains six bits of charge d, c_2, c_1, c_0, w, q, a few integer variables, e.g., $b, f, \phi, \varphi, noise$, and four integer vectors $\boldsymbol{p}, \boldsymbol{s}, \boldsymbol{o}, \boldsymbol{pole}$. Most properties spread to the expanding cells, with the exception of the vector $\boldsymbol{p}$, which is passed to a single cell in its path.

A *bubble* is an expanding spherical wavefront of information organized on the registers. One extra variable named *code* is used to qualify bubble superpositions.

A bubble is eventually reissued from a point calculated on its surface by resetting the origin vector ($\boldsymbol{o} = \mathbf{0}$) when interacting with other bubbles. Case, Rajan and Shende show in [15] that the accommodation of the wavefront takes $2D$ clock ticks (one light step), where D is the cube diagonal, so bubbles expand with the same speed c, increasing $|\boldsymbol{o}|$ in the occupied registers.

Each bubble lives in a separate 3d-space L_i, $i = \{1...2L\}$ to avoid propagation issues. F superposing bubbles with a common bond $b_j = B$, $j = \{1...F\}$, have frequency $f_j = F$. Two such bubbles with some or all opposite charges is called a *pair.*

Bubbles also have a sinusoidal phase ϕ coupled to f, achieved by a recurrent algorithm. Together with the related variable φ, they implement interference and self-interference (see Sciarretta [11]). Each occupied register has $\varphi = \phi$, which decays as

$$\varphi^{k+1} = \varphi^k \left(1 - \frac{1}{2k}\right)$$

at each *light step* k. During wavefront accommodation the value of *noise* is updated and latter compared with $|\phi + \varphi|$, which indicates whether a bubble-bubble interaction is legal — this produces the observed harmonic behavior at the ensemble level.

Charges are represented by bits. The new *dualitat* charge d was introduced to preserve symmetries on a global level. The *electric* charge q is associated as ever with attraction/repulsion. The three *color* charges c_2, c_1, c_0 enforce the strong force structure. Let

[1] The exact granularity will be obtained when it is verified that the model generates the same number of particles present in the universe.

signature be $sig = c_2 + c_1 + c_0$. A bubble is matter M if $sig < 2$, or antimatter $\overline{M}$, otherwise. Also, it is neutral N, if $sig = 0$ or anti-neutral $\overline{N}$, if $sig = 3$. The definition $color = 2^2 c_2 + 2^1 c_1 + 2^0 c0$ will be used latter. On the other hand, the *weak* charge w, or *chirality*, is associated with congruence.

Vector $\boldsymbol{p}$ is related to motion direction, while vector $\boldsymbol{s}$ to spatial rotation. I will refer to them as *momentum* and *spin* for convenience. The cell on the surface of the bubble pointed by vector $\boldsymbol{p}$ from its own center is defined as its *pole*.

Finally, a loose association between the terms *bubble* and *(unit of) energy* is assumed.

4 Interactions

4.1 Basic rules

Interactions are evaluated at the last tick of the wavefront accommodation. Prior to interaction, the frequency and noise variables of the bubbles are updated. Superposing bubbles are classified according to their charge content.

When a bubble is reissued after interacting with another bubble and, in addition, their poles coincide, all bonded bubbles are also reissued, characterizing an ontological *collapse*. The possibility of the collapsing parts having a space-like separation is supported by the fact that the phase of accommodation of the wavefront lasts $2D$ ticks, sufficient for the information to propagate to all regions of the lattice.

4.2 Interactions

The detailed algorithmic description of all interaction rules is contained in the Appendix. Half of the cells are active, while the other half are passive, alternating roles in time. The basic loop consists of the following steps

- **Commute**
  The active/passive roles are exchanged and data from the active cells are copied to the passive cells.

- **Update**
  Passive cells are shifted in the v dimension and compared until a complete loop of $SIDE^2$ steps. Properties such as the frequency are updated.

- **Interact**
  After having data being copied back to the active cells, again, the passive cells are shifted in the v dimension and compared for possible interactions, which are encoded in the *code* variable.

- **Expand**
  All bubbles expand one light step in their respective xyz sub-lattice, constrained by the *code* variable content.

4.3 Initial state

Let S be the number of states resultant of the combination of all register values, all positions in the lattice and all bubbles L. From any state k, the system eventually enters an endless period loop T_k with definite net Shannon entropy. The real world corresponds to one of these loops with $T_R \ll S$.

Among the countless possibilities, I choose the following platonic solution for the initial state problem. A total of $L \equiv SIDE^2$ bubbles are uniformly distributed on the $z = 0$ plane of the lattice at start up, the *hologram*. Since $SIDE\,\boldsymbol{mod}\,3 = 1$, one single row of the hologram has all $s_x = s_y = 0$, $s_z = \pm SIDE/2$ and $d = s_z \geq 0$, inducing one topologically trapped magnetic monopole, per sector, in line with Smith [13]. The momentum vectors, in turn, receive the value $\boldsymbol{p} = \boldsymbol{k} \times \boldsymbol{s}$, where $\boldsymbol{k}$ is the z direction.

We are done with the axiomatic part by now. In the remainder of the paper, the arguments give support to the choices made and compose a minimalist interpretation, carefully avoiding unnecessary speculation.

The system evolves through this *unphysical era* until it reaches a stationary sequence of states, the very very long *physical cycle* of period T_R. During the unphysical era, most bubbles are annihilated, creating a vacuum, both in *Orbis*, the sector with $d = 0$, or in the *Dark Sector*, with $d = 1$. The remaining bubbles within each sector, segregate on islands of same size with positive or negative charges (charge quanta) due to the aforementioned monopole. Antimatter tends to migrate to the Dark Sector due to inter sector interactions. Observe that masses from Orbis are not seen from the Dark Sector and vice versa.

4.4 Packets

Each region of space contains a homogeneous distribution of electrically neutral superposing bubbles (zero-point energy, or a vacuum), basically photons and Z particles, but also the charged W bosons, whether completely or partially formed. Some of these bubbles are recruited via the messenger interaction above, being dynamically added to a local *packet* of bonded bubbles. If the packet contains colored or neutral bubbles with $f = 1$, different pairs will be captured from the vacuum.

Meanwhile, other bubbles wander away from the packet (dissipation) such that, when combined with the inherent non-linearity of the underlying system, an equilibrium situation is reached including many *propellers* (see definition below), configuring in this way the *mass* of the packet. The non-equilibrium caused by nearby charges or masses can change the motion of the packet.

Packets possessing a quantized set of bubbles with $f = 1$ will have a collective "fermionic" character, while the pairs overlaid with anti-aligned spins give a packet a "bosonic" character, distinguished by their charge balance. The exception are the neutrino fragments, formed as NN (ν) or $\bar{N}\bar{N}$ ($\bar{\nu}$) with their aligned spins, which, even possessing $f = 2$, also present a "fermionic" character. In other words, if the packet includes a (quantized) population of bubbles with $f = 1$ identical charge q then we have a *fermion*. Rather, if the population is formed by equal net weak charge, we have a neutral massive *boson*, and if the pairs also have non trivial electric balance then we have a charged weak boson. If, diversely, color is envolved and $f = 1$, we have a quark fragment. Finally, if these bubbles are combined in pairs with the same non-neutral color, then we have a gluon fragment. The exception to the rule is the photon, which is an expading shell 'packet'.

Ephemeral resonance states, including radial vibration modes[2] (see Itô [16]) induced by the presence of neutrinos (which also help to conserve angular momentum), are also possible, adding to the formation of a mass spectrum.

The *Hofer effect* is the expected tendency for all spins of a packet to align radially either inward or outward (spin up/down), as predicted in Hofer [17]. In that work, there is an explanation of how magnetic effects emerge from symmetry breaking of this spherical pattern.

[2]Empirically in three generations of leptons and quarks.

4.5 Long range energy exchange

A pure *photon* γ is a multipair ($f = 2n$, $n > 0$) where each pair has all its charges in opposition. A photon fragment bonded to a packet is dubbed a *propeller*.

The long range behavior of photons is due to the absence of other bubbles with the same b value to allow an inertial interaction (not a propeller), interacting instead either as a light-matter scattering or a refraction process above.

It may happen that two bubbles in a packet, when interacting as above, are re-emmited from the same point, that is, their poles coincide, so a pair is formed. These coincidences may repeat so that overlapping of many bubbles having a common b value becomes possible. If they move away stimulated by another bubble-bubble process, a photon is released — spontaneous emission being a special case for faint fields. In other words, photons are normally released in an atomic electronic decay, shaped by the spherical harmonics originating from charge quantization. This is the main explanation for the ubiquitous presence of all sort of quanta. The primary quantized quantity, is truly the electric charge.

Photons also come similarly from *bremsstrahlung*. In this scenario, the spectrum is continuous since it has nothing to do with spherical harmonics.

The messenger *versus* bubble interaction also implies that photons may lose components while traveling (photon aging) thereby supporting General Relativity observations and the CMB.

4.6 Weak decay

No randomness is involved in the calculation of the interactions, so the model is in fact deterministic, but the ubiquitous presence of weak charges imply in an apparently random decay of particles. The W^- and Z bosons, even if not completely formed (virtual particles?), are responsible for it.

4.7 Higher order particle structures

When reorganizing after a collapse, bosons and fermions can be formed in a variety of ways, spins can be flipped etc. With all these ingredients, bound states of the strong and electromagnetic forces are a natural consequence.

5 Discussion

G. 'tHooft [12] shows that systems of this type can be associated to a permutation operator and, therefore, can be mapped to a large Hilbert space. Thus, at least in principle, all the machinery of operator mechanics, in particular the Schrodinger equation, can be used to analyze them — the point here is that the system certainly presents a quantum behavior. In this context, Born's rule arises naturally without the need to be postulated, bringing with it quantum probabilities. Perhaps new analysis tools should be devised to explore the model in search of physics beyond the Standard Model.

Last but not least, a gravity-like dynamics emerges as a residual effect of the electromagnetic force (see also Assis [18]) — the halos formed in the sea of messengers around the masses caused by the absorption of messengers (perceived as not shielding because of the relatively low number of messengers absorbed) causes an imbalance in the distribution of momentum, resulting in an always attractive phenomenon, or gravity.

The model is non-local under the light-time basis, though being strictly local, but no signaling is possible at any classical limit. An intuitive argument allows us to associate

$SIDE$ to the much sought for cardinality of natural numbers $\aleph_0$ (see Asperó and Schindler [19]) — the maximum number with physical meaning in the universe is just $SIDE$.

We are, therefore, facing an ontological[3] economic framework on a subplankian scale. It promises to be robust at high momentum transmitted to the package / particle as in nature. The huge number of bubbles forming the particles — indeed a mini universe each — gives material support to superpositions and qubits. These rules can be refined, given sufficient computational power and programming support, and evaluated if they in fact allow building a predictive, *bona fide,* theory.

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Appendix: source code

Here are gathered all the rules of information exchange between cells of the cellular automaton. They are the essence of this work, intended to possess an **axiomatic** character.

I have used a C-like notation instead of traditional algorithm convention for clearness. The parameter ORDER comes from Section 2.