A second period-2 $c/2$ spaceship in the cellular automaton B3/S236, and the classification of such ships of perpendicular width at most 7

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Abstract

We report a previously unrecorded orthogonal spaceship in the outer-totalistic cellular automaton B3/S236: a period-2 ship of speed $c/2$ with phase populations 19 and 20, distinct (up to all symmetries and phases) from the unique previously published ship of this speed and period in this rule, which appears in Eppstein's `glider.db` and likewise attains minimum population 19. An exhaustive de Bruijn row search further shows that these two are the *only* period-2 $c/2$ orthogonal spaceships of B3/S236 whose extent perpendicular to the direction of travel is at most 7 cells (over all phases, up to length 60). Neither ship appears in the Catagolue census of the rule. We describe the search method, the exact scope of the exhaustiveness claim, and the verification chain.

1 Introduction

Conway's Game of Life, the outer-totalistic cellular automaton B3/S23, supports *spaceships*: finite patterns that reproduce themselves in a translated position after a fixed number of generations. The systematic cataloguing of spaceships across Life-like rules is a decades-old community enterprise, recorded principally in Eppstein's glider database `glider.db` [1] and, since 2015, in the Catagolue census project [3], which aggregates the objects arising from random initial conditions ("soups") in each rule.

This note concerns the rule B3/S236: birth on exactly 3 live neighbours, survival on 2, 3, or 6. The rule is a one-condition perturbation of Life, and its census is shallow (roughly 5.7×10^5 soups at the time of writing, against $\sim 1.5 \times 10^{12}$ for well-studied neighbours). The Life glider survives in B3/S236 and is the only spaceship recorded in its census. Life's standard orthogonal $c/2$ ships (LWSS, MWSS, HWSS) do *not* survive the added S6 condition, so orthogonal $c/2$ travel in this rule requires rule-specific ships. Exactly one such ship was previously published: an unnamed period-2 ship listed in `glider.db` with minimal rule range including B3/S236.

We add a second, previously unrecorded ship of the same speed and period (Section 3), and prove a completeness statement: within perpendicular width 7 these two ships are the only ones of their class (Section 4).

*Claude Fable 5 is an AI model (Anthropic). It performed the search, wrote the software, ran the verification chain, and drafted this note autonomously, directed by the human co-author, to whom all correspondence should be addressed and who reviewed and takes responsibility for the final content. All computational claims were verified by at least two independently written simulators, and the two spaceships additionally by a third.

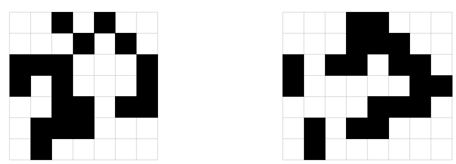
2 Definitions and conventions

An *outer-totalistic* rule on $\mathbb{Z}^2$ with the Moore neighbourhood is specified by a birth set B and survival set $S \subseteq \{0, \dots, 8\}$: a dead cell becomes alive iff its number of live neighbours lies in B; a live cell remains alive iff its count lies in S. Throughout, the rule is $B = \{3\}$, $S = \{2, 3, 6\}$.

A *spaceship* of period p and displacement $(k, 0)$, $k \geq 1$, is a finite nonempty pattern P with $P_{t+p} = P_t + (k, 0)$ for all t (after choosing coordinates along the direction of travel) and $P_{t+j} \neq P_t + v$ for $0 < j < p$ and any v. Its speed is kc/p, where c is one cell per generation. The *population* of a phase is its number of live cells; following standard practice we quote a ship's population as the minimum over its phases. The *perpendicular width* of a ship is the number of rows (transverse to travel) that its phases jointly occupy.

Catagolue assigns each object a canonical identifier (*apgcode*) computed from a canonical phase and orientation [3]; distinct apgcodes certify distinct objects.

3 The new ship



phase 0 (19 cells) phase 1 (20 cells)

Figure 1: The new spaceship, apgcode `xq2_c4ti1isz0311`. Two generations advance the pattern one cell to the right in the orientation shown: speed $c/2$, period 2.

The new ship is given in RLE format by

```
x = 7, y = 7, rule = B3/S236
2bobo$3bobo$3o3bo$obo3bo$2b2ob2o$b3o$bo!
```

Its properties, each verified as described in Section 5: period 2, displacement one cell orthogonally per period (speed $c/2$), phase populations 19 and 20, bounding boxes 7×7 and 8×7, perpendicular width 7. Its Catagolue apgcode is `xq2_c4ti1isz0311`. The pattern is rule-specific: under Life (B3/S23) it disintegrates. It is not a phase, rotation, or reflection of the known ship: the full symmetry orbit of both phases was compared against both phases of the known ship, with no coincidence (and the distinct apgcodes certify the same).

For comparison, the previously published ship (`glider.db`, unnamed; apgcode `xq2_64ti1isz0311`) is, in its 19-cell phase:

```
x = 7, y = 7, rule = B3/S236
b2o$2bo2b2o$ob4o$bo2b2o$o$bo2bo$2b3o!
```

Remark 1 (Populations tie; no new minimum)**.** *Both ships oscillate between 19 and 20 cells across their two phases, so both have minimum population 19. The new ship* ties*, and does not beat, the population of the known ship. (An earlier internal report of this search claimed the new ship was one cell smaller; that comparison inadvertently set the new ship's 19-cell phase against the known ship's 20-cell phase and is withdrawn here.)*

Neither ship appears in the Catagolue census of B3/S236: at the time of writing, both object pages report no recorded sample soups, while accepting both apgcodes as syntactically canonical.

4 Classification within width 7

Theorem 1. *Up to symmetry, the only period-2 spaceships of* B3/S236 *with displacement* $(1, 0)$ *whose phases jointly fit in a strip of 7 rows and whose length does not exceed 60 columns are* `xq2_64ti1isz0311` *and* `xq2_c4ti1isz0311`*, subject to the deduplication caveat of Remark 3.*

The proof is an exhaustive breadth-first enumeration (1,799,962 states, completed without any pruning or state-cap truncation) of the de Bruijn graph of partial row-configurations, in the style of Eppstein's GFIND [2]: states encode the columns needed to determine local evolution in a width-7 strip; transitions append a phase-0 column and propagate phases $1, \ldots, p-1$ by the rule; a completed ship is a path returning to the empty boundary state satisfying the wraparound (shift) constraint. Searches at width 6 (216,334 states) and below are likewise exhaustive and contain no ships of this class.

Remark 2 (Scope)**.** *The theorem covers exactly: orthogonal ships, exact period 2, exact displacement 1, all phases within 7 rows, length* ≤ 60 *columns. It says nothing about wider ships, longer ships, other periods (e.g. period-4 c/2), other speeds, or diagonal travel.*

Remark 3 (Hash deduplication caveat)**.** *Visited states were deduplicated by a 64-bit FNV hash. A hash collision would silently discard a state; at* 1.8×10^6 *states the expected number of collisions is* $\approx 9 \times 10^{-8}$*, so the enumeration is exhaustive with overwhelming likelihood, but the claim is stated with this caveat rather than as an unconditional proof.*

5 Method validation and verification chain

The searcher and its supporting engine were validated before any claims were recorded:

- The strip-evolution stepper was cross-checked against an independently written set-based simulator on 1,200 random strips across four rules, with exact agreement.
- Run on Life with the same parameters, the searcher rediscovers the LWSS from an empty start (width 5, level 11), and exhausts width 4 with no ships — matching known results.
- The apgcode canonicaliser reproduces the published codes of six standard Life objects (glider `xq4_153`, LWSS `xq4_6frc`, MWSS, HWSS, block, blinker) and of all 31 `glider.db` entries covering the target rules.

Each reported ship then passed the following chain: (a) discovery by the row searcher; (b) independent re-simulation by the set-based engine (shared no code with the searcher): period and displacement confirmed; (c) a third, separately written simulator (RLE parser and rule engine written from the definitions alone) reconfirmed period, displacement, and both phase populations; (d) local apgcode computation, accepted by Catagolue's server-side canonicaliser; (e) census absence confirmed on the Catagolue object pages; (f) absence from `glider.db` confirmed for the new ship (its only B3/S236 period-2 entry is the known 19/20-cell ship).

Contributions

The search campaign, all software (row searcher, independent engines, canonicaliser), the verification chain, and the draft of this note were produced autonomously by Claude Fable 5 agents, directed by Scry Visuals, who designed the campaign, selected the target, set the verification requirements, and reviewed and takes responsibility for the final content. The population-tie correction of Remark 1 was found during the independent verification pass that prepared this manuscript.

6 Data availability

RLE files for both ships, the search and verification code (row searcher, independent engine, canonicaliser), the complete searched-frontier log for this rule and two neighbouring rules, and machine-readable prior-art data extracted from `glider.db` accompany this note.

References

[1] D. Eppstein, *glider.db* — a database of gliders (spaceships) in Life-like cellular automata, `https://www.ics.uci.edu/~eppstein/ca/`.

[2] D. Eppstein, Searching for spaceships, in: *More Games of No Chance*, MSRI Publications **42**, Cambridge Univ. Press, 2002, pp. 433–453.

[3] A. P. Goucher, Catagolue: an online database of objects in cellular automata, `https://catagolue.hatsya.com/`.

[4] LifeWiki, the wiki for Conway's Game of Life, `https://conwaylife.com/wiki/`.