Recovery of global symmetries in a 't Hooftian universe

Alexandre Furtado Neto*

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ORCID 0000-0001-9435-6566

UNESP Alumnus

Abstract

All fundamental Planck scale symmetries are restored on a global level when a new charge is postulated in a finite, closed, Euclidean discrete space. 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. Randomness is identified using a Chaintin argument. Aleph0 definite value is tied to the size of the universe. 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.

*alexandre.com@yahoo.com

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

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

Finaly, the reader will be delighted when he sees that purely intuitive arguments are used, leaving out obscure or abstract concepts.

2 Space and time

2.1 The register

Each cell contains the same amount of information characterized by a bit string formatted as shown in the table below.

Name	Type	Symbol	Obs.
active	B	*on*	Cell role (stable/draft)
Physical properties			
charge	B6	*ch*	Bits d, c_2, c_1, c_0, w, q
momentum	V	$\boldsymbol{p}$	
spin	V	$\boldsymbol{s}$	
frequency	U	f	
affinity	U	a	Used to group bubbles in packets
Wavefront			
lifetime	U	t	
direction	U3	*dir*	
origin	V	$\boldsymbol{o}$	
synchronism	U	*sync*	
sine gen.	S	u, v	v carries the sinusoidal phase
Superluminal variables			
flash	U	*flash*	
pole	V	***pole***	
Footprint			
propensity	V	***vp0***	
Auxiliary data			
code	U4	*code*	Interaction code
noise	U	n	Interaction test
floor	U	*floor*	Sublattice index

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where U means unsigned integer, S signed integer, V three-dimensional integer vector and B a boolean. This structure is called a *register*.

2.2 The lattice

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 a register and are synchronized by a common time $t \in \mathbb{N}$, that is, they pulsate in unison, 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 $(1/2^{59})$[1] of the Planck scale as

$$\begin{aligned} SIDE &= 2^{order}, \\ &\approx 4.78 \times 10^{80}, \end{aligned}$$

where $order = 268$. 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]).

The space is endowed with memory, which records the visit of the particles. This contributes to the appearance of self-interference, as in the case of the double slit experiment. This scheme was originally conceived by Sciarretta in [11]. The main idea is to leave a copy of the visitor's momentum on the lattice, which decays following the rule

$$p[t+1] = p[t] \left(1 - \left(\frac{p_0}{t}\right)^2\right),$$

being eventually passed to the evolving bubble, which in turn decays as

$$p[t+1] = p[t] \left(1 - \frac{1}{2t}\right),$$

where p_0 is the momentum since the last transfer to the particle and t is the lifetime of the particle.

Taking all contributions into account in a typical tabletop experiment, after many repetitions, this value converges to the known QM probabilities involving a square root and a space-dependent sine function. Note that these expressions must be carefully adapted for integer arithmetic.

3 Bubbles

Most properties in the registers spread to the expanding cells (see table above).

A *bubble* is an expanding spherical wavefront of information organized on the registers. Whenever vector $\boldsymbol{p}$ aligns with vector $\boldsymbol{o}$, such a perturbation is cast. The von Neumann

[1]The exact granularity of the universal fabric will be obtained when it is verified that the model generates the same number of particles present in the universe. This provisional value was estimated using four times the Eddington number, thus taking into account electrons as well as antiparticles.

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neighborhood $Dirs$ is explored in a Case, Rajan and Shende algorithm from [15]. There they show that the accommodation of the wavefront takes $2D$ clock ticks (one light step, $LIGHT$), where D is the cube diagonal, so bubbles expand with the same speed c, increasing $|\boldsymbol{o}|$ in the occupied registers. In some cases, concurrent access to a common cell is attempted, being *per se* an undecidable problem. A tree algorithm is then Just classical logic and plain integer math, along with a hint of topology, are used in the dynamics, composing a constructive approach.used to overcome this limitation and select a path. Incidentally, this direction index behaves like a modulo 6 random number, being the basis for decision making in interactions (see Chaitin [17] arguing the intrinsic randomness of mathematics). Only time $LIGHT$ has physical meaning, the time tick is only for low-level sync.

A bubble is eventually reissued from a point calculated on its surface by resetting the origin vector ($\boldsymbol{o} = \mathbf{0}$) and/or aligning vectors $\boldsymbol{o}$ and $\boldsymbol{p}$ when interacting with other bubbles.

Each bubble lives in a separate 3d-space L_i, $i = \{1...2L\}$ to avoid propagation issues. F bubbles with a common affinity $a_j = A$, $j = \{1...F\}$, have frequency $f_j = F$, their *de Broglie frequency*. If two such bubbles with some or all opposite charges and having $\boldsymbol{o}_1 = \boldsymbol{o}_2$ (that is, superposing) is called a *pair*.

The bubbles also have a ϕ sine phase coupled to f, achieved by an integer-only recursive oscillator (see Turner [18]). Moreover, they leave a footprint of their passage every time they are re-emitted, consisting of the vector **o,** vector **p** and affinity a. They allow self-interference.

During wavefront accommodation the value of *noise* is updated using the selected direction index ($Dirs[index]$) and latter compared with $|\phi|$, 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 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 $color = 2^2c_2 + 2^1c_1 + 2^0c0$ will be used latter. On the other hand, the *weak* charge w, or *chirality*, is associated with congruence. Since the universe is closed, the addition of the dualitat charge is not an *ad hoc* solution, but actually guarantees this sense of 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, so energy is a conserved property, since bubbles are never created or destroyed. Vector $\boldsymbol{p}$ of each bubble never changes, so momentum is a globally conserved quantity also.

4 Interactions

4.1 Overview

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

When a bubble is reissued after interacting with another bubble and, in addition, their poles coincide, all bubbles with the same affinity are also reissued, characterizing an ontological *collapse*. The possibility of the collapsing parts having a space-like separation

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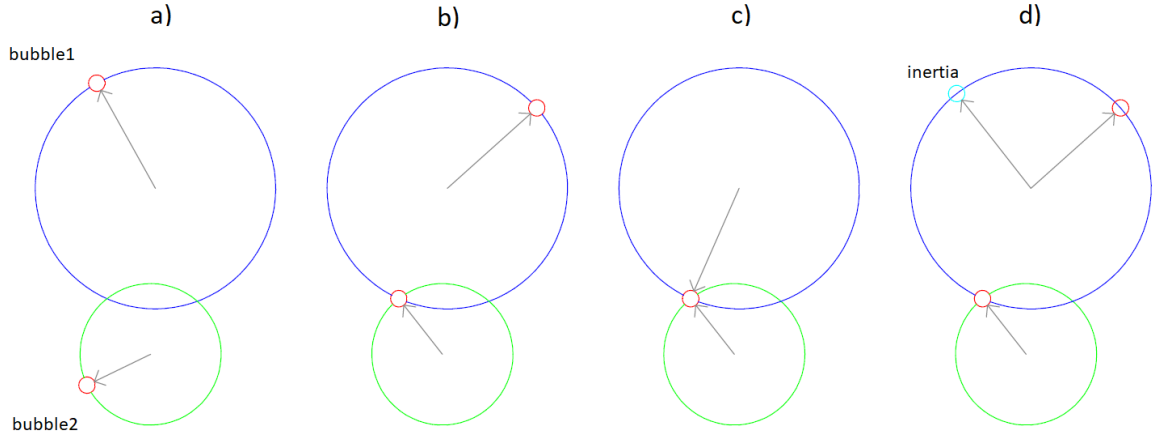
Figure 1: General interaction types.



Four types of interactions can occur when the surfaces of the expanding bubbles cross each other: *a)* phase only; *b)* reissue of the two bubbles; *c)* collapse; *d)* parallel transport (inertia). The red ball is the momentum cell, the arrow is the momentum vector. The cyan ball is the parallel transported point. See Section 4.1 for details.

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.

There are four possible results for the two interacting bubbles: *i)* they cross each other just changing their phases; *ii)* both are re-emitted from the contact point, *cp* (annihilation); *iii)* they are re-emitted from their respective poles (cohesion); *iv)* one is re-emmited from the *cp*, while the other from the parallel transported pole (inertia). Figure 1 depicts these cases.

4.2 Basic cycle

The detailed algorithmic description of all interaction rules is contained in the Appendix. Below I will make a brief description of those rules.

Half of the cells are active, while the other half are passive, alternating roles in time. The basic loop consists of the following steps

- **Pairing**
  Data is copied from draft cells to the stable cells.

- **Update**
  Draft cells are shifted in the v dimension and compared with their stable couterparts until a complete loop of $SIDE^2$ steps. Properties such as the frequency and pair classification are updated.

- **Interact**
  After having data being copied back to the stable cells, again, the draft cells are shifted in the v dimension and compared for possible interactions. Besides using the sinusoidal phase, all possibilities of charge content and overlapping are considered to complete the interaction detection, being finally filtered by the selection rules of empirical evidences, being enforced or supressed.

- **Expand**
  All bubbles expand one light step in their respective xyz sub-lattice. When momentum $\boldsymbol{p}$ completes a light step, it releases a new perturbation wavefront from its old

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position in the form of a *messenger*, the carrier of the static forces. The sinusoidal signal is also evaluated during this phase. Simultaneously, a superluminal signal, the *flash*, spreads at the maximum speed, helping to enforce the collapse mechanism.

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 $SIDE \, \mathbf{mod} \, 3 = 1$, 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.

4.4 Evolution

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, or Poincaré cycle. 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. Clearly, the two sectors coexist spatially.

4.5 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 same affinity bubbles. If the packet contains colored or neutral non-superposing bubbles, 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 *rest mass* of the packet. In other words, we have self-organization and entanglement[2]. The non-equilibrium caused by nearby charges or masses can change the motion of the packet, which in turn changes the effective mass.

Packets possessing a quantized set of non-superposing bubbles 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 $N\!N$ (ν) or $\bar{N}\bar{N}$ ($\bar{\nu}$) with their aligned spins, which cannot form

[2] A recent study supports this view (see Zhi-Bo Yang et al. [16]).

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pairs as above, and therefore also present a "fermionic" character. In other words, if the packet includes a (quantized) population of non-overlapping bubbles with 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 no overlapping, then 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[3] (see Itô [19]) 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 [20]. In that work, there is an explanation of how magnetic effects emerge from symmetry breaking of this spherical pattern, thereby supporting the Stern-Gerlach experiment.

4.6 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 having the same affinity of a packet is dubbed a *propeller*.

The long range behavior of photons is due to the absence of other bubbles with the same a 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 a 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.

4.7 Weak decay

No randomness is involved in the calculation of the interactions, so the model is in fact deterministic, but the ubiquituous 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.

4.8 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.

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

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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 Schrödinger 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. As a consequence, violation of Bell-type inequalities are expected, induced by the intrinsic non-locality. Perhaps new analysis tools should be devised to explore the model in search of physics beyond the Standard Model.

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 [21]) — the maximum number with physical meaning in the universe is just $SIDE$.

Last but not least, a gravity-like dynamics emerges as a residual effect of the electromagnetic force (see also Assis [22]) — 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.

We are, therefore, facing an ontological[4] 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[5], 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. No subroutines were used, nor were any optimizations attempted to keep the code as general as possible.. The parameter *ORDER* comes from Section 2.

```
/*
 ==========================================
 Toy universe source code

 Author: Alexandre Furtado Neto

 Version  : V1.2
 ==========================================
 */

// CA symbols

#define ORDER    268
#define SIDE     (1<<ORDER)
#define MASK     (SIDE-1)
#define DIAG     (2*MASK)
#define LIGHT    (2*DIAG)
#define LIGHT2     (LIGHT*LIGHT)
#define SIDE2    (SIDE*SIDE)
#define SIDE3    (SIDE*SIDE2)
#define SHIFT    (ORDER/2)
#define S    (SIDE/2)

// Physical symbols (used with variable code)

#define PHOTON     0x0010
#define GLUON    0x0020
#define NEUTRINO   0x0040
#define Z    0x0080
#define W    0x0100
#define ELECTRON   6
#define QUARK    7
#define FERMION    (ELECTRON | QUARK | NEUTRINO)
#define BOSON    (PHOTON | GLUON | Z | W)
#define COLLAPSE   0x02

// Color symbols

#define C_MASK     0x07
#define Q_MASK     0x08
#define W_MASK     0x10
#define D_MASK     0x20
#define NEUTRAL    0x00
```

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```
44
45 // Automaton cell structure (register)
46
47 typedef struct {
48   uint t;      // lifetime
49   uint3 dir;     // uint3: 3 bit unsigned int
50   bool active;     // sublattice
51   uint f;      // frequency
52   uint a;      // affinity
53   uint5 chrg;    // charge (d,c2,c1,c0,w,q)
54   uint o[3], p[3], s[3];   // vectors
55   uint vp0[3];     // mpmentum propensity
56   int phi;     // int: signed int with ORDER bits
57   uint noise;    // uint: unsigned int with ORDER bits
58   uint4 code;    // interaction result
59   uint sync;     // wavefront sync
60   uint u, v;     // harmonic phase
61
62   // Superluminal variables
63
64   uint flash;
65   uint pole[3];
66
67 } Cell;
68
69 // Macros
70
71 #define ISNULL(v) (v[0]==0 && v[1]==0 && v[2]==0)
72 #define ISEQUAL(v,u)  (v[0]==u[0] && v[1]==u[1] && v[2]==u[2])
73 #define RESET(v)  {v[0]=0;v[1]=0;v[2]=0;}
74 #define COPY(u,v) {u[0]=v[0];u[1]=v[1];u[2]=v[2];}
75 #define MOD2(v)   (v[0]*v[0]+v[1]*v[1]+v[2]*v[2])
76 #define ALIGNED(u,v)  (u[1]*v[2]-u[2]*v[1]+u[2]*v[0]-u[0]*v[2]+u
    [0]*v[1]-u[1]*v[0]==0)
77
78 Cell *stb, *draft;
79
80 /*
81  * Same code for all cells.
82  */
83 void main() {
84
85   ////////// STEP1: PAIRING //////////
86
87   Copy all variables from draft to stb
88
89   ////////// STEP2: COMPARE //////////
90
91   // Compare columns
92
```

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```
93    if (draft->t % LIGHT == 0) {
94
95      Shift 'vertically' all draft cells
96
97      // Compare 'columns'
98
99      if (stb->b == draft->b && ISEQUAL(stb->o, draft->o)) {
100       // Same sector?
101       //
102       if (((draft->chrg ^ stb->chrg) & D_MASK) == 0) {
103         // Do they have same affinity?
104         //
105         if (draft->a == stb->a) {
106           if (draft->code == COLLAPSE) {
107             stb->code = 0;
108             stb->f = 1;
109             stb->a = stb->floor;
110           }
111           //
112           // Are bubbles superposing
113           //
114           else if(ISEQUAL(draft->o, stb->o)) {
115             // Virgin?
116             //
117             if (stb->code == 0) {
118               // Pair formation
119               //
120               unsigned char cc =
121                 (stb->chrg & C_MASK) ^ (draft->chrg & C_MASK);
122               unsigned char ww =
123                 (stb->chrg & W_MASK) ^ (draft->chrg & W_MASK);
124               unsigned char qq =
125                 (stb->chrg & Q_MASK) ^ (draft->chrg & Q_MASK);
126               //
127               if (cc == 0 && ww == 0 && qq == Q_MASK) {
128                 stb->a = draft->a;
129                 stb->code = NEUTRINO;
130                 stb->f++;
131               } else if (cc == 0 && ww == W_MASK && qq == Q_MASK)
                    {
132                 stb->a = draft->a;
133                 stb->code = GLUON;
134                 stb->f++;
135               } else if (cc == C_MASK && ww == 0 && qq == 0) {
136                 stb->a = draft->a;
137                 stb->code = W;
138                 stb->f++;
139               } else if (cc == C_MASK && ww == 0 && qq == Q_MASK)
                    {
140                 stb->a = draft->a;
```

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```
141                     stb->code = Z;
142                     stb->f++;
143                   } else if (cc == C_MASK && ww == W_MASK && qq ==
                        Q_MASK) {
144                     stb->a = draft->a;
145                     stb->code = PHOTON;
146                     stb->f++;
147                   }
148                 }
149               }
150             }
151           }
152         }
153       }
154
155       /////////// STEP3: REPLICATE ///////////
156
157       // Once each light step
158       //
159       if (draft->t % LIGHT == 0) {
160         //
161         // Copy only variables that changed in compare()
162         //
163         stb->b = draft->b;
164         stb->f = draft->f;
165         stb->code = draft->code;
166       }
167
168       /////////// STEP4: INTERACT ///////////
169
170       if (draft->t % LIGHT == 0)
171       {
172         // Play pseudo dices against the sine phase
173         //
174         if (stb1->noise > abs(stb1->v) &&
175           stb2->noise > abs(stb1->v) &&
176           (!ISNULL(stb1->p) || !ISNULL(stb2->p))) {
177           // Preserve momentum for parallel transport
178           //
179           COPY(draft1->pole, stb2->p);
180           COPY(draft2->pole, stb1->p);
181           //
182           if (stb1->code == BOSON && stb2->code == BOSON) {
183             // Boson x boson
184             //
185             // Same sector?
186             //
187             if (((stb1->chrg ^ stb2->chrg) & D_MASK) == 0) {
188               // Gluon x gluon?
189               //
```

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```
190             if ((stb1->chrg & C_MASK) != 0 && (stb1->chrg & C_MASK)
                    != C_MASK &&
191                 (stb2->chrg & C_MASK) != 0 && (stb2->chrg & C_MASK)
                        != C_MASK) {
192                 // Exchange colors, ignoring other chrgs
193                 //
194                 draft1->chrg &= ~C_MASK;
195                 draft2->chrg &= ~C_MASK;
196                 draft1->chrg |= stb2->chrg & C_MASK;
197                 draft2->chrg |= stb1->chrg & C_MASK;
198                 //
199                 // Pole pole
200                 //
201                 // Copy momentum information for flash
202                 //
203                 COPY(draft1->pole, draft1->p);
204                 COPY(draft2->pole, draft2->p);
205                 //
206                 // Start flash flooding
207                 //
208                 draft1->flash = SIDE;
209                 draft2->flash = SIDE;
210             }
211             //
212             // Neutral 1?
213             //
214             else if ((stb1->chrg & C_MASK) == 0) {
215                 if((stb1->code & Q_MASK) == 1) {
216                     // Photon 1 or Z 1
217                     //
218                     if ((stb1->code & W_MASK) == 1) {
219                         // Photon 1
220                         //
221                         if ((stb2->code & W_MASK) == 0 && (stb2->code &
                                Q_MASK) == 0 &&
222                             (((stb2->chrg>>1) ^ stb2->chrg) & 1) == 0)
223                         {
224                             // Photon 1 x W 2
225                             //
226                             // Pole pole
227                             //
228                             // Copy momentum information for flash
229                             //
230                             COPY(draft1->pole, draft1->p);
231                             COPY(draft2->pole, draft2->p);
232                             //
233                             // Start flash flooding
234                             //
235                             draft1->flash = SIDE;
236                             draft2->flash = SIDE;
```

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```
237                     }
238                   } else {
239                     // Z 1
240                     //
241                     if ((stb2->code & W_MASK) == 0 && (stb2->code &
                            Q_MASK) == 0 &&
242                       (((stb2->chrg >> 1) ^ stb2->chrg) & 1) == 0) {
243                       // Z 1 x W 2
244                       //
245                       // Pole pole
246                       //
247                       // Copy momentum information for flash
248                       //
249                       COPY(draft1->pole, draft1->p);
250                       COPY(draft2->pole, draft2->p);
251                       //
252                       // Start flash flooding
253                       //
254                       draft1->flash = SIDE;
255                       draft2->flash = SIDE;
256                     }
257                   }
258                 }
259               }
260               else if ((stb2->chrg & C_MASK) == 0) {
261                 if ((stb2->code & Q_MASK) == 1) {
262                   // Photon 2 or Z 2
263                   //
264                   if ((stb2->code & W_MASK) == 1) {
265                     // Photon 2
266                     //
267                     if ((stb1->code & W_MASK) == 0 && (stb1->code &
                            Q_MASK) == 0 &&
268                       (((stb1->chrg >> 1) ^ stb1->chrg) & 1) == 0) {
269                       // Photon 2 x W 1
270                       //
271                       // Pole pole
272                       //
273                       // Copy momentum information for flash
274                       //
275                       COPY(draft1->pole, draft1->p);
276                       COPY(draft2->pole, draft2->p);
277                       //
278                       // Start flash flooding
279                       //
280                       draft1->flash = SIDE;
281                       draft2->flash = SIDE;
282                     }
283                   } else {
284                     // Z 2
```

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```
285                     //
286                     if ((stb1->code & W_MASK) == 0 && (stb1->code &
                            Q_MASK) == 0 &&
287                        (((stb1->chrg >> 1) ^ stb1->chrg) & 1) == 0) {
288                        // Z 2 x W 1
289                        //
290                        // Pole pole
291                        //
292                        // Copy momentum information for flash
293                        //
294                        COPY(draft1->pole, draft1->p);
295                        COPY(draft2->pole, draft2->p);
296                        //
297                        // Start flash flooding
298                        //
299                        draft1->flash = SIDE;
300                        draft2->flash = SIDE;
301                     }
302                  }
303               }
304            }
305         }
306      }
307      else if (stb1->code == FERMION && stb2->code == BOSON) {
308         // Fermion x boson
309         //
310         // Isolate chrg bits
311         //
312         unsigned c1 = (stb1->chrg & C_MASK) & C_MASK;
313         unsigned q1 = ((stb1->chrg & Q_MASK) >> 3) & 1;
314         unsigned w1 = ((stb1->chrg & W_MASK) >> 4) & 1;
315         unsigned d1 = (stb1->chrg & D_MASK) >> 5;
316         unsigned c2 = (stb2->chrg & C_MASK) & C_MASK;
317         unsigned q2 = ((stb2->chrg & Q_MASK) >> 3) & 1;
318         unsigned w2 = ((stb2->chrg & W_MASK) >> 4) & 1;
319         unsigned d2 = (stb2->chrg & D_MASK) >> 5;
320         //
321         if (d1 != d2) {
322            // SUPRESSED
323            // (Only same sector are allowed to interact in this
                  way)
324            //
325            return;
326         }
327         //
328         // Quark x gluon?
329         //
330         if (c1 != NEUTRAL && c1 != ~NEUTRAL && c2 != NEUTRAL &&
               c2 != ~NEUTRAL) {
331            if (c1 == ~c2)     // TODO why?? {
```

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```
332             // Blindly exchange colors, ignoring all other chrgs
333             //
334             draft1->chrg &= ~C_MASK;
335             draft2->chrg &= ~C_MASK;
336             draft1->chrg |= c2;
337             draft2->chrg |= c1;
338             //
339             // Pole pole
340             //
341             // Copy momentum information for flash
342             //
343             COPY(draft1->pole, draft1->p);
344             COPY(draft2->pole, draft2->p);
345             //
346             // Start flash flooding
347             //
348             draft1->flash = SIDE;
349             draft2->flash = SIDE;
350           }
351         }
352         //
353         // Quark x [photon, Z, W]?
354         //
355         else if (c1 != NEUTRAL && c1 != ~NEUTRAL) {
356           // Is it a propeller?
357           //
358           if (stb1->a == stb2->a) {
359             // Inertia
360             //
361             // Copy momentum information for flash
362             //
363             if (ALIGNED(draft1->o, draft1->p)) {
364               COPY(draft1->pole, draft2->p);
365               COPY(draft2->pole, draft2->p);
366             } else {
367               COPY(draft1->pole, draft1->p);
368               COPY(draft2->pole, draft1->p);
369             }
370             //
371             // Start flash flooding
372             //
373             draft1->flash = SIDE;
374             draft2->flash = SIDE;
375           } else if (q1 == q2) {
376             // Pole pole
377             //
378             // Copy momentum information for flash
379             //
380             COPY(draft1->pole, draft1->p);
381             COPY(draft2->pole, draft2->p);
```

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```
382                 //
383                 // Start flash flooding
384                 //
385                 draft1->flash = SIDE;
386                 draft2->flash = SIDE;
387               } else {
388                 // Pole pole
389                 //
390                 // Copy momentum information for flash
391                 //
392                 COPY(draft1->pole, draft1->p);
393                 COPY(draft2->pole, draft2->p);
394                 //
395                 // Start flash flooding
396                 //
397                 draft1->flash = SIDE;
398                 draft2->flash = SIDE;
399               }
400             }
401             //
402             // Electron x [photon, Z, W]?
403             //
404             else {
405               // Is it a propeller?
406               //
407               if (stb1->a == stb2->a) {
408                 // Inertia
409                 //
410                 // Copy momentum information for flash
411                 //
412                 if (ALIGNED(draft1->o, draft1->p)) {
413                   COPY(draft1->pole, draft2->p);
414                   COPY(draft2->pole, draft2->p);
415                 } else {
416                   COPY(draft1->pole, draft1->p);
417                   COPY(draft2->pole, draft1->p);
418                 }
419                 //
420                 // Start flash flooding
421                 //
422                 draft1->flash = SIDE;
423                 draft2->flash = SIDE;
424               } else if (q1 == q2) {
425                 if (w1 == w2) {
426                   if (c1 == c2 == 0 && w1 == 1) {
427                     // Pole pole
428                     // Copy momentum information for flash
429                     //
430                     COPY(draft1->pole, draft1->p);
431                     COPY(draft2->pole, draft2->p);
```

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```
432                     //
433                     // Start flash flooding
434                     //
435                     draft1->flash = SIDE;
436                     draft2->flash = SIDE;
437                   } else if (c1 == c2 == C_MASK && w1 == 0) {
438                     // Pole pole
439                     //
440                     // Copy momentum information for flash
441                     //
442                     COPY(draft1->pole, draft1->p);
443                     COPY(draft2->pole, draft2->p);
444                     //
445                     // Start flash flooding
446                     //
447                     draft1->flash = SIDE;
448                     draft2->flash = SIDE;
449                   }
450                 }
451               } else {
452                 if (w1 == w2) {
453                   if (c1 == c2 == 0 && w1 == 1) {
454                     // Pole pole
455                     // Copy momentum information for flash
456                     //
457                     COPY(draft1->pole, draft1->p);
458                     COPY(draft2->pole, draft2->p);
459                     //
460                     // Start flash flooding
461                     //
462                     draft1->flash = SIDE;
463                     draft2->flash = SIDE;
464                   } else if (c1 == c2 == C_MASK && w1 == 0) {
465                     // Pole pole
466                     //
467                     // Copy momentum information for flash
468                     //
469                     COPY(draft1->pole, draft1->p);
470                     COPY(draft2->pole, draft2->p);
471                     //
472                     // Start flash flooding
473                     //
474                     draft1->flash = SIDE;
475                     draft2->flash = SIDE;
476                   }
477                 }
478               }
479             }
480           }
481           //
```

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```
482         // Boson x fermion
483         //
484         else if (stb1->code == BOSON && stb2->code == FERMION) {
485           // Isolate chrg bits
486           //
487           unsigned c1 = (stb1->chrg & C_MASK) & C_MASK;
488           unsigned q1 = ((stb1->chrg & Q_MASK) >> 3) & 1;
489           unsigned w1 = ((stb1->chrg & W_MASK) >> 4) & 1;
490           unsigned d1 = (stb1->chrg & D_MASK) >> 5;
491           unsigned c2 = (stb2->chrg & C_MASK) & C_MASK;
492           unsigned q2 = ((stb2->chrg & Q_MASK) >> 3) & 1;
493           unsigned w2 = ((stb2->chrg & W_MASK) >> 4) & 1;
494           unsigned d2 = (stb2->chrg & D_MASK) >> 5;
495           //
496           if (d1 != d2) {
497             // SUPRESSED
498             // (Only same sector are allowed to interact in this
                  way)
499             //
500             return;
501           }
502           //
503           // Quark x gluon?
504           //
505           if (c2 != NEUTRAL && c2 != ~NEUTRAL && c1 != NEUTRAL &&
                c1 != ~NEUTRAL) {
506             if (c2 == ~c1)     // TODO why?? {
507               // Blindly exchange colors, ignoring all other chrgs
508               //
509               draft2->chrg &= ~C_MASK;
510               draft1->chrg &= ~C_MASK;
511               draft2->chrg |= c2;
512               draft1->chrg |= c1;
513               //
514               // Pole pole
515               //
516               // Copy momentum information for flash
517               //
518               COPY(draft1->pole, draft1->p);
519               COPY(draft2->pole, draft2->p);
520               //
521               // Start flash flooding
522               //
523               draft1->flash = SIDE;
524               draft2->flash = SIDE;
525             }
526           }
527           //
528           // Quark x [photon, Z, W]?
529           //
```

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```
530           else if (c1 != NEUTRAL && c1 != ~NEUTRAL) {
531             // Is it a propeller?
532             //
533             if (stb1->a == stb2->a) {
534               // Inertia
535               //
536               // Copy momentum information for flash
537               //
538               if (ALIGNED(draft1->o, draft1->p)) {
539                 COPY(draft1->pole, draft2->p);
540                 COPY(draft2->pole, draft2->p);
541               } else {
542                 COPY(draft1->pole, draft1->p);
543                 COPY(draft2->pole, draft1->p);
544               }
545               //
546               // Start flash flooding
547               //
548               draft1->flash = SIDE;
549               draft2->flash = SIDE;
550             } else if (q1 == q2) {
551               // Pole pole
552               //
553               // Copy momentum information for flash
554               //
555               COPY(draft1->pole, draft1->p);
556               COPY(draft2->pole, draft2->p);
557               //
558               // Start flash flooding
559               //
560               draft1->flash = SIDE;
561               draft2->flash = SIDE;
562             } else {
563               // Pole pole
564               //
565               // Copy momentum information for flash
566               //
567               COPY(draft1->pole, draft1->p);
568               COPY(draft2->pole, draft2->p);
569               //
570               // Start flash flooding
571               //
572               draft1->flash = SIDE;
573               draft2->flash = SIDE;
574             }
575           }
576           //
577           // Electron x [photon, Z, W]?
578           //
579           else {
```

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```
580             // Is it a propeller?
581             //
582             if (stb1->a == stb2->a) {
583               // Inertia
584               //
585               // Copy momentum information for flash
586               //
587               if (ALIGNED(draft1->o, draft1->p)) {
588                 COPY(draft1->pole, draft2->p);
589                 COPY(draft2->pole, draft2->p);
590               } else {
591                 COPY(draft1->pole, draft1->p);
592                 COPY(draft2->pole, draft1->p);
593               }
594               //
595               // Start flash flooding
596               //
597               draft1->flash = SIDE;
598               draft2->flash = SIDE;
599             } else if (q1 == q2) {
600               if (w1 == w2) {
601                 if (c1 == c2 == 0 && w1 == 1) {
602                   // Pole
603                   // Copy momentum information for flash
604                   //
605                   COPY(draft1->pole, draft1->p);
606                   COPY(draft2->pole, draft2->p);
607                   //
608                   // Start flash flooding
609                   //
610                   draft1->flash = SIDE;
611                   draft2->flash = SIDE;
612                 } else if (c1 == c2 == C_MASK && w1 == 0) {
613                   // Pole pole
614                   //
615                   // Copy momentum information for flash
616                   //
617                   COPY(draft1->pole, draft1->p);
618                   COPY(draft2->pole, draft2->p);
619                   //
620                   // Start flash flooding
621                   //
622                   draft1->flash = SIDE;
623                   draft2->flash = SIDE;
624                 }
625               }
626             } else {
627               if (w1 == w2) {
628                 if (c1 == c2 == 0 && w2 == 1) {
629                   // Pole pole
```

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```
630                 //
631                 // Copy momentum information for flash
632                 //
633                 COPY(draft1->pole, draft1->p);
634                 COPY(draft2->pole, draft2->p);
635                 //
636                 // Start flash flooding
637                 //
638                 draft1->flash = SIDE;
639                 draft2->flash = SIDE;
640               } else if (c1 == c2 == C_MASK && w2 == 0) {
641                 // Pole pole
642                 //
643                 // Copy momentum information for flash
644                 //
645                 COPY(draft1->pole, draft1->p);
646                 COPY(draft2->pole, draft2->p);
647                 //
648                 // Start flash flooding
649                 //
650                 draft1->flash = SIDE;
651                 draft2->flash = SIDE;
652               }
653             }
654           }
655         }
656
657       }
658       //
659       // fermion x fermion
660       //
661       else {
662         // Isolate chrg bits
663         //
664         unsigned c1 = (stb1->chrg & C_MASK) & 7;
665         unsigned q1 = ((stb1->chrg & Q_MASK) >> 3) & 1;
666         unsigned w1 = ((stb1->chrg & W_MASK) >> 4) & 1;
667         unsigned d1 = (stb1->chrg & D_MASK) >> 5;
668         unsigned c2 = (stb2->chrg & C_MASK) & 7;
669         unsigned q2 = ((stb2->chrg & Q_MASK) >> 3) & 1;
670         unsigned w2 = ((stb2->chrg & W_MASK) >> 4) & 1;
671         unsigned d2 = (stb2->chrg & D_MASK) >> 5;
672         //
673         //
674         // Matter/antimatter flags
675         //
676         bool matter1 = c1 == 0 || c1 == 1 || c1 == 2 || c1 == 4;
677         bool matter2 = c2 == 0 || c2 == 1 || c2 == 2 || c2 == 4;
678         //
679         // Same sector?
```

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```
680             //
681             if (d1 == d2) {
682               // quark x quark?
683               //
684               if (c1 != NEUTRAL && c1 != ~NEUTRAL &&
685                   c2 != NEUTRAL && c2 != ~NEUTRAL) {
686                 // Same color and electric chrg?
687                 //
688                 if (c1 == c2 && q1 == q2) // TODO: include affinity??
                        weak chrg?? {
689                   // Quark cohesion
690                   //
691                   // Copy momentum information for flash
692                   //
693                   COPY(draft1->pole, draft1->p);
694                   COPY(draft2->pole, draft2->p);
695                   //
696                   // Start flash flooding
697                   //
698                   draft1->flash = SIDE;
699                   draft2->flash = SIDE;
700                 }
701                 //
702                 // Complementary charges?
703                 //
704                 else if (c1 == ~c2 && w1 == ~w2 && q1 == ~q2) {
705                   // Quark annihilation?
706                   //
707                   // cp x cp
708                   //
709                   // Copy momentum information for flash
710                   //
711                   if (ALIGNED(draft1->o, draft1->p)) {
712                     COPY(draft1->pole, draft1->p);
713                     COPY(draft2->pole, draft1->p);
714                   } else {
715                     COPY(draft1->pole, draft2->p);
716                     COPY(draft2->pole, draft2->p);
717                   }
718                   //
719                   // Start flash flooding
720                   //
721                   draft1->flash = SIDE;
722                   draft2->flash = SIDE;
723                   //
724                   if (collapse) {
725                     // Disintegrate the packet
726                     //
727                     draft1->code = COLLAPSE;
728                     draft2->code = COLLAPSE;
```

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```
729                 }
730               }
731             }
732             //
733             // quark x electron?
734             //
735             else if (c1 != NEUTRAL && c1 != ~NEUTRAL) {
736               if (q1 == q2 && matter1 == matter2) {
737                 // Implement repulsion
738               } else if (q1 != q2 && matter1 == matter2) {
739                 // Implement attraction
740               }
741             }
742             //
743             // Electron x electron
744             //
745             else if ((c1 == NEUTRAL || c1 == ~NEUTRAL) && c1 == c2)
                    {
746               if (q1 == q2 && matter1 == matter2) {
747                 // Implement cohesion
748                 //
749                 // Copy momentum information for flash
750                 //
751                 COPY(draft1->pole, draft1->p);
752                 COPY(draft2->pole, draft2->p);
753                 //
754                 // Start flash flooding
755                 //
756                 draft1->flash = SIDE;
757                 draft2->flash = SIDE;
758               } else if (q1 != q2 && w1 != w2 && matter1 != matter2
                    ) {
759                 // Electron annihilation?
760                 //
761                 // cp cp
762                 // Copy momentum information for flash
763                 //
764                 if (ALIGNED(draft1->o, draft1->p)) {
765                   COPY(draft1->pole, draft1->p);
766                   COPY(draft2->pole, draft1->p);
767                 } else {
768                   COPY(draft1->pole, draft2->p);
769                   COPY(draft2->pole, draft2->p);
770                 }
771                 //
772                 // Start flash flooding
773                 //
774                 draft1->flash = SIDE;
775                 draft2->flash = SIDE;
776                 //
```

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```
777                 if (collapse) {
778                   // Disintegrate the packet
779                   //
780                   draft1->code = COLLAPSE;
781                   draft2->code = COLLAPSE;
782                 }
783               }
784             }
785           }
786           //
787           // Different sectors
788           //
789           else {
790             bool s1 = (c1 == c2 == 0 && q1 == q2 == 1 && d1 == d2
                    == 0);
791             bool s2 = (c1 == c2 == 7 && q1 == q2 == 0 && d1 == d2
                    == 1);
792             bool s3 = (c1 == c2 != 0 != 7 && q1 == q2);
793             //
794             bool c1 = (q1 == q2 && w1 == w2 && s1 == s2);
795             bool c2 = (q1 != q2 && w1 != w2 && s1 != s2);
796             bool c3 = (d1 == 0 && w1 == 0 && w1 != w2);
797             bool c4 = (d1 == 1 && w1 == 1 && w1 != w2);
798             //
799             if ((d1 == 0 && s1 == s2) || (d1 == 1 && s1 == s3 && s1
                    != s2)) {
800               // Swap colors
801               //
802               int c1 = stb1->chrg & C_MASK;
803               int c2 = stb2->chrg & C_MASK;
804               draft1->chrg &= ~C_MASK;
805               draft2->chrg &= ~C_MASK;
806               draft1->chrg |= c2;
807               draft2->chrg |= c1;
808               //
809               // cp cp
810               //
811               // Copy momentum information for flash
812               //
813               if (ALIGNED(draft1->o, draft1->p)) {
814                 COPY(draft1->pole, draft1->p);
815                 COPY(draft2->pole, draft1->p);
816               } else {
817                 COPY(draft1->pole, draft2->p);
818                 COPY(draft2->pole, draft2->p);
819               }
820               //
821               // Start flash flooding
822               //
823               draft1->flash = SIDE;
```

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```
824               draft2->flash = SIDE;
825               //
826               if (collapse) {
827                 // Disintegrate the packet
828                 //
829                 draft1->code = COLLAPSE;
830                 draft2->code = COLLAPSE;
831               }
832             }
833             //
834             // Chiral?
835             //
836             else if (c1 || c2 || c3 || c4) {
837               // Change hands
838               //
839               int w1 = stb1->chrg & W_MASK;
840               int w2 = stb2->chrg & W_MASK;
841               draft1->chrg &= ~W_MASK;
842               draft2->chrg &= ~W_MASK;
843               draft1->chrg |= w2;
844               draft2->chrg |= w1;
845               //
846               // Copy momentum information for flash
847               //
848               COPY(draft1->pole, draft1->p);
849               COPY(draft2->pole, draft2->p);
850               //
851               // Start flash flooding
852               //
853               draft1->flash = SIDE;
854               draft2->flash = SIDE;
855             }
856           }
857         }
858       }
859     }
860
861     ////////// STEP5: EXPAND //////////
862
863       draft->t++;
864       //
865       // Decay momentum propensity
866       //
867       if(stb->t > 0 && !ISNULL(stb->p)) {
868           // Non-trivial affinity?
869           //
870           if (stb->a) {
871               // Decay as space
872               //
873               draft->p[0] *= ((draft->t * draft->t) -
```

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```
874                 draft->vp0[0] * draft->vp0[0]) / (draft->t *
                        draft->t);
875             draft->p[1] *= ((draft->t * draft->t) -
876                 draft->vp0[1] * draft->vp0[1]) / (draft->t *
                        draft->t);
877             draft->p[2] *= ((draft->t * draft->t) -
878                 draft->vp0[2] * draft->vp0[2]) / (draft->t *
                        draft->t);
879         } else {
880             // Decay as particle
881             //
882             draft->p[0] *= (2 * draft->t - 1) / (2 * draft->t);
883             draft->p[1] *= (2 * draft->t - 1) / (2 * draft->t);
884             draft->p[2] *= (2 * draft->t - 1) / (2 * draft->t);
885         }
886     }
887     //
888     // Spread cell contents if not empty
889     //
890     if (stb->f > 0 || draft->flash > 0) {
891         // Last tick?
892         //
893         if (stb->t % LIGHT == 0) {
894             // Sine recursive algorithm
895             //
896             draft->v = (K2D * stb->v + K2N * ((K1D * stb->u -
897                 K1N * stb->v) / K1D)) / K2D;
898             draft->u = (K1D * ((K1D * stb->u - K1N * stb->v) /
                        K1D) -
899                 K1N * draft->v) / K1D;
900         }
901         //
902         // Re-emmited?
903         //
904         if (stb->flash && ALIGNED(stb->o, stb->pole)) {
905             // Bubble is in fact reissued
906             //
907             draft->t = 0;
908             draft->sync = LIGHT2;
909             draft->u = SIDE2 / 2;
910             draft->v = 0;
911             RESET(draft->o);
912             draft->flash = 0;
913             return;
914         }
915         //
916         // Explore von Neumann directions
917         //
918         Cell* neighbor;
919         bool mature = stb->f > 0 && stb->t * stb->t > stb->sync;
```

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```
920             for (int dir = 0; dir < 6; dir++) {
921                 char vdir[3] = { 0, 0, 0 };
922                 neighbor = getPointer(dir, draft, (char*)vdir);
923                 //
924                 // Is flash active?
925                 //
926                 if (stb->flash > 0 && neighbor->flash == 0) {
927                     neighbor->flash = stb->flash;
928                     COPY(neighbor->pole, stb->pole);
929                 }
930                 //
931                 // Test if branch is legal
932                 //
933                 if(mature && isAllowed(dir, vdir, stb->o, stb->dir))
                        {
934                     // Copy necessary values
935                     //
936                     neighbor->t = draft->t;
937                     neighbor->dir = dir;
938                     neighbor->f = stb->f;
939                     neighbor->a = stb->a;
940                     neighbor->chrg = stb->chrg;
941                     neighbor->u = draft->u;
942                     neighbor->v = draft->v;
943                     //
944                     neighbor->o[0] = (stb->o[0] + vdir[0]);
945                     neighbor->o[1] = (stb->o[1] + vdir[1]);
946                     neighbor->o[2] = (stb->o[2] + vdir[2]);
947                     //
948                     COPY(neighbor->s, stb->s);
949                     COPY(neighbor->p, stb->p);
950                     //
951                     // Schedule for spherical evolution
952                     //
953                     neighbor->sync = LIGHT2 * MOD2(neighbor->o);
954                 }
955             }
956             //
957             // Decrement flash
958             //
959             if (draft->flash > 0)
960                 draft->flash--;
961             //
962             // Bubble propagated?
963             //
964             if(mature) {
965                 // Clean data
966                 //
967                 draft->code = 0;
968                 //
```

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```
969                 // Bubble meets itself?
970                 //
971                 if (MOD2(stb->o) == 3 * SIDE * SIDE / 4) {
972                     // Reissue by wrapping
973                     //
974                     draft->sync = 0;
975                     draft->t = 0;
976                 } else {
977                     // Erase origin cell
978                     //
979                     draft->f = 0;
980                 }
981             }
982         }
983 }
```