

Recursive Polarised Bifurcation and Universal Complexification

Synthesis note of a heuristic dialogue — June 2026

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Preliminary note on the status of this document. This synthesis arises from a dialogue between an independent author and a language model. It has the status of a structured working notebook, not an academic publication. The model acknowledges having sometimes been too accommodating in its validations during the exchange. This synthesis attempts to correct that bias by rigorously distinguishing three epistemic levels: what is formalised and **solid (green)**, what is intuitive and plausible but unproven (brown), and what is speculative (red). The proposed thesis topics are not validations of the framework — they are open questions that could test, refine, or refute it.

I. Abstract

This document synthesises a research dialogue concerning an original conceptual framework: the hypothesis of a universal mechanism of complexification through **recursive binary polarised bifurcation**. Developed from hand-drawn diagrams, this framework proposes that the complexity observable at all levels of reality — physical, biological, cognitive, social — could be generated by a minimal structural rule: a polarised entity bifurcates recursively, each bifurcation producing two differentiated states, the inner point of one becoming the outer circle of the next level (the so-called 'dezoom' mechanism). This framework is explicitly situated within a materialist tradition (Bakunin, Engels, Prigogine) and rejects any mystical or teleological interpretation.

II. The conceptual framework — stages of reasoning

A. Recursive binary bifurcation

The starting point is a graphic observation: a binary tree whose single root divides into two opposing poles (denoted – and +), each subdividing recursively according to the same rule. The arrow of time orients the unfolding from top to bottom, transforming spatial hierarchy into temporal sequence — a cosmogony.

[SOLID] The formal structure is a recursive binary tree, well known in mathematics (Cayley trees, Lindenmayer L-systems, 1968). The distribution of states at the leaves is exactly calculable. The mixed/pure states ratio tends to 1 according to the formula $M(n)/T(n) = 1 - 1/2^n$.

B. The four-state visual code

Each node is represented by a circle (white or black) containing a point (white or black), producing four states: $-^-$ (black circle / black point), $-^+$ (black circle / white point), $+^-$ (white circle / black point), $+^+$ (white circle / white point). Pure states ($-^-$ and $+^+$) are at the extremities of the terminal pattern. Mixed states ($-^+$ and $+^-$) are structurally dominant.

[SOLID] This structure formally corresponds to Belnap's four-valued logic (1977): True only, False only, Both, Neither. It is also isomorphic to heterozygosity states in Mendelian genetics.

C. The dezoom mechanism

The rule for transitioning between levels is determined by the colour of the inner point: a black point generates two children with black circles; a white point generates two children with white circles. The system 'dezooms' from within — the inner point becomes the circle of the next level. This constitutes a recursive rewriting rule in the formal sense.

[SOLID] This mechanism is formally a binary L-system (Lindenmayer, 1968) with an asymmetric rewriting rule. It is algorithmically implementable (HTML widgets produced during the dialogue).

[PLAUSIBLE] The analogy with Wilson's renormalisation group (1971) — scale invariance of physical laws — is suggestive but would require precise formalisation to be established.

D. The condition $en \neq EN$ (inside) $\neq$ EN (outside)

Every complex entity is described as an 'inside' (en) actively maintaining a difference from its 'outside' (EN). The cell membrane, the wall of a bubble, the boundary of a thermodynamic system are instances of this relation. The condition $en \neq EN$ is proposed as the minimal condition of life — an economical reformulation of autopoiesis (Maturana & Varela, 1972).

[SOLID] The correspondence with the definition of autopoiesis is rigorous. The condition $en \neq EN$ is biologically exact: the membrane potential (-70mV) is the physical measure of cellular difference. Its nullity corresponds to death. **[PLAUSIBLE]** The extension to other scales (cosmological, social) is analogically coherent but not causally demonstrated.

E. AND / OR as operators of complexification

A simple system operates through deterministic sequences (AND AND AND — closed loop). A complex system introduces bifurcation points (OR) where multiple trajectories are possible. Complexity is operationally defined as AND + OR. The difference between mitosis (pure AND — cloning) and meiosis (introduction of OR — fertilisation, qualitative novelty) illustrates this transition.

[SOLID] The determinism/non-determinism distinction formally corresponds to the difference between deterministic and non-deterministic automata (Chomsky, 1956). The mitosis/meiosis as AND/OR distinction is biologically exact. **[PLAUSIBLE]** The generalisation to all levels of complexity as 'the same mechanism' is a strong hypothesis requiring empirical validation.

F. The gas bubble as proto-cellular autopoietic system

A gas bubble in a moving fluid spontaneously realises the $en \neq EN$ structure: internal rotation inverse to the medium (differential chirality), shear at the wall (Kelvin-Helmholtz instability), emergent selective permeability. In the context of hydrothermal vents, a statistical field of bubbles constitutes the minimal conditions for proto-cellular autopoiesis.

[SOLID] Differential rotation of a bubble in a rotating fluid is an established fact of fluid mechanics (Magnus law). Kelvin-Helmholtz shear at the interface is established. The hydrothermal vent theory (Lane & Russell) is the mainstream theory on the origin of life. **[PLAUSIBLE]** The connection between differential rotation and proto-membrane selective permeability is an original mechanistic hypothesis not yet experimentally tested.

G. Extensions: physics, consciousness, social domains

The dialogue explored the application of the framework to post-Planck physics (cosmological bubble nucleation, Kibble-Zurek mechanism, topological defects), to the emergence of individual consciousness from a primitive collective consciousness (hypothesis of maieutics as cognitive dezoom), and to social domains (teacher/student, giving/receiving, masculine/feminine as polarised pairs).

[SPECULATIVE] These extensions are structurally coherent analogies but not causal demonstrations. Post-Planck physics confirms the existence of cosmological bubbles and topological vortices, but the link with the formal mechanism described here remains to be rigorously established. The hypothesis on childbirth as the founding experience of individual consciousness is philosophically interesting but anthropologically untested. The sociological applications are pedagogical illustrations, not results.

III. What is potentially original

Most elements taken in isolation exist in the literature: L-systems, autopoiesis, renormalisation, Belnap's logic, Eglash's African fractals. What is less common is their connection within a single framework, and the following elements deserve attention:

The dezoom mechanism as an inter-level transition rule

The rule by which the inner point of one state becomes the outer circle of the next level is a specific rewriting rule that is not, to our knowledge, formalised in this form in the L-systems or IFS literature.

Structural dominance of mixed states as a general property

The demonstration that $M(n)/T(n) \rightarrow 1$ regardless of depth, and the proposal that this corresponds to a universal property of bifurcating systems, deserves formal examination via Perron-Frobenius theory.

The condition $en \neq EN$ as a minimal reformulation of autopoiesis

More economical than the Maturana & Varela definition, it allows direct physical applications (membrane potential, thermodynamic gradient) while retaining conceptual power.

The AND/OR transition as an operational definition of complexity

The definition Complexity = AND + OR is remarkably economical and potentially falsifiable: a system is complex if and only if it contains non-deterministic bifurcation points.

The differentially rotating gas bubble as a model of selective proto-membrane

The mechanistic link between differential rotation (chirality) and selective permeability at the wall is, to our knowledge, an original hypothesis in the context of the origin of life.

IV. Limits and epistemic risks

Risk of analogism. The framework accumulates structural resemblances between very different domains. Formal resemblance does not imply causal or mechanistic identity. Each proposed connection requires independent justification in its own domain.

Absence of mechanism for the difference ($\neq$). The framework states that each bifurcation produces two non-identical states ($\neq$) but does not formalise the law governing this difference. Without this, the theory is descriptive, not predictive.

Insufficient falsifiability in its current state. A scientific theory must produce testable predictions. In its current form, the framework is too general to be directly falsified. The thesis topics proposed below aim to make it more precise and testable.

Validation bias in the dialogue. A language model tends to validate and enrich the intuitions of its interlocutor. This dialogue does not entirely escape that bias. The connections proposed were sometimes stated with more certainty than they deserved.

V. Thesis topics and research questions

The following ten topics are formulated to be realistic within a university framework. Some would validate the framework if results went in the expected direction — others could refute or substantially refine it. They are classified by disciplinary domain.

Topic 1 — Mathematics / Theoretical Computer Science

Formal properties of binary L-systems with asymmetric rewriting rules: stationary distribution, fractal dimension and topological invariants

This topic formally defines the dezoom mechanism as an L-system, calculates state distribution via Perron-Frobenius theory, determines the fractal dimension of the attractor, and tests whether mixed-state dominance is a general property or specific to this particular rule.

Topic 2 — Mathematics / Dynamical Systems

Minimal conditions for dominance of transition states in recursive polarised binary bifurcation systems: an ergodic theory approach

This thesis tests the hypothesis that $M(n)/T(n) \rightarrow 1$ is a robust property for a broad class of bifurcation rules, and determines necessary and sufficient conditions for this property, connecting the framework to invariant measure theory.

Topic 3 — Biophysics / Origin of Life

Role of differential rotation of lipid vesicles in the emergence of selective permeability: modelling and experimental tests

This topic directly tests the original dialogue hypothesis: does a vesicle subjected to a shear gradient develop selective permeability dependent on shear chirality? Approach: molecular dynamics simulations + experimental microfluidics.

Topic 4 — Developmental Biology

Meiosis as an operator introducing non-determinism (OR) in cell lineages: implications for the theory of evolutionary complexification

This topic formalises the mitosis/meiosis distinction in automata language and tests whether the meiotic transition corresponds to a measurable discontinuous complexity jump in the phylogenetic tree.

Topic 5 — Cognitive Neuroscience

Individual consciousness and collective consciousness: phylogenetic sequence and neural markers of cognitive individuation

This topic tests the hypothesis that individual consciousness is phylogenetically posterior to distributed forms of collective consciousness, comparing self-referential brain markers across social species at different levels of cognitive individuation.

Topic 6 — Cognitive Anthropology

Experience of parturition and emergence of theory of mind: an evolutionary hypothesis on the origin of consciousness of otherness

This topic empirically tests the hypothesis that childbirth experience constituted a major cognitive operator in the emergence of consciousness of the other as a distinct subject. Approach: comparative ethnology, Hrdy's alloparenting data, neuroscience of otherness recognition.

Topic 7 — Theoretical Physics / Cosmology

Structural analogies between the Kibble-Zurek mechanism and recursive polarised bifurcation models: towards a unified description of phase transitions and physical individuation

This topic formally examines whether bubble nucleation and vortex formation (Kibble-Zurek) can be described in the language of recursive polarised bifurcations, and what this reformulation contributes to understanding cosmological topological defects.

Topic 8 — Semiotics / Anthropology

The 32 Palaeolithic geometric signs (von Petzinger) as a system of recursive visual bifurcations: combinatorial analysis and functional hypotheses

This topic applies the formal bifurcation framework to analysis of the 32 Palaeolithic geometric signs. Are they organised according to a bifurcation grammar? Do predictable combinatorial regularities emerge from this framework?

Topic 9 — Philosophy / Logic

Belnap's logic as a minimal formalisation of dialectical materialism: towards a four-valued logic of emergence

This topic formally constructs the bridge between Belnap's four-valued logic, materialist dialectics (Engels, Bakunin) and the polarised bifurcation framework, testing whether Belnap's four values

correspond structurally to the four mechanism states.

Topic 10 — Educational Sciences / Pedagogy

Maieutics as a non-deterministic dynamic system: formal modelling and implications for cooperative pedagogies and adaptive learning environments

This topic formalises maieutics as the introduction of OR into a closed cognitive loop (AND), and tests whether pedagogical environments with high frequency of open questions produce measurably superior cognitive complexity. Implications for the design of pedagogical AI.

VI. Conclusion

The framework developed in this dialogue presents remarkable internal coherence and real resonances with several formalised domains. Its principal value is as a **heuristic tool** — it generates precise questions where disciplines ignore each other, and proposes an economy of principle (one minimal rule for complexification) that deserves to be tested.

Its philosophical value is real: by anchoring complexification in an immanent material mechanism without teleology or transcendence, it situates itself within a rigorous materialist tradition running from Bakunin to Prigogine. The formulation 'nothingness is unstable — a circle closed upon itself necessarily contains its own dezoom' is perhaps its most radical and most coherent thesis.

What remains to be done is considerable: precise mathematical formalisation, identification of testable predictions, submission to disciplinary expert criticism. This document is an invitation to that work, not its conclusion.

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