Exploration

E8 Physics from Cl(8) via Elementary Cellular Automata Bits

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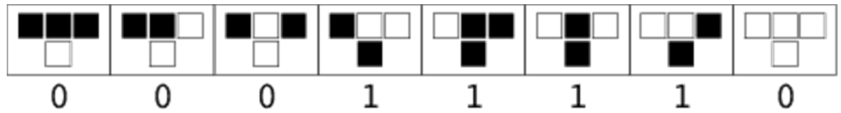
Abstract

In this article, I describe E8 Physics from Cl(8) via pairing elementary cellular automata bits. Smith relates the 256 dimensions of the Cl(8) Clifford Algebra to the 256 rules of Elementary Cellular Automata. The graded dimensions of Cl(8) correspond to graded dimensions of the E8 Lie Algebra used in Smith's physics model. Six Cellular Automata (CA) rules with four one-bits are related to Smith's 8-dim Primitive Idempotent bookended by the single rule with no one-bits and the single rule with all eight bits as ones. The 64 other four one-bit rules are related to E8's 64-dim vector representation used by Smith for a spacetime 8-dim position by 8-dim momentum. The two 28-dim D4 subalgebras of E8 are used for bosons and their ghosts and relate to the CA rules with two one-bits and six one-bits. Paired up CA bits are related to the Cartan subalgebras of these D4s. The two remaining 64-dim spinor representations for E8 are used for eight component fermions/antifermions and relate to the CA rules with one, three, five and seven one-bits.

Keywords: E8 physics, Clifford algebra, Lie algebra, cellular automata, bit, subalgebra.

1. Introduction

Tony Smith [1] relates the 256 dimensions of the Cl(8) Clifford Algebra to the 256 rules of Elementary Cellular Automata [2]. The graded dimensions of Cl(8) correspond to graded dimensions of the E8 Lie Algebra used in Smith's physics model. An 8-dim Primitive Idempotent half spinor along with the 248-dim E8 are embedded in the 256-dim Cl(8). The grading of this Cl(8) is 1 8 28 56 70 56 28 8 1 which sum to the 256 dimensions. This grading gives the quantity of Cellular Automata (CA) rules that have a certain number of one-bits.



The rule above is called rule 30 because the 4 one-bits produce a binary 2+4+8+16=30. The Cl(8) grading indicates there are 70 rules with 4 of the 8 bits being a one. In other words there

*Correspondence: John C. Gonsowski, Independent Researcher. Email: jcgonsowski@yahoo.com are 70 ways to place 4 ones in the 8 bits to form a rule. The bits for the rule represent the next state value for the 8 possible values of the current state and the states to the left and right of the current state being evaluated. Via the Cl(8) grading there is one way to have 0 of 8 ones in the rule; 8 ways to have a single one; 28 ways to have two ones; 56 ways to have three ones; 70 ways to have four ones; 56 ways to have five ones; 28 ways to have six ones; 8 ways to have seven ones; and one way to have 8 ones.

2. Relating Basis Vectors to Cellular Automata Bits

Two CA bits are related via Smith's model to the Y and X basis vectors of a YX spatial rotation [3].

Y X

01000000 00001000

Two CA bits are related to the temporal T and spatial Z basis vectors of a Lorentz group TZ boost.

T Z

10000000 00100000

Two CA bits relate to the Conformal group (C) basis vector and an Anti-de Sitter/de Sitter group (A) translation basis vector to form a dilation (CA). This dilation is the Higgs VEV in Smith's physics model.

C A

00000001 00000100

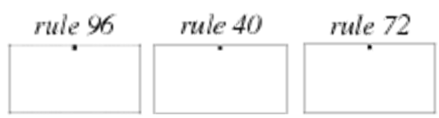
The final two CA bits allow Standard Model Ghosts in Smith's physics using basis vectors M (magenta/minus for strong force anticolor and weak force negative charge) and G (green/greater than zero for strong force color/weak force positive charge). The MG bivector is a propagator phase in Smith's model.

M G

00000010 00010000

3. Rotations and Boosts

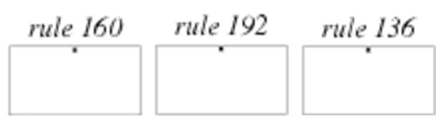
The grading of the 248-dim E8 in Smith's physics model is 28 64 64 64 28. The following bivectors are in the 28s of his E8 grading which match to the 28s in the Cl(8) grading. The E8 28s come from two D4 subalgebras which also relate to the four axes and 24 vertices of a 24-cell, D4's root vector polytope. The 28 Cellular Automata with 2 one-bits and the 28 CA with 6 one-bits will match to these two D4s. Here are the three Lorentz Group gravity spatial rotation [3] bivectors/double one-bits.



ZY ZX YX

01100000 00101000 01001000

Here are the three Lorentz group gravity boost bivectors/double one-bits.



TZ TY TX

10100000 11000000 10001000

4. Translations, Dilation and Special Conformal Transformations

Here are the four Anti-de Sitter/de Sitter group gravity translation bivectors/double one-bits, the dilation (Smith's Higgs VEV), and the four special conformal transformations (dark energy related for Smith).

Translations:

rule 132	rule 36	rule 68	rule 12
			
TA	ZA	YA	XA
10000100	00100100	01000100	00001100

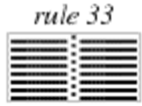
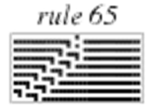
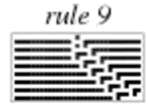
Dilation:

rule 5

CA

00000101

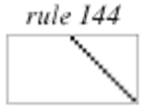
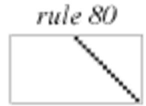
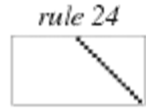
Conformal Transformations:

rule 129	rule 33	rule 65	rule 9
			
TC	ZC	YC	XC
10000001	00100001	01000001	00001001

5. Ghosts for the Standard Model Bosons and Propagator Phase

Here are the bivectors/double one-bits for the Standard Model ghosts and propagator phase of Smith's physics model.

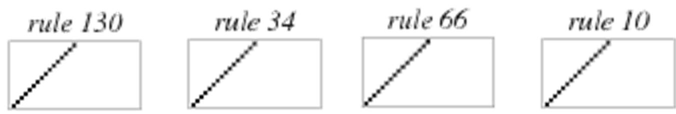
rgb/rg/rb/gb "half" Gluons:

rule 144	rule 48	rule 80	rule 24
			
TG	ZG	YG	XG
10010000	00110000	01010000	00011000

Photon/Z0/W-/W+/Phase:

CM	CG	AM	AG	MG
00000011	00010001	00000110	00010100	00010010

cmy/cm/cy/my "half" Gluons:



TM	ZM	YM	XM
10000010	00100010	01000010	00001010

6. Ghosts for Rotations and Boosts

The above conformal gravity and Standard Model ghost bivectors fit with the 28 Cellular Automata rules with double one-bits. These 28 CA relate to the first 28 in the E8 and Cl(8) grading. The conformal gravity ghost and Standard Model bivectors fit with the 28 CA with six one-bits. These CA relate to the second 28 in the E8 and Cl(8) grading. The CA with six one-bits are also the CA with double zero-bits. These double zero-bits will be matched to Smith's D4 conformal gravity ghost and Standard Model bivectors.

Besides using double zero-bits instead of double one-bits, this ghost boson-actual boson bivector mapping also exchanges XYZT vectors with GMAC vectors thus forming a negative transformation [4]. This may relate to how in Smith's model, the XYZT physical spacetime interacts with the GMAC Kaluza-Klein internal symmetry space. Here are the three Lorentz Group gravity spatial rotation bivectors/double zero-bit ghosts.

AM	AG	MG
11111001	11101011	11101101

Here are the three Lorentz group gravity boost bivectors/double zero-bit ghosts.

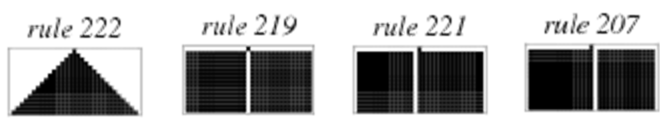
CA CM CG

11111010 11111100 11101110

7. Ghost Translation, Dilation and Special Conformal Transformations

Here are the four Anti-de Sitter/de Sitter group gravity translation bivectors/double zero-bit ghosts, the dilation ghost (for Smith's Higgs VeV), and the four special conformal transformation ghosts (dark energy related for Smith).

Translations:



CZ AZ MZ GZ

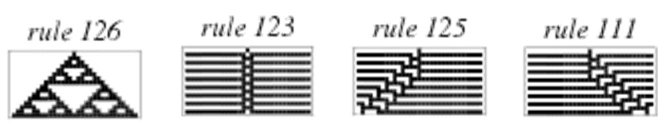
11011110 11011011 11011101 11001111

Dilation:

TZ

01011111

Conformal Transformations:



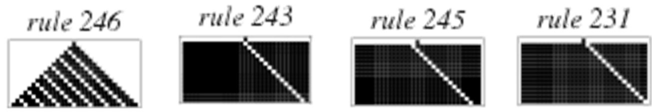
CT AT MT GT

01111110 01111011 01111101 01101111

8. Standard Model Bosons and Propagator Phase Ghost

Here are the bivectors/double zero-bits for the Standard Model bosons and propagator phase ghost of Smith's physics model.

rgb/rg/rb/gb "half" Gluons:

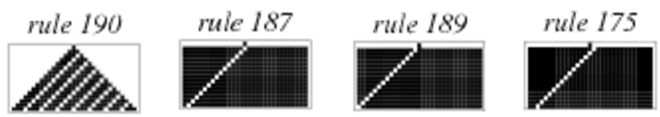


CX	AX	MX	GX
11110110	11110011	11110101	11100111

Photon/Z0/W-/W+/Phase:

TY	TX	ZY	ZX	YX
00111111	01110111	10011111	11010111	10110111

cmy/cm/cy/my "half" Gluons:

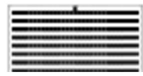


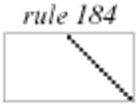
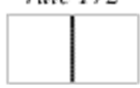
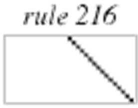
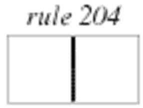
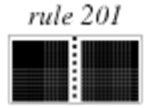
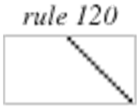
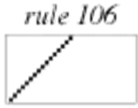
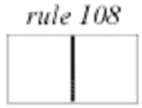
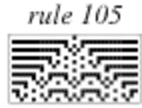
CY	AY	MY	GY
10111110	10111011	10111101	10101111

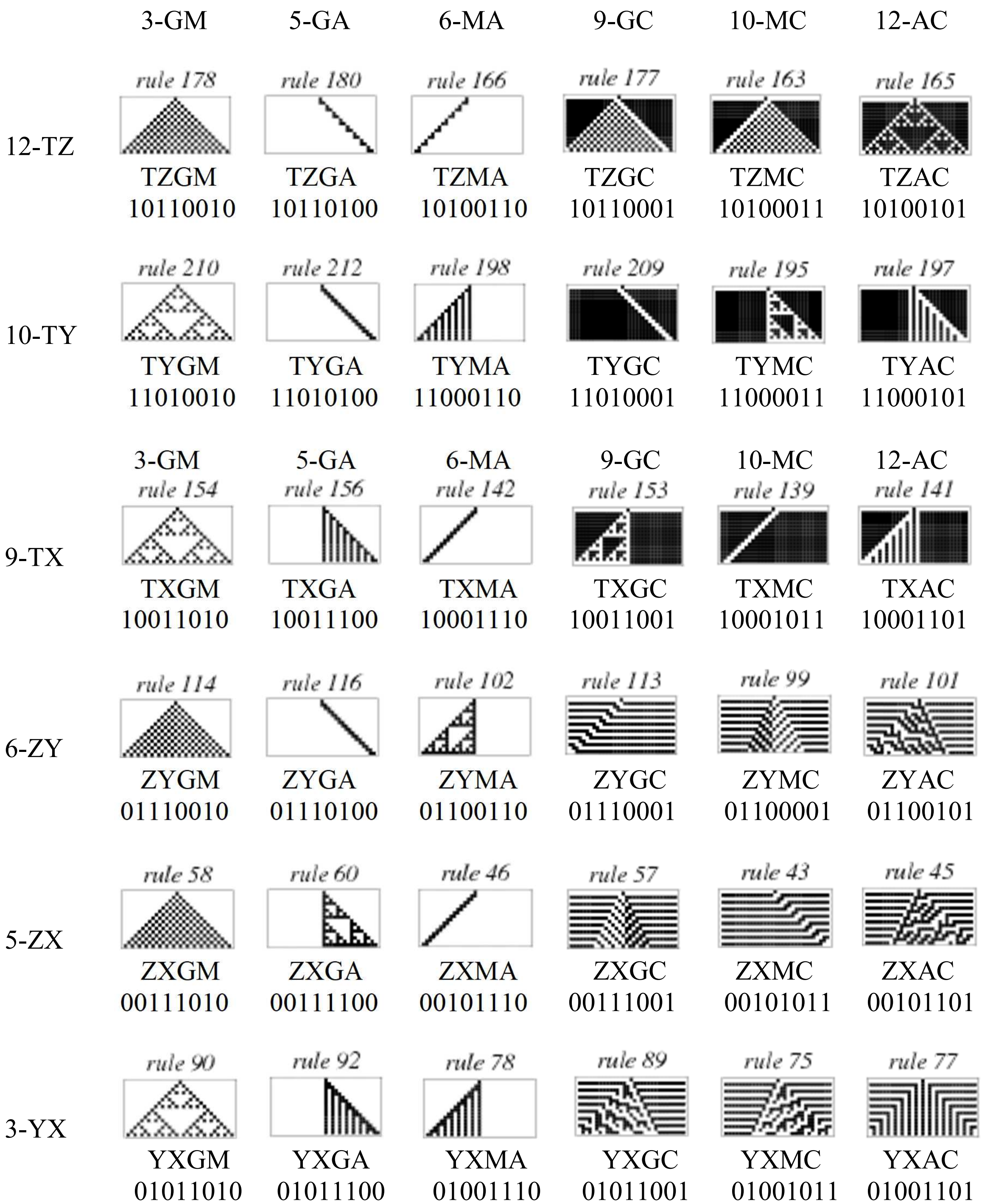
There's a pattern where rules (with G vs. M) that slant to the left vs. slanting to the right may relate to charge for the Standard Model bosons and direction change (X vs. Y) for gravity bosons. These reflection transformation [4] bits perhaps relate to how charge, mass, and change of direction are related in Smith's 4-dim Feynman Checkerboard.

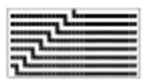
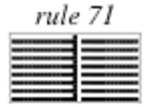
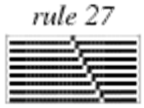
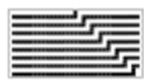
9. The Primitive Idempotent and Spacetime Position and Momentum

The grading of the 8-dim Primitive Idempotent (PI) half spinor embedded with E8 in Cl(8) is 1 6 1. In Smith's physics, the PI performs a Standard Model Higgs-like role. This 6-dim PI middle grade is the lower left to upper right diagonal of the 6x6 matrix below. Subtracting the 6 middle grade of the PI from the 70 Cl(8) middle grade gives the 64 middle grade for E8. This 64 middle grade is the position by momentum 8x8=64-dim vector part of Smith's E8 physics model [5]. This 64-dim part of E8 thus relates to the 4-vector/four one-bit CA rules not used for the 6-dim PI middle grade though the upper left to lower right diagonals of the two 4x4 matrices below form another PI half spinor that is part of the E8 middle grade. Both PI half spinors fit with the 16 Pertti Lounesto terms using basis vectors MGCATYZX [6]. The position and momentum are 8-dim due to the GMAC Kaluza-Klein internal symmetry space added to the XYZT physical spacetime in Smith's model.

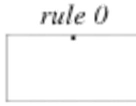
	0	15-GMAC
	rule 232	rule 23
15-TZYX / 0		
	TZYX	GMAC
	11101000	00010111

	1-G	2-M	4-A	8-C
	rule 240	rule 226	rule 228	rule 225
14-TZY				
	TZYG	TZYM	TZYA	TZYC
	11110000	11100010	11100100	11100001
	rule 184	rule 170	rule 172	rule 169
13-TZX				
	TZXG	TZXM	TZXA	TZXC
	10111000	10101010	10101100	10101001
	rule 216	rule 202	rule 204	rule 201
11-TYX				
	TYXG	TYXM	TYXA	TYXC
	11011000	11001010	11001100	11001001
	rule 120	rule 106	rule 108	rule 105
7-ZYX				
	ZYXG	ZYXM	ZYXA	ZYXC
	01111000	01101010	01101100	01101001


3-GM
5-GA
6-MA
9-GC
10-MC
12-AC
12-TZ
rule 178
TZGM
10110010
rule 180
TZGA
10110100
rule 166
TZMA
10100110
rule 177
TZGC
10110001
rule 163
TZMC
10100011
rule 165
TZAC
10100101
10-TY
rule 210
TYGM
11010010
rule 212
TYGA
11010100
rule 198
TYMA
11000110
rule 209
TYGC
11010001
rule 195
TYMC
11000011
rule 197
TYAC
11000101
3-GM
5-GA
6-MA
9-GC
10-MC
12-AC
9-TX
rule 154
TXGM
10011010
rule 156
TXGA
10011100
rule 142
TXMA
10001110
rule 153
TXGC
10011001
rule 139
TXMC
10001011
rule 141
TXAC
10001101
6-ZY
rule 114
ZYGM
01110010
rule 116
ZYGA
01110100
rule 102
ZYMA
01100110
rule 113
ZYGC
01110001
rule 99
ZYMC
01100001
rule 101
ZYAC
01100101
5-ZX
rule 58
ZXGM
00111010
rule 60
ZXGA
00111100
rule 46
ZXMA
00101110
rule 57
ZXGC
00111001
rule 43
ZXMC
00101011
rule 45
ZXAC
00101101
3-YX
rule 90
YXGM
01011010
rule 92
YXGA
01011100
rule 78
YXMA
01001110
rule 89
YXGC
01011001
rule 75
YXMC
01001011
rule 77
YXAC
01001101

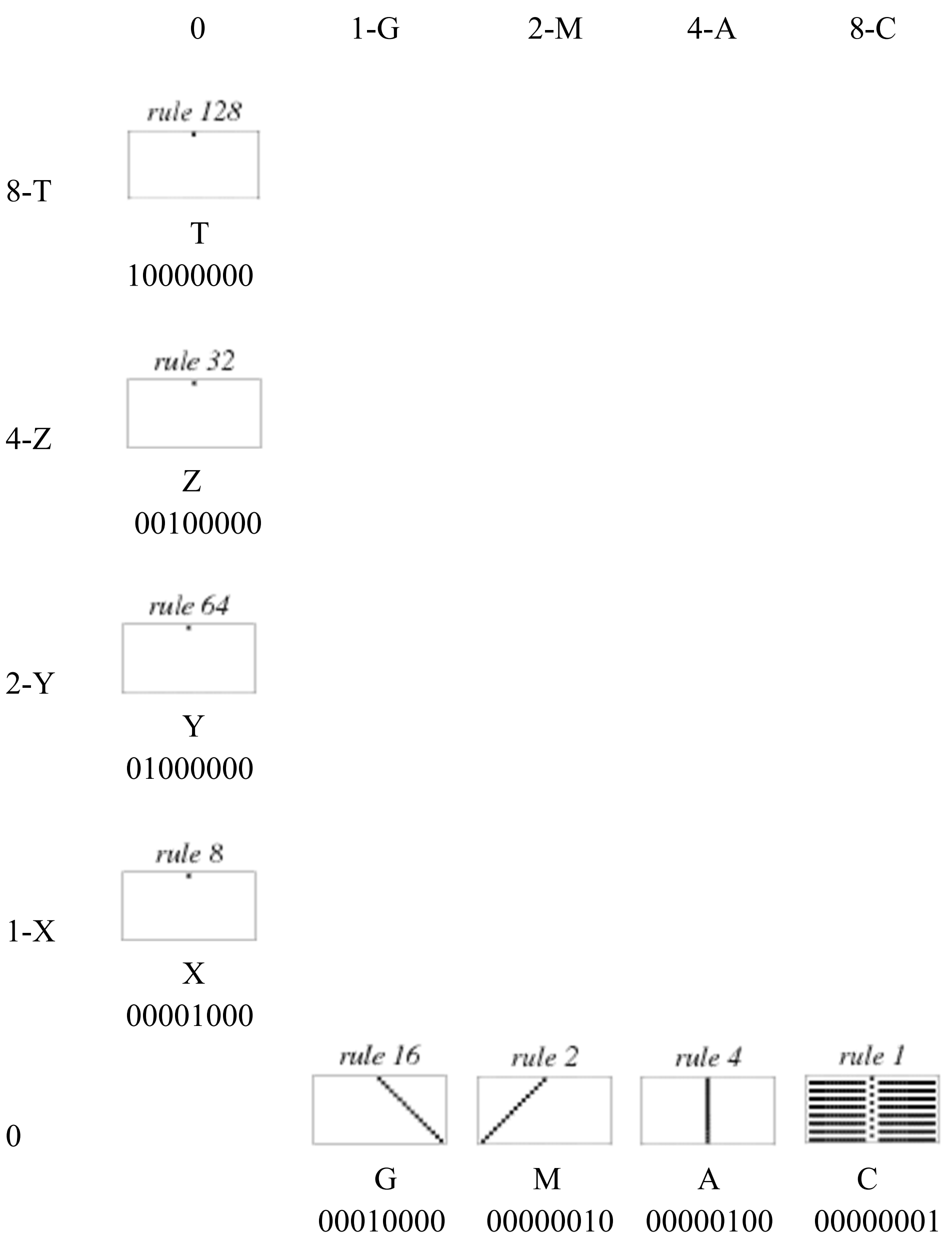
	7-GMA	11-GMC	13-GAC	14-MAC
	rule 150	rule 147	rule 149	rule 135
8-T				
	TGMA	TGMC	TGAC	TMAC
	10010110	10010011	10010101	10000111
	rule 54	rule 51	rule 53	rule 39
4-Z				
	ZGMA	ZGMC	ZGAC	ZMAC
	00110110	00110011	00110101	00100111
	7-GMA	11-GMC	13-GAC	14-MAC
	rule 86	rule 83	rule 85	rule 71
2-Y				
	YGMA	YGMC	YGAC	YMAC
	01010110	01010011	01010101	01000111
	rule 30	rule 27	rule 29	rule 15
1-X				
	XGMA	XGMC	XGAC	XMAC
	00011110	00011011	00011101	00001111

The two ones of the PI and Cl(8) grading fit with the CA rules having 0 of 8 ones and 8 of 8 ones:

rule 0	rule 255
	
	TZYXGMAC
00000000	11111111

10. Spacetime Components of Fermion Creation Operators

The two remaining 64s in the E8 grading of Smith's model are for 8 spacetime components of fermion creation operators and 8 spacetime components of antifermion creation operators. The E8 64 grading for fermions comes from the 8 Cl(8) vectors plus the 56 Cl(8) 3-vectors. Thus the fermions relate to the Cellular Automata rules with a single one-bit and the rules with three one-bits. Here are the rules for the neutrino creation operator [7].



Here are the rules for the electron creation operator.

0 7-GMA 11-GMC 13-GAC 14-MAC

rule 224

14-TZY 

TZY

11100000

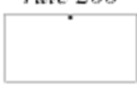
rule 168

13-TZX 

TZX

10101000

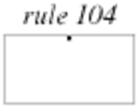
rule 200

11-TYX 

TYX

11001000

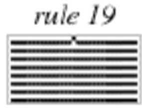
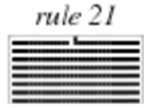
rule 104

7-ZYX 

ZYX

01101000

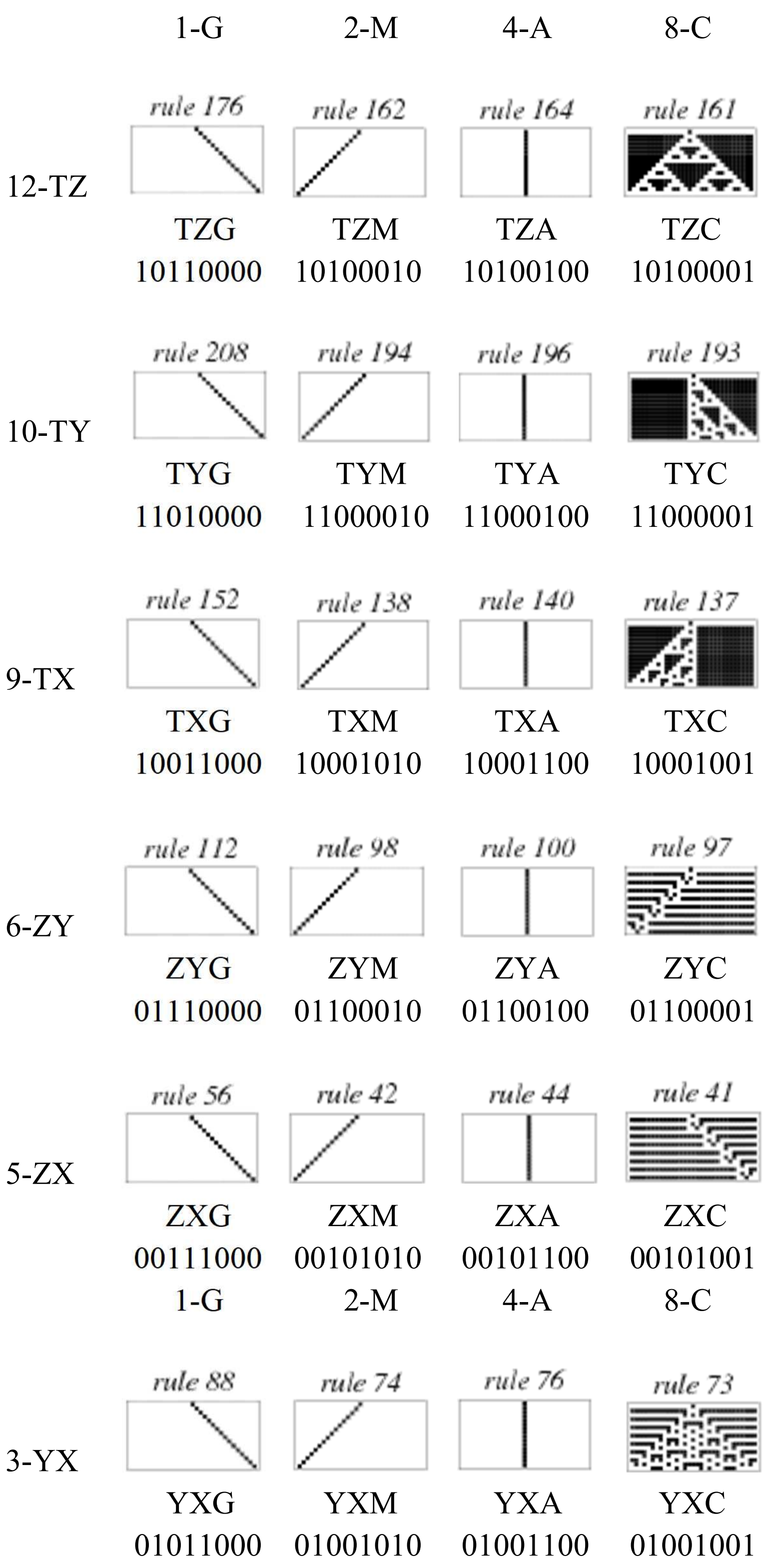
rule 22 *rule 19* *rule 21* *rule 7*

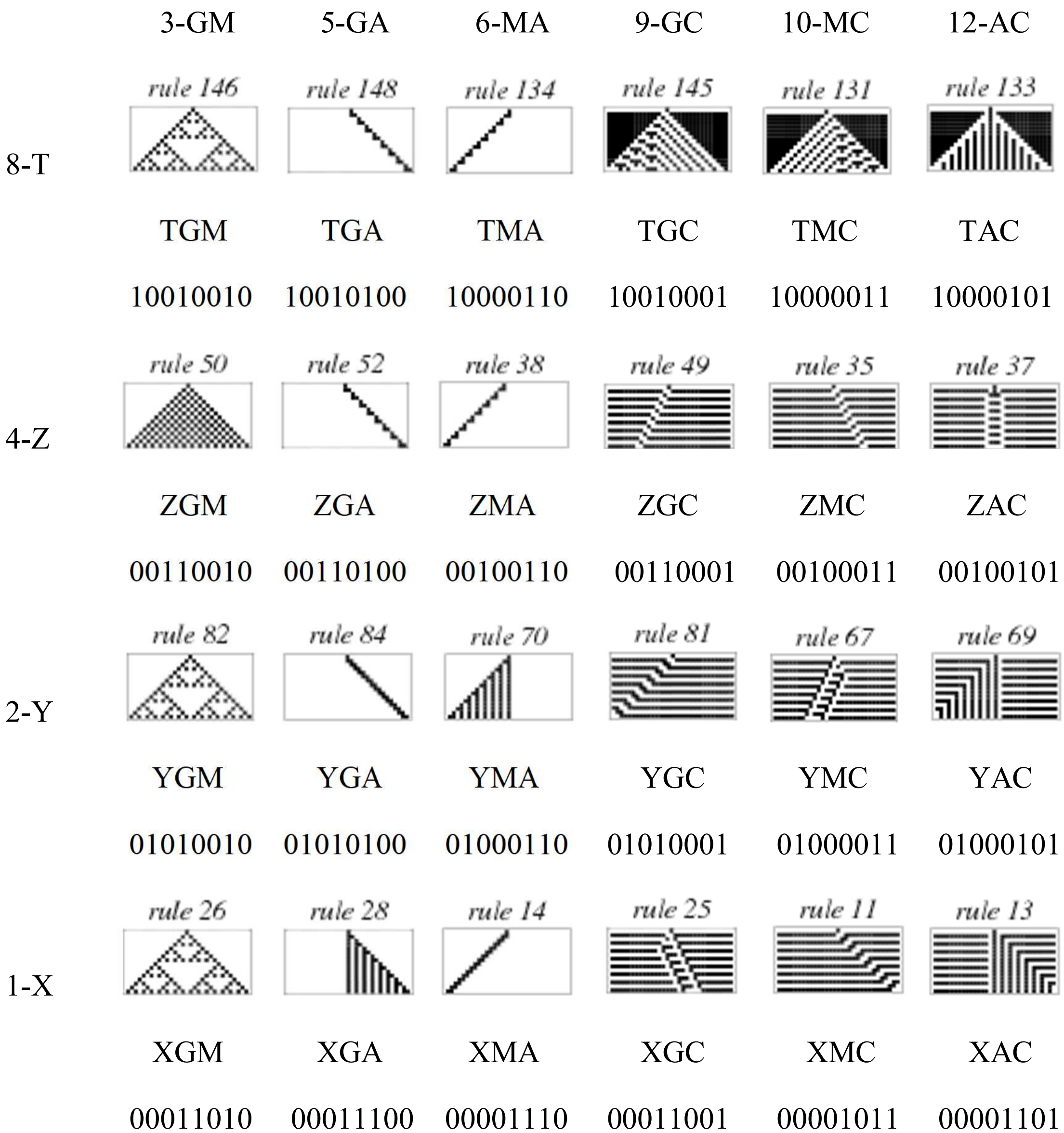
0    

7-GMA 11-GMC 13-GAC 14-MAC

00010110 00010011 00010101 00000111

Here are the rules for quark creation operators.

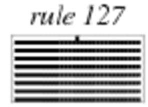




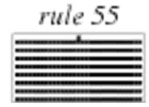
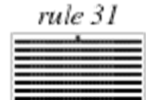
11. Spacetime Components of Antifermion Creation Operators

The E8 64 grading for antifermions comes from the 8 Cl(8) 7-vectors plus the 56 Cl(8) 5-vectors. Thus the related Cellular Automata rules for the spacetime components of each antifermion creation operator have five one-bits or seven one-bits. Like with the ghost boson to actual boson mapping done earlier, the fermion to antifermion mapping is a negative transformation [4].

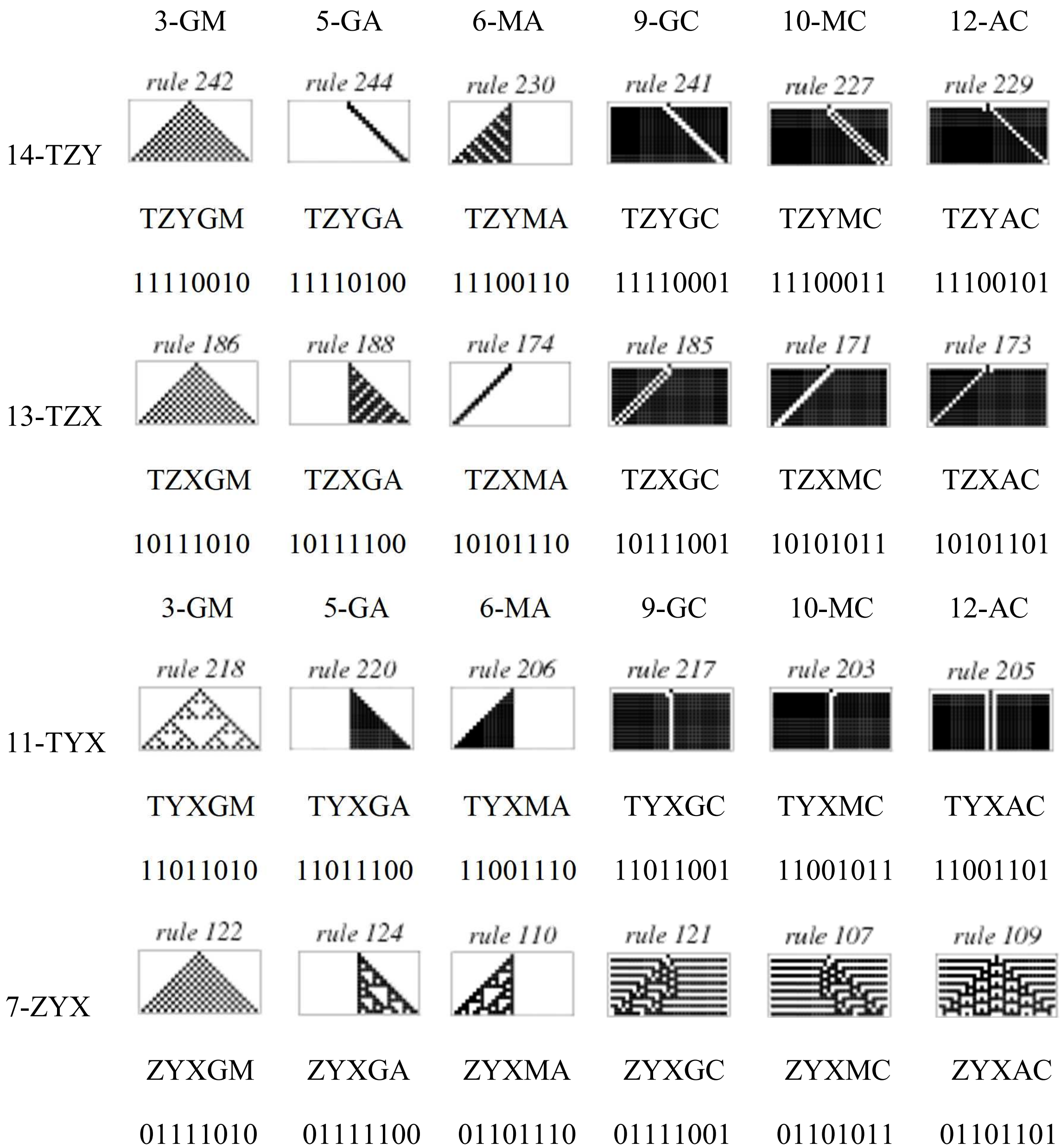
Here are the rules for the antineutrino creation operator.

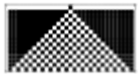
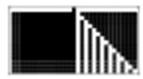
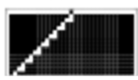
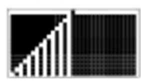
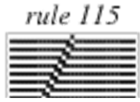
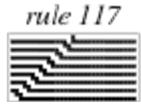
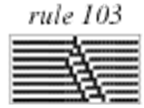
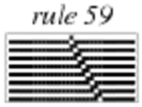
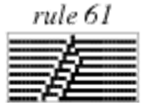
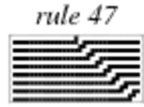
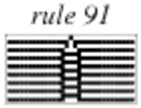
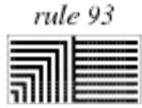
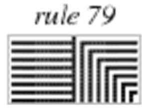
	7-GMA	11-GMC	13-GAC	14-MAC	15-GMAC
15-TZYX	*rule 254*  TZYXGMA 11111110	*rule 251*  TZYXGMC 11111011	*rule 253*  TZYXGAC 11111101	*rule 239*  TZYXMAC 11101111	
14-TZY					*rule 247*  TZYGMAC 11110111
13-TZX					*rule 191*  TZXGMAC 10111111
11-TYX					*rule 223*  TYXGMAC 10111111
7-ZYX					*rule 127*  ZYXGMAC 01111111

Here are the rules for the positron creation operator.

	1-G	2-M	4-A	8-C	15-GMAC
15-TZYX	*rule 248*  TZYXG 11111000	*rule 234*  TZYXM 11101010	*rule 236*  TZYXA 11101100	*rule 233*  TZYXC 11101001	
8-T					*rule 151*  TGMAC 10010111
4-Z					*rule 55*  ZGMAC 00110111
2-Y					*rule 87*  YGMAC 01010111
1-X					*rule 31*  XGMAC 00011111

Here are the rules for antiquark creation operators.



	7-GMA	11-GMC	13-GAC	14-MAC
12-TZ	*rule 182*  TZGMA 10110110	*rule 179*  TZGMC 10110011	*rule 181*  TZGAC 10110101	*rule 167*  TZMAC 10100111
10-TY	*rule 214*  TYGMA 11010110	*rule 211*  TYGMC 11010011	*rule 213*  TYGAC 11010101	*rule 199*  TYMAC 11000111
9-TX	*rule 158*  TXGMA 10011110	*rule 155*  TXGMC 10011011	*rule 157*  TXGAC 10011101	*rule 143*  TXMAC 10001111
6-ZY	*rule 118*  ZYGMA 01110110	*rule 115*  ZYGMC 01110011	*rule 117*  ZYGAC 01110101	*rule 103*  ZYMAC 01100111
5-ZX	*rule 62*  ZXGMA 00111110	*rule 59*  ZXGMC 00111011	*rule 61*  ZXGAC 00111101	*rule 47*  ZXMAC 00101111
3-YX	*rule 94*  YXGMA 01011110	*rule 91*  YXGMC 01011011	*rule 93*  YXGAC 01011101	*rule 79*  YXMAC 01001111

12. Discussion

The reflection transformation bits mentioned earlier, G vs. M or X vs.Y, may relate to color (with neither/both bits making up the third color) for quarks and antiquarks. The bits may affect slant patterns in general (along with A/Z straight line and C/T periodicity/chaos) for bosons, position-momentum, and fermions/antifermions. Here is the partitioning of rule space [8] associated with this mapping of Cl(8), E8 [9], and Elementary Cellular Automata.

	0	1 G	2 M	4 A	8 C	3 GM	5 GA	6 MA	9 GC	10 MC	12 AC	7 GMA	11 GMC	13 GAC	14 MAC	15 GMAC
15 TZYX	232 PM	248 P	234 P	236 P	233 P	250 BO	252 BO	238 BO	249 RO	235 RO	237 RO	254 AN	251 AN	253 AN	239 AN	255 PI
14 TZY	224 E	240 PM/PI	226 PM	228 PM	225 PM	242 AQ	244 AQ	230 AQ	241 AQ	227 AQ	229 AQ	246 GL	243 GL	245 GL	231 GL	247 AN
13 TZX	168 E	184 PM	170 PM/PI	172 PM	169 PM	186 AQ	188 AQ	174 AQ	185 AQ	171 AQ	173 AQ	190 GL	187 GL	189 GL	175 GL	191 AN
11 TYX	200 E	216 PM	202 PM	204 PM/PI	201 PM	218 AQ	220 AQ	206 AQ	217 AQ	203 AQ	205 AQ	222 TR	219 TR	221 TR	207 TR	223 AN
7 ZYX	104 E	120 PM	106 PM	108 PM	105 PM/PI	122 AQ	124 AQ	110 AQ	121 AQ	107 AQ	109 AQ	126 CO	123 CO	125 CO	111 CO	127 AN
12 TZ	160 BO	176 Q	162 Q	164 Q	161 Q	178 PM	180 PM	166 PM	177 PM	163 PM	165 PI	182 AQ	179 AQ	181 AQ	167 AQ	183 PR
10 TY	192 BO	208 Q	194 Q	196 Q	193 Q	210 PM	212 PM	198 PM	209 PM	195 PI	197 PM	214 AQ	211 AQ	213 AQ	199 AQ	215 EW
9 TX	136 BO	152 Q	138 Q	140 Q	137 Q	154 PM	156 PM	142 PM	153 PI	139 PM	141 PM	158 AQ	155 AQ	157 AQ	143 AQ	159 EW
6 ZY	96 RO	112 Q	98 Q	100 Q	97 Q	114 PM	116 PM	102 PI	113 PM	99 PM	101 PM	118 AQ	115 AQ	117 AQ	103 AQ	119 EW
5 ZX	40 RO	56 Q	42 Q	44 Q	41 Q	58 PM	60 PI	46 PM	57 PM	43 PM	45 PM	62 AQ	59 AQ	61 AQ	47 AQ	63 EW
3 YX	72 RO	88 Q	74 Q	76 Q	73 Q	90 PI	92 PM	78 PM	89 PM	75 PM	77 PM	94 AQ	91 AQ	93 AQ	79 AQ	95 DI
8 T	128 N	144 GL	130 GL	132 TR	129 CO	146 Q	148 Q	134 Q	145 Q	131 Q	133 Q	150 PM/PI	147 PM	149 PM	135 PM	151 P
4 Z	32 N	48 GL	34 GL	36 TR	33 CO	50 Q	52 Q	38 Q	49 Q	35 Q	37 Q	54 PM	51 PM/PI	53 PM	39 PM	55 P
2 Y	64 N	80 GL	66 GL	68 TR	65 CO	82 Q	84 Q	70 Q	81 Q	67 Q	69 Q	86 PM	83 PM	85 PM/PI	71 PM	87 P
1 X	8 N	24 GL	10 GL	12 TR	9 CO	26 Q	28 Q	14 Q	25 Q	11 Q	13 Q	30 PM	27 PM	29 PM	15 PM/PI	31 P
0	0 PI	16 N	2 N	4 N	1 N	18 PR	20 EW	6 EW	17 EW	3 EW	5 DI	22 E	19 E	21 E	7 E	23 PM

PI: Primitive Idempotent; RO: Rotation boson/ghost; BO: Boost boson/ghost; TR: Translation boson/ghost
CO: Conformal boson/ghost; DI: Dilation boson/ghost; EW: Electroweak boson/ghost; GL: Gluon boson/ghost
PR: Propagator Phase; Q: Quark creation; E: Electron creation; N: Neutrino creation
AQ: Antiquark creation; P: Positron creation; AN: Antineutrino creation; PM: Position-Momentum
Wolfram Class 1 Rule; Wolfram Class 2 Rule; Wolfram Class 3 Rule; Wolfram Class 4 Rule

The line of symmetry for the Wolfram Rule Classes (diagonal line from rule 232 to rule 23) has the same rules as the line of symmetry for Rodrigo Obando's [10] rule space partitioning. However, the two lines of symmetry have the rules in different locations on the line. These line of symmetry rules are the rules that are their own negative transformation [4].

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