Steganogramic representation of the baryon octet in cellular automata

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Introduction

Simple computations, such as those performed by one-dimensional cellular automata (CAs), are known to produce unexpected complexity in many instances[1]. Many people experimenting with CAs in the last twenty years or so are prone to suggesting, mostly on intuitive grounds, that hiding among the vast number of possible CAs are a few simple ones that may very well be "ultimate models for the universe[2]." In this report I show how a simple cellular automaton unexpectedly encodes the baryon octet of elementary particle physics. In ref. 3, I discussed the relevance of the instant CA to elementary processes of visual perception, and in ref. 4 this CA was linked to dialectical processes. The confluence of such diverse models in one trivial computation is unexpected and intriguing. I submit that something very fundamental is unfolding here and respectfully invite from readers critical evaluation of my findings.

Findings

Wolfram's systematization[5] of 2-state nearest-neighbor (k=2, r=1) one-dimensional cellular automata comprises 256 rules. One of these, i.e., rule 129, is selected here as a starting point. Rule 129 (10000001), starting from a "seed" of a single site, generates the pattern shown in fig. 1. This pattern is a self-similar fractal with some simple regularities and symmetries that are easily observable. However, this CA is scantly interesting for it is not particularly spectacular or computationally promising, as compared with some others. For example, rule 110 generates much more complexity and is widely suspected of being in Wolfram's class 4, where class 4 admits CAs capable of universal computation.

My main aim here is to unfold unexpected complexity that is embedded in a certain pattern that is quite similar to fig. 1, by showing that it includes "surreptitious," or steganogramic[a],

[a] *Steganography*, a part of *cryptology*, is a mode of concealing the presence of some "secret" information, sometimes in the body or context of "open" information. For example, some people hide text, such as e-mail, as white noise among the pixels of digital pictures transmitted over the Internet. The visual quality of such pictures is unaffected, so that an interceptor has no basis to suspect the existence of any additional information beyond the picture itself. Concealed information may or may not be protected in addition by encryption. A *steganogram* is a message whose presence and meaning are hidden by means of some steganographic means. In ordinary encryption situations, the *cryptanalyst* is aware of the existence of the encrypted message and has access to it in order to attempt decryption. In cases of steganograms, the cryptanalyst may not even be aware of the presence of a concealed message, which may compound the difficulty in uncovering such information. Thus, for example, from a purely cryptological point of view, the breaking of the genetic code was a case of cryptanalysis, while discovering a representation of baryons in an innocuous cellular automaton is a case of breaking a steganogram.

representation of the baryon octet of elementary particle physics at the quark level.

In ref. 4 I show that rule 129 (named "triunation" therein) is functionally equivalent (after some minor encoding that is specified therein) to a 4-state nearest-neighbor (k=4, r=1) rule named "tetracoding." Thus, replacing rule 129 by tetracoding, fig. 2 is obtained. This new pattern is also a self-similar fractal, generally quite similar to fig. 1. Additionally, one can discern nine occurrences of the structure:

```
] O [
O O O
[ = ]
```

, and in the middle of the pattern there is an additional tenth structure that is a modified version of the above, i.e.,

```
[ = ]
O O O
= = =
```

. Treating these ten structures as potentially constituting a steganogram, we apply standard decryption techniques, such as filtering and substitution, in order to bring out a suspected message. This is demonstrated below through a few stages.

* Applying a filter that eliminates all but the above-mentioned 10 structures, one obtains fig. 3.

* Substituting by means of a simple code: **] -> u**, **[-> d**, and **O -> s**, where u, d, and s stand, respectively, for "up," "down," and "strange" types of quarks in Gell-Mann's quark theory, the pattern in fig. 4 is obtained.

* Applying a second filter that filters out all but three select symbols in each of the ten structures, one obtains fig. 5.

Note that fig. 5 is nearly identical to the baryon decuplet of particle physics. The only discrepancy is in the "s" in the middle position in the leftmost and the rightmost structures at the bottom, which should be "u" and "d", respectively[b].

* Applying a third filter that drops the apex structure and the leftmost and rightmost bottom structures, one obtains the seven structures shown in fig.6.

```
Now, consider the structure underlying  d  u, which is [ = ]  .
                                          s             0 0 0
                                                        = = =
```

* Applying two tetracoding steps to this structure, one obtains:

```
[ = ]
0 0 0
= = =
[ = ]
0 0 0
```

* Substituting again u, d, and s for], [, and 0, respectively, one obtains:

```
d = u
s s s
= = =
d = u
s s s
```

* Filtering out all but the middle "s" in the second and fifth lines above, one obtains:

```
d   u
  s
= = =
d   u
  s
```

*Pasting the above structures back into fig. 6, one obtains fig. 7.

[b] There are a number of simple ways to accommodate this minor discrepancy, but since this paper deals with the baryon octet, where these two structures from the decuplet simply do not belong, there is no point in elaborating on this issue here.

Result: Fig. 7 is identical to the baryon octet of elementary particle physics, first proposed by Murray Gell-Mann and others in the early 1960s.

Additionally, fig. 7 appears to be more structured and involves more symmetries and regularities than quark specifications for baryons obtained through the combinatorics of the algebra of SU(3). Also, the representation in fig. 7 is a time-lapse record of a dynamic process, where the structures in question (representations of baryons) are actively constructed in a chronological sequence, as opposed to being static entries in a printed diagram or table. However, it is still an open question whether said additional attributes are in fact material to baryonic physics.

Discussion

The set of all k=4 r=1 one-dimensional CAs includes 2^{128} (or $3.402823669209*10^{38}$) possible rules. Because of this huge number, very little is known about the behaviour of the vast majority of these CAs. Back in 1964 I selected out of these a particular CA, i.e., the one governed by tetracoding, for study in the context of computer analysis of digital images. It turned out that, if a digital image is very "thin," i.e., one-dimensional, a minimal condition for perception of any patterns in it is the ability to make distinctions between neighboring pixels in the image. Therefore, making and recording such distinctions is the essence of tetracoding. When tetracoding is applied to initial finite strings of arbitrary symbols, and then recursively to their successors, all having the same fixed length, very interesting and unexpected patterns emerge. Some of these are reported in ref. 4, where the more intriguing patterns are those that mimic patterns of the Hegelian dialectic[c].

In this report I used a degenerate case of image processing, where a digital image comprised of an arbitrary single pixel is the initial input to recursive tetracoding, without constraints on the lengths of successive strings. What one sees in fig. 2 then is a display of structures associated with a "degenerate" analysis of a single-pixel image. This kind of analysis is seemingly trivial and inconsequential, by ordinary commonsensical intuition. Therefore, the fact that the baryon octet was found encoded in the wake of this kind of bizarre processing deserves special attention, I think.

To drive home my point, I offer a bit of folk wisdom, cited from an ancient Eastern tale. A poor peasant approached the Buddha and said: "Oh, wise and mighty Buddha, show me how do I get to know all there is to know?" The Buddha pointed to a single piece of

[c] Hegelian dialectic is an influential, yet controversial, philosophical doctrine that holds that the universe operates, through-and-through, according to complicated schemata of interacting opposites and their continual mediation. My discovery, in the early 1970s, of these kinds of schemata in the patterns generated by recursive tetracoding had been

dung on the path and said: "Meditate on that -- it will come to you..."

I propose that, at a minimum, when attempting to perceive but a single speck of something, we mentally activate a process that is similar to fig. 2. Now, (as if by Leibnitzian *pre-established harmony*) this very act of elementary perception turns out to subsume a steganogramic representation of elementary particles at the quark level, albeit without awareness thereof. My conjecture then is that acts of elementary perception involve mental, or abstract, structures that are remarkably similar to the most fundamental structures that our science ascribes to matter at the quark level; which is very close to saying that here and now we are pointed in the direction of an intersection between mind and matter, in the context of this simple and innocuous cellular automaton.

In closing, I point out that the demonstration of the above-described steganogramic representation of the baryon octet is entirely independent from the validity of any proposals in regards to elementary principles of perception, and certainly also from any Hegelian conceptions. I submit that, on its own merits, said

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totally unexpected and inexplicable. In combination with the more recent discovery (May 1997) of baryon representations among the very same dialectical patterns, the surprise effect is compounded manyfold.

representation is a significant finding in regard to heretofore certain concealed connections between cellular automata and fundamental physics.

References

1. Wolfram, S. Cellular automata as models of complexity. *Nature* **311**, 419-423 (1984).
2. Wolfram, S. *A New Kind of Science.* (Wolfram Media, Champaign, forthcoming; cited from p. 531, available online at http://www.wolframscience.com/preview/pages/pageviewer.cgi/531).
3. Isaacson, J. D. *Dialectical Machine Vision: Applications of dia-lectical signal-processing to multiple sensor technologies.* (Tech. Rep. No. IMI-FR-N00014-86-C-0805 to SDIO, Office of Naval Research, 31 July 1987).
4. Isaacson, J. D. *Autonomic String-Manipulation System.* (U.S. Patent No. 4,286,330, Aug. 25, 1981; accessible online on U.S. Patent Office server via the Internet: www.uspto.gov).
5. Wolfram, S. (ed.) *Theory and Applications of Cellular Automata.* (World Scientific, Singapore, 1986).

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Figure Legends [Steganogramic representation of the baryon octet in cellular automata]

Fig. 1 The pattern generated by rule 129 from a single-site "seed." Successive lines correspond to successive steps in the cellular automaton evolution that is carried here through 16 steps only.

Fig. 2 The pattern generated by the "tetracoding" rule from an arbitrary seed '**B**', carried through 16 steps. The four states are represented by the ideographic symbols: '**O**', '**]**', '**[**', and '**=**', that code for distinction/indistinction between states of adjacent sites.

Fig. 3 Result of applying the first filter to Fig. 2.

Fig. 4 Result of substituting quark symbols for the ideographic symbols in Fig. 3.

Fig. 5 Result of applying the second filter to Fig. 4. Note the similarity to the baryon decuplet, as discussed in the text.

Fig. 6 Result of applying the third filter to Fig. 5.

Fig. 7 Result of additional tetracoding of the middle structure in Fig. 6, as discussed in the text. Note the complete agreement with the baryon octet of elementary particle physics.

Fig. 1
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```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 0 0 1 1 0 0 1 0 0 1 1 0 0 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1
1 1 1 1 1 1 0 0 1 1 0 0 1 1 1 1 1 1 1 1 1 0 0 1 1 0 0 1 1 1 1 1 1
1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 1 0 0 1 1 1 1 1 1 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 0 0 1 1 1 1
1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1
1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
```

Fig. 2
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```
 0    = = = = = = = = = = = = = = = = B = = = = = = = = = = = = = = = =
 1    = = = = = = = = = = = = = = = ] O [ = = = = = = = = = = = = = = =
 2    = = = = = = = = = = = = = = ] O O O [ = = = = = = = = = = = = = =
 3    = = = = = = = = = = = = = ] O [ = ] O [ = = = = = = = = = = = = =
 4    = = = = = = = = = = = = ] O O O O O O O [ = = = = = = = = = = = =
 5    = = = = = = = = = = = ] O [ = = = = = ] O [ = = = = = = = = = = =
 6    = = = = = = = = = = ] O O O [ = = = ] O O O [ = = = = = = = = = =
 7    = = = = = = = = = ] O [ = ] O [ = ] O [ = ] O [ = = = = = = = = =
 8    = = = = = = = = ] O O O O O O O O O O O O O O O [ = = = = = = = =
 9    = = = = = = = ] O [ = = = = = = = = = = = = = ] O [ = = = = = = =
10    = = = = = = ] O O O [ = = = = = = = = = = = ] O O O [ = = = = = =
11    = = = = = ] O [ = ] O [ = = = = = = = = = ] O [ = ] O [ = = = = =
12    = = = = ] O O O O O O O [ = = = = = = = ] O O O O O O O [ = = = =
13    = = = ] O [ = = = = = ] O [ = = = = = ] O [ = = = = = ] O [ = = =
14    = = ] O O O [ = = = ] O O O [ = = = ] O O O [ = = = ] O O O [ = =
15    = ] O [ = ] O [ = ] O [ = ] O [ = ] O [ = ] O [ = ] O [ = ] O [ =
16    ] O O O O O O O O O O O O O O O O O O O O O O O O O O O O O O O [
|                                     |                               |
v                                     v                               v
                                     etc. (indefinite progression)
```

Fig. 3
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```
 0    = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 1    = = = = = = = = = = = = = =   ] O [   = = = = = = = = = = = = = =
 2    = = = = = = = = = = = = = =   O O O   = = = = = = = = = = = = = =
 3    = = = = = = = = = = = = =     [ = ]     = = = = = = = = = = = = =
 4    = = = = = = = = = =                           = = = = = = = = = =
 5    = = = = = = = = = =   ] O [           ] O [   = = = = = = = = = =
 6    = = = = = = = = = =   O O O           O O O   = = = = = = = = = =
 7    = = = = = = = = =     [ = ]   [ = ]   [ = ]     = = = = = = = = =
 8    = = = = = =                   O O O                   = = = = = =
 9    = = = = = =   ] O [           = = =           ] O [   = = = = = =
10    = = = = = =   O O O                           O O O   = = = = = =
11    = = = = =     [ = ]                           [ = ]     = = = = =
12    = =                                                           = =
13    = =   ] O [           ] O [           ] O [           ] O [   = =
14    = =   O O O           O O O           O O O           O O O   = =
15    =     [ = ]           [ = ]           [ = ]           [ = ]     =
16
```

Fig. 4
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```
 0   = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 1   = = = = = = = = = = = = = =   u s d   = = = = = = = = = = = = = =
 2   = = = = = = = = = = = = = =   s s s   = = = = = = = = = = = = = =
 3   = = = = = = = = = = = = =     d = u     = = = = = = = = = = = = =
 4   = = = = = = = = = =                           = = = = = = = = = =
 5   = = = = = = = = = =   u s d           u s d   = = = = = = = = = =
 6   = = = = = = = = = =   s s s           s s s   = = = = = = = = = =
 7   = = = = = = = = =     d = u   d = u   d = u     = = = = = = = = =
 8   = = = = = =                   s s s                   = = = = = =
 9   = = = = = =   u s d           = = =           u s d   = = = = = =
10   = = = = = =   s s s                           s s s   = = = = = =
11   = = = = =     d = u                           d = u     = = = = =
12   = =                                                           = =
13   = =   u s d           u s d           u s d           u s d   = =
14   = =   s s s           s s s           s s s           s s s   = =
15   =     d = u           d = u           d = u           d = u     =
16
```

Fig. 5
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```
 0   = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 1   = = = = = = = = = = = = = =     s     = = = = = = = = = = = = = =
 2   = = = = = = = = = = = = = = s   s     = = = = = = = = = = = = = =
 3   = = = = = = = = = = = = =               = = = = = = = = = = = = =
 4   = = = = = = = = = =                           = = = = = = = = = =
 5   = = = = = = = = = =   u s               s d   = = = = = = = = = =
 6   = = = = = = = = = =   s                   s   = = = = = = = = = =
 7   = = = = = = = = =             d   u             = = = = = = = = =
 8   = = = = = =                     s                     = = = = = =
 9   = = = = = =   u s                               s d   = = = = = =
10   = = = = = =                                           = = = = = =
11   = = = = =         u                           d         = = = = =
12   = =                                                           = =
13   = =     u               u   d           u   d               d   = =
14   = =       s                                               s     = =
15   =         u               u           d               d         =
16
```

Fig. 6
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```
 0   = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 1   = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 2   = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 3   = = = = = = = = = = = = =               = = = = = = = = = = = = =
 4   = = = = = = = = = =                           = = = = = = = = = =
 5   = = = = = = = = = =   u s               s d   = = = = = = = = = =
 6   = = = = = = = = = =   s                   s   = = = = = = = = = =
 7   = = = = = = = = =             d   u             = = = = = = = = =
 8   = = = = = =                     s                     = = = = = =
 9   = = = = = =   u s                             s d   = = = = = =
10   = = = = = =                                           = = = = = =
11   = = = = =         u                         d         = = = = =
12   = =                                                           = =
13   = =                   u   d           u   d                   = =
14   = =                                                           = =
15   = =                       u           d                       = =
16
```

Fig. 7
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```
 0    = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 1    = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 2    = = = = = = = = = = = = = =           = = = = = = = = = = = = = =
 3    = = = = = = = = = = = = =               = = = = = = = = = = = = =
 4    = = = = = = = = = =                           = = = = = = = = = =
 5    = = = = = = = = = =   u s               s d   = = = = = = = = = =
 6    = = = = = = = = = =   s                   s   = = = = = = = = = =
 7    = = = = = = = = =             d   u             = = = = = = = = =
 8    = = = = = =                     s                     = = = = = =
 9    = = = = = =   u s             = = =             s d   = = = = = =
10    = = = = = =                   d   u                   = = = = = =
11    = = = = =         u             s             d         = = = = =
12    = =                                                           = =
13    = =                   u   d         u   d                     = =
14    = =                                                           = =
15    =                         u         d                           =
16
```

[End steganogramic paper]