A Concordance for Rule 110

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Abstract

Typical places where the triangles can be found in Rule 110.

Contents

1 Introduction

1.1 Records and curiosities

largest triangle seen in a lattice	T11	Fig. 57
largest triangle found in a collision	T26	Fig. 82
largest triangle found outside a collision	T30	
hardest triangle to find anywhere	T27	
largest possible emergent triangle	T42	Fig. 83

1.2 The distribution of tiles in the regular lattices

There is a version of NXLCAU21 which can calculate de Bruijn diagrams up to ten generations in a reasonable time and with the available memory. These diagrams deliver shift periodic lattices whose unit cells already have the shift-period as one edge, but for which another edge must be extracted from the diagram. For superluminal combinations there is only one cycle, whose length is the horizontal dimension of the unit cell. The number of nodes in the de Bruijn diagram is an extreme limit on the length of cycles, which are usually quite small in comparison. However, an occasional encounter with a long cycle should be expected.

Unit cells can be arranged into more convenient shapes by choosing better edges, just as larger cells can be obtained by joining smaller cells in clumps. Consequently, the same lattice can appear several times in the de Bruijn map under variant forms.

Quite different lattices can coincide in their shift periods, opening the possibility of composite lattices. In the superluminal region this cannot happen, isolating each lattice in its own cycle. Otherwise composites are possible, and need to be noted in the map. Conversely, each different cycle is capable of producing its one superluminal variant, resulting in many lattices grouped around a common theme.

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.
4	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.
5	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.
6	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.
7	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.
8	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.
9	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
10	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*

The basic layout of the map is shown above. Rather than exhibiting one single, all inclusive map, less congestion arises from classifying the lattices according to the largest triangle contained within their primitive unit cell. In the region studied, two large triangles seldom sit in the same unit lattice cell.

1.3 The distribution of tiles in the gliders

	A	B	BBar	C	D	E	EBar	F	G	H
T1	n	1	14	3	8	7	20	26	35	
T2	-	-	3	-	-	2	5	1	6	
T3	1	1	3	1	-	-	17	8	25	
T4	-	-	3	-	2	-	4	4	7	
T5	-	-	1	-	-	1	2	1	3	
T6	-	-	-	1	-	-		2	2	1
T7	-	-	-	-	-	-		1	1	1
T8	-	-	-	-	-	1			1	5
T9	-	-	-	-	-					1
T10	-	-	-	-	-					
T11	-	-	-	-	-					
T12	-	-	-	-	-					
T18	-	-	-	-	-					

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Figure 1: There is some leeway in assigning ether tiles to the gliders or not. Otherwise gliders have characteristic distributions of the primitive triangular tiles, with a loose correlation between the size of the dominant tile and the species of glider, and an even looser connection between the size of that tile and the velocity of the glider.

1.4 The distribution of tiles in boundary layers

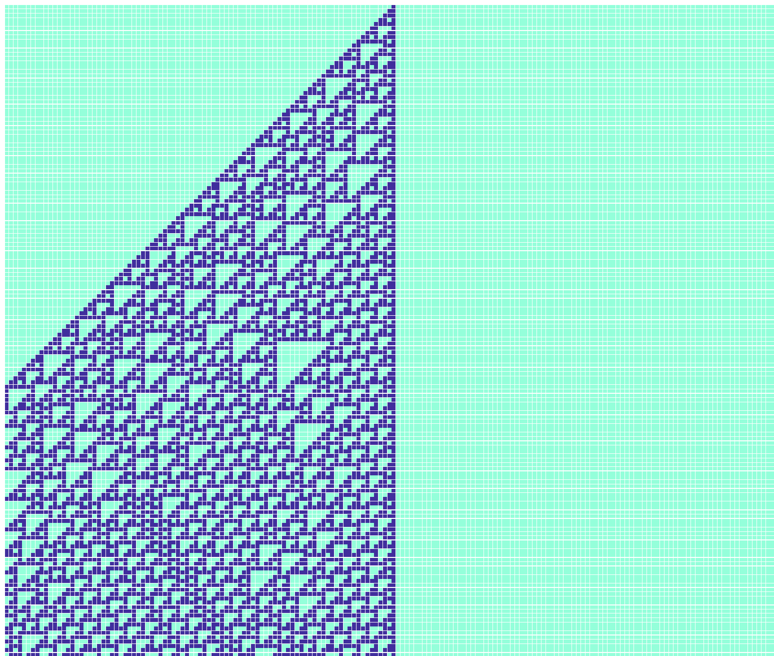


Figure 2: Evolution from a single cell in Rule 110 produces a boundary layer which gradually extends and stabilizes.

The fixed content of the wedge where two large triangles make contact severely constrains the way lattices can be filled up. The restriction manifests itself in many contexts, for example in trying to run triangles off in a given direction in a long strip.

Introducing defects into any lattice will almost certainly generate a wedge containing an alternate evolution. In time, although the time may be quite large, an equilibrium between the wedge and the undisturbed lattice will be reached. The boundary layers may define shift-periodic systems on their own account. None of these combinations have been indexed in the concordance.

2 T1

2.1 cross references

subdiagonal space filler in nearly every evolution	
in a cluster accompanying T4 in D gliders	Figure 11
triplet characterizing EBar gliders	Figure 56
a conspicuous cluster in an F glider	Figure 36

2.2 periodic lattice component

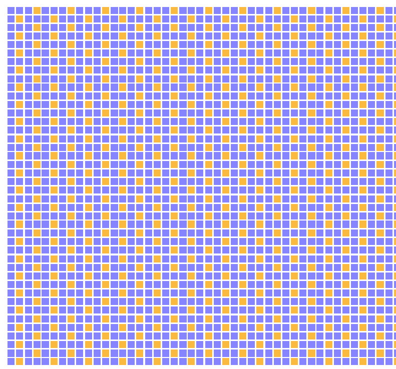


Figure 3: T1 is the smallest triangle, but nevertheless can crystallize in a lattice of pure T1's. The enantiomorphic diagonal reflection also tiles the plane, but cannot evolve under rule 110.

The prime occurrence of T1 is in a cycle of length 4, generating staggered columns of T1's.

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	c	.	.	.	c	.	.	.	c	.	.	.	c	.	.	.	c	.	.	.	c
2	.	.	c	.	.	.	c	.	.	.	z	.	.	.	c	.	.	.	c	.	
3	c	.	.	.	c	.	.	.	c	.	.	.	A	.	.	.	c	.	.	.	c
4	.	.	c	.	.	.	c	.	.	.	z	.	.	.	c	.	.	.	c	.	
5	c	.	.	.	c	.	.	.	f	.	.	.	c	.	.	.	c	.	.	.	c
6	.	.	c	.	.	.	c	.	.	.	z	.	.	.	A	.	.	.	c	.	
7	c	.	.	.	c	.	.	.	c	.	.	.	c	.	.	.	c	.	.	.	c
8	.	.	c	.	.	.	f	.	.	.	z	.	.	.	c	.	.	.	c	.	
9	c	.	.	.	c	.	.	.	f	.	.	.	f	.	.	.	A	.	.	.	c
10	.	.	c	.	.	.	f	.	.	.	z	.	.	.	c	.	.	.	c	.	

Table 1: At certain shift-periods, the cycle may coincide with other patterns (marked by f), especially in the formation of the A gliders (marked by A). It may also end abruptly at a half-space of zeroes (marked by z), as regularly happens in static configurations.

3 T2

3.1 cross references

links T4's in the D gliders	Figure 11
a pair always sits below T8 in E gliders	Figure 18

3.2 periodic lattice component

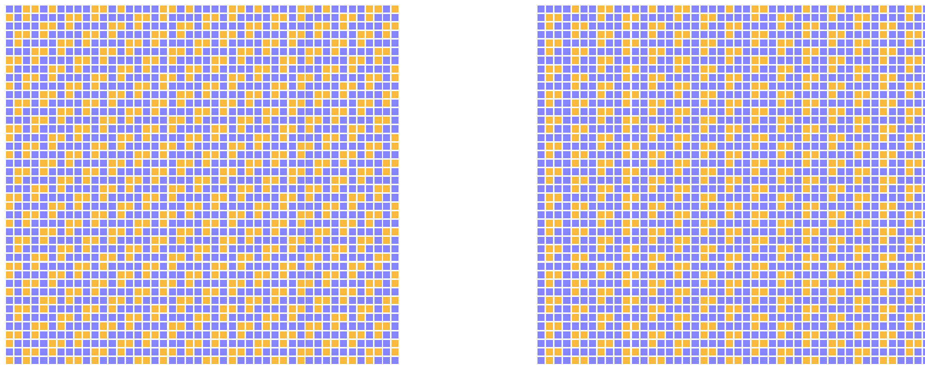


Figure 4: T2 crystallizes in two forms. Left: diagonally nested. Right: stacked in vertical columns, for which only one relative alignment is possible. The enantiomorphic stacking in rows is geometrically possible for triangles as such, but would run counter to the prohibition of contiguous top margins for evolutionary reasons.

There are two prime cycles for T2, consisting exclusively of T2's which are stacked diagonally in the first cycle of length 8, and vertically in the second cycle of length 9. There are no alternatives, but larger composites may arise when the shift period coincides with other designs.

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	.	.	.	.	c	.	.	d	.	.	.	.	.	c	.	d	.	.	.	.	.
2	.	.	.	.	d	.	.	.	.	.	.	.	d	.	.	.	c	.	.	.	d
3	.	x	.	.	.	.	.	.	.	d	.	.	.	.	.	.	.	d	.	c	.
4	.	.	.	.	c	.	d	.	.	.	.	.	.	c	d	.	.	.	.	.	.
5	.	.	.	d	.	.	.	.	.	.	.	d	.	.	.	.	c	.	.	d	.
6	d	c	.	.	.	.	.	.	d	.	.	.	.	.	.	.	d	.	.	c	.
7	.	.	.	.	c	d	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.
8	.	.	d	.	.	.	.	.	.	.	d	.	.	.	.	.	c	.	d	.	.
9	.	c	.	.	.	.	.	d	.	.	.	.	.	.	.	d	.	.	.	c	.
10	.	.	.	.	x	.	.	.	.	.	.	.	d	c	.	.	.	.	.	.	d

Table 2: multiples of the unit cell for diagonal stacking are marked d, for columnar stacking by c. Where other designs have coincidental shift periods, the mark is x.

4 T3

4.1 cross references

4.2 periodic lattice component

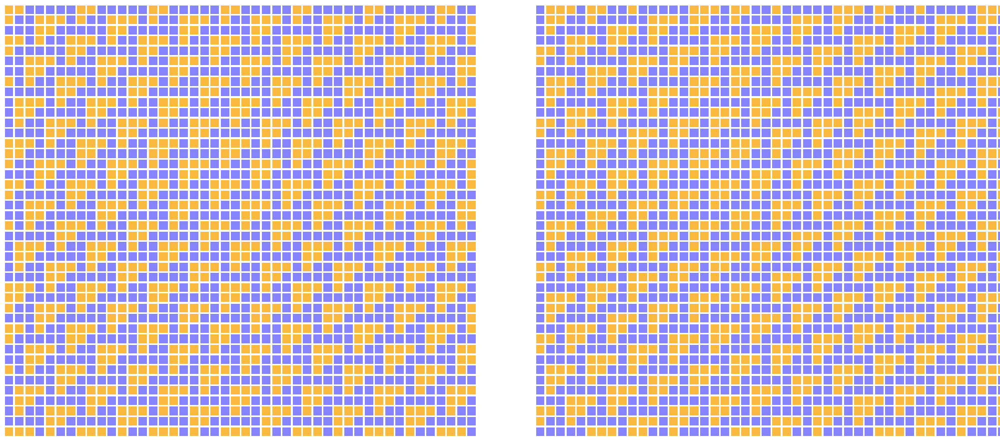


Figure 5: T3 crystallizes in two enantiomorphic forms, of which the form shown on the right is by far the most common and comprises the ether. The other is a minority component in some gliders.

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	d	.	.	.	.	.	.	d	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	d	.	.	.	.	.	.	d	.	.	.	.	.	.	.	d	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	d	.	.	.	.	.	.	d	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	d	.	.	.	.	.	.	d	.	.	.	.	.	.	d	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	d	.	.	.	.	.	.	d	.	.	.	.	.	.	d	.	.

Table 3: The antiether enantiomer has period 7 and only manifests in even generations.

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	.	.	.	.	.	.	d	.	.	.	.	.	.	.	.	.	.	.	.	.	d
2	.	.	d	.	.	.	.	.	.	.	.	.	.	.	.	.	d	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	A	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	B	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	d	.	.	.	.	.	.	.	.	.	.	.	.	.	d	.	.
6	d	.	.	.	.	.	.	.	.	.	.	.	.	.	A	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	C	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	d	.	.	.	.	.	.	.	.	.	.	.	.	.	A	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.D	.	.	.	.	.	.	.		

Table 4: The cycle length of the ether is 14, but the shift period may admit inclusions.

5 T4

5.1 cross references

5.2 periodic lattice component

5.2.1 diagonally extended lattice

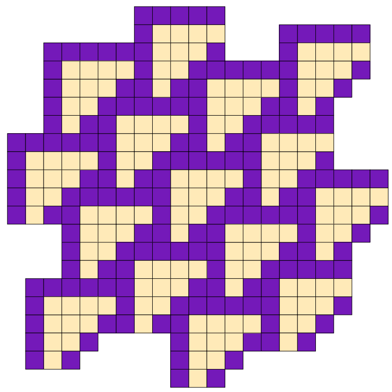


Figure 6: T4's can crystallize all by themselves into a periodic lattice. To do so, they join diagonally.

5.2.2 columnar lattices

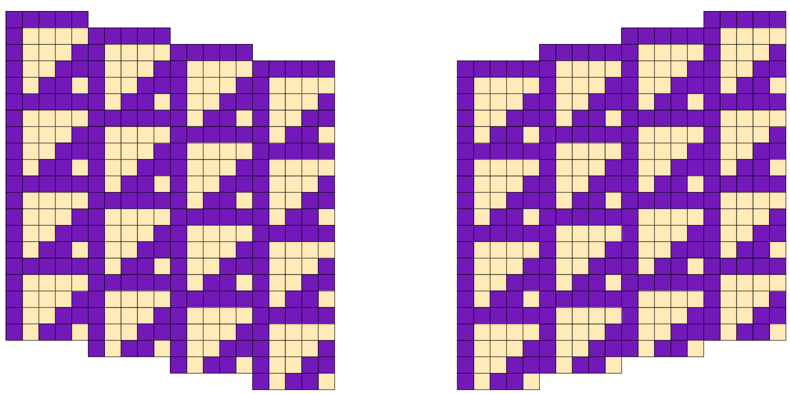


Figure 7: T4's can also combine with other small triangles to form crystal lattices, or even aperiodic ones when the joining rules are sufficiently flexible.

5.2.3 less orderly lattices

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	.	D2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	37	.
3	.	D1	.	74	.	37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	37	.	.	.	.	.	.
6	37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.
8	.	D2	.	.	.	.	.	.	.	37	.	.	.	.	.	.	74	25	.	.	.
9	161	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	D	.	f	.	.	.	37	.	.

Table 5: Besides the columnar and diagonal forms of T4 lattices, there is enough flexibility in packing the smaller triangles that many ofhter lattices are possible. Among these are the ones involving D gliders.

Figure 8: Diagonally slanting lines of T4's can be separated by T3's and some additional packing. However the packing does not quite make an ether string. The left lattice has a cycle of 25, with shifts "left 9 in 4" and 11right 7 in 8." The right lattice has a cycle of 17, corresponding to "left 10 in 7" and to "right 7 in 7," which is just light velocity.

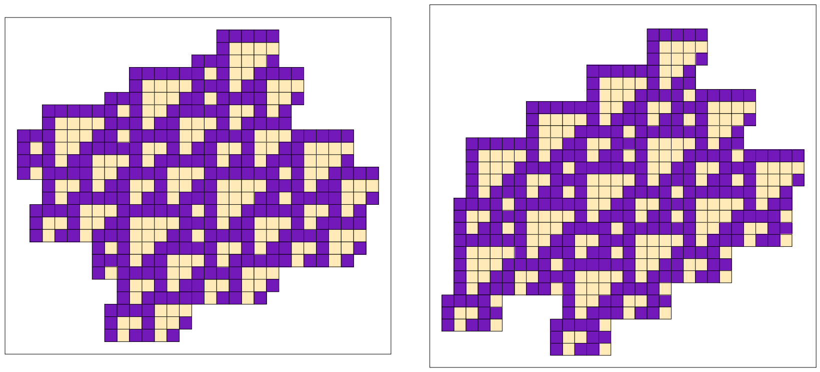


Figure 9: Somewhat shallower diagonal strings of T4's. The left lattice has a small unit cell containing 38 cells, and a cycle length of 37. It appears 6 times in the de Bruijn map, at “right 4 in 5,” “right 8 in 10,” “right 9 in 2,” “left 1 in 8,” “left 5 in 8,” and “left 10 in 6.”

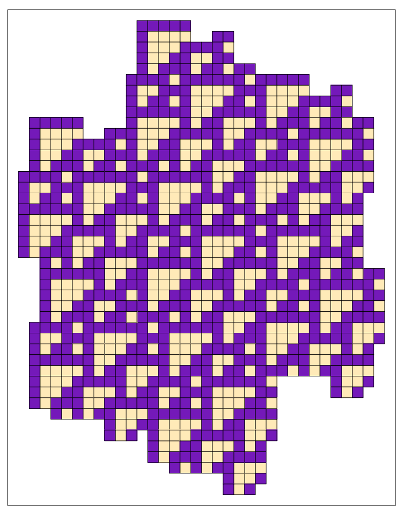


Figure 10: T4's can make diagonals in both directions. This example is very close to the format of the D gliders, but fails to develop an ether interface. The unit cellhhas 151 cellular automaton cells, with a cycle length of 161. It sits in the de Bruijn map at “left 10 in 9.”

5.3 dominant D glider component (velocity 2c/10)

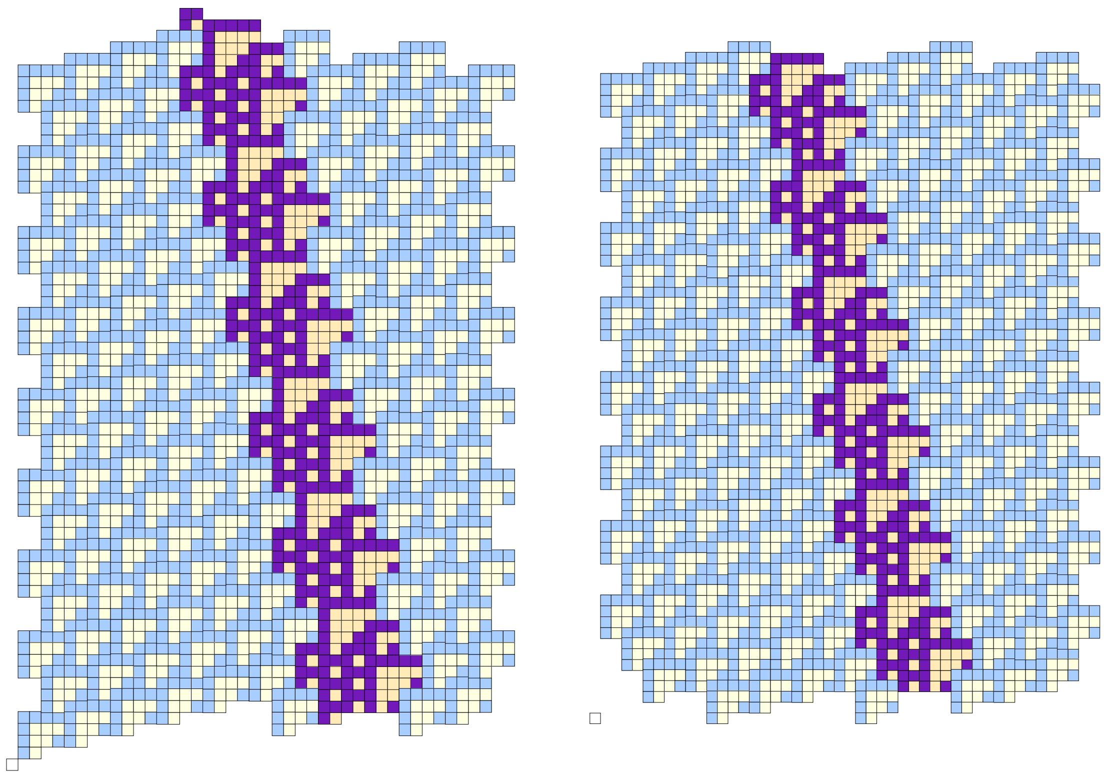


Figure 11: T4 is the largest triangle in the D gliders, which only differ by their interfacing to the ether along their left margins. Left: D1 glider. Right: D2 glider.

The contents of a D1 glider are

triangle	number
T0	2
T1	8
T2	1
T4	2

6 T5

6.1 cross references

constituent and extender of E glider	Figure 44
constituent of BBar8 glider	Figure 47
constituent and extender of G glider	Figure 45

6.2 periodic lattice component

Figure 12: Although the T5's will not fit together in a lattice of which they are the only component, they go well with T1's, in two enantiomorphic forms.

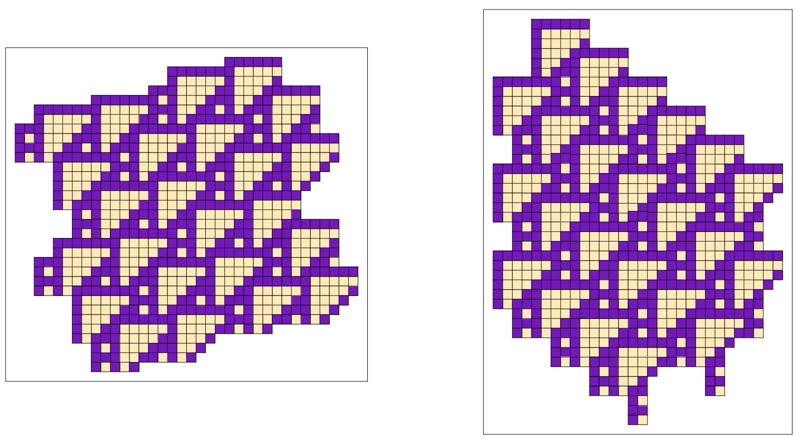


Figure 13: If other fillers besides single T1's are considered, the T5's can crystalize in still further periodic lattices. Here two T2's are used instead of a singlet; the latice still accomodates them although slopes and spacings have changed.

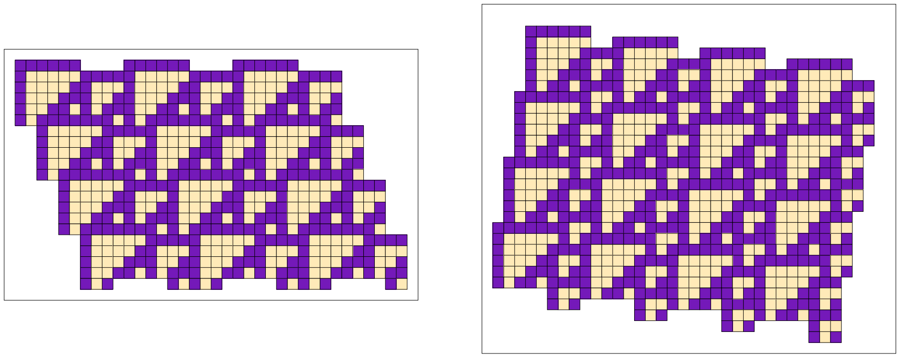


Figure 14: In the left image a diagonal of T1's and T3's separates diagonals of T5's. In fact, these diagonal stripes can be combined arbitrarily, but only the one shown has the shift-periodicity of "right 2 in 5." In the tight image, a column of T2's separates columns of T5's. Inclusion of the T2 stripe is optional, but two of them cannot be placed alongside of each other because of violating the alignment restriction for upper margins. If they could have been, the result would have been a new T2 lattice.

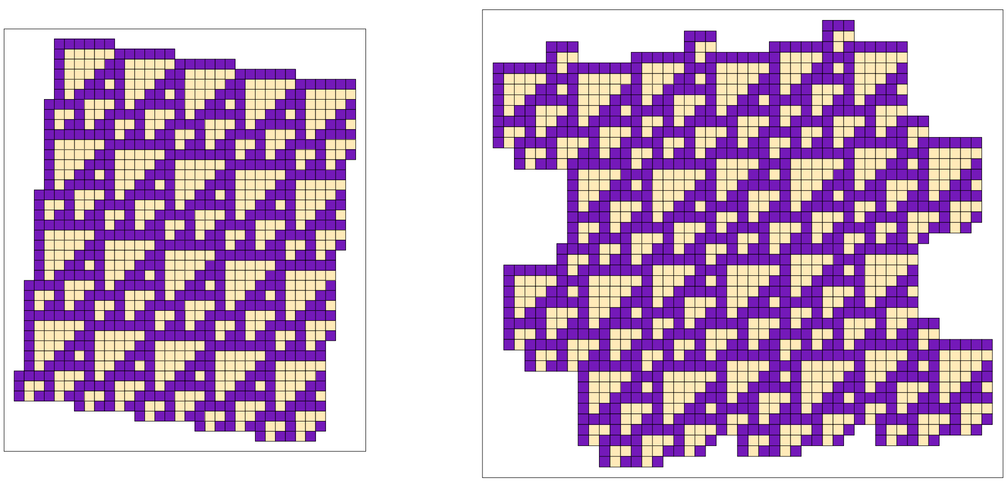


Figure 15: If still further combinations are considered, we can look at the two above. In the left image, a horizontal stripe composed of T2's and T3's separates horizontal stripes composed of T5's. This buffer stripe allows successive T5's to fall by a single cell, in contrast to the right image in Figure 12, where they fall by two cells. In the right image, T4's join with T5's to make a grid, within which slightly rising horizontal stripes can be discerned.

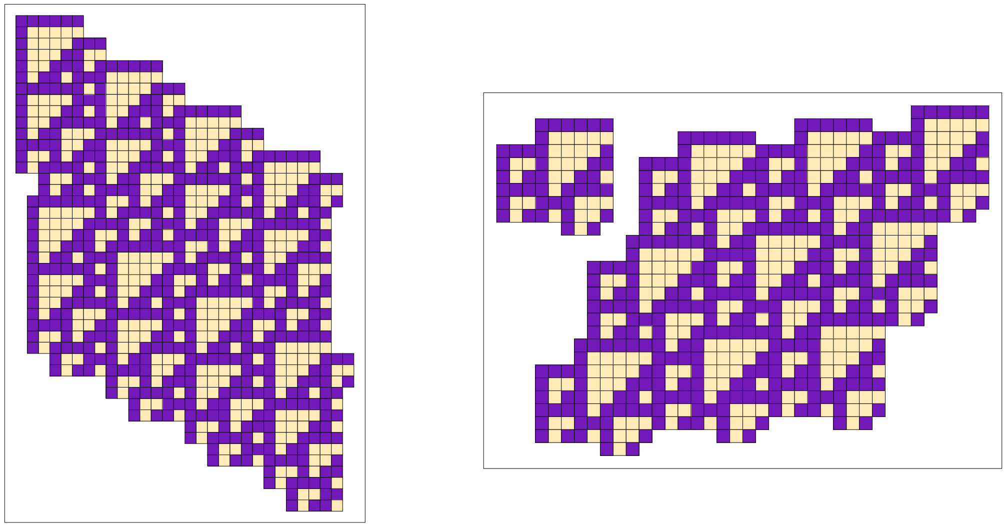


Figure 16: Rather than aligning vertically, a T4-T5 pair can align vertically, although it is hard to say whether the result is vertical stripes separated by a shim, or successive stripes of T5's and T4's respectively, with their own lamination. In the right image, T4's join with T5's to make a grid whose unit cell is shown to one side.

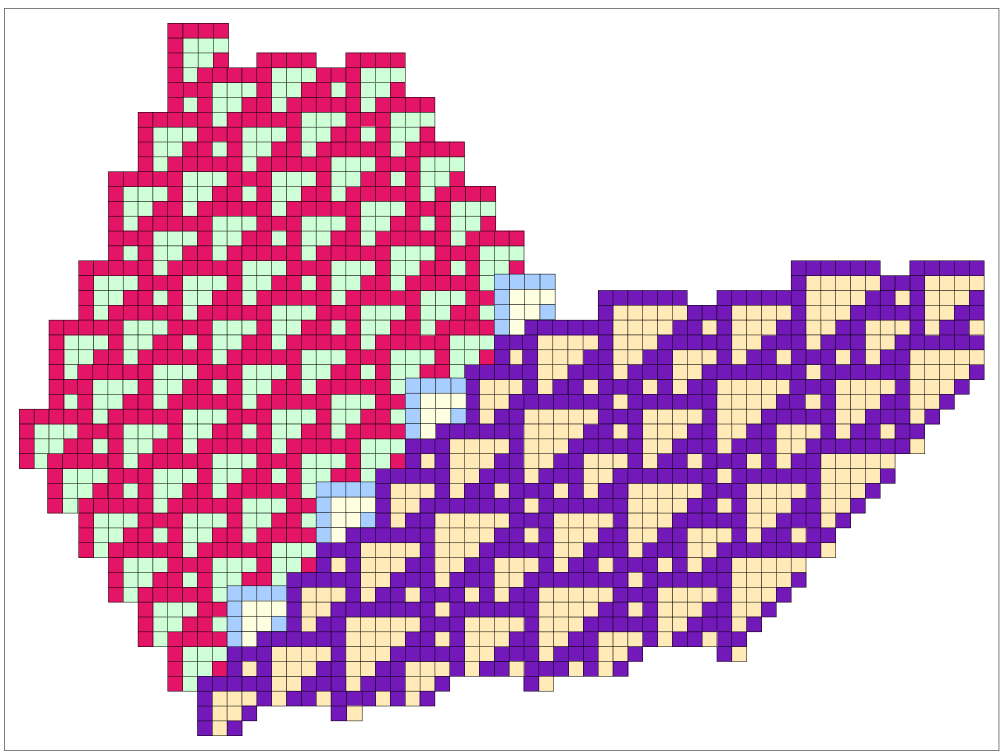


Figure 17: When two lattices are compatible they can sometimes be merged along a variant seam, of the same symmetry.

6.3 glider component

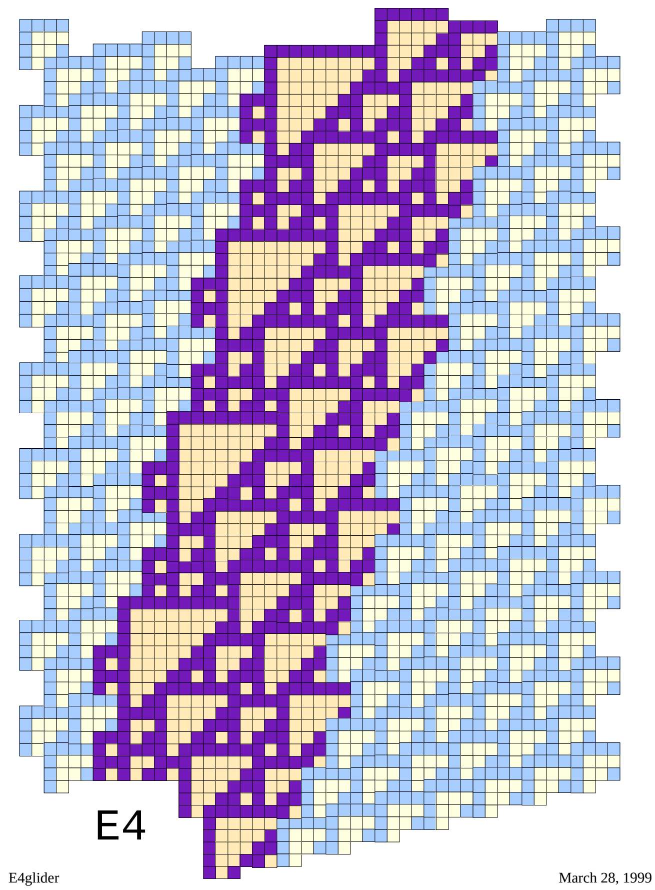


Figure 18: T5 is a prominent component in all the E gliders. Together with T1's and T3's, actually parts of an alpha lattice in their own right, they are the principal feature responsible for the expansion or contraction of E gliders.

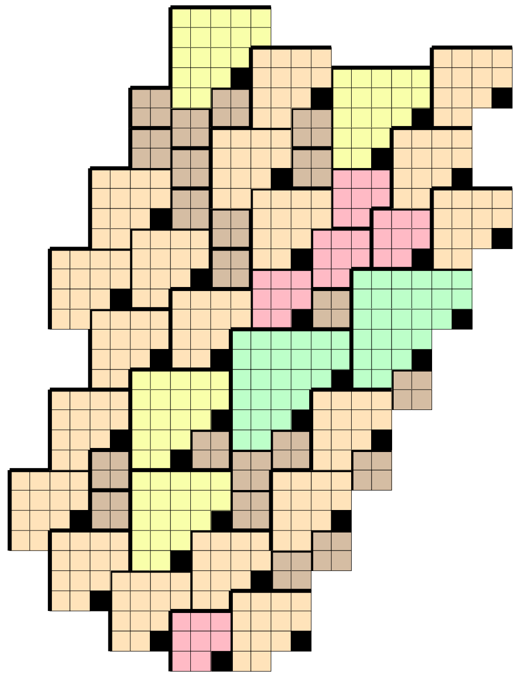


Figure 19: T5 is the largest triangle in EBar gliders.

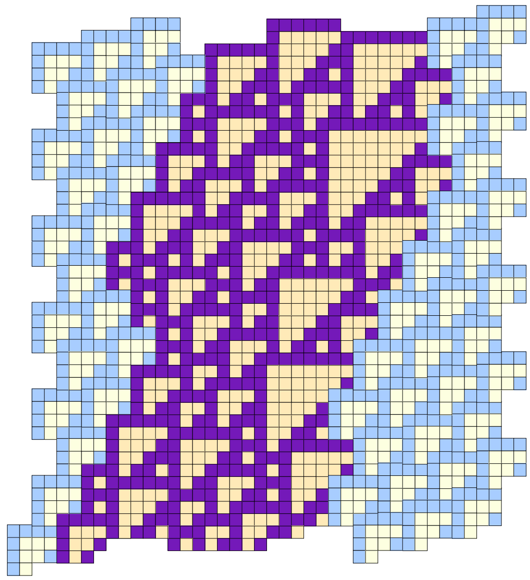


Figure 20: T5 plays a role in G gliders similar to the one it has in E gliders, although it does so while forming part of a slightly different alpha lattice.

7 T6

7.1 cross references

constituent of a shift 10 in 8 lattice Figure 57

7.2 periodic lattice component

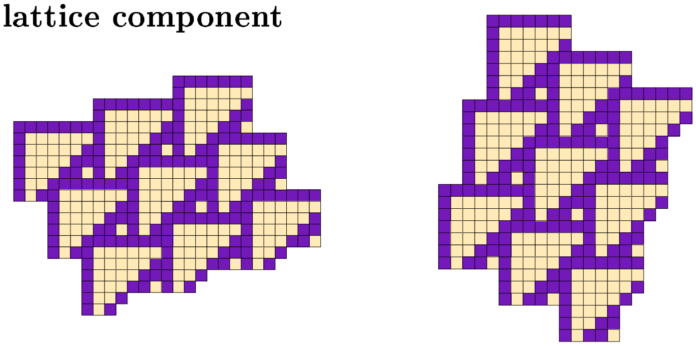


Figure 21: Although the T6's will not fit together in a lattice of which they are the only component, they go well with T1's, in two enantiomorphic forms.

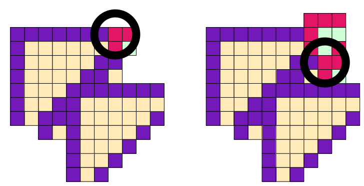


Figure 22: However, the symmetric form in which T6's repeat along the diagonal to make a light velocity lattice, is impossible.

	10	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
1	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.
3	.	C3	.	.	.	.	.	*	.	.	.	.	.	*	.	.	hi	.	.	C3	lo
4	.	.	.	hi	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	C3	.
5	.	C2	.	.	.	*	.	.	.	.	.	.	.	lo	.	*	.	.	.	.	.
6	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	hi
7	.	C1	.	.	.	.	LO	.	HI	.	.	.	.	.	.	.	.	*	.	C1	.
8	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.
9	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C2	.
10	*	.	.	.	.	.	.	.	.	.	.	.	.	hi	.	.	lo	.	.	.	*

Table 6: The columnar form of stacked T6's is C gliders, which show up in superluminal form in various parts of the map. Diagonal stacking is also possible, with a high position marked hi and a low position marked lo. In the subluminal region some composites are possible, marked HI or LO. Many other, less simple, combinations are possible.

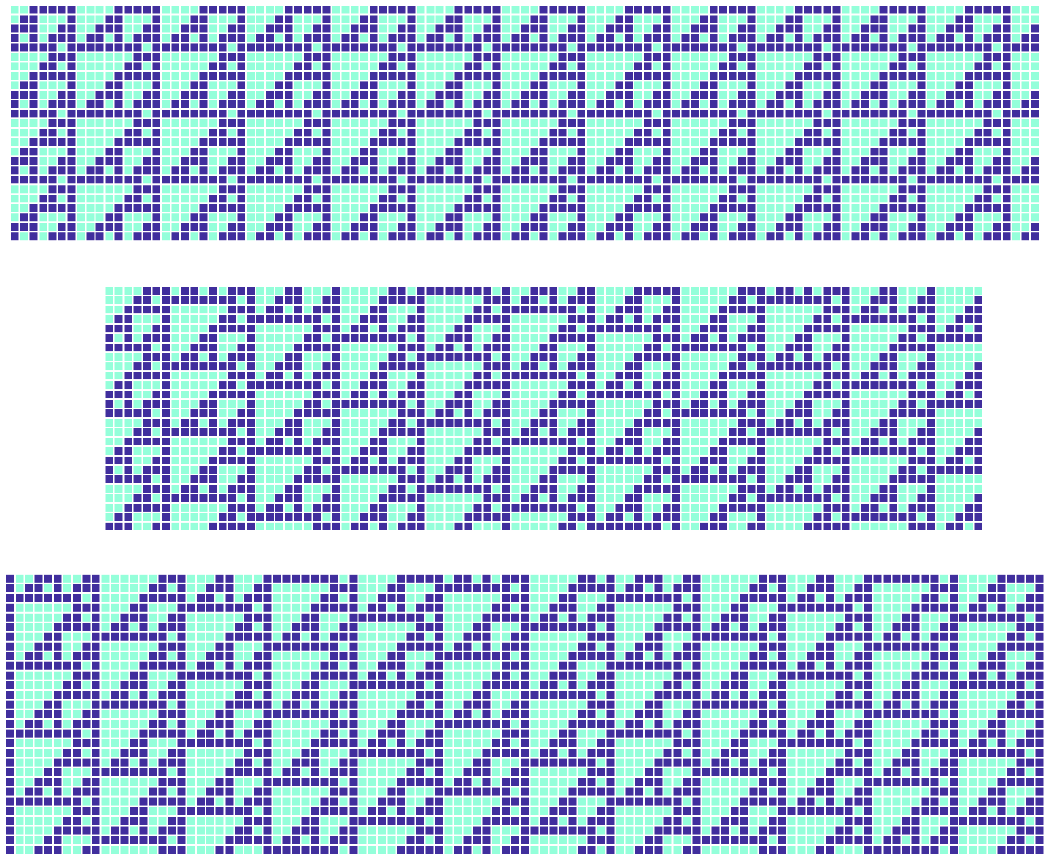


Figure 23: T6 is the largest triangle in the C gliders. The three C's are distinguished by the alignment of T6's and T1's wherever two columns join. The C gliders pack readily into lattices. An enormous variety eventually results from varying the staggering from column to column.

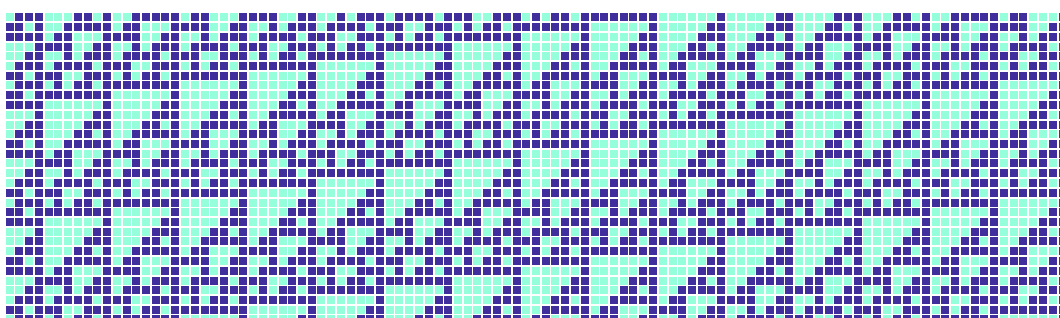


Figure 24: Columns which somewhat resemble the C gliders result when the T6's are separated by padding of the same width.

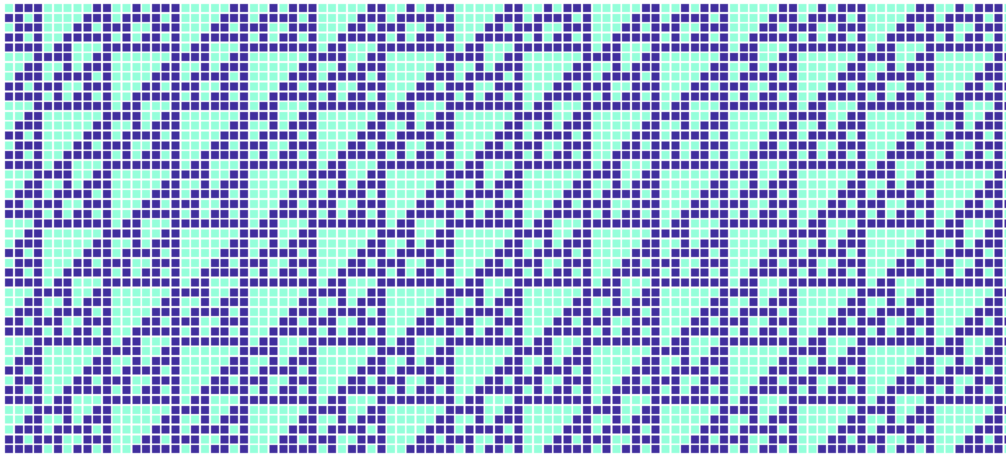


Figure 25: The same unit cell from Fig. 24 gives another lattice when its alignment is changed, this time with a steeper diagonal slant.

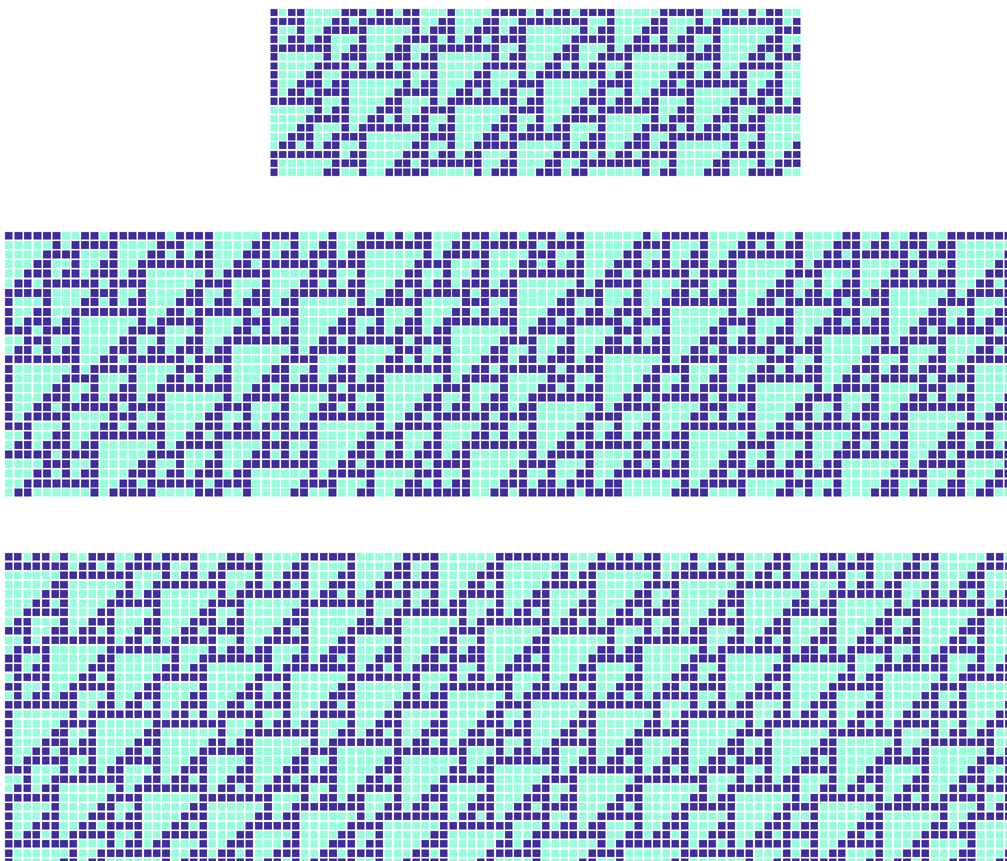


Figure 26: Three more variations on a slanting theme.

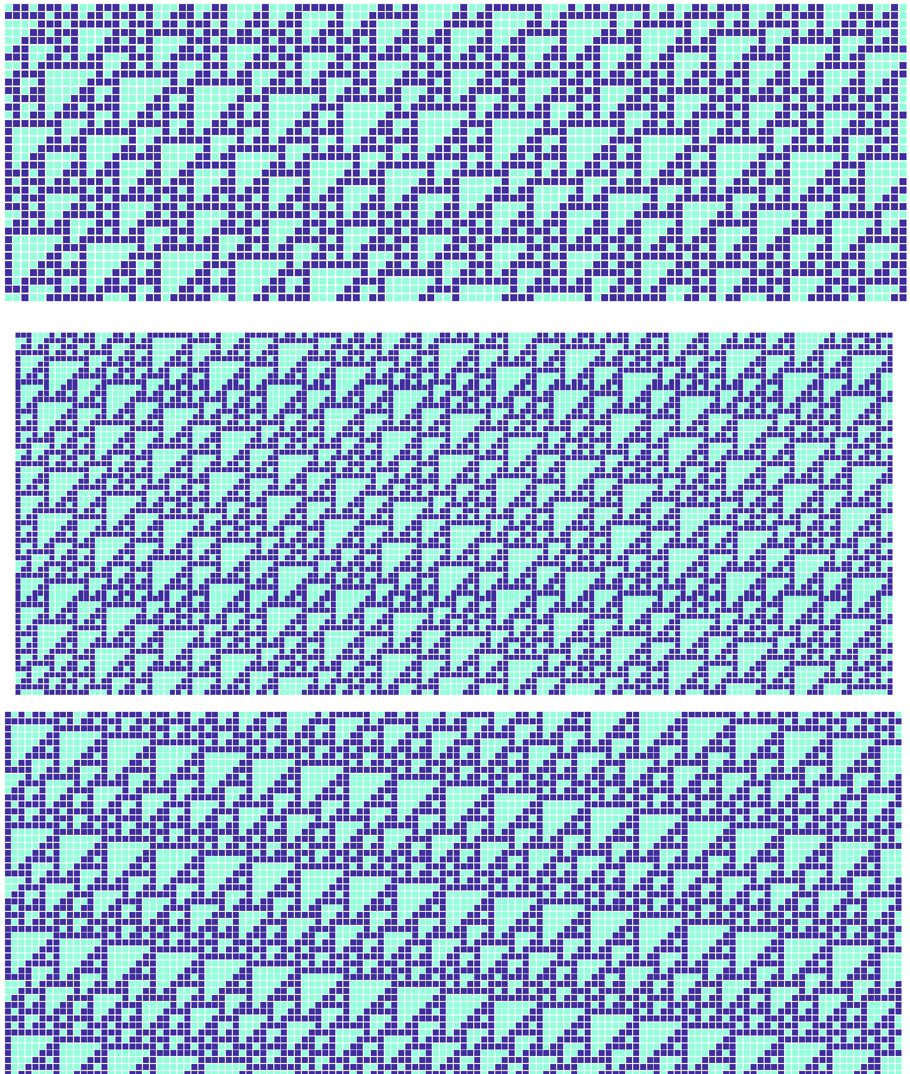


Figure 27: Another three variations on a downward slanting theme.

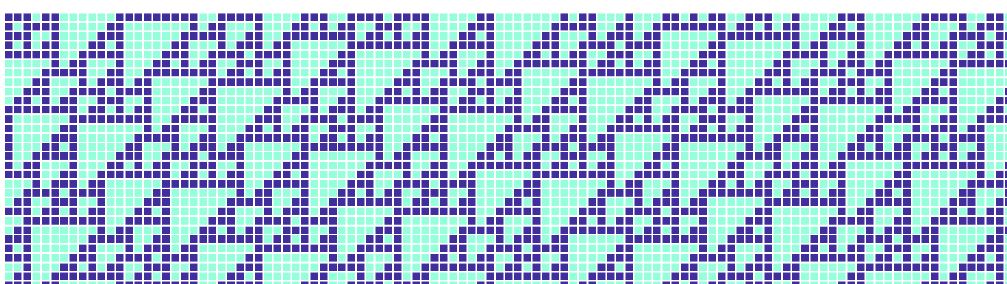


Figure 28: A lattice in which a T6 and a T7 share a unit cell.

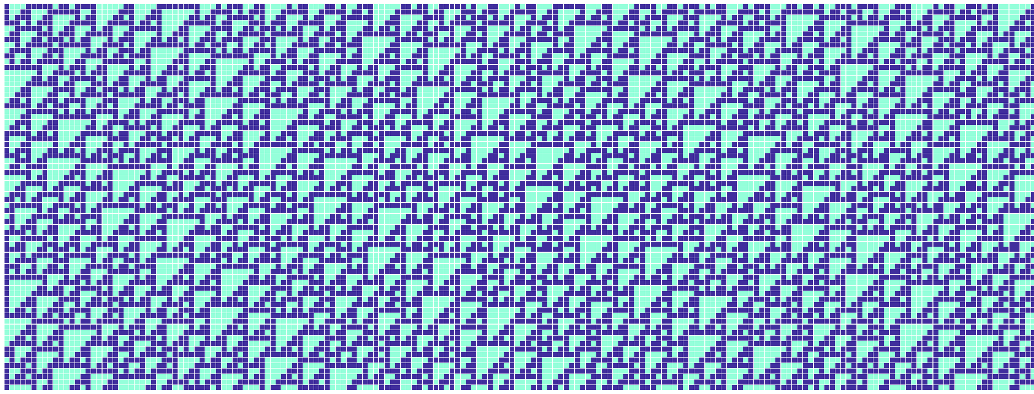


Figure 29: A much more complex T6 lattice, of cycle 372, corresponding to 10 right every 9 generations. Note the family resemblance to the middle image in Fig 27 where only two T4's mesh with T6's.

7.3 C glider component (static - velocity 0)

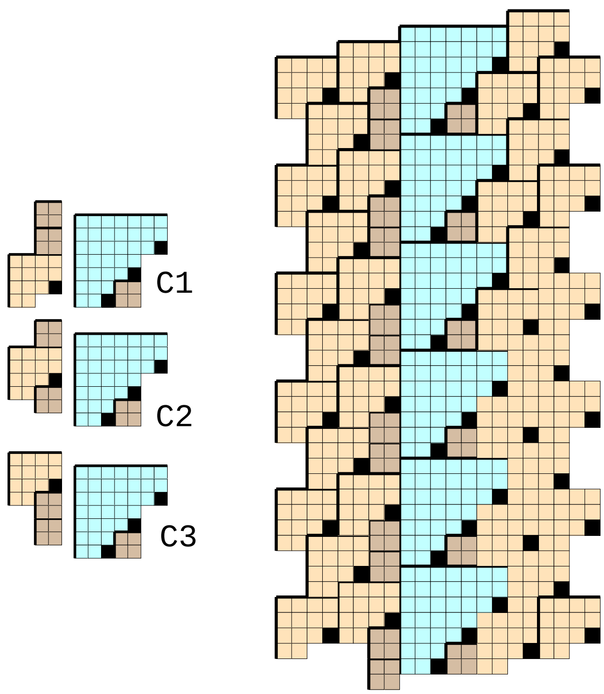


Figure 30: T6 is the largest triangle in the C gliders. The three C's are distinguished by the alignment of their left margin with the ether lattice. In contrast, there is only one alignment possible on the right side.

8 T7

8.1 cross references

precursor to EBar glider	Figure 56
constituent of an H glider	Figure 52
satellite to T18 in a boundary layer	Figure 68

8.2 periodic lattice component

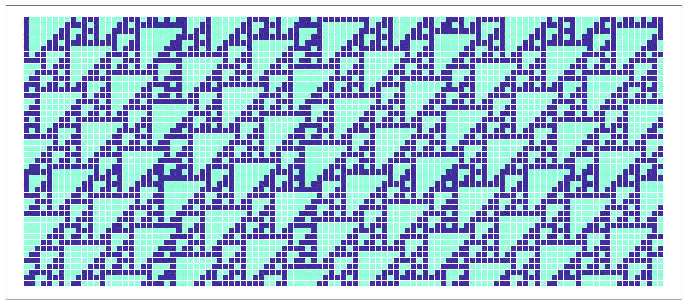


Figure 31: T7's will not stack diagonally, but will almost do so when a little bit of buffer is included. Here the lattice is "right seven in five generations," wherein two diagonal stripes are discernible.

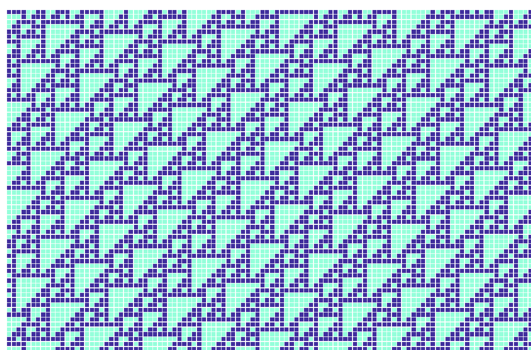


Figure 32: One of the smallest lattices in which T7's participate is the shift-periodic lattice "five left in eight generations." In this lattice there are two buffers between T7 stripes, one thick and one thin, which can alternate aperiodically.

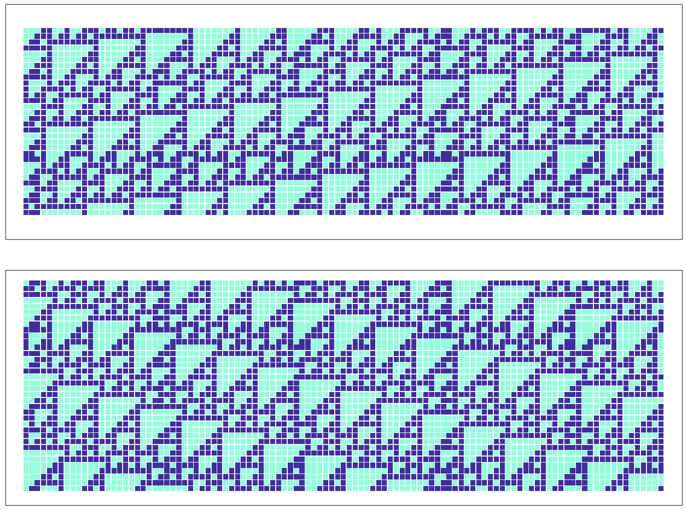


Figure 33: More nearly horizontal stripes of T7's can be formed; the upper stripes rise to the right, whilst the lower stripes fall to the right. In both cases they are separated by a slight buffer.

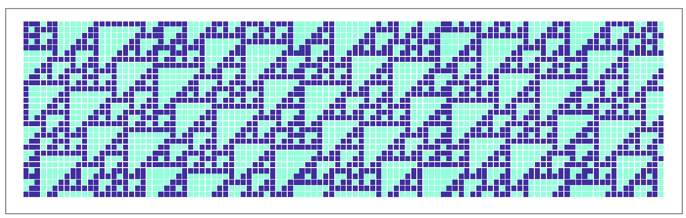


Figure 34: There is no reason why composites cannot form, wherein two or more large triangles occupy the same unit cell. Here T6 and T7 combine to form diagonal stripes.

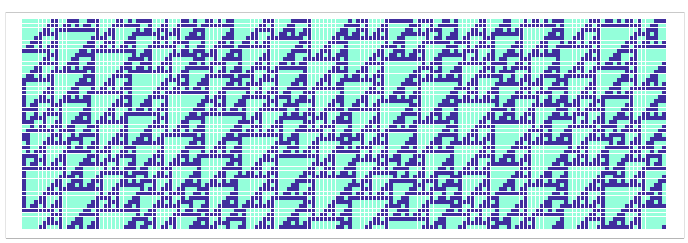


Figure 35: Here T6, T7 and T9 combine to form diagonal stripes with a shift period of "right 9 in 5."

8.3 F glider component (velocity -c/9)

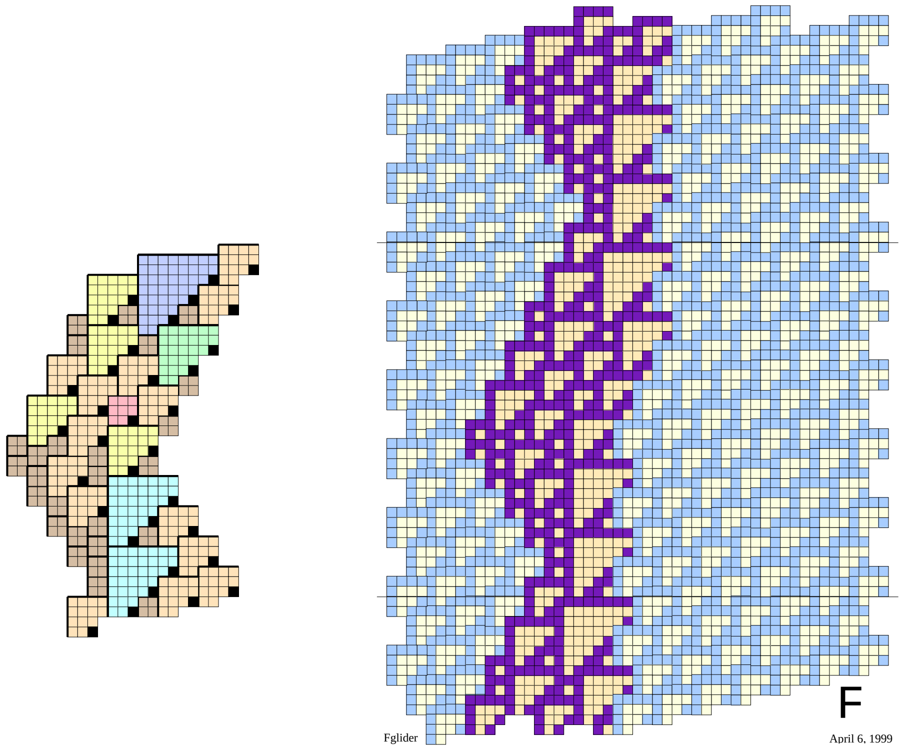


Figure 36: T7 is the largest triangle in the F glider.

9 T8

9.1 cross references

precursor to EBar glider	Figure 56
satellite to T18 in a boundary layer	Figure 68

9.2 periodic lattice component

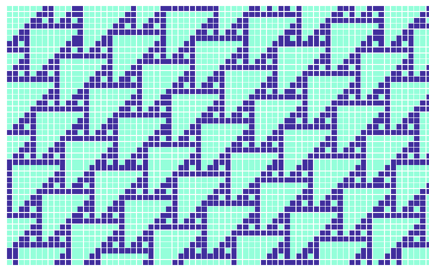


Figure 37: T8's can still be stacked diagonally to produce a light velocity lattice. They require T1's to fill the interstices.

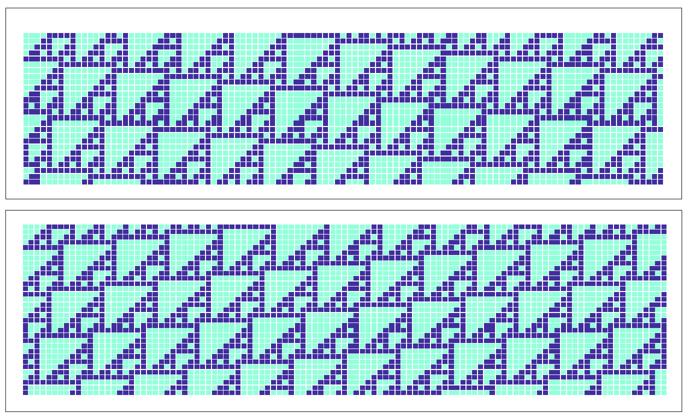


Figure 38: T8's can be strung out along horizontal rows, either rising or falling.

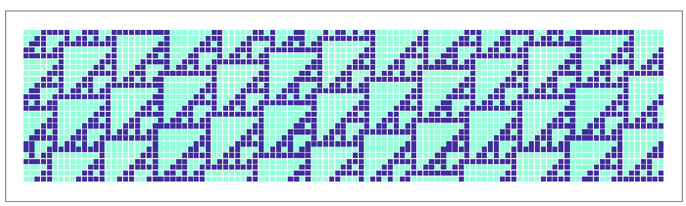


Figure 39: A horizontal row of T8's can also rise slightly more rapidly [left 9 in 2] than in the figure above.

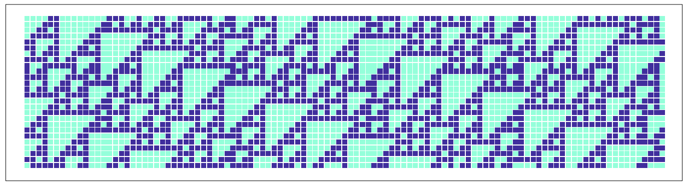


Figure 40: Falling rows of T8's.

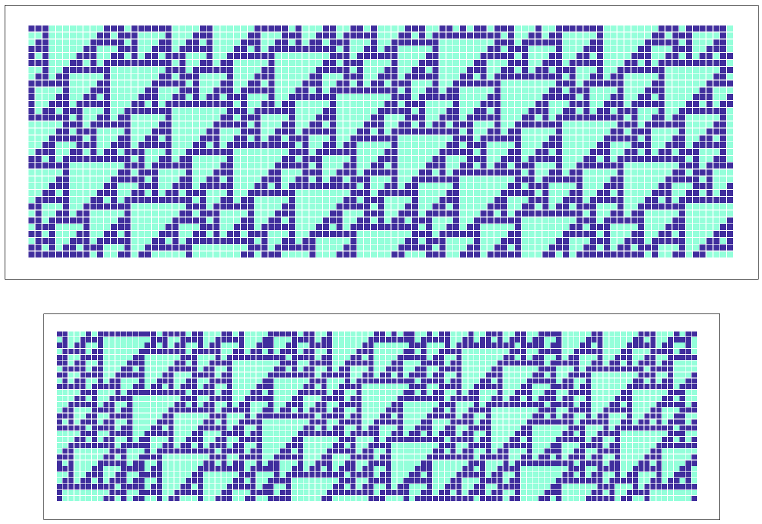


Figure 41: Falling rows, nearly diagonals, can arise even though the T8's are not contiguous and include other large triangles.

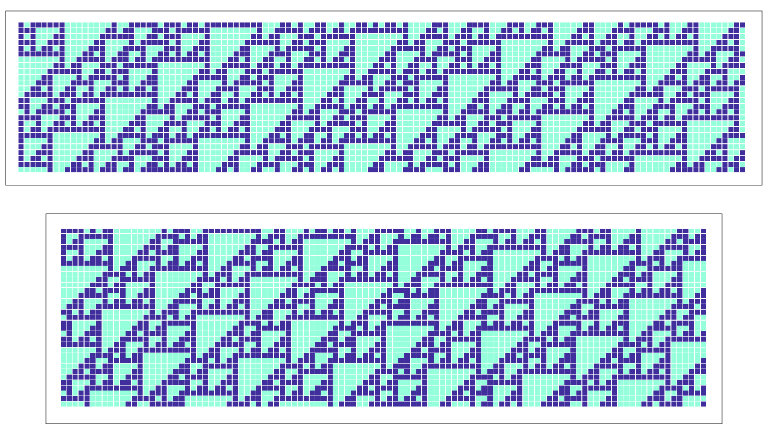


Figure 42: Two different families of diagonal stripes featuring T8's. In each case the stripes are separated in their own way.

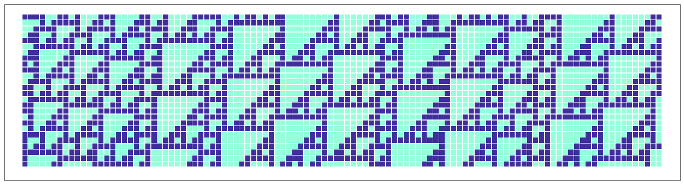


Figure 43: T8's can form nearly vertical stripes, separated by optional vertical stripes of T2's (which, however, cannot be juxtaposed), and possiblt terminating a T5 lattice on its right.

9.3 participating gliders

T8, like T5, is a common, often dominant, portion of a glider. If we enumerate the gliders whose featured triangle is T8, or which contain a T8, we find the following data.

glider	velocity	parity
BBar8	-c/2	odd
G	-c/3	even
E	-4c/15	odd

9.4 E glider main component (velocity -4/15)

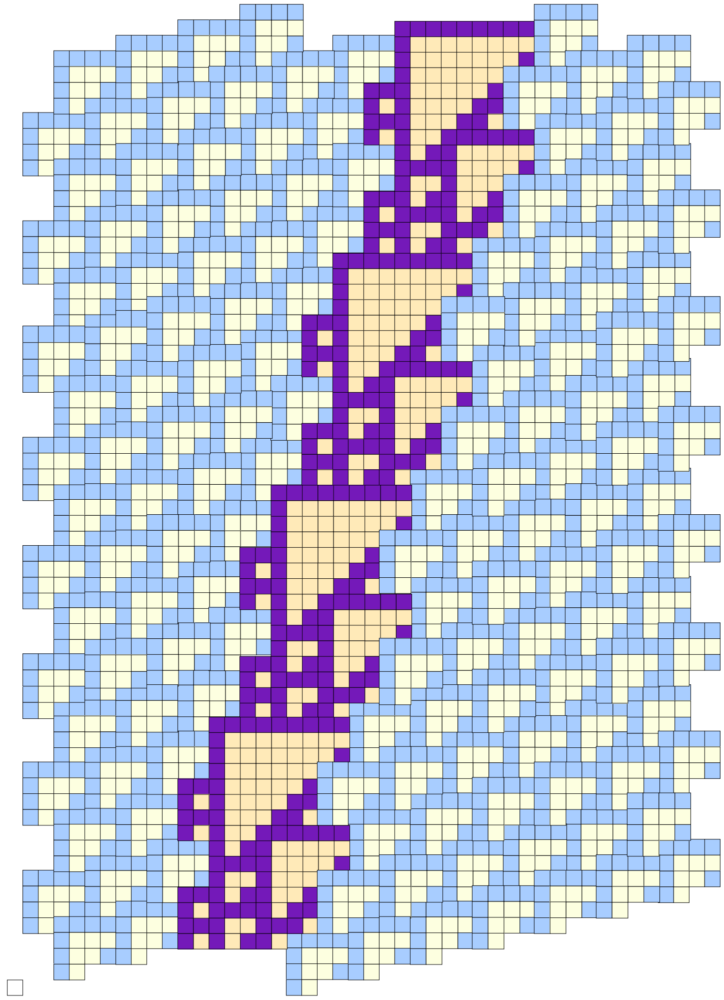


Figure 44: T8, the dominant triangle in the E family of gliders, sits on the leading edge, with any number of T5's following along.

9.5 G glider trailing component

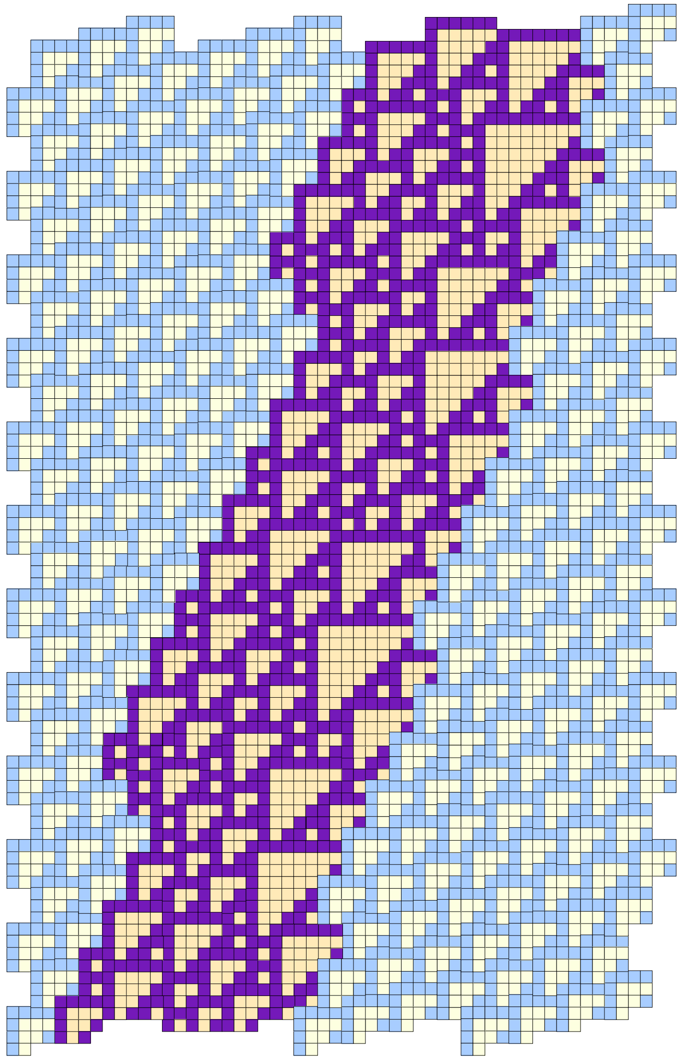


Figure 45: T8 is the largest triangle in a G glider (velocity -c/3), where it occupies a trailing position from which it can interface with α gliders.

9.6 BBar8 trailing component

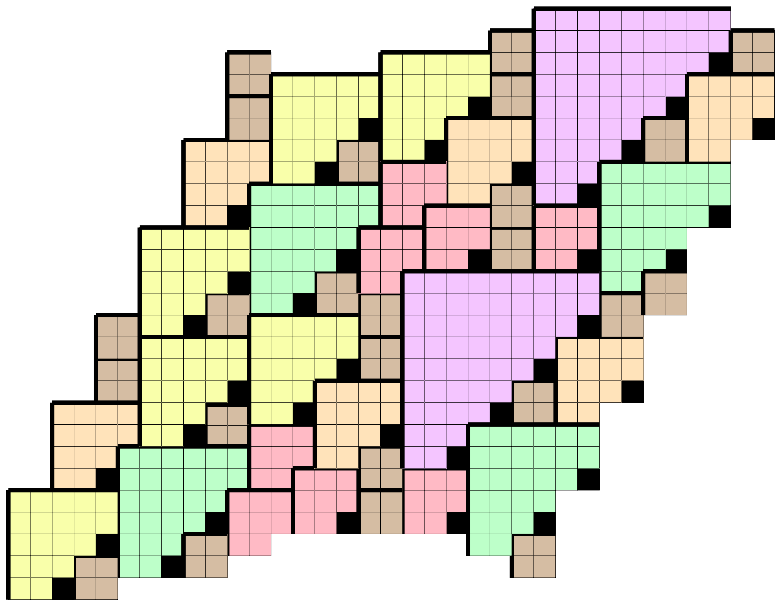


Figure 46: T8 is the largest triangle in the BBar8 glider (velocity -6c/12) where it occupies a trailing position.

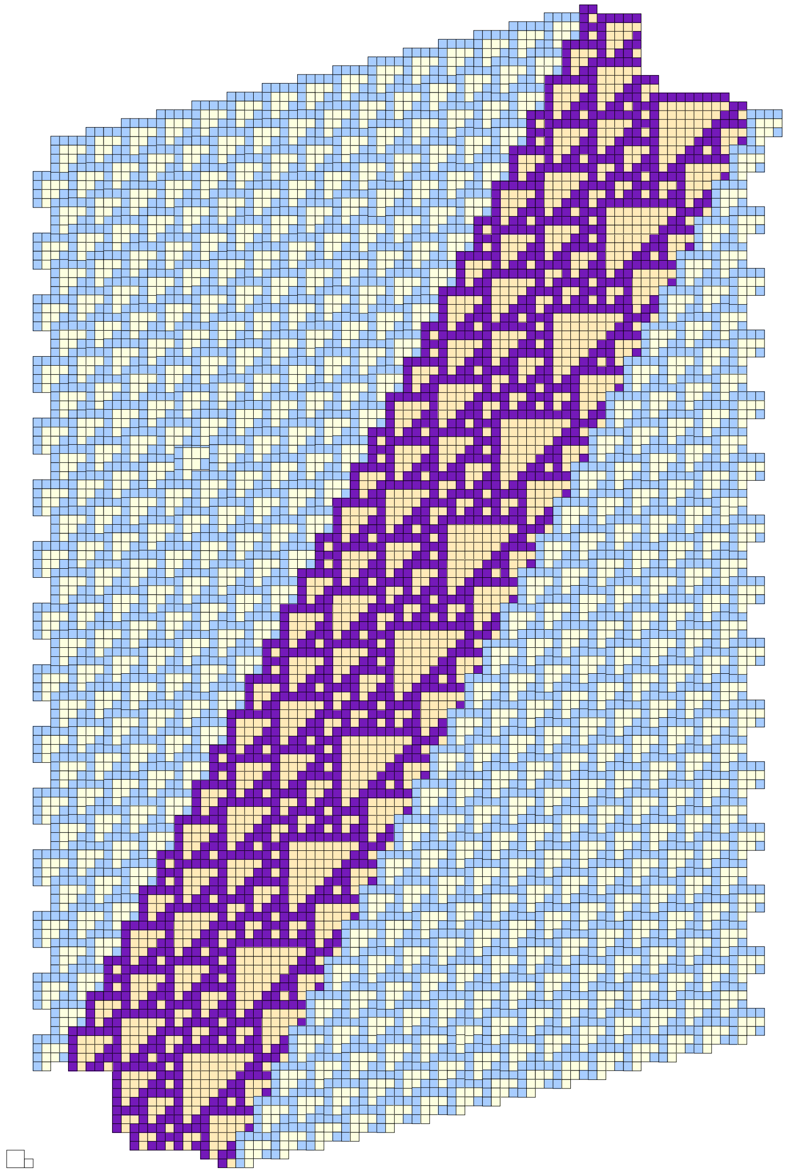


Figure 47: T8 is the largest triangle in the BBar8 glider (velocity -6c/12) where it occupies a trailing position.

10 T9

10.1 cross references

10.2 periodic lattice component

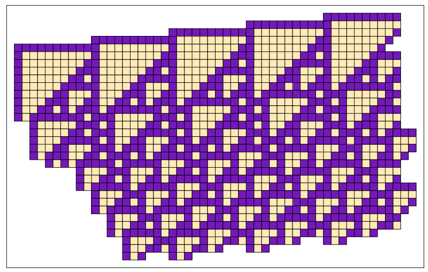


Figure 48: The technique of creating a periodic lattice by using a staircase of large triangles fails when inconsistencies arise in trying to fill the space under the hypotenuses with tiles which will eventually recreate the large triangle.

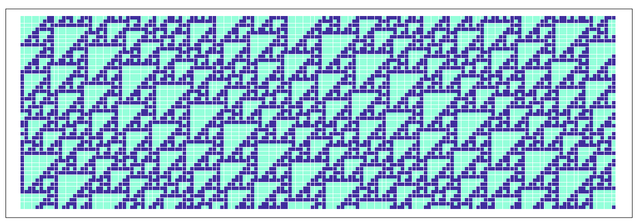


Figure 49: T9 can be found in the downward slanting stripe "right 9 in 5 generations", but it is liberally surrounded by T1, T2, T3, T4 and T5's.

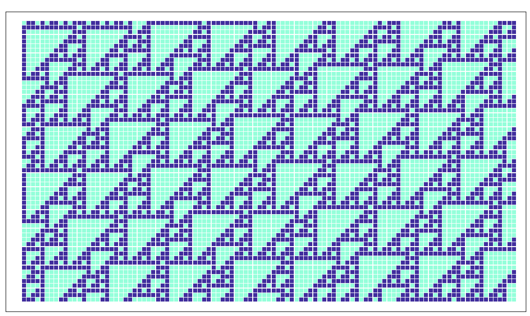


Figure 50: T9 alternates diagonals with T10 in a "right 9 each 10 generations" lattice. The packing also includes T1, T2, T3, T4 and T5's.

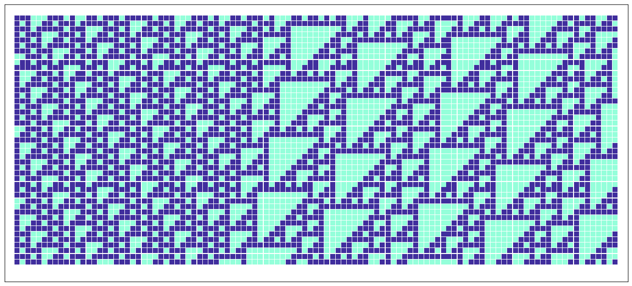


Figure 51: T9 can be found in a complicated de Bruijn diagram for "left 2 in 10 generations." An A-polymer flotilla in a right ideal gives way to vertical stripes in which T9's and filaments of T2's and T3's can be sometimes accompanied by an additional filament of T5's. Two T5 filaments would have adequate margins but standing side by side would violate the horizontal abutment rule.

10.3 H glider component

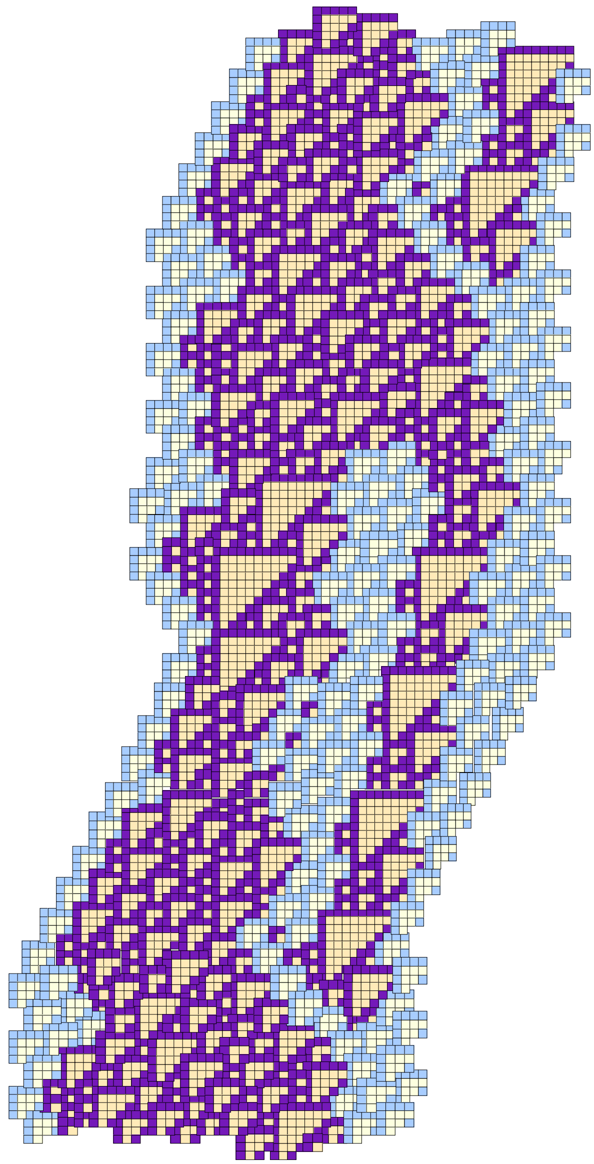


Figure 52: A T9 is fairly well hidden in the H glider.

10.4 product of a D-E collision

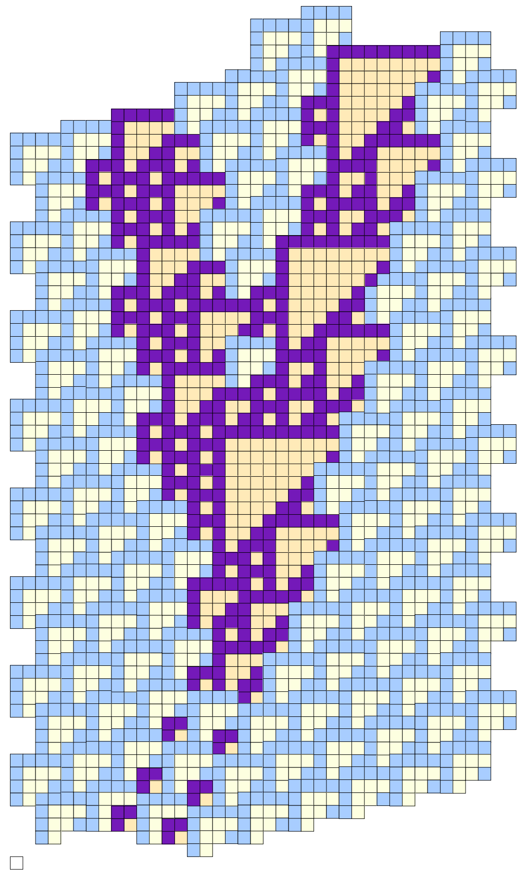


Figure 53: A T9 appears momentarily in the D1 + E lo collision.

11 T10

11.1 cross references

alternates with T9 in a "right 9 every 10" lattice	Figure 50
precursor to EBar glider	Figure 56
satellite to T18 in a boundary layer	Figure 68

11.2 periodic lattice component

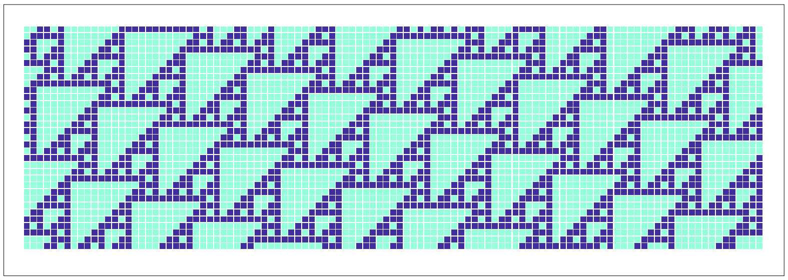


Figure 54: T10's do not lend themselves very well to inclusion in lattices of small period, a trait held in common with all the larger triangles. The problem is that it is hard to fill the crannies under the diagonal. This lattice corresponds to "right 9 in 3 generations."

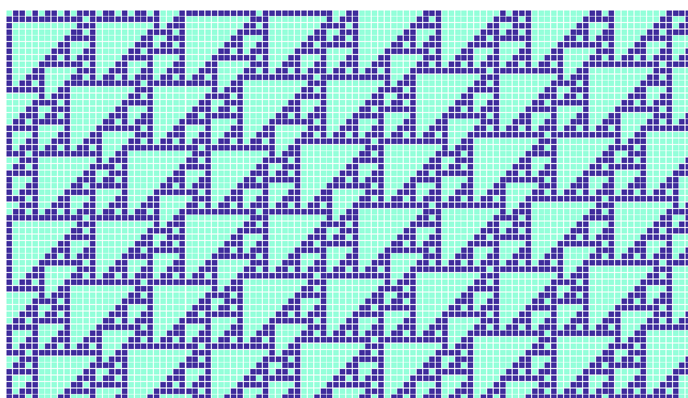


Figure 55: Another T10 lattice corresponde to "right 9 in 10 generations."

11.3 precursor to an EBar glider

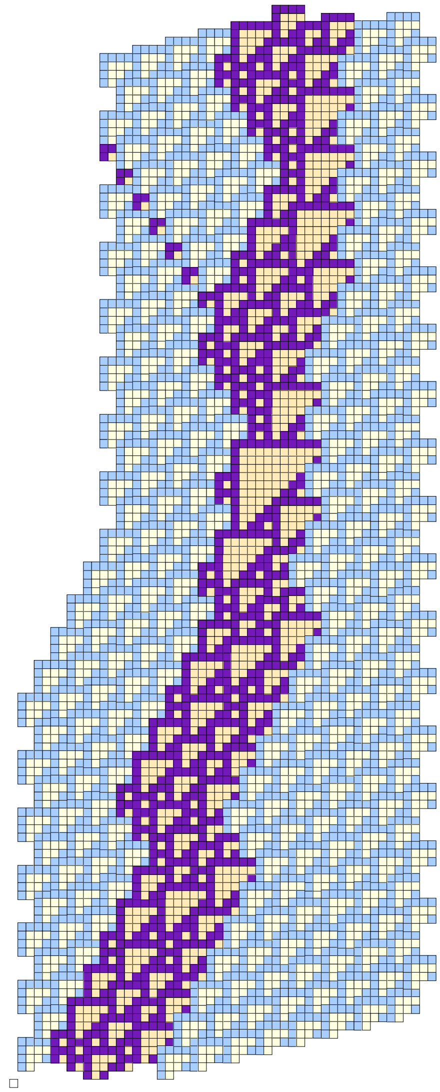


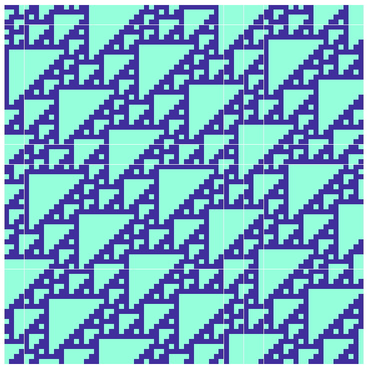
Figure 56: T10 is a frequently occurring precursor to an EBar glider.

12 T11

12.1 cross references

constituent of an α boundary	Figure 67
transient in an α boundary layer	Figure 63

12.2 periodic lattice component



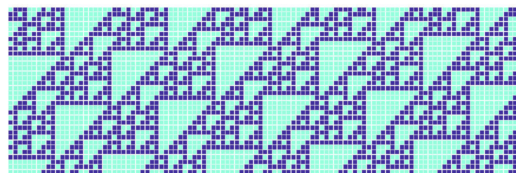


Figure 57: The smallest de Bruijn diagram in which T11 appears is for the shift 10 in 8, (left lattice) but there is another one close by at shift 10 in 10 (right lattice). T11 is the dominant triangle, but T6, T5, T4, and all the smaller triangles also appear.

12.3 transient in a glider collision

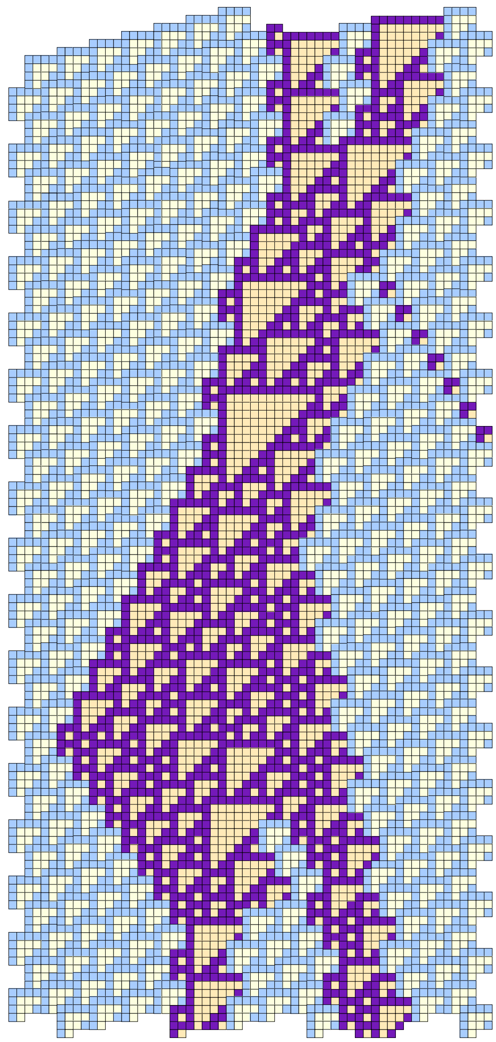


Figure 58: T11 is a constituent in E glider collisions.

13 T12

13.1 cross references

evolution from a single live cell	Figure 2
transient in an α boundary layer	Figure 67

14 T13

14.1 cross references

14.2 isolated precursor of a G glider

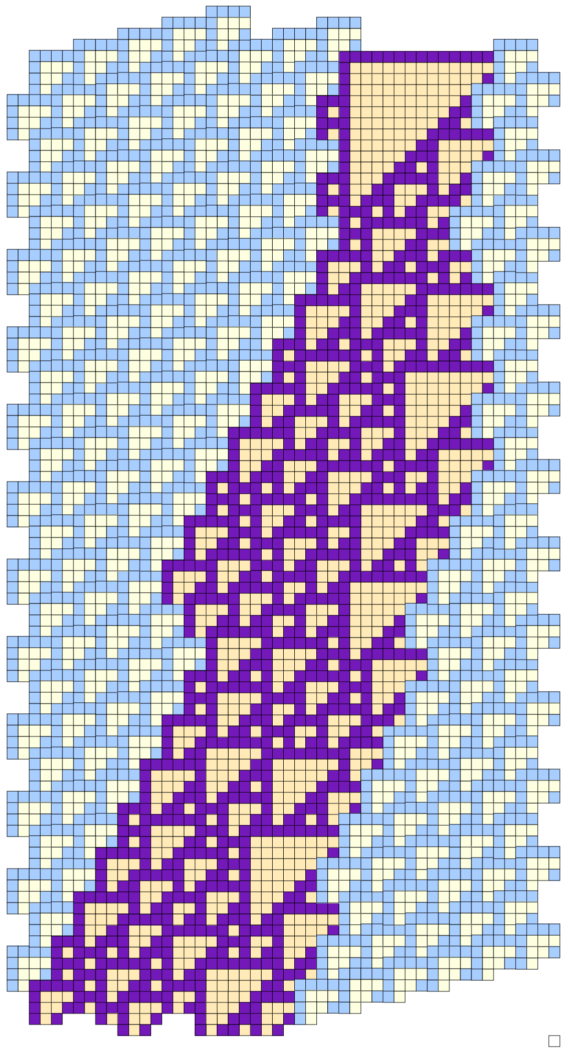


Figure 59: A single isolated T13 will generate a G glider.

14.3 intermediate in C - E collisions

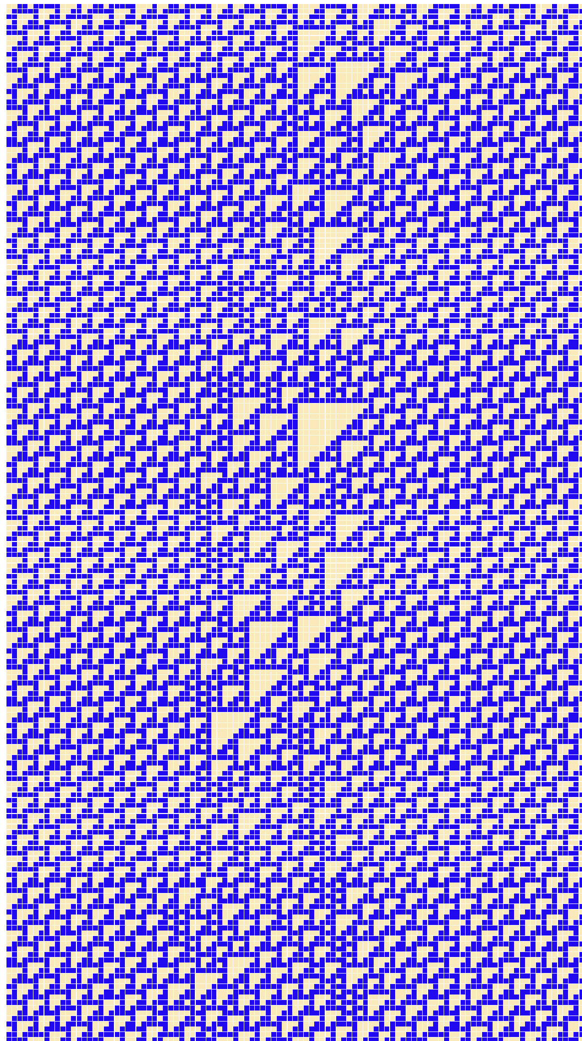


Figure 60: T13 is an intermediate in C - E glider collsions.

14.4 intermediate in a double D - E collision

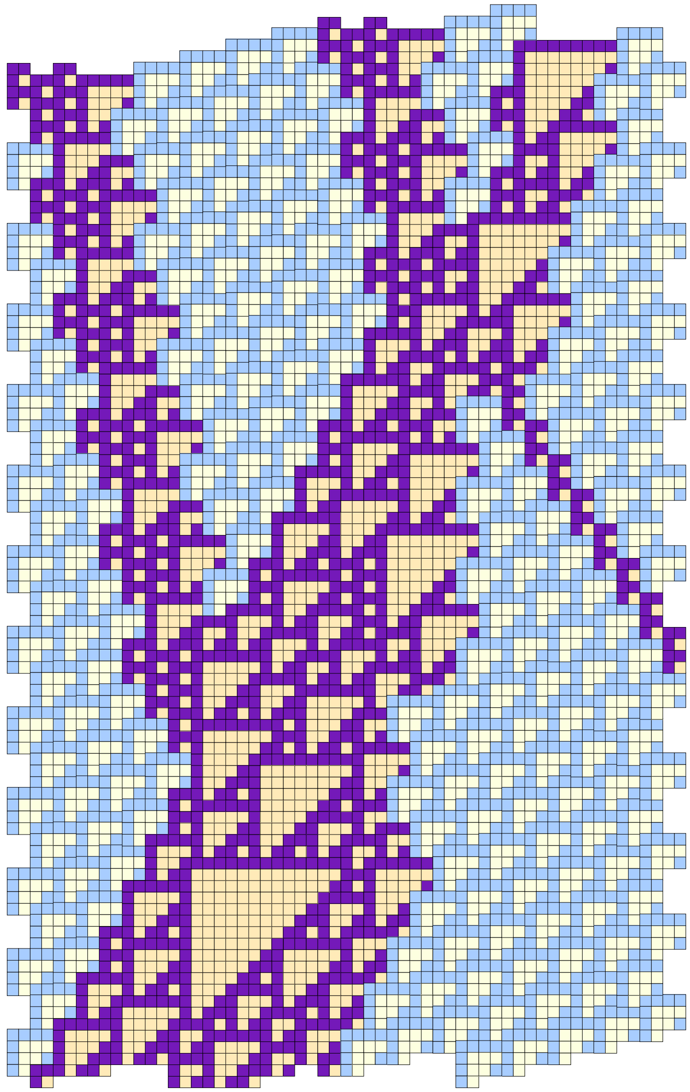


Figure 61: T13 is an intermediate in a double D - E glider collsion.

15 T14

15.1 cross references

15.2 intermediate in the C2-E4(lo) glider collision

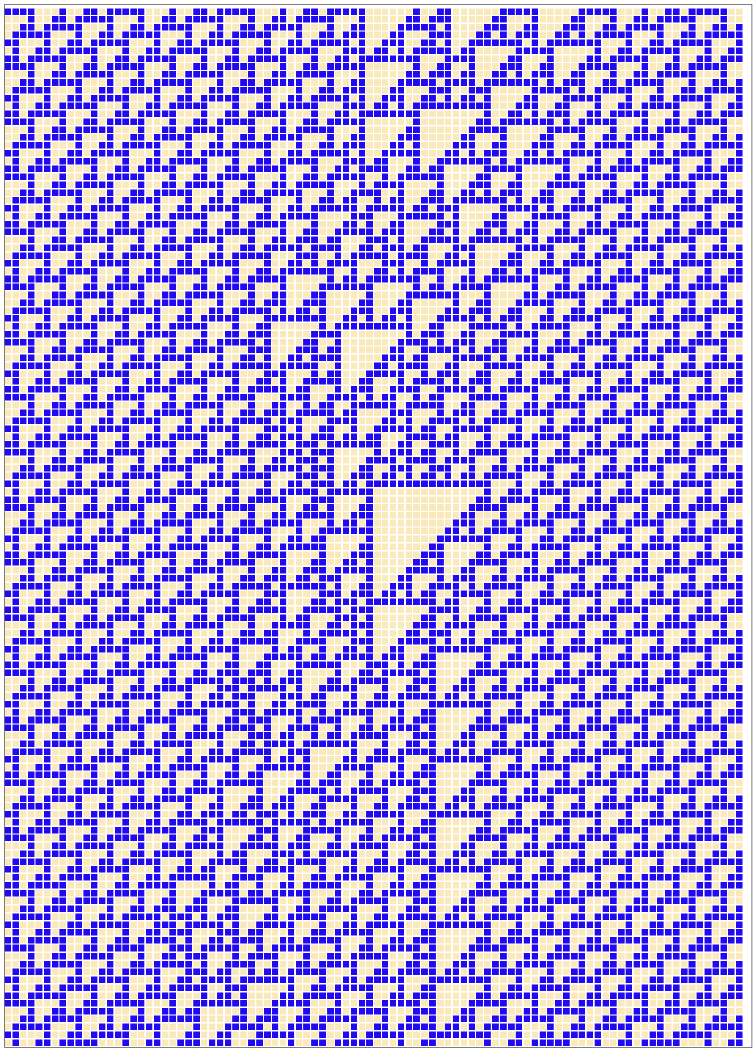


Figure 62: T14 is an intermediate in the C2E4lo collision.

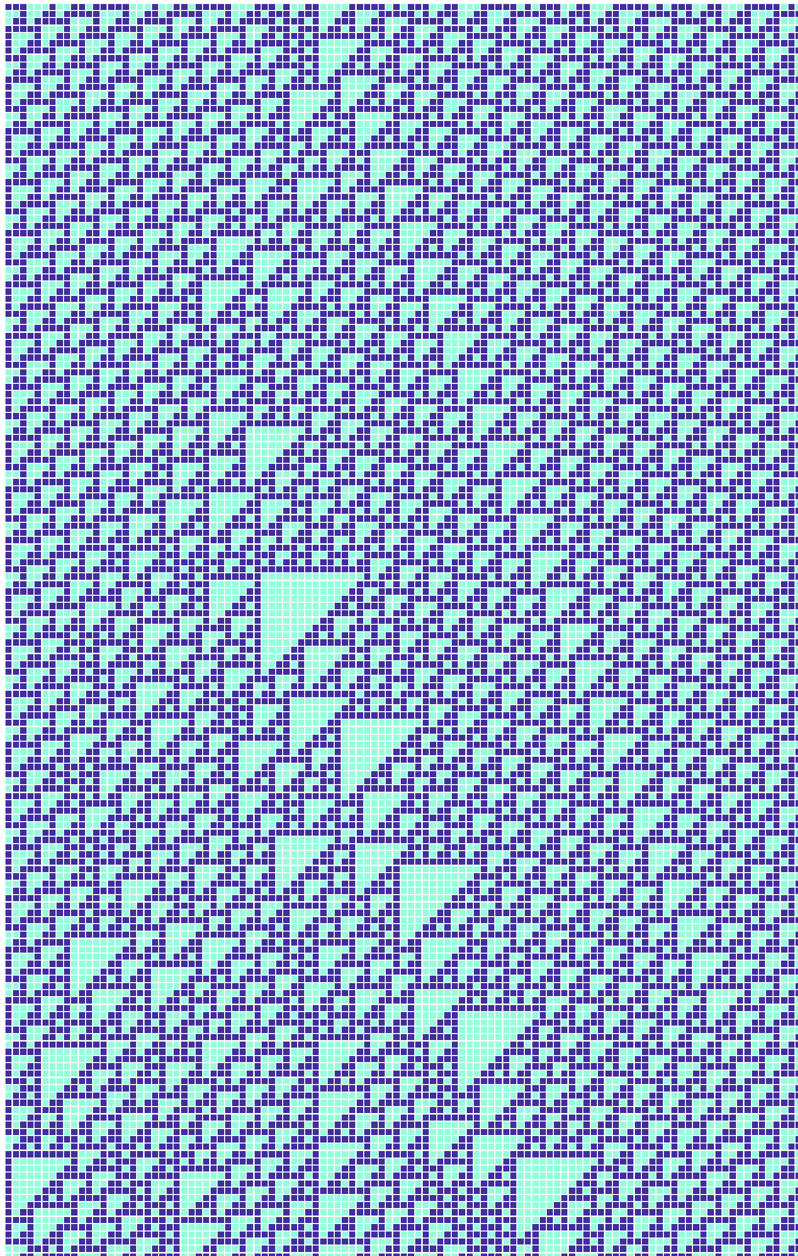


Figure 63: T14 is an intermediate in a composite En-C3-C2 collision, but in this view it is directly attached to the alpha lattice. The T11's are stable, as their spine, including the T3 just below it, is sufficient to form a macrocell and protect the evolution of the next T11.

16 T15

16.1 cross references

16.2 product of a C1, EBar, B dyad collision

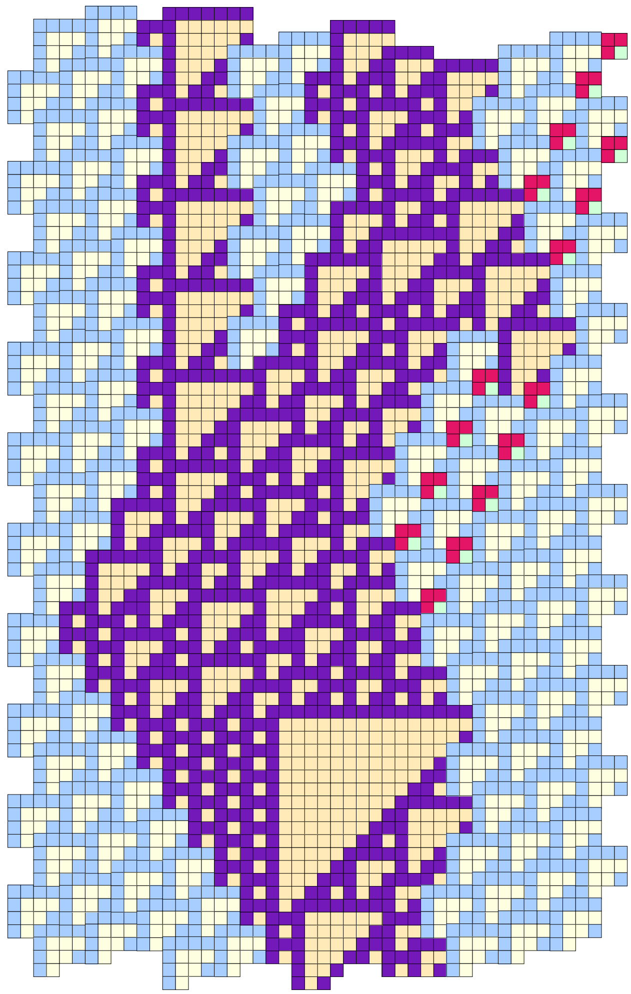


Figure 64: T15 can be formed by the triple collision of C1, EBar, and a B dyad. In collisions such as these, the timing of the oncoming B's could be modified slightly.

17 T16

17.1 cross references

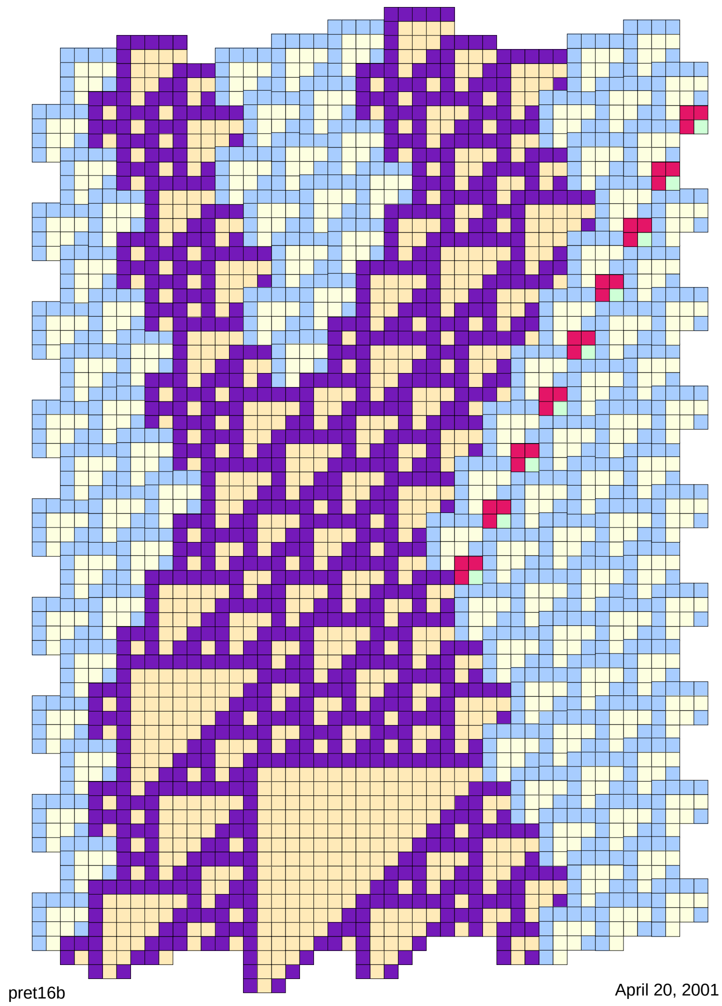


Figure 65: T16 can be formed by the triple collision of D1, EBar, and B gliders.

18 T17

18.1 cross references

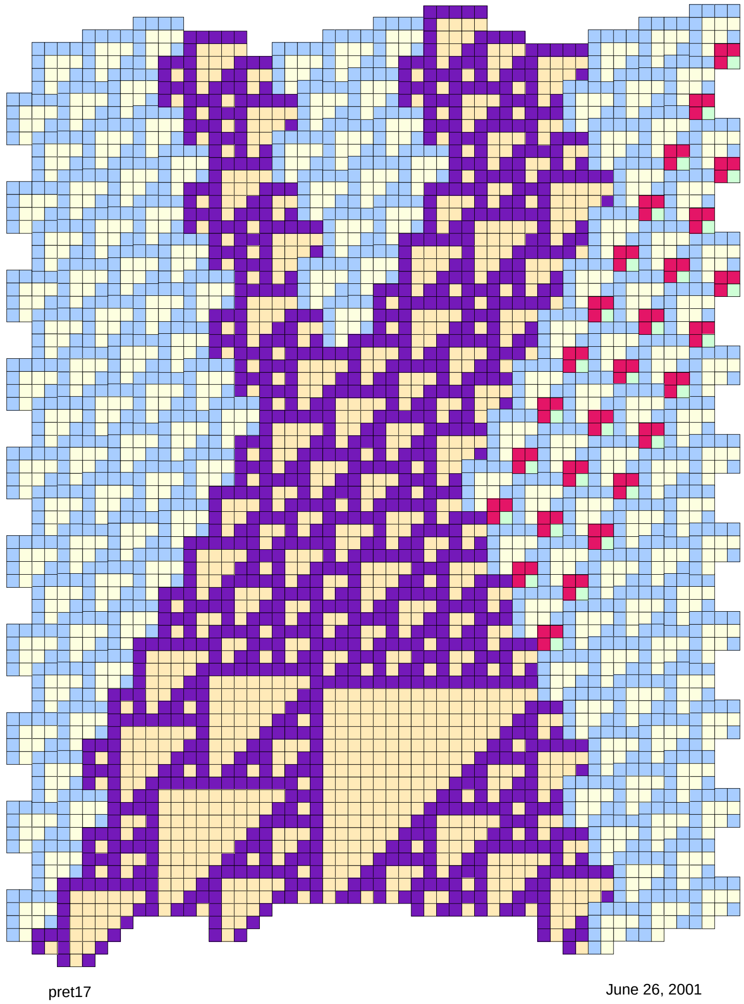


Figure 66: T17 can be formed by the triple collision of D2, EBar, and a B triad.

19 T18

19.1 cross references

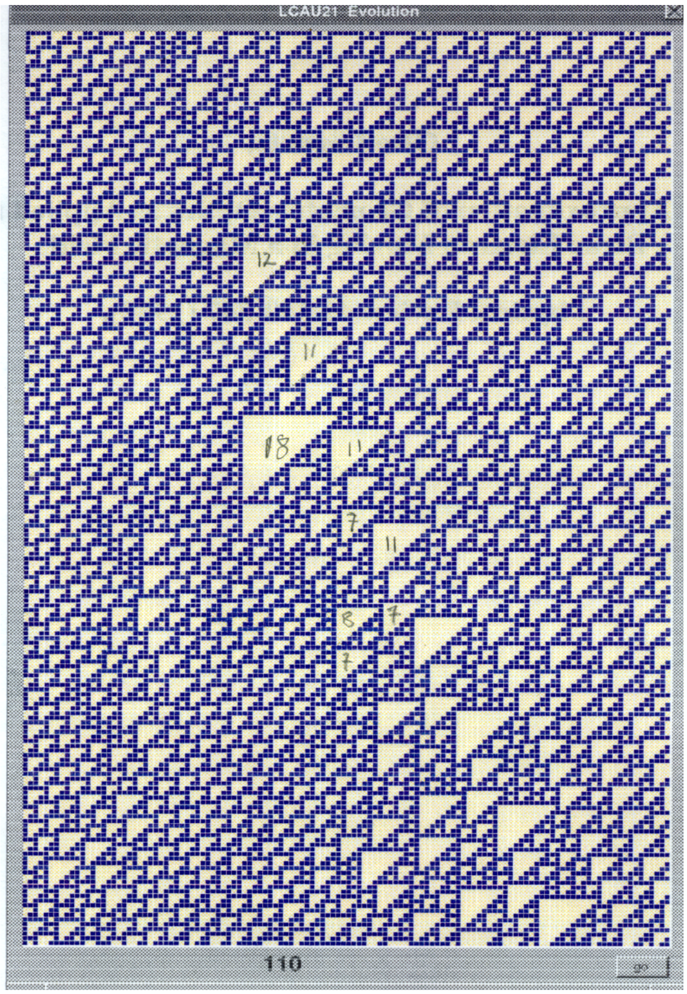


Figure 67: T18 is an intermediate in the disintegration of the edge of the superluminal (7 right in 6 generations), appearing to form a boundary layer which moves 14 right every 36 generations, something consistent with the periodicity of the lattice.

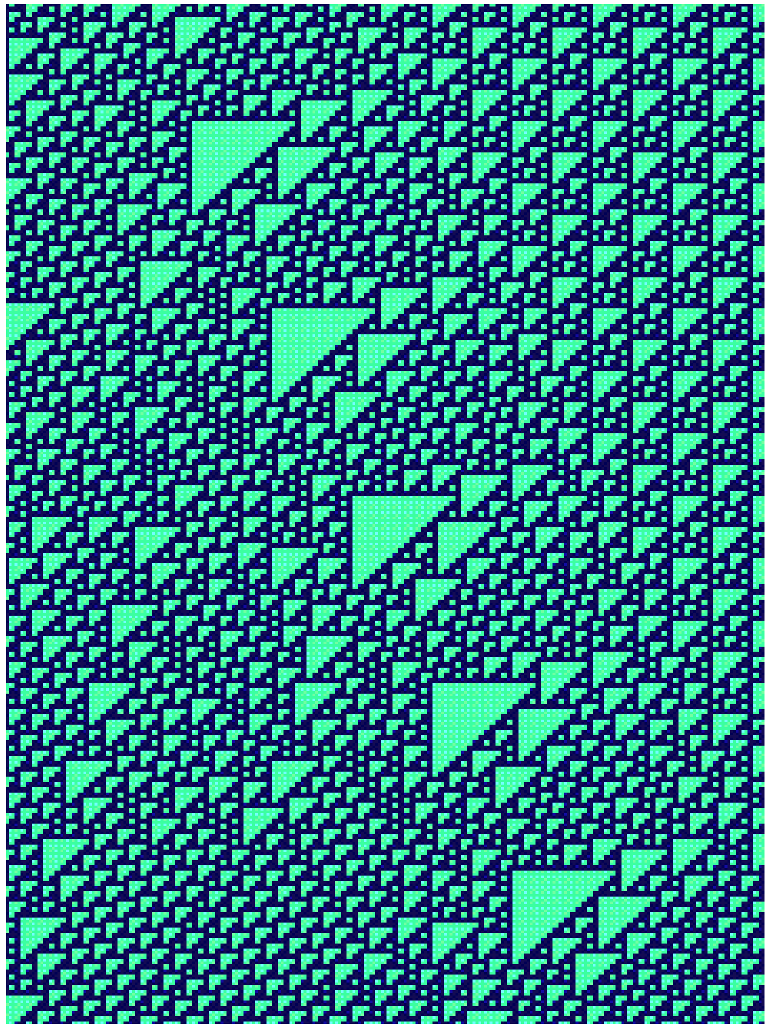


Figure 68: T18 is an intermediate in the disintegration of the edge of the superluminal lattice (shift seven in six generations).

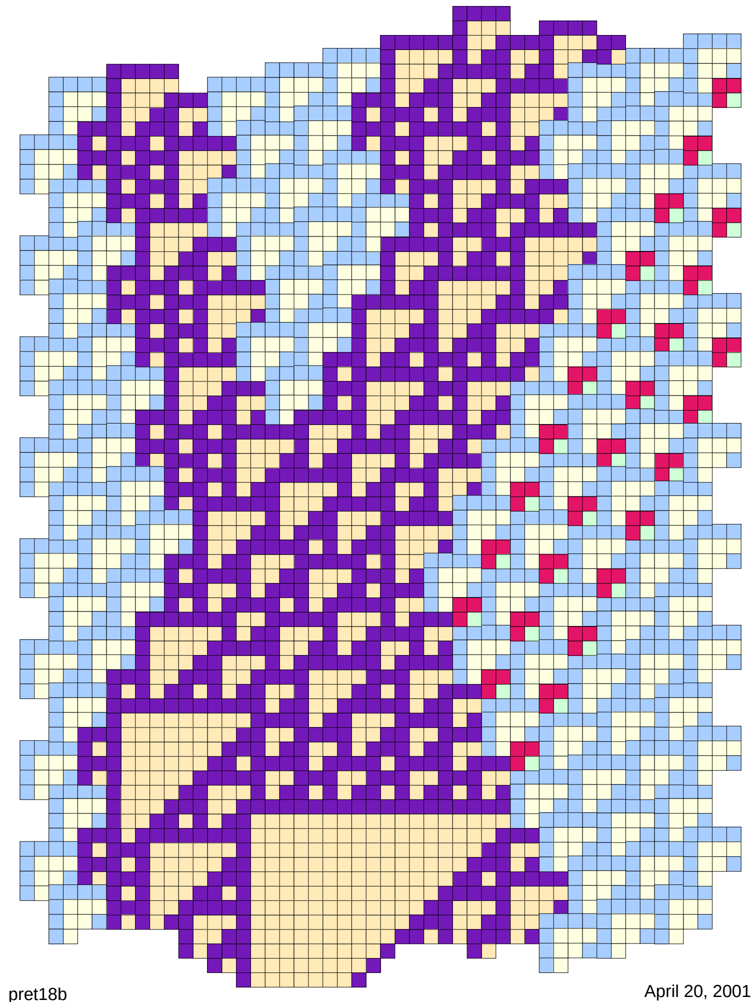


Figure 69: T18 can be formed by the triple collision of D1, EBar, and a B triad. The difference in the way D1 and D2 mesh with the ether leaves space for an extra cell in the top margin of the T18 compared to the T17.

20 T19

20.1 cross references

preliminary T10 resulting from A - F collision   Figure 56

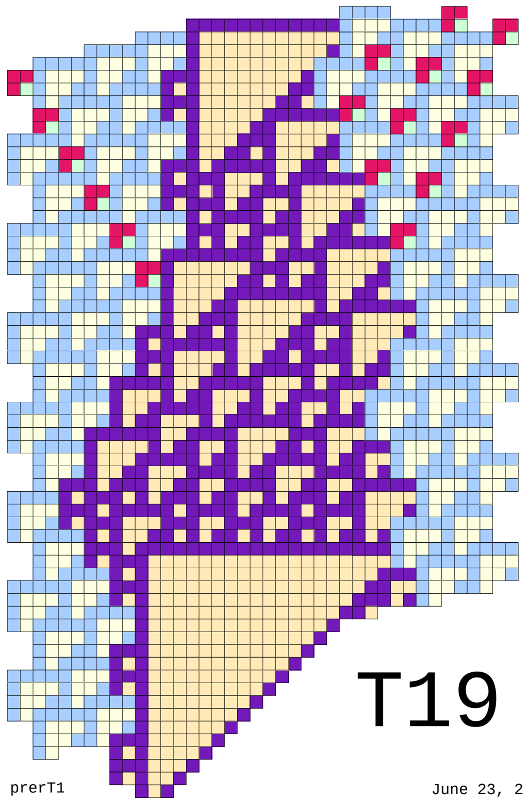


Figure 70: T19 can result from the collision of an A and a B triad with an isolated T10, such as the one produced in an A - F collision.

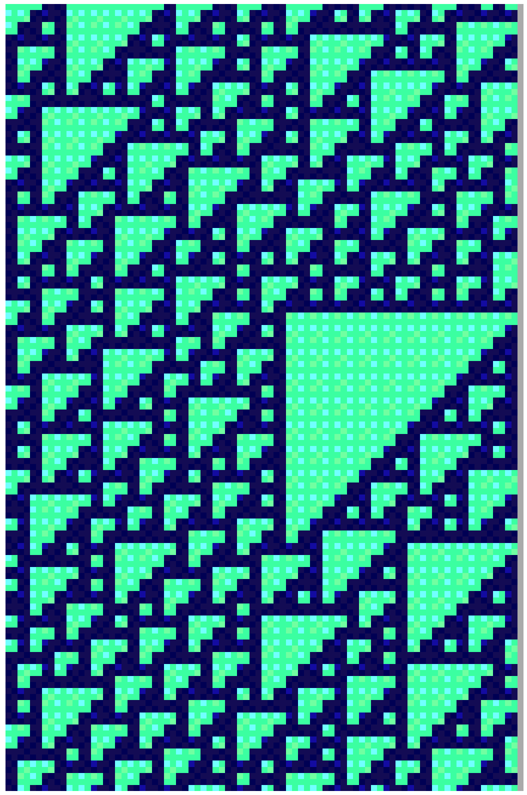


Figure 71: T19 is an intermediate in the disintegration of the edge of the superluminal lattice (shift two left in nine generations).

21 T20

21.1 cross references

21.2 product of a double D1 - C2 - B triad collision

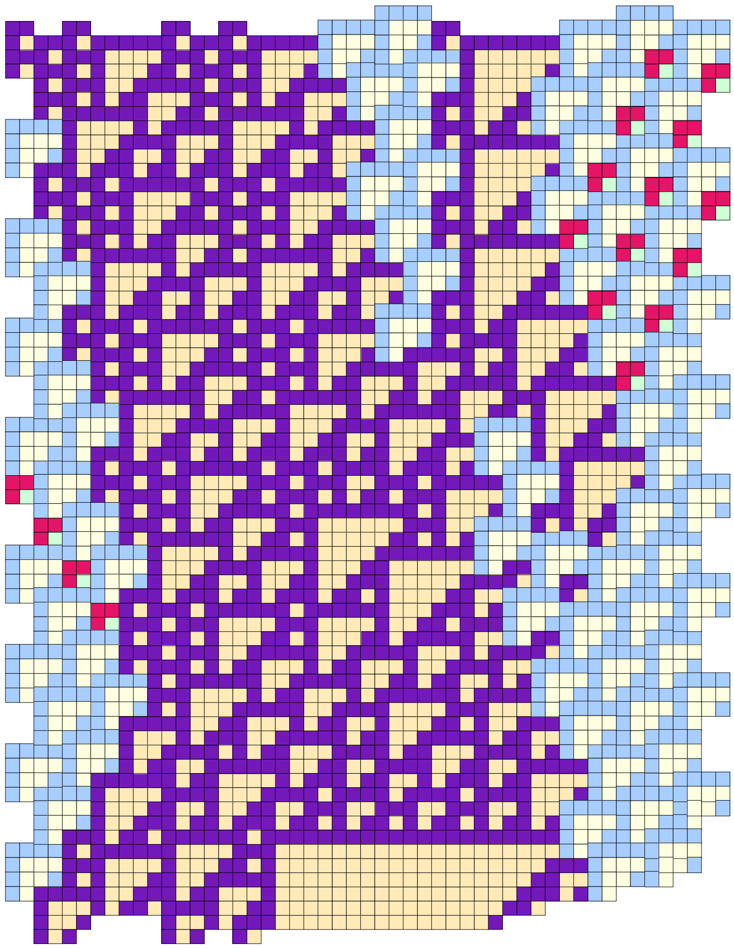


Figure 72: T20 arises in glider collisions; in this figure a double D1 glider collides with a single C2 glider, which is enhanced at the moment of impact by three B gliders. Varying the number of these gliders changes the size of the large triangle produced.

21.3 product of a D1 - EBar - B dyad collision

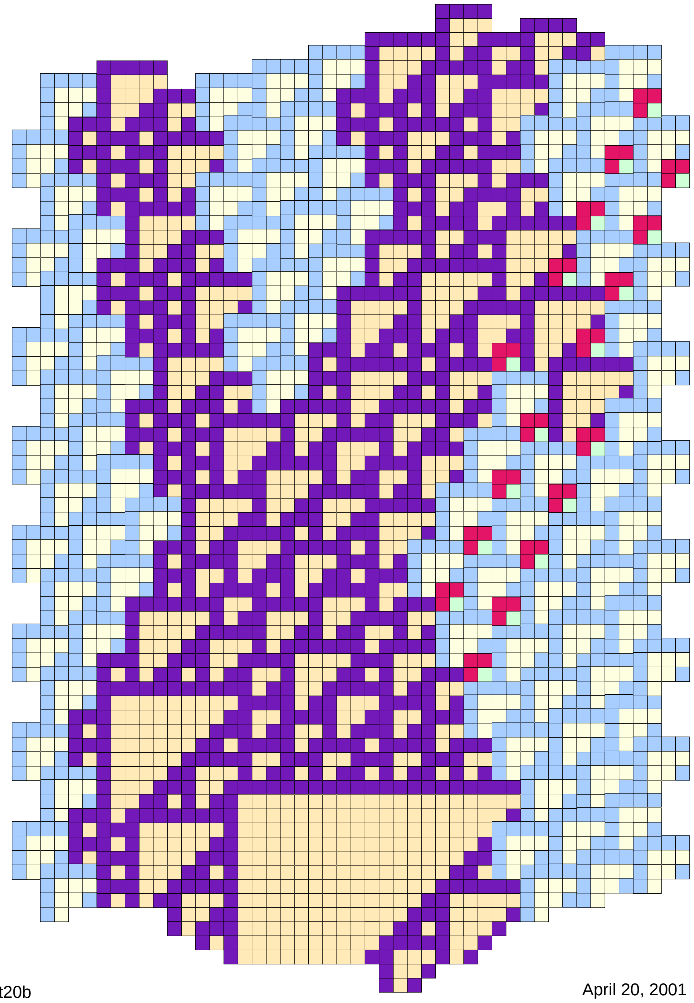


Figure 73: T20 arises in glider collisions; in this figure a single D1 glider collides with a BBar glider, which was modified just before the impact by a collision with two B gliders which had the effect of extending a T5 on the right edge of the EBar.

22 T21

22.1 cross references

22.2 product of a C2 - D - B pentad collision

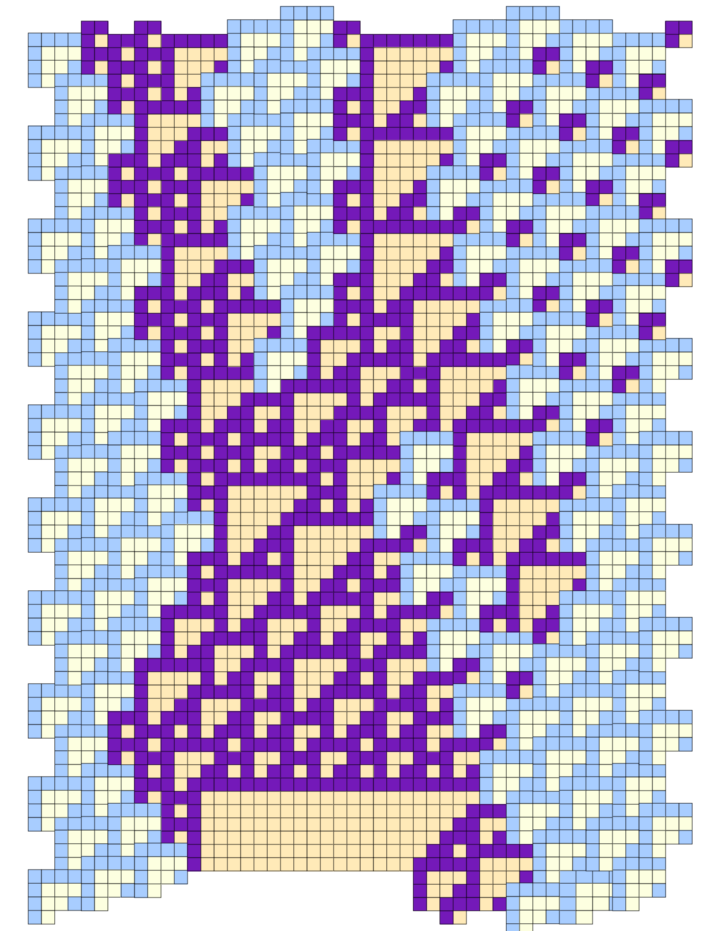


Figure 74: T23 is a large emergent triangle. A slight alteration of the collision which produces it will yield a T21. Further tweaking does not seem capable of producing a T24, for instance.

23 T22

23.1 cross references

23.2 product of a D dimer - C2 - B pentad collision

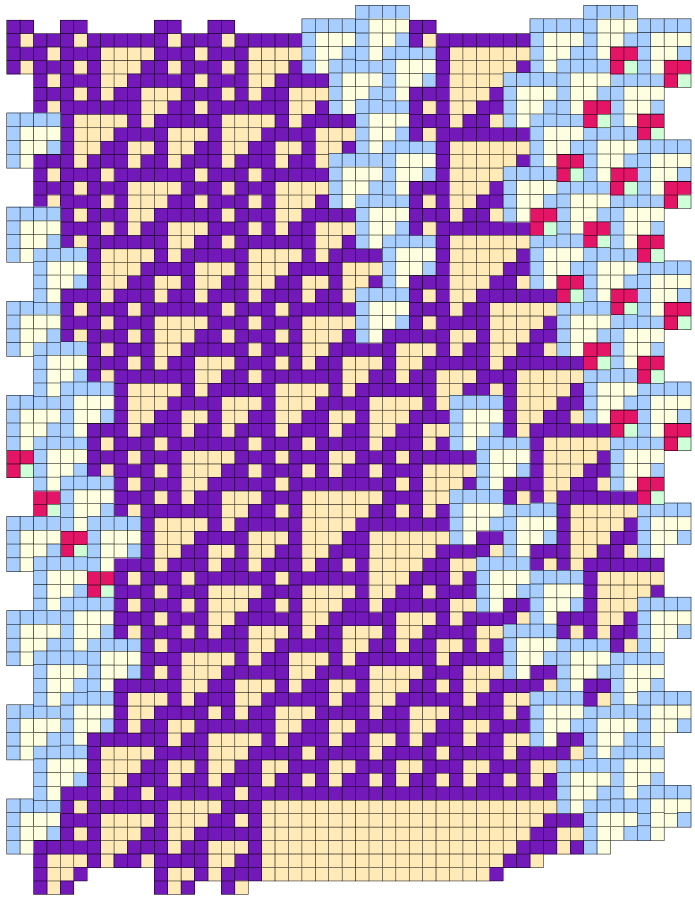
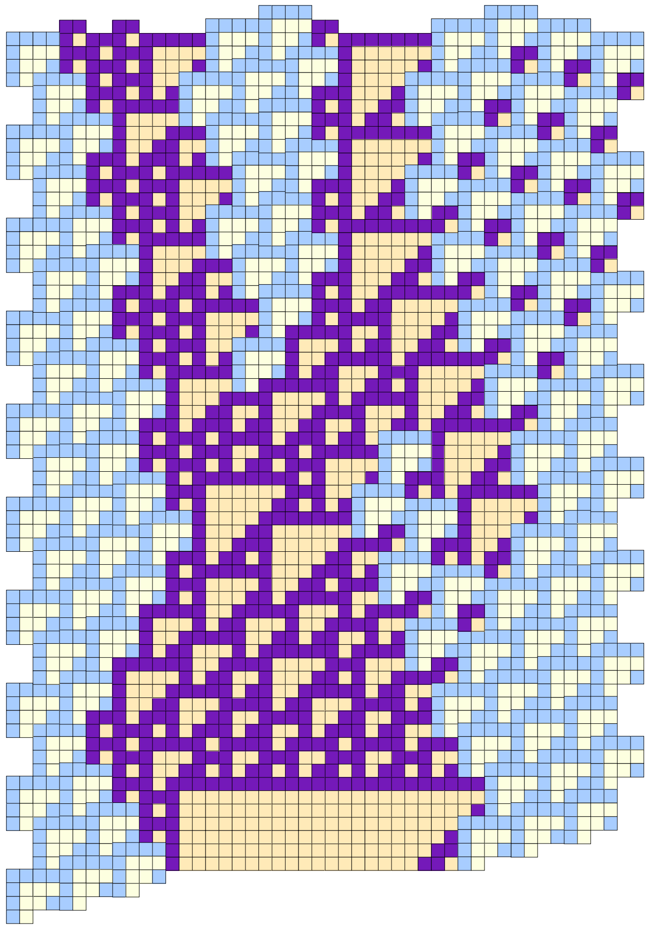


Figure 75: T22 arises as a transient in the collision of a D1 dimer with a C2 when the latter is enhanced by colliding with four B's. Changing the number of B's changes the width of the large transient triangle leading to a T20 or a T24.

24 T23

24.1 cross references

24.2 product of a C2 - D - B tetrad collision



T23 August 15, 1999

Figure 76: Because T23 is the result of a triple glider collision, it can be made to appear arbitrarily late in the evolution of Rule 110.

25 T24

25.1 cross references

variant collision produces T20	Figure 72
variant collision produces T22	Figure 75

25.2 product of a D dimer - C2 - B pentad collision

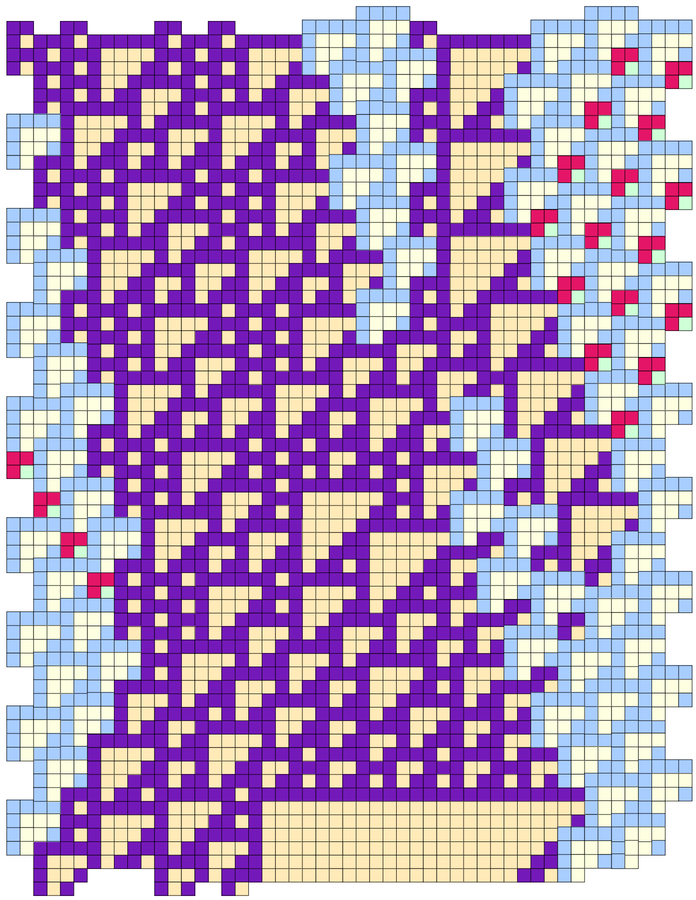


Figure 77: T24 arises as a transient in the collision of a D1 dimer with a C2 when the latter is enhanced by colliding with four B's. Changing the number of B's changes the width of the large transient triangle leading to a T20 or a T22.

26 T25

26.1 cross references

26.2 product of a triple C and G collision

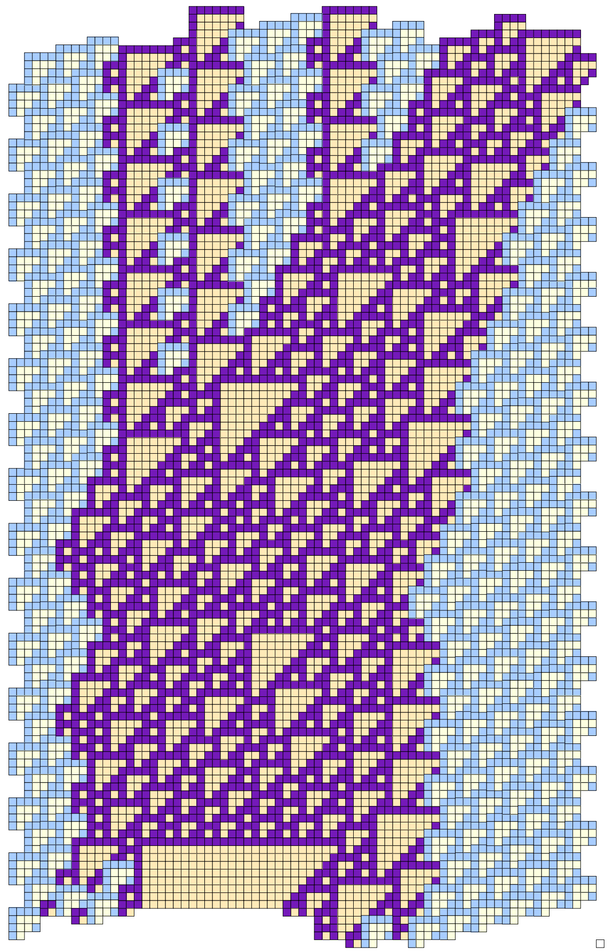


Figure 78: T25 arises in a collision of C3, two C2's, and a G glider.

26.3 product of an A, BBar, double E and EBar collision

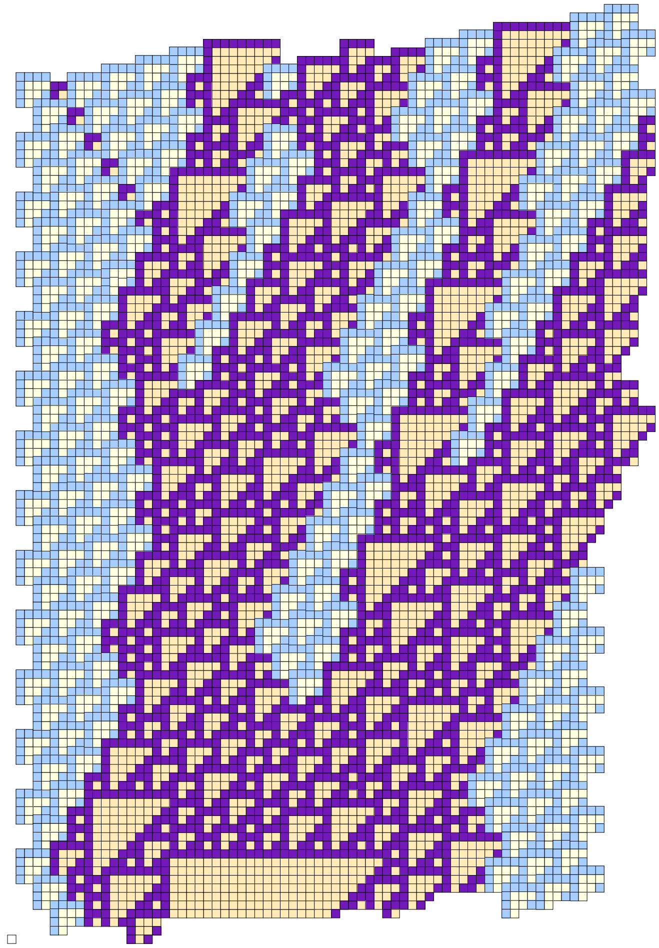


Figure 79: T25 also arises in the quintuple collision of A, BBar, double E and EBar gliders. However the A E collision creates an isolated D1, which could have been used directly.

27 T26

27.1 cross references

decomposition product	Figure 80
quadruple collision	Figure 81
quintuple collision	Figure 82

27.2 decomposition product in a shift periodic lattice

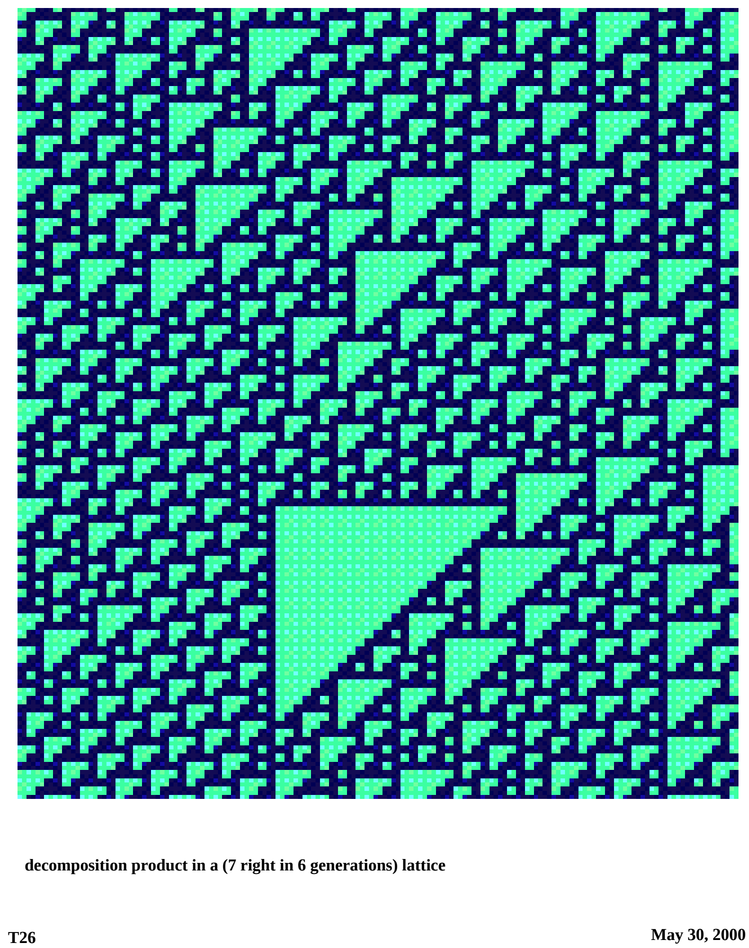
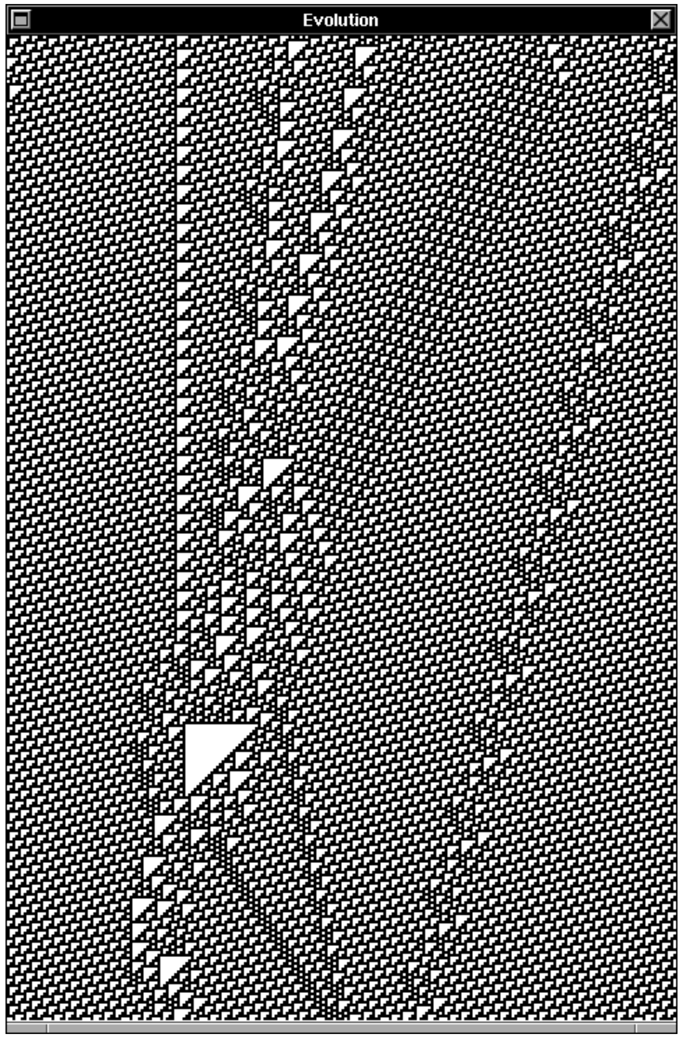


Figure 80: T26 appears as a decomposition product in a 5 right in 6 lattice.

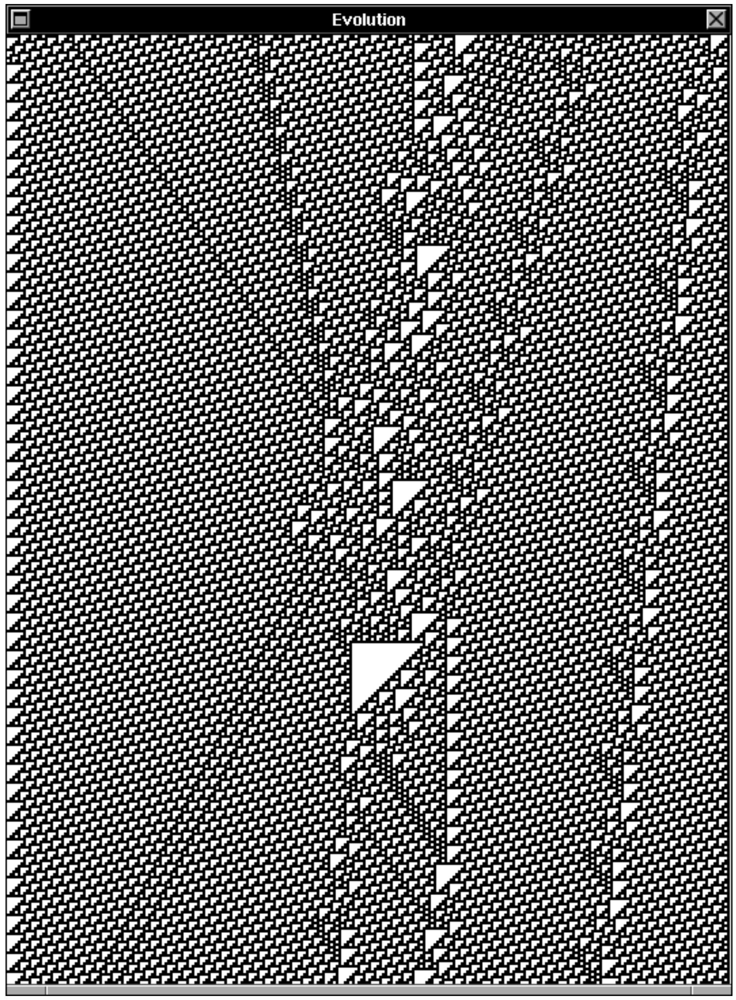
27.3 product of a C1, F, E3, and B hexad collision



C1(A)-2e-F(A)-e-E(D)-2e-6B, T26

Figure 81: T26 can arise in a multiple collision involving C1, F, E3 gliders and a B hexad which comes along just after a T11 has been formed. (Collision and image courtesy Genaro Juarez Martinez)

27.4 product of a quintuple A, C, D, E, and EBar collision

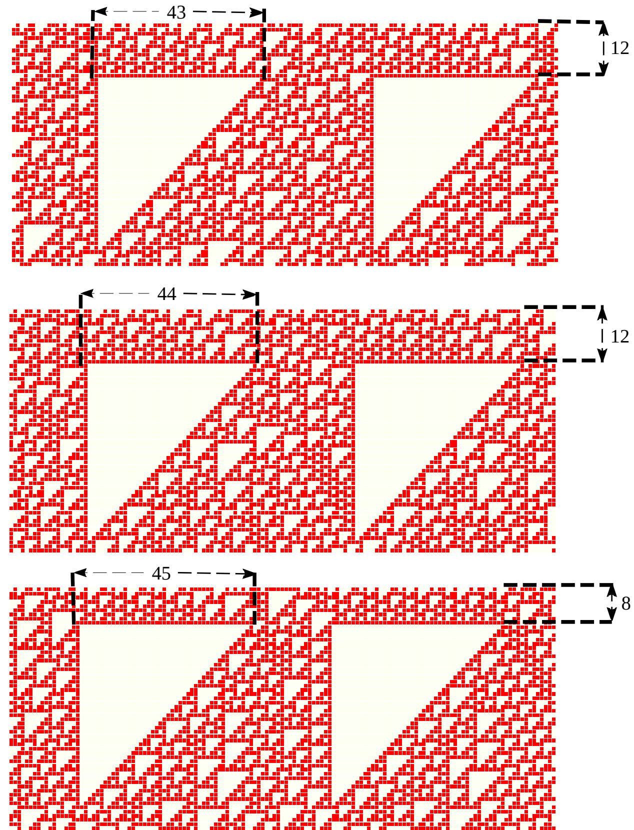


A-3e-D1-3e-C2(B)-E(A)-3B-2B-Ebar, T26

Figure 82: T26 can arise in a quintuple collision between A, D1, C2, E6 and EBar gliders. (Collision and image courtesy Genaro Juarez Martinez)

28 T42

Formación de Triángulos Grandes en la Regla 110



Para secuencias formadas solamente con el estado 1 de longitud 43 y 44, se pueden encontar ancestros en más de 8 generaciones, situación que ya no se presenta para secuencias de longitud 45 en adelante .

Figure 83: Up to the ninth generation, the evolution of arbitrarily large triangles can be arranged, by following out paths in the de Bruijn diagram governing evolution into the constant 1. The nucleus of the diagram for nine generations of evolution is empty, meaning there is nothing for the tenth generation. However, it is acyclic with width 44, so that limited T's, up to and including T42's, can still be be formed. (figure courtesy J. C. Seck Touh Mora)

May 12, 1991