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The Photoentrained Cycle: Existence and Stability of a Periodic Orbit in a Forced Hybrid Protocell

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Declared conflict

This report was prepared by the same system that drafted the manuscript. That is a conflict of the first order and nothing below is independent confirmation. Every point is framed so that a reader may check it against the manuscript and against a standard reference rather than against the reporter. There is no author-reply section.

> **Scope of Review**
>
> The manuscript asks whether the steps supplied by the preceding two articles compose into a closed cycle, and poses the question as the existence of a fixed point of a return map on a

periodically forced hybrid system with an impulsive reset at division. It assembles a flow from four parts, a cooperatively coupled isomer clock, a strand separation formulated as a depinning front, an entropically catalysed polymerisation, and a division gated by reduced volume, and reduces the return map to two coordinates. It then gives two answers. Unconditionally, the number of impermeant internal particles is conserved, so a lineage buds some forty times and runs down, and total membrane across a population grows only as the cube root of cell number. Conditionally on a source of such particles, the map has a fixed point, and under supply-limited growth the map is a contraction of multiplier one half.

Compiled disposition

Major revision. The paper's principal result, that the architecture reproduces and does not grow, is correct, important, and derived by a conservation argument that is robust to everything else in the manuscript. But the theorem the paper uses to distinguish itself from a regulated system is proved for a reduction that the manuscript's own propositions contradict; a mechanism introduced in Section 9 appears to destroy a premise of Section 9; and the population section is modelled inconsistently with Section 10. None of the three threatens the principal result, which is why the recommendation is revision rather than rejection.

Required before print

Blocking before acceptance. Restate Theorem 6.x for what it proves, or exhibit the coupled system and bound the loop gain. Compute the competition between azo-lipid permeability and osmotic pinning in the body, and give the mole fraction at which both survive. Restate Theorem 11.x with the finite maternal lifespan that Theorem 10.x imposes. The reporter would re-review points 1 and 2.

Contents

1 What the manuscript does well **3**

2 Major points **3**

3 Further points **4**

4 Minor and editorial **5**

1 What the manuscript does well

Conservation, error record, budding convergence, return map

The principal result is a conservation argument and is correspondingly robust. That no process of the architecture raises the impermeant particle number is checked against every mechanism the corpus has introduced, and the conclusion follows without any dynamical assumption. The manuscript's own scholium on the trapdoor makes the right observation. This is the one result that no rearrangement of the other sections can disturb. The error that produced it is recorded in full. Appendix D states that the withdrawn condition left every other section standing and the conclusion false. Two unrelated arguments converge on budding. Asymmetry is gentler on the solute budget and protects the lineage against failed cycles. The return-map formulation earns its place. It converts the cycle works into a statement with a multiplier, and the growth-law dichotomy is a distinction no narrative account could have drawn.

2 Major points

1 — The no-oscillation theorem is proved for a reduction the manuscript's own Proposition 9.x contradicts

Theorem 6.x establishes that $\dot{\theta} = \Phi_\sigma I(1-\theta) - k(\theta)\theta$ is a scalar monotone field with no periodic orbit. That is correct with A and N held fixed. The manuscript does not hold them fixed. Three couplings are asserted elsewhere in the same paper. Proposition 9.x has the isomer state change the membrane area, since cis packs larger and azo-lipids swing the area by about a tenth. Theorem 9.x has area and particle number fix the reduced volume and hence the tension. And it is standard mechanochemistry that tension shifts an azobenzene photostationary state toward the smaller-area isomer, so tension feeds back on $k(\theta)$.

The loop $\theta \to A \to$ tension $\to k \to \theta$ is therefore closed, and it is closed through mechanics, not through the orientational state that the signalling paper's corollary forbids. Its sign is instructive. Within a period the feedback is positive, which gives bistability rather than oscillation. But across a division it is negative and delayed. High cis yields excess area, which triggers division, which halves the area, which raises the tension, which favours trans. Delayed negative feedback in a hybrid system with an impulsive reset is precisely the standard recipe for a relaxation oscillator. So the manuscript may have an autonomous oscillator and has not looked. The claim that oscillation is impossible, which Section 1.3 lists under Proved here and which Scholium 6.x builds the paper's identity upon, is not established. Requested: restate Theorem 6.x for what it proves, the isomer subsystem alone admits no periodic orbit. Then either exhibit the coupled system and show the loop gain is insufficient, or state that autonomous oscillation in the coupled hybrid system is open. The second is honest and costs the manuscript one rhetorical claim. The first, if it succeeds, is a stronger paper than the one submitted.

2 — The azo-lipid population appears to destroy the osmotic pinning

Theorem 9.x requires the internal solute to be impermeant, and the requirement is quantitative. Pinning holds only if the solute relaxation time $\tau_s = R/3P_s$ exceeds the period. A bare bilayer to small ions sits near 10^{-13} to 10^{-14} and is pinned. But photoswitchable azo-lipids are used deliberately for photo-triggered release, precisely because the cis isomer packs poorly and the permeability rises on switching. Reported increases are one to two orders. At a base of 10^{-13} and a hundredfold switch the volume unpins within an hour of dawn.

And the conflict is phase-locked, which is what makes it serious. The light phase is when the cis fraction is highest. It is therefore when excess area accumulates and pinning is most needed, and it is exactly then that the leak is worst. If the effect is at the reported magnitude, Theorem 9.x fails during the only phase in which it is used, and with it the division condition and the whole of Section 9. Appendix C raises this and does not compute it. Given that it may remove a section, an appendix is the wrong place. Requested: compute the competition in the body. Give the azo-lipid mole fraction at which pinning survives a twelve-hour light phase, and compare it with the fraction Proposition 9.x requires for the area swing. If no fraction satisfies both, the gating mechanism must be replaced or the pinning abandoned, and the manuscript should say which.

3 — Section 11 is modelled inconsistently with Section 10

Theorem 11.x gives budding lineages mean offspring $m = 1 + (1 - p)$ and concludes that they persist at any failure rate short of certainty. That conclusion follows only because the mother is taken to contribute one daughter every cycle indefinitely. Theorem 10.x says the mother does no such thing. She shrinks by $(1 - \alpha)^{2/3}$ per cycle and reaches the floor in about forty cycles at $\alpha = 0.1$, six at $\alpha = 0.5$. The two sections are not in conflict about the answer. The population law of Theorem 10.x already gives the correct growth. But they are in conflict about the model, and as written Section 11 suggests an exponential growth that Section 10 forbids. The correct object is an age-structured branching process with a finite maternal lifespan L_m, and $m = 1 + (1 - p)$ is valid only for the first L_m cycles.

Requested: restate Theorem 11.x with the finite lifespan Theorem 10.x imposes, and remove or qualify the inference that budding lineages persist at any failure rate.

3 Further points

4 — The three-cap band is obtained partly by choosing a range

Corollary 12.x reports a common band of 100–400 bp. But the clock cap is $\delta T/t_{\mathrm{add}}$, and the manuscript obtains its contribution by assuming $t_{\mathrm{add}} \in [10^2, 10^3]\,\mathrm{s}$. At $t_{\mathrm{add}} = 10\,\mathrm{s}$ the clock cap is 4320 bp and imposes nothing, and the band is set by the other two alone. The manuscript says t_{add} is the free parameter and is measurable, which is correct and creditable. What it does not say is that the convergence it reports is contingent on a range for that parameter which was not derived. Requested: state the band as a function of t_{add} rather than at an assumed range, and say at what value the three caps cease to agree.

The effective molarity carries the polymerisation claim and spans six orders. Theorem 8.x quotes 10^2 to 10^8 M. Appendix C concedes that the upper end requires rigid juxtaposition and that a chrysene held by a flexible connector is not that. Since t_{add} follows from this quantity and condition C3 follows from t_{add}, the six orders propagate into the paper's central existence condition. Requested: take the conservative half of the range in the body and let C3 inherit it.

The unzipping forces are imported from a different geometry. The 10–11 and 15–20 pN figures are single-molecule values obtained by pulling a free end. Here the force is transmitted through tethers to anchors in two apposed membranes, with a different lever arm and loading rate. Appendix C says so. Since Theorem 7.x's origin selection depends only on the ordering of the two figures, the result is safe. The manuscript should say that explicitly where the theorem is stated rather than in an appendix.

Condition C4 is invoked in Lemma 10.x and never stated. The lemma reduces the map to two coordinates on the ground that the isomer coordinate has relaxed by dawn by Theorem 6.x and condition C4. C4 appears in the list at Theorem 10.x as Jz in the window of Section 6 but is nowhere given as an inequality. Requested: state C4 as a relation between $E_a + Jz$ and the dark interval.

The reduction discards the fork coordinate too quickly. Lemma 10.x sets $x = 0$ at dawn by division or completion. But the failure mode of Theorem 11.x is precisely a cycle in which neither occurred. In that case $x \neq 0$ at dawn and the state is not on the reduced manifold. Requested: either treat the failed cycle as a reset of x to zero with the strands re-annealing, and say so, or carry x in the map.

4 Minor and editorial

1. Four bibliography entries remain unfilled, including the two that carry points 2 and 5.
2. Block V2 leaves I_c uncomputed. The manuscript correctly notes that the structural result, extremes rather than mean, does not depend on it, but the block should say what two quantities would close it.
3. The patent citation is not yet at figure level, which the ledger's purpose requires.
4. Theorem 9.x's proof cites concavity of $t \mapsto t^{2/3}$ for the maximum of Q at $\alpha = \frac{1}{2}$. Symmetry plus concavity is the argument and both should be named.

On what the paper establishes

A closing observation, offered as comment. The manuscript is the fourth in an arc whose form has been to state conditions and derive bounds. This one differs, and the difference is worth naming. It contains a result that is not a bound but a prohibition derived from a conservation law, and the prohibition is about the architecture rather than about what can be known of it. The architecture reproduces and does not grow, and no premise of the paper is load-bearing in that conclusion. That is also why the three points above are revisions rather than objections. Points 1 and 2 could remove Sections 6 and 9 respectively and the principal result would stand, because it depends on neither the clock nor the division geometry, only on the fact that nothing makes an osmolyte. A paper whose main theorem survives the loss of two of its sections has located something, and the revision should make that independence explicit rather than leaving it to be inferred.

Summary of requested changes

Points 1, 2 and 3 before acceptance. Points 4–8 at the author's discretion, with 4 and 7 recommended. The reporter would re-review points 1 and 2.

References

[Art63] C. D. Schaper. Structural adequacy for signalling. *Annals of the Chrysene Formalism* 1(3):1321–1347, 2026. Article 63. DOI: `https://doi.org/10.68366/0e3gsg12`.

Revision history

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