

# Clifford Algebra VoDou Physics of Wolfram's 256 Cellular Automata Rules

The 256 [Cellular Automata](#) Rules of [Wolfram](#) correspond to the 256 basis elements of the 256-dimensional [Clifford Algebra](#) of  $16 \times 16$  Real Matrices,  $Cl(8)$  and  $Cl(1,7)$ , and [its discrete counterpart](#), as well as to the 256 Odu of [IFA](#).

To visualize the correspondence, write the rule numbers in binary notation, put them with the pictures of the 30-level actions of each of the 256 rules as shown on pages 55 and 56 of [Wolfram's](#) book [A New Kind of Science](#), and organize them with respect to the

$$1 + 8 + 28 + 56 + (35+35) + 56 + 28 + 8 + 1 = 256 = 16 \times 16 = 2^8$$

graded structure of  $Cl(8)$ . Here is some more about Cellular Automata.

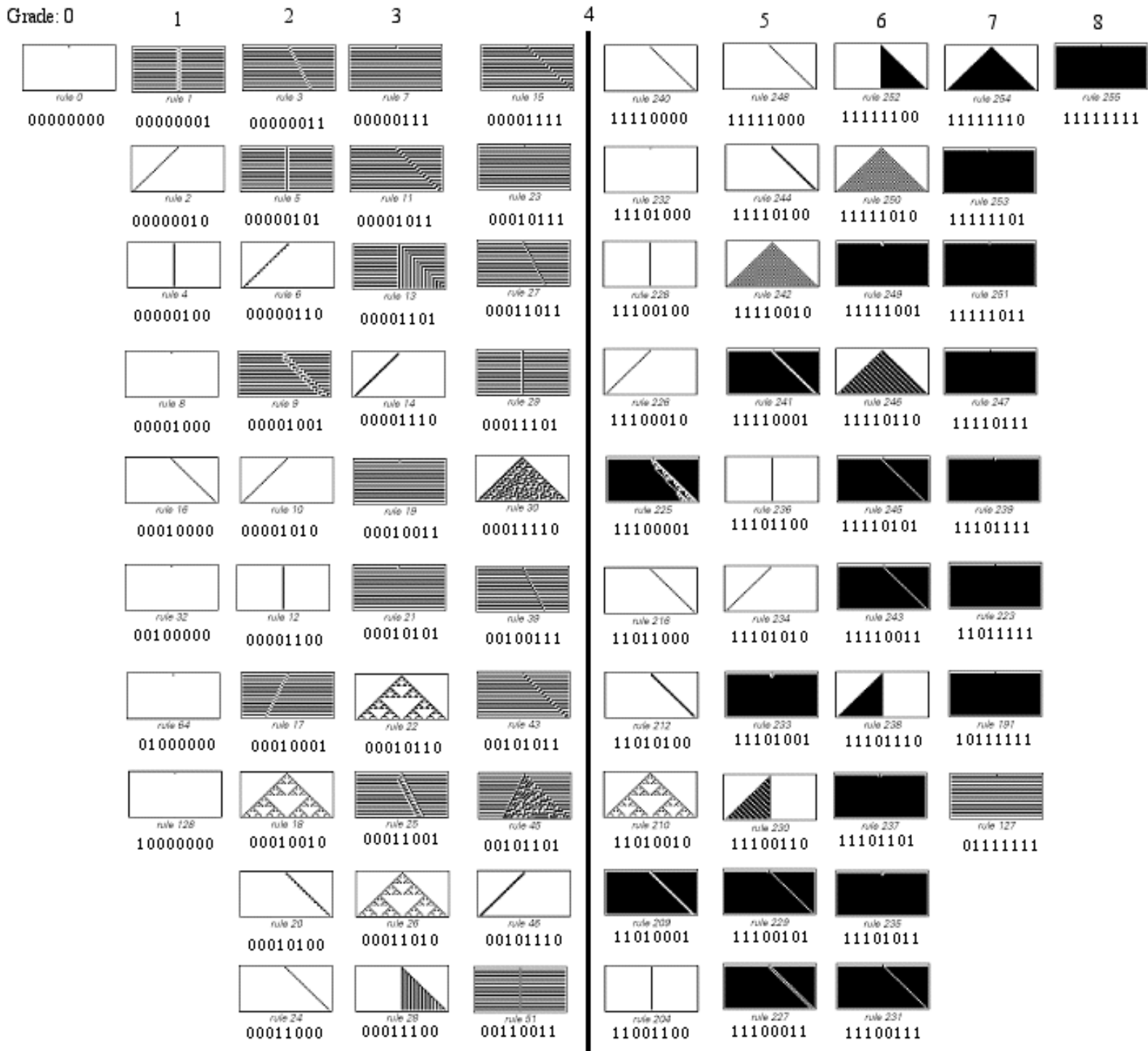
Graded structure details include:

- [Grades 0,1,7,](#) including scalars and vectors;
- [Grades 2,6,](#) including bivectors and their Lie algebra;
- [Grades 3,5;](#)
- [Grade 4;](#)
- [All grades 0,1,2,3,4,5,6,7,8 in binary.](#)

Here are 78 of the 256, including:

- all  $1+8+8+1 = 18$  of grades 0, 1, 7, 8;
- 10 of the 28 in each of grades 2, 6;
- 10 of the 56 in each of grades 3, 5;
- $10+10 = 20$  of the  $35+35 = 70$  in grade 4.

The vertical line is a symmetry line of the symmetry of exchanging 0s and 1s in the binary numbers.



Note that:

- the grade-0 scalars



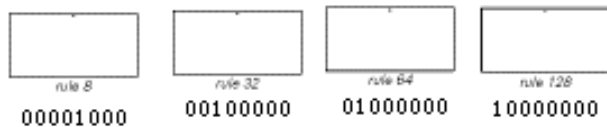
are related to the Spinors and Primitive Idempotents of  $Cl(0,8)$ .

- the grade-1 vectors 1, 2, 4, 16 (the subset sequence  $2^0 = 1, 2^1 = 2, 2^2 = 4, 2^4 = 16$  related to [Fermat primes](#))



correspond to [the 4 dimensions of physical spacetime](#);

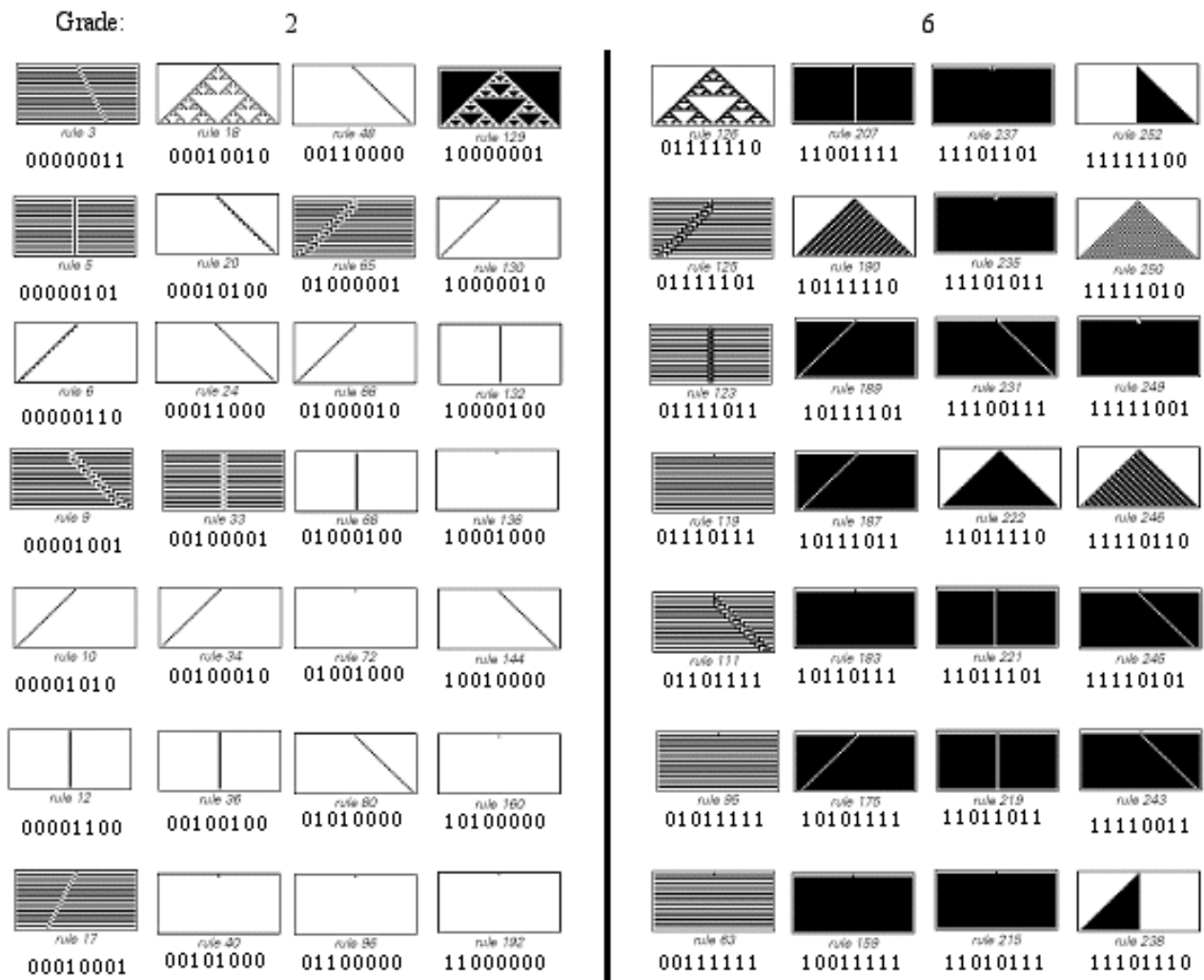
- 1 gives a succession of bands, the procession of time;
- 2 gives a slope to the left, one of three space dimensions;
- 4 gives a vertical slope, a second of three space dimensions;
- 16 gives a slope to the right, the third of three space dimensions;
- the grade-1 vectors 8, 32, 64, 128 (all giving all white)



correspond to [the 4 dimensions of internal symmetry space](#);

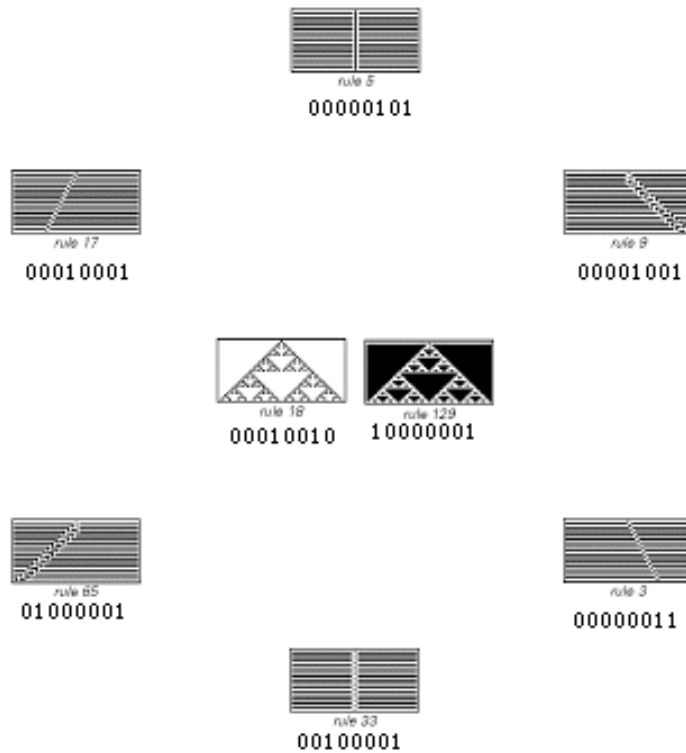
- rule 18 = 00010010 is the first rule to include both 16 = 00010000 with right slope and 2 = 00000010 with left slope and is the first rule with triangular self-similar fractal structure;
- rule 30 = 00011110 is the first rule to include 16, 8, 4, and 2 and is in the self-dual grade-4 and is the first rule with triangular chaotic behavior.

Here are all 28 rules for each of grades 2 and 6.



Note that:

- all 28 grade-2 bivectors correspond to the 28 generators of the Spin(8) [Lie algebra](#);
- 8 of the grade-2 bivectors,



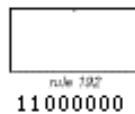
after [dimensional reduction to 4-dimensional physical spacetime](#), correspond to [the 8 generators of color force SU\(3\)](#), whose [root vector diagram](#) is illustrated above;

- 3 of the grade-2 bivectors,











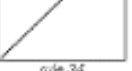

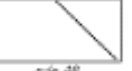



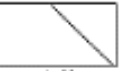

after [dimensional reduction to 4-dimensional physical spacetime](#), correspond to [the 3 generators of weak force SU\(2\)](#);

- 1 of the grade-2 bivectors,

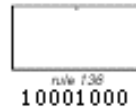


after [dimensional reduction to 4-dimensional physical spacetime](#), correspond to [the 1 generator of electromagnetic U\(1\)](#);

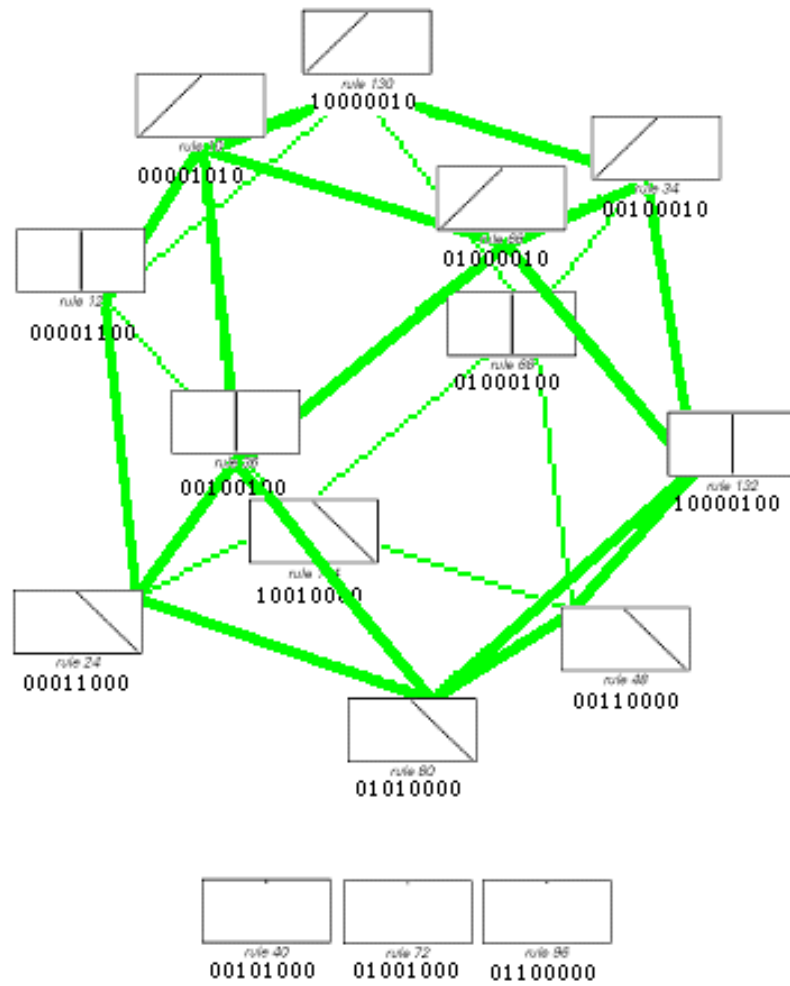
- 16 of the grade-2 bivectors,

 rule 130 10000010	 rule 12 00001100	 rule 144 10010000	 rule 40 00101000
 rule 10 00001010	 rule 36 00100100	 rule 24 00011000	 rule 72 01001000
 rule 34 00100010	 rule 68 01000100	 rule 48 00110000	 rule 96 01100000
 rule 66 01000010	 rule 132 10000100	 rule 80 01010000	 rule 136 10001000

after [dimensional reduction to 4-dimensional physical spacetime](#), correspond to [the 16 generators of Gravity/Higgs/phase U\(2,2\)](#). One of them

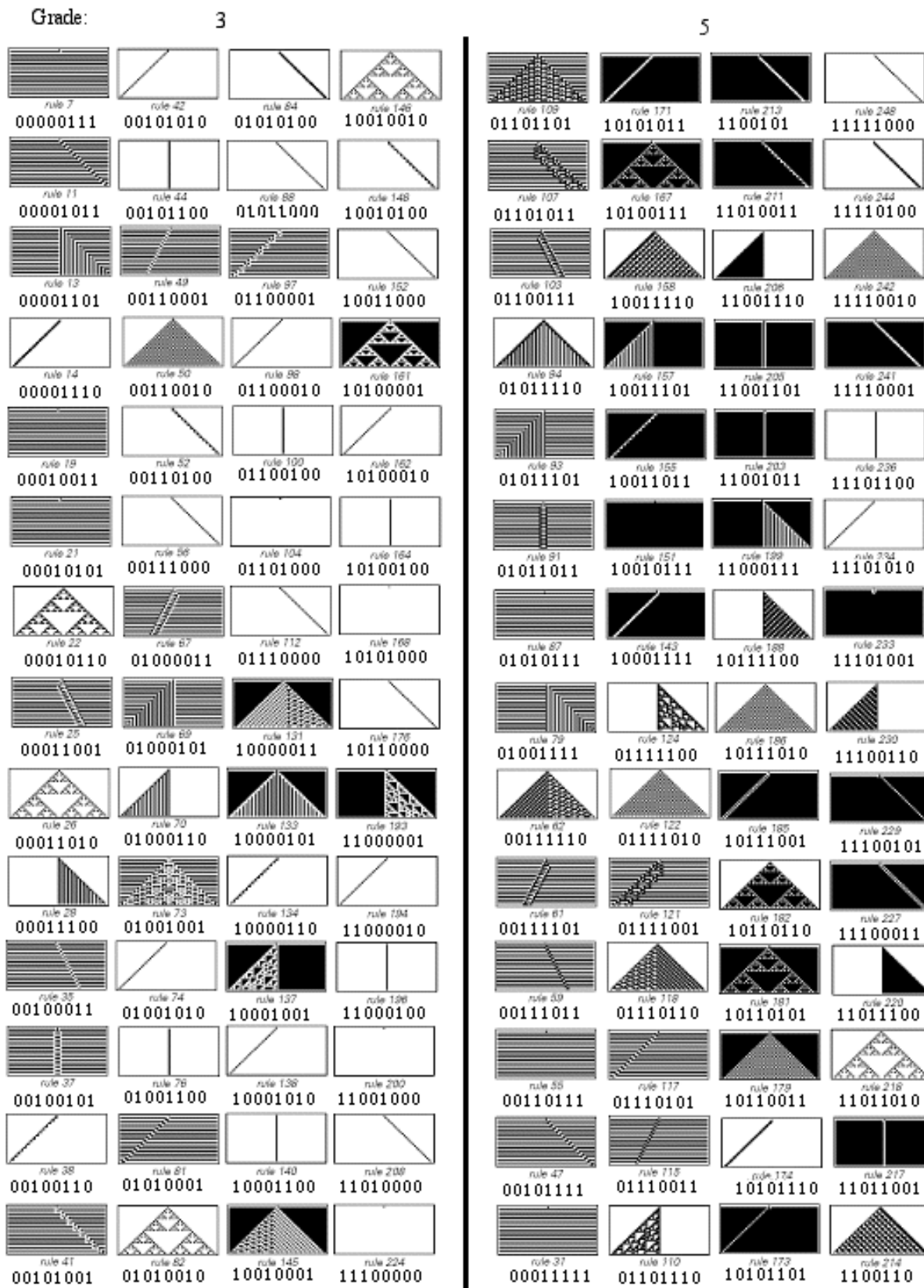


corresponds to the propagator phase U(1) while the other 15 correspond to the [Conformal](#) Group  $SU(2,2) = Spin(2,4)$  [whose root vector diagram](#)



is a 12-vertex cuboctahedron (the other 3 bivectors corresponding to the 3 generators of the Cartan Subalgebra).

Here are all 56 rules for each of grades 3 and 5.

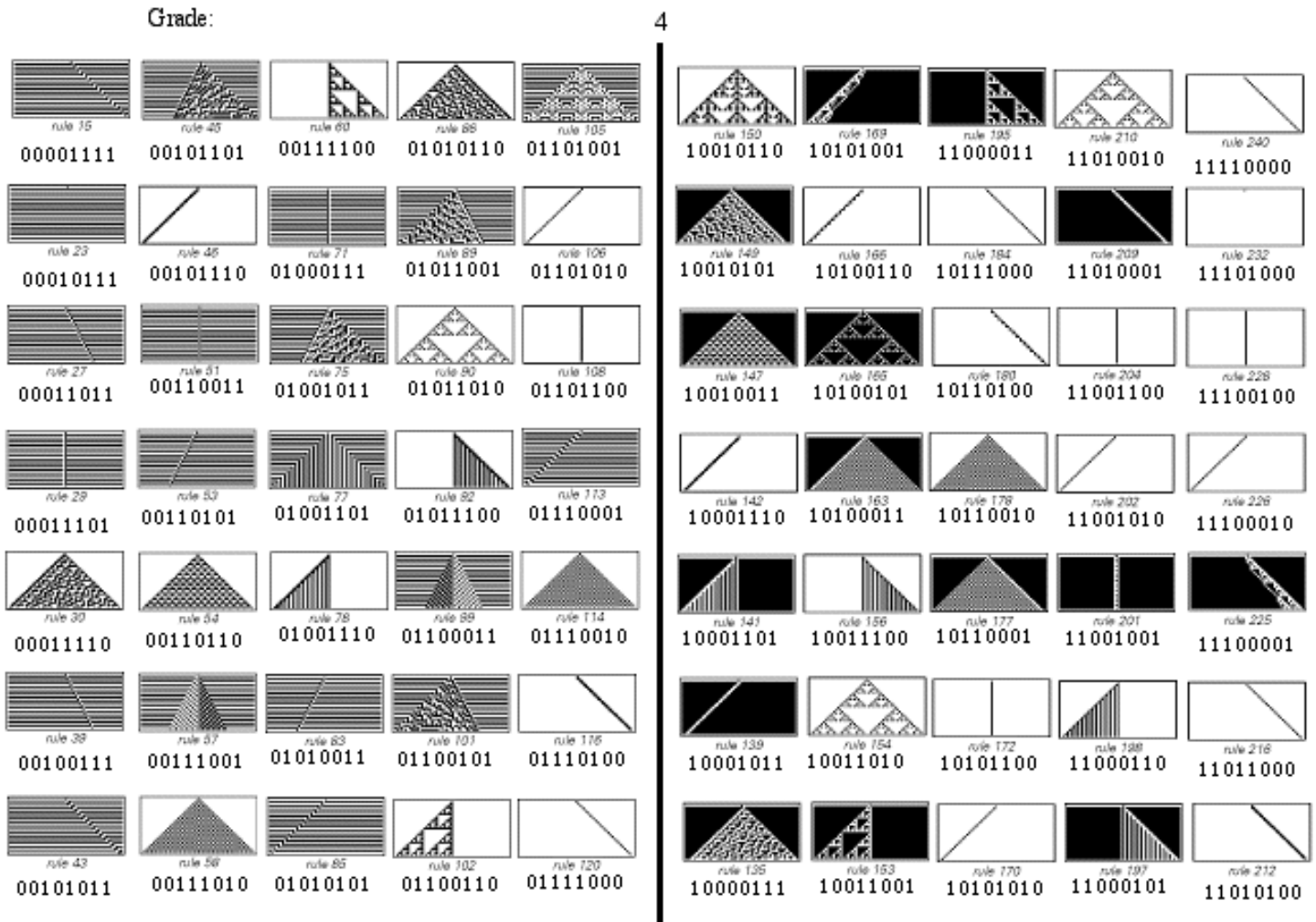


Note that:

- the 56 rules correspond to the 56-dimensional representation of [the exceptional Lie algebra E7](#), which in turn is related to [27-dimensional M-theory](#) and [strings, branes, and the standard model](#).



Here are all  $35+35 = 70$  rules for grade 4.



Note that:

- grade 4 is self-dual, has some rules with chaotic patterns, and may be related to [quantum game theory](#). For example, grade 4 includes rule 30 = 00011110, which is the first rule to include 16, 8, 4, and 2, and is the first rule with triangular chaotic behavior. Grade 4 is also related to the Spinors and Primitive Idempotents of  $Cl(0,8)$ .

Here is a numerical (no pictures) list of all 256, with grade indicated:

Grade:	0	1	2	3	4	5	6	7	8
000	00000000								
001		00000001							
002			00000010						

003		00000011		
004	00000100			
005		00000101		
006		00000110		
007			00000111	
008	00001000			
009		00001001		
010			00001010	
011			00001011	
012		00001100		
013			00001101	
014			00001110	
015				00001111
016	00010000			
017		00010001		
018		00010010		
019			00010011	
020		00010100		
021			00010101	
022			00010110	
023				00010111
024		00011000		
025			00011001	
026			00011010	
027				00011011
028			00011100	
029				00011101
030				00011110
031				00011111
032	00100000			
033		00100001		
034		00100010		
035			00100011	
036		00100100		
037			00100101	
038			00100110	
039				00100111
040		00101000		
041			00101001	
042			00101010	
043				00101011
044			00101100	
045				00101101
046				00101110
047				00101111
048		00110000		
049			00110001	
050			00110010	
051				00110011
052			00110100	
053				00110101
054				00110110
055				00110111
056			00111000	
057				00111001
058				00111010
059				00111011
060			00111100	
061				00111101
062				00111110

063				00111111
064	01000000			
065		01000001		
066		01000010		
067			01000011	
068		01000100		
069			01000101	
070			01000110	
071				01000111
072		01001000		
073			01001001	
074		01001010		
075			01001011	
076			01001100	
077			01001101	
078			01001110	
079				01001111
080		01010000		
081			01010001	
082			01010010	
083			01010011	
084			01010100	
085			01010101	
086			01010110	
087				01010111
088			01011000	
089			01011001	
090			01011010	
091				01011011
092			01011100	
093				01011101
094				01011110
095				01011111
096		01100000		
097			01100001	
098			01100010	
099			01100011	
100			01100100	
101			01100101	
102			01100110	
103				01100111
104			01101000	
105			01101001	
106			01101010	
107				01101011
108			01101100	
109				01101101
110				01101110
111				01101111
112			01110000	
113			01110001	
114			01110010	
115				01110011
116			01110100	
117				01110101
118				01110110
119				01110111
120			01111000	
121				01111001
122				01111010

123				01111011
124			01111100	
125				01111101
126				01111110
127				01111111
128	10000000			
129		10000001		
130		10000010		
131			10000011	
132		10000100		
133			10000101	
134			10000110	
135				10000111
136		10001000		
137			10001001	
138			10001010	
139				10001011
140			10001100	
141				10001101
142				10001110
143				10001111
144		10010000		
145			10010001	
146			10010010	
147				10010011
148			10010100	
149				10010101
150				10010110
151				10010111
152			10011000	
153				10011001
154				10011010
155				10011011
156				10011100
157				10011101
158				10011110
159				10011111
160		10100000		
161			10100001	
162			10100010	
163				10100011
164			10100100	
165				10100101
166				10100110
167				10100111
168			10101000	
169				10101001
170				10101010
171				10101011
172				10101100
173				10101101
174				10101110
175				10101111
176			10110000	
177				10110001
178				10110010
179				10110011
180				10110100
181				10110101
182				10110110

183			10110111			
184		10111000				
185			10111001			
186			10111010			
187				10111011		
188			10111100			
189				10111101		
190				10111110		
191					10111111	
192	11000000					
193		11000001				
194		11000010				
195			11000011			
196		11000100				
197			11000101			
198			11000110			
199				11000111		
200		11001000				
201			11001001			
202			11001010			
203				11001011		
204			11001100			
205				11001101		
206				11001110		
207					11001111	
208		11010000				
209			11010001			
210			11010010			
211				11010011		
212			11010100			
213				11010101		
214				11010110		
215					11010111	
216			11011000			
217				11011001		
218				11011010		
219					11011011	
220				11011100		
221					11011101	
222					11011110	
223						11011111
224		11100000				
225			11100001			
226			11100010			
227				11100011		
228			11100100			
229				11100101		
230				11100110		
231					11100111	
232			11101000			
233				11101001		
234				11101010		
235					11101011	
236				11101100		
237					11101101	
238					11101110	
239						11101111
240			11110000			
241				11110001		
242				11110010		

243		11110011	
244	11110100		
245		11110101	
246		11110110	
247			11110111
248	11111000		
249		11111001	
250		11111010	
251			11111011
252		11111100	
253			11111101
254			11111110
255			11111111

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[Frank D. \(Tony\) Smith, Jr.](#) - May 2004 (June 2004 correction to SU(3) diagram suggested by Michael Gibbs )

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[Tony Smith's Home Page](#) - Here is some more about Cellular Automata.

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