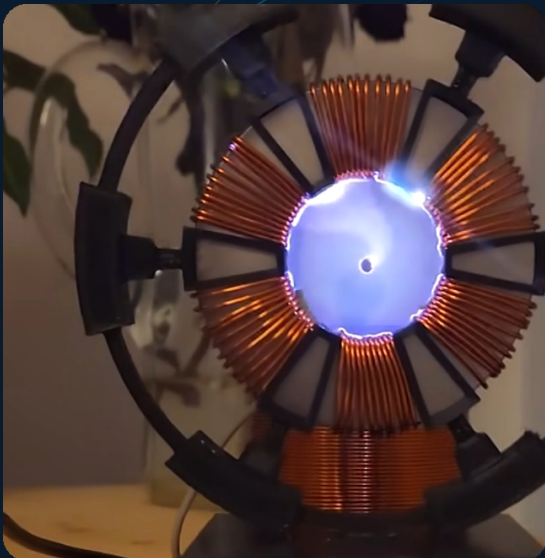


COHERENT LUMINOUS NODE LABORATORY ENGINEERING DICTIONARY & REPRODUCIBILITY WHITE PAPER

Formation, handoff, sustainment, containment, manipulation,
boundary control, environmental attractors, diagnostics, and falsification



Blue/violet ring state - user-supplied online
screenshot



Later orange/yellow-dominant state - same
online source

Status. Speculative hypothesis synthesis and adversarial computational record. The report does not claim that natural ball lightning has been explained, does not identify the mechanism in any online video, does not establish gravity control, propulsion, fusion, or free energy, and intentionally omits hazardous construction parameters. Published microwave-plasma experiments are treated as independent conventional-physics comparators, not as proof of RBFL.

Scientific boundary

This report separates five evidence classes throughout:

- **[LITERATURE]** peer-reviewed or published laboratory/natural observations;
- **[MODEL]** normalized RBFL/CLN reduced-order computational results;
- **[UNVERIFIED MEDIA]** online media observations whose provenance/authenticity is unresolved;
- **[HYPOTHESIS]** mechanistic interpretations that remain to be tested;
- **null/falsifier:** an explicit condition expected to weaken or reject a hypothesis.

No online screenshot is treated as proof. No normalized model coefficient is presented as a physical volt, ampere, kelvin, pascal, newton, metre, or thrust value.

Executive statement

The current CLN programme has reached a point where a detailed hypothesis report is scientifically useful because the same qualitative picture has survived multiple independent mathematical attacks while external plasma literature provides several conventional-physics analogues. The strongest internal result is not that one specific burden variable is correct; it is that **persistent, spatially local boundary loading produces a distinctive migration response that matched non-spatial rivals do not reproduce**. A separate fresh-medium/global-relief model can reproduce the aggregate survival rescue, however, so environmental replenishment remains a live rival. A third layer shows that if processed medium exits through a preferred inter-anchor gap, ordinary momentum conservation is sufficient to generate opposite recoil in the model.

A major external convergence emerged after these hypotheses had been developed: Ohtsuki and collaborators published microwave-generated plasma fireballs in natural air, barrier passage through a ceramic plate, unusual mobile/stable fireball behaviour, and a later experiment in humid air containing water droplets and vapour in which the luminous objects *grew and shifted toward red* relative to the dry case [1, 2, 5]. A separate natural spectroscopic observation recorded a 1.64-s ball-lightning event whose colours evolved through purple, orange, white and red while soil-element emission persisted through its lifetime [6]. These publications do not prove the CLN mechanism, but they make the multi-state/environment-dependent interpretation a serious hypothesis rather than a purely visual analogy.

Current synthesis in one sentence

CLN is best treated as a family of bounded luminous plasma/field attractors whose formation, survival, colour state, transport, venting and apparent barrier passage can depend on different environmental support channels; the same visible “orb” need not have one universal microscopic mechanism.

Engineering closure added in v0.20

The final integrated normalized control sweep requires creation/sustainment plus fourteen manipulation tasks. On the deterministic 64-case stress subset, 89.06% passed the complete optimized control battery. The later local-boundary failure model reduces the fixed-anchor complete mission to 3.13%, while broad persistent pair migration restores it to 89.06%; the

independent fresh-medium relief rival gives 87.50% with fixed anchors. This paper therefore treats the architecture as ready for laboratory analogue engineering and falsification, not as a demonstrated natural-ball-lightning mechanism.

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1 Scope, claim ladder, and what is frozen

1.1 The CLN branch does not modify the RBFL gravity law

The CLN work is an engineering/explanatory sandbox layered outside the locked RBFL acceleration architecture. None of the v0.2-v0.19 variables below is inserted into the gravitational force law. In particular, anchor burden, fresh-medium supply, aperture opening, vapour/mass flux, colour state and recoil are not gravity terms.

The foundational CLN diagnostic remains a state-classification quantity:

$$\boxed{\mathcal{N}_{\text{CLN}} = R_\phi L_\Omega S_T} \quad (1)$$

where R_ϕ measures phase/coherence organisation, L_Ω localisation, and S_T bounded temporal persistence. A high value is a *candidate coherent-node state*, not a claim of a new force.

1.2 Conventional null model first

The minimum physical interpretation of the current CLN results is conventional:

$$\boxed{\text{electromagnetic/plasma dynamics} + \text{boundary conditions} + \text{environment} + \text{feedback}} \quad (2)$$

Any specifically RBFL phase-coupling interpretation must beat that conventional model in a future experiment. The present report therefore gives conventional plasma/EM explanations equal standing wherever they can explain the same observation.

1.3 Claim ladder

Level	Allowed statement	Current status
C0	A reduced-order equation can reproduce a declared behaviour.	Achieved for several CLN behaviours.
C1	The behaviour survives adversarial nulls and alternative equations.	Achieved for local-memory migration class.
C2	Independent conventional experiments show analogous behaviour.	Partly achieved: microwave fireballs, humidity effects, barrier passage.
C3	A specific natural/online event matches frozen predictions.	Not yet achieved; source video needed.
C4	The physical mechanism is identified experimentally.	Not achieved.
C5	A safe laboratory analogue is independently reproduced.	Future work.

2 From a single orb to a multi-attractor framework

A single visual category called “ball lightning” can hide different physical states. The synthesis used here is:

$$\dot{\mathbf{X}} = \mathbf{F}_{\text{CLN}}(\mathbf{X}, \mathbf{u}; \mathbf{E}), \quad (3)$$

where $\mathbf{X}$ is the frozen CLN state vector, $\mathbf{u}$ represents allowed control/sustainer variables, and $\mathbf{E}$ is an environmental vector. Different environments may select different bounded attractors:

$$\mathbf{X}(t) \longrightarrow \mathcal{A}_k(\mathbf{E}), \quad k = 1, 2, \dots \quad (4)$$

without requiring a different core law for every visible behaviour.

A useful environment vector is

$$\mathbf{E} = \{\rho_{\text{drop}}, q_v, \sigma_{\text{air}}, \sigma_{\text{surface}}, \mathbf{v}_{\text{air}}, \mathcal{G}_{\text{EM}}, A_{\text{acoustic}}, \text{attachment topology}\}. \quad (5)$$

The components are deliberately generic. They allow wet/droplet-supported, dry/indoor, conductive-surface, field-guided and acoustically perturbed branches to coexist.

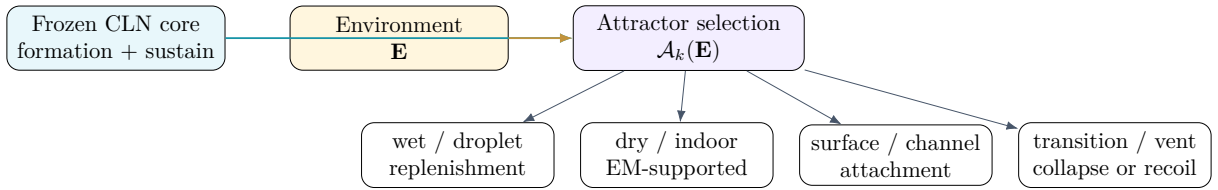


Figure 1. Multi-environment attractor architecture. This is a synthesis wrapper around the frozen CLN core, not a new force law.

3 Observational trigger: two bright anchors and a blue-to-orange transition

[UNVERIFIED MEDIA] The user-supplied plasma-vortex screenshots show two persistent bright loci near the upper rim of a blue/violet rotating luminous state, followed later by a strong yellow/orange takeover. These screenshots are online media and their apparatus description is not independently verified here; they are used only as visual motivation.



(a) Blue/violet-dominated state with two bright upper-rim loci.



(b) Later yellow/orange-dominated state.

Figure 2. User-supplied online screenshots. The visible colour change is real in the images; the microscopic meaning of the colours is not identified.

The colour itself must not be equated with temperature, coherence or composition. A safe observable is simply a measured emission state:

$$C(t) \in \{B, W, O, R, \dots\}, \quad (6)$$

where B is blue/violet-dominant, W white/saturated, O orange/yellow-dominant and R red-dominant. The hypothesis is that transitions such as $B \rightarrow O$ may mark a state change, but only spectroscopy can determine whether the change is thermal, compositional, chemical, electrical or optical-camera related.

External colour evidence that matters

Two independent publications make colour-state tracking scientifically reasonable without making colour diagnostic by itself:

- Kondo, Ofuruton and Ohtsuki (1997) reported that microwave-produced plasma luminous objects in a high-humidity atmosphere containing water droplets and vapour **grew and changed colour toward red** relative to the case without droplets/vapour [2].
- Cen, Yuan and Xue (2014) recorded a natural event for 1.64 s and reported the colour sequence **purple, orange, white and red** together with time-resolved spectroscopy [6].

These results show that luminous-orb colour can evolve with state and environment; they do not identify the CLN blue/orange interpretation.



4.2 Break-test result

[MODEL] v0.14 exactly reconfirmed the v0.13 headline: fixed anchors gave 50.78% late survival, whereas continuous pair migration gave 96.88%. Collapse fell from 47.66% to 3.13%. The decisive identity null disconnected H from all CLN dynamics; fixed and moving structural histories then became exactly identical. Direct shape-stress by itself also failed to create the migration advantage.

The strongest causal mediation result was monotonic locality: when burden was global the migration advantage was zero; as the causal burden was made more local, migration became progressively more valuable.

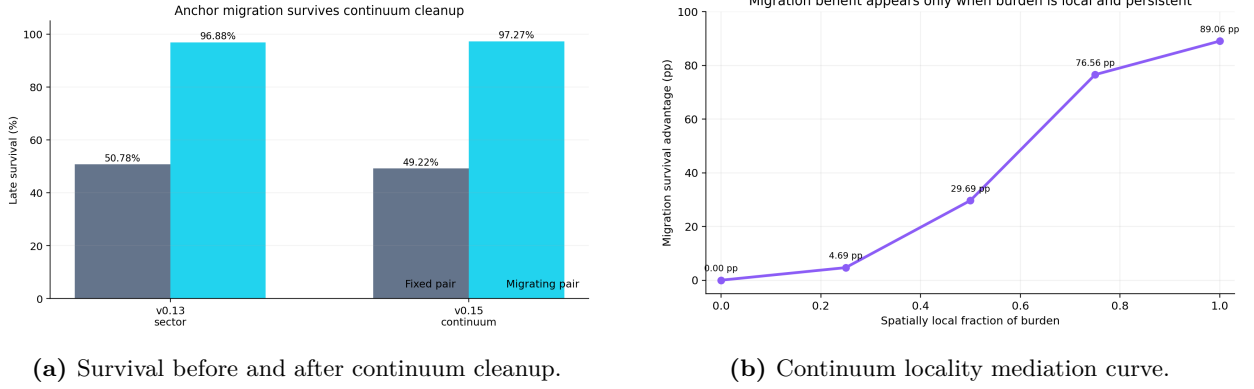


Figure 4. The migration result survives both causal and numerical attacks.

4.3 Continuum boundary formulation

The v0.14 caveat was angular grid dependence. v0.15 replaced the coarse sector field with a periodic finite-volume representation on S^1 :

$$\frac{\partial H}{\partial t} = \lambda L(\theta, t) - R(H) + D_\theta \frac{\partial^2 H}{\partial \theta^2}, \quad \theta \in S^1. \quad (9)$$

No burden coefficient or failure threshold was retuned. The full 256-case result became 49.22% fixed versus 97.27% moving, with collapse 49.61% to 2.73% and median peak H 1.257 to 0.561. Independent finite-volume and Fourier/spectral solvers agreed at the 10^{-4} -level or better in the audited quantities, and periodic mean-balance residuals were at floating-point precision.

Frozen mathematical rule after v0.15

If a damaging boundary state is spatially local, repeatedly loading the same two physical sectors is fragile. Broad and persistent redistribution of both anchors, while preserving the two-anchor relationship, reduces local accumulation in this reduced-order system.

5 v0.16: removing the symbol H

The next attack removed the abstract H field entirely and replaced it with four independently written boundary-memory classes.

5.1 Thermal-memory surrogate

$$\frac{\partial T^*}{\partial t} = k_T L^2 - \frac{T^*}{\tau_T} + D_T \frac{\partial^2 T^*}{\partial \theta^2}, \quad (10)$$

$$\eta_T = \frac{1}{1 + (T^*/T_c)^p}. \quad (11)$$

5.2 Signed charge/attachment-memory surrogate

$$\frac{\partial q^*}{\partial t} = k_Q (s_1 L_1 - s_2 L_2) - \frac{q^*}{\tau_Q} + D_Q \frac{\partial^2 q^*}{\partial \theta^2}, \quad (12)$$

$$\eta_Q = \frac{1}{\sqrt{1 + (|q^*|/q_c)^2}}. \quad (13)$$

5.3 Saturating deposition/coverage surrogate

$$\frac{\partial c^*}{\partial t} = k_C L \left(1 - \frac{c^*}{c_{\max}}\right) - \frac{c^*}{\tau_C} + D_C \frac{\partial^2 c^*}{\partial \theta^2}, \quad (14)$$

$$\eta_C = \exp[-(c^*/c_c)^2]. \quad (15)$$

The electrothermal class coupled the thermal source to a signed-charge state and used $\eta_{ET} = \sqrt{\eta_T \eta_Q}$.

[MODEL] Across the full 256-case nominal tests, migration improved survival for all four classes. Across 384 independently sampled parameter sets, migration reduced peak local surrogate state in 384/384 and improved minimum CLN health in 384/384, with zero reverse failures in the central ensemble.

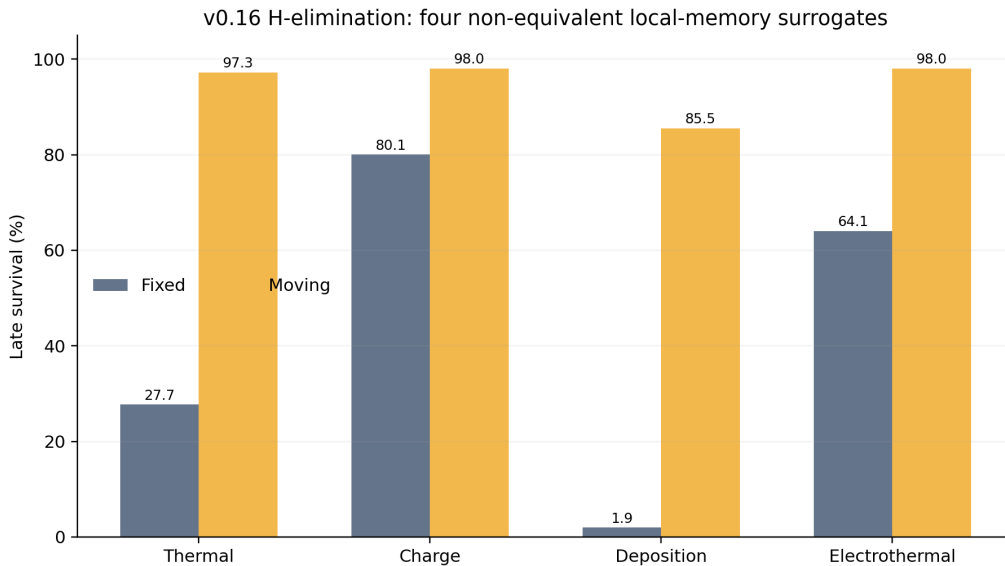


Figure 5. v0.16 H-elimination. The direction of the migration result is not specific to one burden equation.

The decisive nulls were stronger than the headline survival numbers. When the surrogate was disconnected from anchor effectiveness, fixed and moving structural histories were identical. When degradation was instantaneous with no memory, fixed and moving were identical. When the source

was spatially globalised, fixed and moving were again identical. Thus the surviving class is

$$\boxed{\text{spatially local} + \text{persistent in time.}} \quad (16)$$

6 v0.17: matched non-spatial rivals

A critic can fit the fixed-anchor failures with a global mechanism. v0.17 therefore calibrated four non-spatial rivals on fixed cases only before revealing the moving result: anchor-identity fatigue, elapsed-time decay, well-mixed cumulative-energy fatigue, and orientation-independent stochastic hazard.

[MODEL] Each rival matched the fixed failure rate closely, but because none possessed a boundary coordinate, each predicted exactly the same structural history for fixed and CONT-180 twins. Across all 16 target-surrogate $\times$ rival pairs, the maximum fixed/moving structural difference was exactly zero. A nonphysical oracle that copied every fixed case perfectly also failed to produce migration rescue when copied into the moving branch.

The held-out topology battery provides the stronger discriminator. The spatial model distinguishes broad pair rotation, small repeated oscillation, one-anchor movement, separation-only movement, random relocation, and motion that stops early. The non-spatial rivals predict no topology dependence at all.

v0.17 discriminator

Within the present reduced-order mathematics, the migration response depends on **where the pair has previously loaded the boundary**, not merely on elapsed time, total energy, anchor identity, or orientation-independent stochastic failure.

7 v0.18: fresh-medium replenishment as a serious critic rival

The moisture/replenishment hypothesis was intentionally introduced as an adversary to the spatial-memory interpretation. v0.18 used no angular memory. Instead it added a global fatigue state $F(t)$ and a global fresh-medium resource $R(t)$:

$$\frac{dR}{dt} = k_{\text{refresh}} \Gamma_{\text{fresh}} (1 - R) - \frac{R}{\tau_R}, \quad (17)$$

$$\frac{dF}{dt} = k_{\text{load}} L^2 - \frac{F}{\tau_F} (1 + k_{\text{relief}} R), \quad (18)$$

$$\eta = \frac{1}{1 + (F/F_c)^p}. \quad (19)$$

The model was calibrated only to a fixed and one CONT-180 development branch, frozen, and then evaluated on held-out cases.

[MODEL] On the held-out full 256 cases, the global-relief rival predicted 51.95% fixed and 96.88% CONT-180 - remarkably close to the earlier spatial headlines. Therefore environmental/global relief is a genuine rival for the *aggregate survival rescue*.

It did not, however, reproduce the full movement-topology fingerprint. Small or separation-only repeated oscillations were heavily over-rewarded because the global model measures motion/refresh but does not remember that the same boundary region is being revisited.

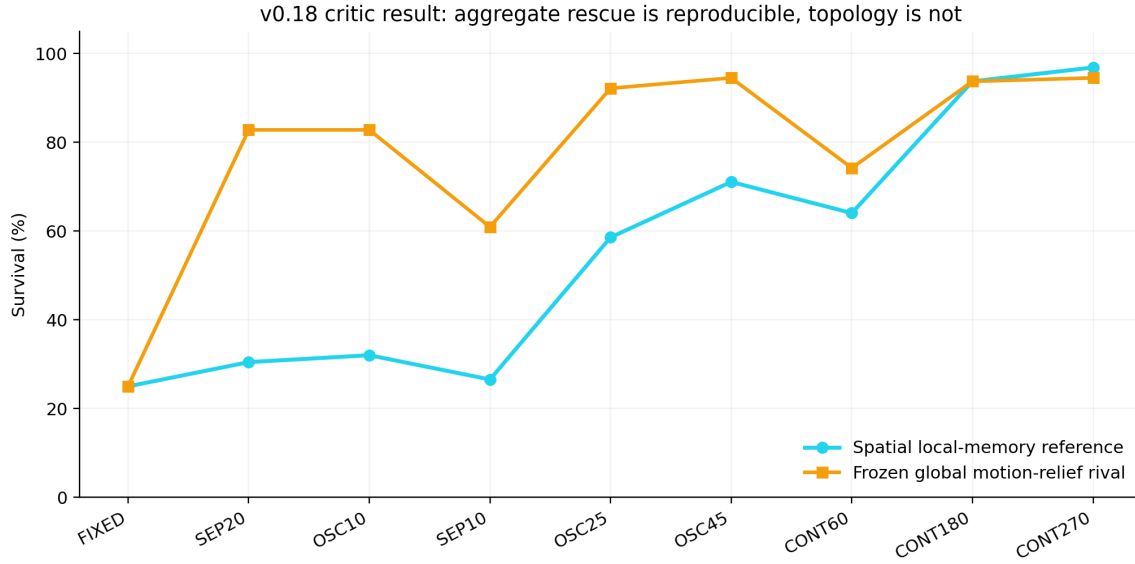


Figure 6. v0.18 critic result. A global motion/fresh-medium relief law can match the overall rescue yet miss the topology that distinguishes broad fresh-sector coverage from repeated local sweeping.

Environmental replenishment interpretation

A wet atmosphere can be treated as a replenished reaction reservoir rather than merely “humidity.” A generic encounter/capture rate is

$$\Gamma_d \sim n_d A_{\text{cap}} v_{\text{rel}}, \quad (20)$$

where n_d is droplet number density, A_{cap} an effective capture cross-section and v_{rel} relative motion. The present model does not identify the microphysics; possible conventional channels include heating/evaporation, charge exchange, plasma chemistry, attachment renewal and cooling.

Retrospective literature convergence: droplets and vapour

The 1997 Waseda/Tokyo group paper is particularly relevant because it predates this project by decades and independently studied microwave plasma luminescence in a high-humidity atmosphere containing water droplets and vapour. The authors reported that the luminous objects **grew and shifted red** compared with the no-droplet/no-vapour case [2]. This does not validate the CLN replenishment equation, but it establishes that moisture can materially alter laboratory fireball size/colour in the same experimental family.

8 v0.19: inter-anchor exhaust and ordinary recoil

The next hypothesis joined the fresh-medium reservoir to the repeatedly observed two-anchor geometry. The proposed kinematic chain is

$$\boxed{\text{fresh medium} \rightarrow \text{capture/process} \rightarrow \text{inter-anchor outflow} \rightarrow \text{opposite recoil.}} \quad (21)$$

Let $\hat{n}_{12}$ point outward through the inter-anchor gap. If processed medium leaves with mass-flow

rate $\dot{m}_{\text{out}}$ and exhaust velocity $\mathbf{v}_{\text{out}} = v_{\text{out}}\hat{\mathbf{n}}_{12}$, ordinary momentum bookkeeping gives

$$\boxed{\mathbf{F}_{\text{recoil}} = -\dot{m}_{\text{out}}v_{\text{out}}\hat{\mathbf{n}}_{12}.} \quad (22)$$

No exotic propulsion term is needed for this kinematic hypothesis.

[MODEL] In the normalized v0.19 model, gap-directed exhaust produced nonzero wandering; isotropic outflow, no droplets, and no aperture produced zero net recoil/translation. Random exhaust could also wander, but lost alignment with the anchor gap. In the GAP-FIXED branch, exhaust preceded the declared launch in 100% of cases where both events occurred, with a median model delay of 553 model-ms.

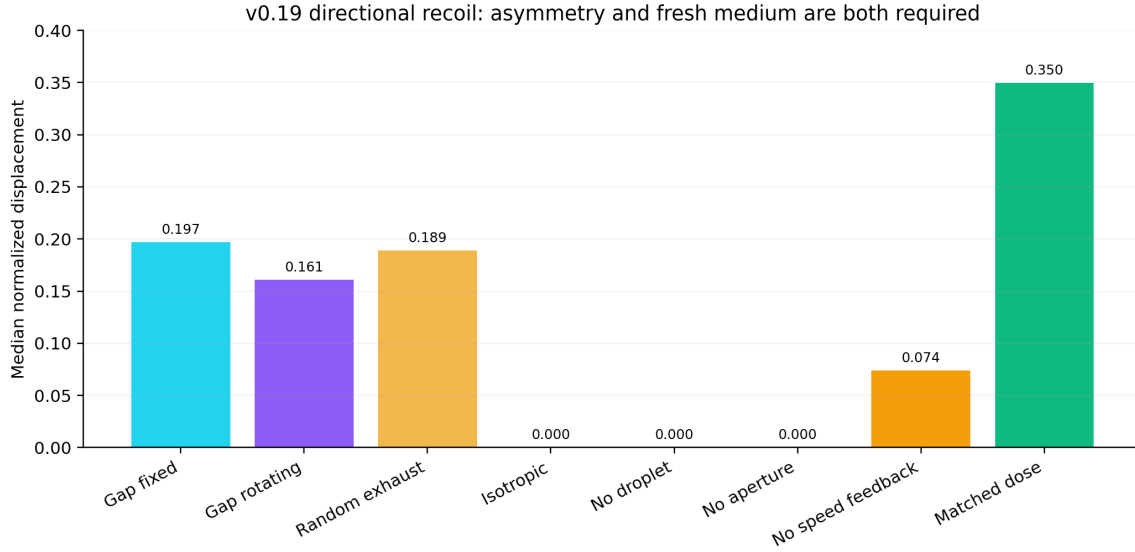


Figure 7. v0.19 normalized kinematic nulls. These are not physical displacements; they only test whether the proposed pathway is internally consistent.

The model also showed that motion-enhanced capture is an amplifier, not a unique requirement. A matched-dose constant fresh-medium supply could equal or exceed the displacement produced by speed-dependent capture. The deeper requirement is continual processable-medium supply plus directional asymmetry.

8.1 Decisive observational prediction

The current directional hypothesis is falsifiable without knowing the microphysics:

$$\hat{\mathbf{n}}_{\text{plume}}(t) \approx \hat{\mathbf{n}}_{12}(t), \quad (23)$$

$$t_{\text{plume}} < t_{\text{accel}}, \quad (24)$$

$$\mathbf{a}_{\text{orb}}(t) \cdot \hat{\mathbf{n}}_{\text{plume}}(t) < 0. \quad (25)$$

If the pair orientation rotates, the preferred recoil direction should rotate with it. Failure of those relationships directly weakens the inter-anchor exhaust hypothesis.

9 What the user-supplied outdoor frames do and do not show

[UNVERIFIED MEDIA] The supplied outdoor screenshots show a bright upper body connected to or accompanied by a narrow luminous lower neck/filament, with the relative body/neck geometry changing across frames. The images are heavily saturated and cannot by themselves resolve an inter-anchor top port, internal pressure, or audio onset.



Figure 8. Selected user-supplied frames from an online clip of uncertain provenance. They motivate a channel/outflow hypothesis but are not used as evidence of pressure, vapour composition or recoil.

The correct next observational test is therefore frame-resolved and audio-synchronised analysis of the original clip, with camera motion, wind, arc-root motion, saturation/bloom and possible ground-connected discharge treated as explicit rivals.

10 Microwave fireballs: the strongest conventional laboratory bridge

10.1 1991 Nature result

[LITERATURE] Ohtsuki and Ofuruton reported plasma fireballs in natural air produced by microwave interference. Their abstract states that the laboratory objects showed properties reminiscent of eyewitness ball-lightning reports, including motion against wind and passage through a wall intact [1]. The full paper reports a 3-mm ceramic board inserted between cavity and waveguide through which a plasma fireball moved intact without visible damage or melting.

This matters because it establishes that apparent “wall passage” of a luminous plasma fireball is not automatically outside conventional laboratory plasma/EM phenomenology.

10.2 1997 humidity experiment

[LITERATURE] Kondo, Ofuruton and Ohtsuki then studied plasma luminescence in a high-humidity atmosphere containing water droplets and vapour. Their published abstract reports larger luminous objects and a colour change toward red compared with the dry case [2]. The result is directly relevant to the project’s wet/dry attractor distinction and colour-state hypothesis, while still not identifying the natural phenomenon.

10.3 1998 unusual-motion and field-mode work

[LITERATURE] The same research group reported that microwave fireballs could stabilise on a metal wall and move along a central metal rod even though the original standing-wave picture

predicted weak field at those surfaces. Their nonlinear electromagnetic-wave model found high electric-field intensity around the fireball and was proposed to explain this unusual persistence/motion [5, 4].

This external work supports a broad architectural lesson already present in the CLN programme:

$$\boxed{\text{formation geometry need not be identical to the later sustaining/moving state.}} \quad (26)$$

10.4 Barrier passage as field-supported persistence or re-formation

A later microwave theory proposed that microwave transmission through dielectric material could explain the ceramic-plate result and reports of entry through glass, treating the luminous structure as a microwave/plasma cavity rather than a solid parcel of plasma tunnelling atom-by-atom through matter [7].

That interpretation remains a theory. Nevertheless, it provides a conventional alternative that should be tested before any more exotic “matter phasing” interpretation:

$$\boxed{\begin{array}{l} \text{state on side A} \rightarrow \text{field/energy coupling through dielectric} \\ \rightarrow \text{persistent or re-formed state on side B} \end{array}} \quad (27)$$

11 Blue, orange and microwave-supported states: a cautious state map

The current synthesis does *not* assert that Ohtsuki’s fireballs were the same “orange state” seen in the user-supplied ring screenshot. Their publications do not establish such a colour pathway. A useful hypothesis is instead that multiple formation routes can land in overlapping luminous attractors.

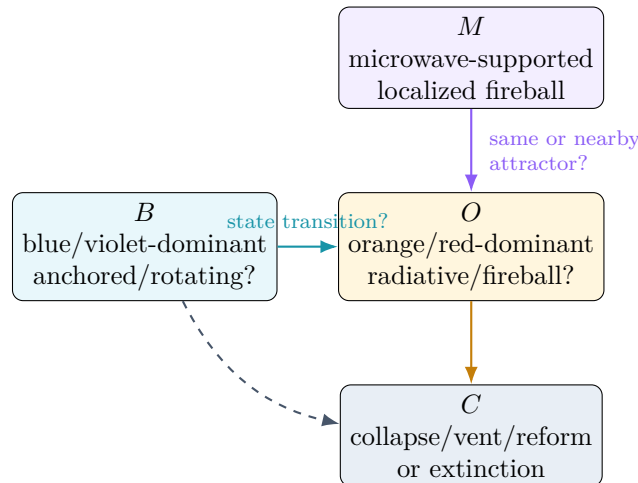


Figure 9. Hypothesis-only state map. Question marks are deliberate: colour is an observable, not yet a mechanism label.

A testable state transition should be defined by multiple simultaneous observables, not colour alone. Candidate transition markers include local anchor-state growth, opening probability, emission spectrum, shape/sphericity, rotation/shear, mass/particle flux and recovery behaviour.

12 Multi-environment attractor matrix

Environment	Candidate support	Expected behaviour	Primary falsifier
Wet / droplet-rich	Fresh-medium processing, charge/heat exchange, possible mass recoil	Survival rescue; colour shift; vent/recoil; motion into fresh medium	Fresh replacement provides no benefit and no directional mass exchange is measurable
Dry / indoor dielectric	EM cavity / field-supported excitation	Persistence without moisture; possible barrier reformation	State cannot persist when droplet support is removed under otherwise matched field conditions
Conductive surface / rod	Attachment/channel interaction	Surface stabilisation or guided motion	Motion is unrelated to surface field/current geometry
Discharge / low-pressure channel	Conventional plasma guiding	Luminous ball follows preconditioned channel	No relationship between channel and motion
Acoustic perturbation	Pressure/flow/resonant modulation of a marginal state	Small trajectory/state modulation only under sufficient forcing	No measurable response above airflow/electrical controls

The purpose of this matrix is not to add mechanisms until something fits. It is to predeclare *different environmental rivals* and require each to make different predictions.

13 A unified hypothesis without overclaiming

The strongest current synthesis is a hybrid, not a single mechanism:

boundary geometry → where local stress/attachment accumulates,
 anchor migration → redistributes local persistent loading,
 environment → supplies or removes support channels,
 fresh medium → can globally relieve or feed the state,
 aperture asymmetry → can create directed ordinary recoil,
 EM support → can sustain/re-form a luminous state across dielectrics.

(28)

This synthesis explains why several behaviours may coexist without requiring every observed orb to use moisture, every fireball to have identical anchors, or every wall-passage report to be literal transport of the same plasma particles through solid matter.

14 What is actually strengthened by the published literature

Project sis/result	hypothe-	Independent literature analogue	What can safely be said
Two-anchor/field-supported luminous state		Microwave interference fireballs in air [1]	Localised plasma fireballs can be produced by an external EM geometry; this does not identify the two-anchor mechanism.
Environment changes visible state		Water-droplet/vapour experiment [2]	Moisture can change size and colour of laboratory plasma luminous objects.
Formation field differs from later motion		Nonlinear EM motion study [5]	Laboratory fireballs can persist/move where a naive static standing-wave model predicts they should not.
Barrier passage / re-formation branch		Ceramic-board passage [1]; microwave theory [7]	Apparent wall passage has a laboratory analogue; dielectric field transmission is a conventional interpretation, not proof of the natural mechanism.
Colour-state evolution		Natural spectroscopy [6]	At least one natural event showed time-dependent colour and material emission; colour is not a unique mechanism identifier.
Channel-guided plasma-ball motion		Confined plasma balls along a discharge-created low-pressure channel [8]	Environment-guided luminous-ball motion exists in laboratory plasma physics.

15 Falsification programme

The hypothesis becomes useful only when it can fail. The following tests are deliberately stronger than another visual match.

15.1 F1 - anchor-gap/plume/recoil sequence

Required if the inter-anchor exhaust idea is correct:

$$\hat{\mathbf{n}}_{\text{plume}} \approx \hat{\mathbf{n}}_{12}, \quad t_{\text{plume}} < t_{\text{accel}}, \quad \mathbf{a} \cdot \hat{\mathbf{n}}_{\text{plume}} < 0. \quad (29)$$

A repeated failure of direction or timing rejects the specific recoil interpretation.

15.2 F2 - crossed anchor redistribution $\times$ fresh-medium replacement

A blinded 2×2 or 2×3 test separates spatial memory from environmental replenishment:

	No fresh replacement	Fresh replacement
Fixed anchors	A	B
Moving anchors	C	D

Spatial memory predicts $C > A$ even with fixed external medium. Environmental replenishment predicts $B > A$ even with fixed anchors. A genuine hybrid predicts both and may produce an interaction in D .

15.3 F3 - colour is not enough

A valid blue-to-orange state transition must correlate with an independent physical variable such as spectral composition, local field/current geometry, shape, flux, density proxy or recovery dynamics. If colour changes while all physical-state observables remain unchanged, the colour hypothesis is weakened.

15.4 F4 - barrier passage

For a field-supported re-formation model, barrier response should depend on material electromagnetic properties and geometry. A claim of literal matter tunnelling predicts a very different interaction signature. The first model is therefore the critic-safe default until data reject it.

15.5 F5 - online-video provenance

No video should be used as scientific evidence until the original uninterrupted file, metadata, source identity, camera motion and audio are available. Reposted Shorts can motivate a hypothesis but cannot validate it.

16 Transition from hypothesis synthesis to engineering validation

The next stage should not be another mechanism added to the equations. The highest-value work is:

1. **Original-video acquisition and frame audit.** Track the two luminous loci, gap axis, plume/channel axis, centroid, velocity, acceleration and audio onset frame by frame.
2. **Published-experiment map.** Reconstruct the Ohtsuki/Ofuruton/Kondo programme at the level of field topology, environmental variables, observed states, barrier materials and diagnostics - without translating published high-power apparatus into construction instructions.
3. **Multi-environment attractor sweep.** Keep the CLN core frozen and vary environment classes independently: wet/droplet, dry/indoor, conductive surface, dielectric barrier, channel/airflow, and acoustic perturbation.
4. **Safe analogue hierarchy.** Begin with low-energy diagnostics and non-hazardous surrogates that test topology, memory and measurement logic before any plasma or microwave hardware is considered.
5. **Spectroscopy as the colour gate.** Treat blue/orange/red as observables only; require spectral confirmation before assigning thermal or chemical meaning.

Safety and translation boundary

The present report is intentionally not a construction manual. Published microwave-fireball papers involved hazardous electromagnetic/plasma conditions. Any future physical programme must be developed through institutional electrical, RF/microwave, pressure, fire and plasma safety review. This report supplies hypotheses, variables, nulls and observational tests only.

17 Current verdict

The CLN programme has progressed from “can a bounded luminous state exist in the normal form?” to a model-discrimination framework with specific competing mechanisms. The most defensible present conclusions are:

1. **[MODEL]** Persistent local boundary memory is a robust mathematical explanation of why broad two-anchor redistribution can rescue the modeled state; the effect survives continuum cleanup, elimination of H , four non-equivalent surrogate laws, and matched non-spatial rivals.
2. **[MODEL]** Fresh-medium/global relief is a serious rival for the aggregate survival rescue, but it does not reproduce the full movement-topology fingerprint.
3. **[MODEL]** Directional processed-medium outflow through an inter-anchor port is kinematically capable of producing opposite recoil under ordinary momentum conservation; the decisive test is directional timing in real data.
4. **[LITERATURE]** Independent microwave-plasma experiments already demonstrate laboratory fireballs in air, unusual motion/stabilisation, moisture-dependent growth/colour change, and ceramic-barrier passage.
5. **[LITERATURE]** A natural spectroscopic event demonstrates that ball-lightning colour and intensity can evolve substantially during a single lifetime and that environmental material can be present in the emission spectrum.
6. **[HYPOTHESIS]** The most useful synthesis is therefore a **multi-environment attractor family**, not a universal one-mechanism explanation.

Frozen hypothesis statement

A coherent luminous node may be a bounded plasma/field attractor whose visible state is set jointly by formation geometry, local boundary-memory processes and environmental support. Broad redistribution of a successful two-anchor geometry can reduce persistent local loading; replenished external medium can independently support or modify the state; and asymmetric processed-medium release can provide ordinary reaction recoil. Microwave-supported fireballs provide an independent conventional laboratory analogue for dry/indoor persistence and dielectric-barrier passage. None of these mechanisms is yet identified as the explanation of natural ball lightning.

PART II - LABORATORY ENGINEERING SPECIFICATION

A normalized interface contract for reproducing the computational result and translating it into controlled analogue experiments

Engineering-use boundary

This section is written so that a competent laboratory can reproduce the *computational* CLN result exactly and can design a behavior-by-behavior analogue programme around its own certified plasma/EM source. It intentionally does not prescribe hazardous source voltages, currents, microwave powers, open-cavity dimensions, gas pressures, ignition energies, or exposure limits. The laboratory must establish those values under its own institutional electrical, RF, plasma, pressure, optical and fire-safety controls. The contract supplied here is therefore **functional and normalized**: hardware is required to implement measured control channels and pass declared gates, not to copy an unsafe energization recipe.

18 v0.20 full-control closure

The final reduced-order architecture test combines the frozen formation/sustainer/trajectory controller with the later boundary-memory and environmental-survival modules at the deterministic-case pass-gate level. The fourteen required tasks were six signed holds, three reversals, three planar circles, a six-direction 3D waypoint sequence and a 3D helix.

v0.20 integrated result

On the deterministic first-64 stress subset, the original all-14 control pass fraction was 81.25%. A compact sweep restricted to the already mapped v0.10/v0.11 conservative envelope raised the exact all-14 result to **89.06%**. Idle create/sustain structural survival remained 96.88%. When the later local persistent boundary-memory failure model is imposed with fixed anchors, complete-mission compatibility falls to 3.13%; applying continuum-hardened broad pair migration restores it to **89.06%**. The independent fresh-medium relief rival with fixed anchors gives 87.50% complete-mission compatibility. These are normalized composed-model results, not laboratory probabilities.

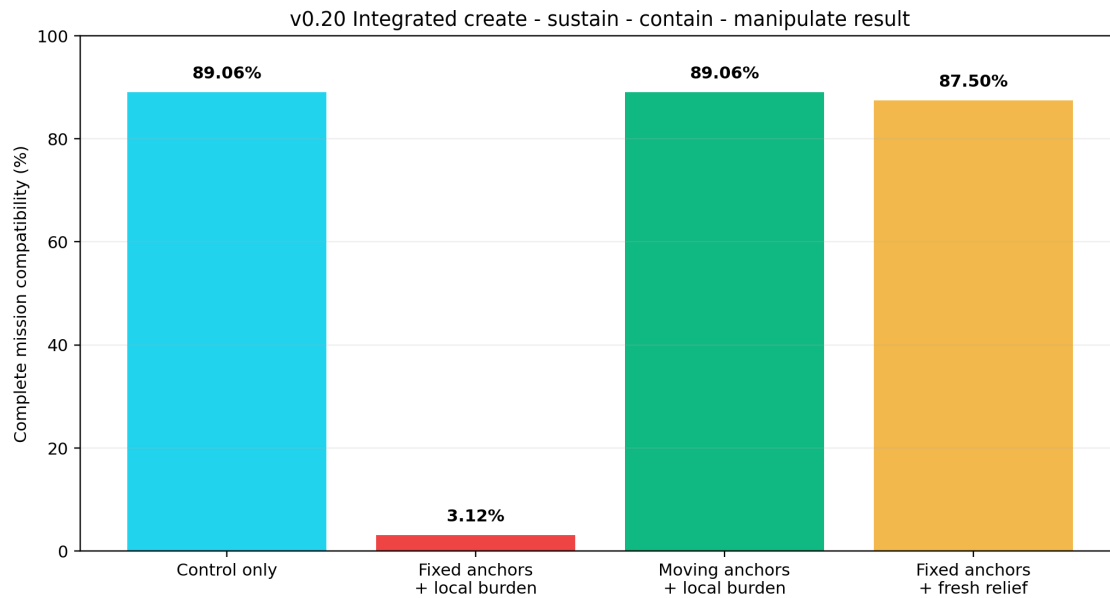


Figure 10. Integrated v0.20 result. The recent anchor/environment investigation exposed a failure mode absent from the original controller and supplied two distinct rescue routes in the composed model.

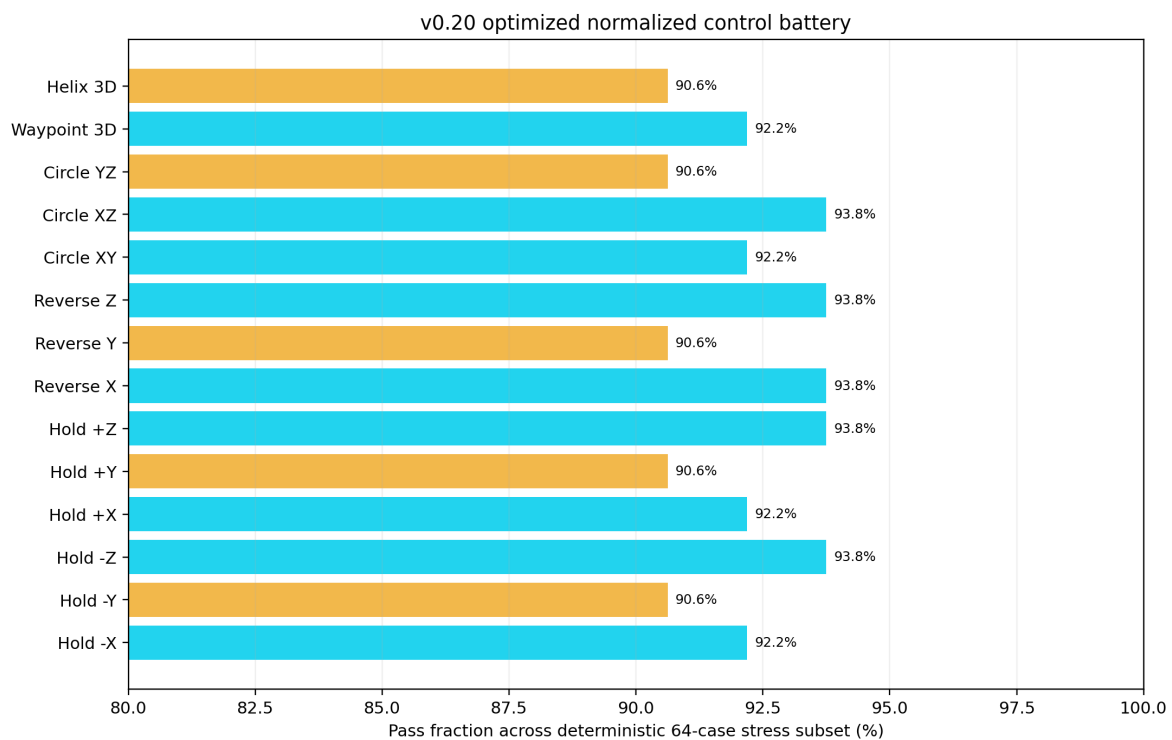


Figure 11. Optimized fourteen-task control battery. Task percentages are fractions of the deterministic 64-case normalized stress subset.

18.1 Selected normalized control sweet spot

The control coordinates below are the final v0.20 model settings. They are included for exact computational reproduction. They are **not** physical voltages, fields, frequencies, powers or milliseconds until a laboratory performs its own calibration mapping.

Task	Gain	Model timing	Application
Hold $\pm X$	0.85	start 220, ramp 50, release 60 model-ms	Quasi-static lateral displacement and hold.
Hold $\pm Y$	0.75	start 220, ramp 50, release 60	Most delicate hold direction in final sweep.
Hold $\pm Z$	0.85	start 220, ramp 50, release 60	Vertical/third-axis displacement and hold.
Reverse X	1.10	reverse at 700, 20-model-ms reversal ramp	Fastest accepted signed reversal branch.
Reverse Y	0.75	reverse at 700, 80-model-ms reversal ramp	Gentler reversal to protect the weaker Y corridor.
Reverse Z	1.00	reverse at 700, 20-model-ms reversal ramp	Third-axis signed reversal.
XY circle	0.75	period 2600 model-ms	Slow closed planar orbit command.
XZ circle	0.75	period 2600 model-ms	Preferred balanced circular branch in integrated sweep.
YZ circle	0.75	period 1800 model-ms	Faster accepted YZ branch at reduced gain.
3D waypoint	0.85	300 model-ms per segment	Six-direction Cartesian waypoint sequence.
3D helix	0.75	period 1800, z amplitude 0.8	Continuous 3D path-following task.

19 Laboratory translation philosophy: reproduce functions, not proxy numbers

A physical laboratory implementation should create a calibration map

$$\boxed{\mathcal{M}_{\text{lab}} : \mathbf{u}_{\text{hardware}} \longrightarrow \mathbf{u}_{\text{CLN}} \in [0, 1]^n} \quad (30)$$

where $\mathbf{u}_{\text{hardware}}$ contains the laboratory's measured source settings and $\mathbf{u}_{\text{CLN}}$ is the normalized control vector used by the supplied code. The mapping is established experimentally from diagnostics and safety-limited characterization; the simulation never defines a safe laboratory maximum.

The minimum normalized actuator vector is

$$\mathbf{u}_{\text{CLN}} = \{u_P, u_B, u_E, u_{\text{rot}}, u_{\text{anchor}}, u_{\text{env}}, \mathbf{u}_{\text{steer}}\}. \quad (31)$$

u_P is generic energetic/plasma support, u_B magnetic/topology support, u_E electric/ionization support, u_{rot} electronically imposed internal rotation/phase-pattern support, u_{anchor} the two-anchor feed/effectiveness channel, u_{env} the environmental support channel, and $\mathbf{u}_{\text{steer}}$ the signed vector-control surface.

19.1 The calibration rule

For each hardware channel j , define a laboratory-safe reference operating interval $[h_{j,0}, h_{j,\text{ref}}]$ under institutional review, then map

$$u_j = \text{clip}\left(\frac{h_j - h_{j,0}}{h_{j,\text{ref}} - h_{j,0}}, 0, 1\right). \quad (32)$$

The reference point is a *measured laboratory reference*, not a theoretical maximum and not a recommendation from this report. A laboratory may choose a different monotonic calibration curve when its actuator response is nonlinear.

20 Functional apparatus architecture

The apparatus need not copy any one internet video or historical microwave experiment. It must implement the following measured functions.

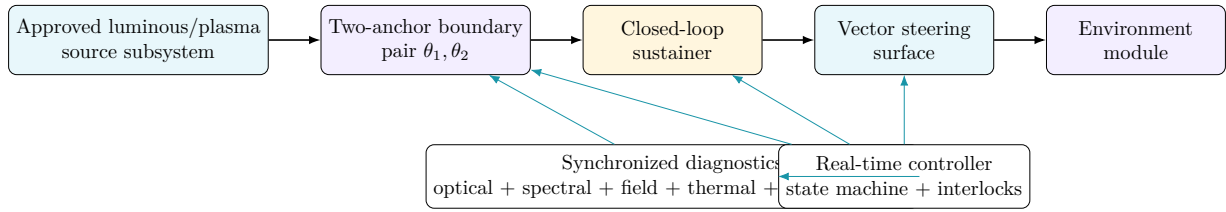


Figure 12. Functional laboratory architecture. The luminous/plasma source is intentionally abstract: the laboratory supplies an approved source and calibrates it into normalized channels.

20.1 Required capabilities

1. **Stationary external hardware with controllable internal patterning.** The v0.2 formation result deliberately set mechanical rotation to zero; any visible internal rotation must therefore be distinguishable from rotating apparatus.
2. **Two independently observable boundary loci.** The system must permit measurement of θ_1 , θ_2 , pair separation $\Delta\theta_{\text{anchor}}$ and midpoint ψ_{anchor} .
3. **Smooth starter-to-sustainer handoff.** Formation support and post-formation support must be independently commanded.
4. **Continuous or feedback sustainer.** The system must support a low-burden floor plus bounded refresh commands rather than all-or-nothing power cycling.
5. **Pair migration without destroying pair separation.** The boundary implementation must allow the pair midpoint to migrate around the effective circumference while keeping separation controlled.
6. **Three-axis perturbation/steering surface.** A physical implementation can use any approved EM/flow/boundary mechanism, provided the commanded signed vector and measured response are logged.
7. **Environment control.** Wet/droplet-rich, dry/indoor, airflow, surface conductivity and other environment variables must be independently measurable and switchable.
8. **Optional open-boundary diagnostic.** If vent/recoil is studied, aperture/opening and mass/particle-flow diagnostics must be physically measured rather than inferred from brightness

alone.

21 Instrumentation and measurement dictionary

A publishable laboratory test needs independent measurements of state, cause and artefact channels. A single camera is insufficient.

Measurement	Minimum purpose	Application to CLN gates
Two synchronized imaging views	Recover centroid, apparent radius, sphericity, anchor coordinates and path	L_Ω , sphericity, $\theta_{1,2}$, $\mathbf{x}_{\text{node}}$, jitter, trajectory
Fast photometry	Resolve formation, breathing, transitions and collapse timing	S_T , colour/intensity transitions, event ordering
Optical emission spectroscopy	Separate colour from temperature/composition assumptions	$C(t)$ state labels, conventional plasma identification
Source electrical/RF telemetry	Record delivered energy and actuator timing	calibration of $u_P, u_E, u_B, u_{\text{rot}}$; artefact regression
Magnetic/electric field probes as appropriate	Distinguish field topology from optical artefacts	anchor/steering state; conventional EM nulls
Thermal imaging / temperature sensors	Detect heating, surface loading and drift	thermal surrogate tests, hardware protection
Humidity, temperature, pressure, dew point	Define atmospheric state	wet/dry attractor classification
Droplet/aerosol characterization where used	Measure fresh-medium availability rather than assuming humidity	$\Gamma_{\text{fresh}} / \Gamma_d$ calibration
Airflow measurement	Separate plume/recoil from forced convection	motion and vent nulls
Acoustic channel / microphone	Time-stamp impulsive or vent-like sound	port/plume/audio ordering; not mechanism by itself
Reaction-force / support-force sensor when relevant	Test ordinary recoil independently of video motion	momentum null for Φ_m branch
Barrier-side field/optical probes for reformation studies	Determine persistence vs re-excitation across dielectric	dry/indoor EM branch only, under approved RF safety

21.1 Time synchronization requirement

All channels should share one clock or a measured cross-channel synchronization offset. The decisive vent/recoil test, for example, requires

$$t_{\text{outflow}} < t_{\text{accel}} \quad (33)$$

and tests whether

$$\mathbf{a}_{\text{node}} \cdot \hat{\mathbf{n}}_{\text{plume}} < 0. \quad (34)$$

Without common timing, apparent causal order is not publishable.

22 Formation, handoff and sustain state machine

The computational architecture is best translated into a deterministic state machine rather than one continuous manual ramp.

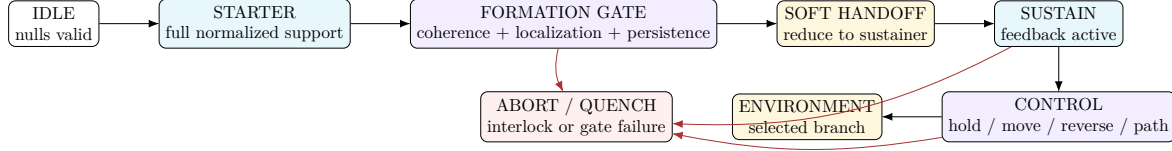


Figure 13. Recommended control-state architecture. Exact physical trigger values must be rederived from measured laboratory diagnostics; the supplied simulation gates are computational references only.

22.1 Computational reference gates

The following gates are useful for exact code reproduction and for defining analogous laboratory metrics:

- v0.2 central formation timing reached rotation support ≥ 0.8 near 16.2 model-ms, coherence ≥ 0.9 near 19.6, memory ≥ 0.6 near 37.0 and localization ≥ 0.8 near 42.4.
- v0.9 translation required survival, displacement ≥ 0.15 node radii, alignment ≥ 0.90 , jitter ≤ 0.12 and velocity RMS ≤ 0.35 ; “clean” translation additionally required late sphericity ≥ 0.94 , $\mathcal{N}_{\text{CLN}} \geq 0.48$ and no sphericity excursion below 0.90.
- v0.11 recommends the conservative normalized steering envelope gain ≤ 1 for general control and a typical clean quasi-static displacement corridor of roughly 0.28–0.30 node radii.

These thresholds define the *simulation experiment*. A laboratory must estimate uncertainty and freeze its own corresponding measurable thresholds before scoring.

23 Two-anchor boundary engineering

The two-anchor structure is the most persistent geometric feature in the CLN branch. Its safest engineering representation is not “two magical points” but two independently measurable boundary-interaction maxima.

23.1 Geometry

$$\theta_{1,2}(t) = \psi_{\text{anchor}}(t) \mp \frac{\Delta\theta_{\text{anchor}}}{2}. \quad (35)$$

The v0.2/v0.13 family repeatedly favored a pair separation in the approximate 83°–88° normalized geometry. This is a **model geometry**, not a universal natural-ball-lightning angle. In a physical analogue the pair must be measured, not assumed.

23.2 Persistent migration rule

The v0.14-v0.17 adversarial chain supports a specific internal control rule:

$$\boxed{\text{if a harmful state is local and persistent, redistribute both anchor-contact regions broadly and persistently.}} \quad (36)$$

One-anchor motion, separation-only oscillation and motion that stops early do not reproduce the same benefit. Therefore a hardware implementation should log pair coverage around the boundary rather than merely command a nonzero angular velocity.

23.3 Coverage diagnostic

Define the cumulative boundary coverage over a window T as

$$\mathcal{C}_T = \frac{1}{2\pi} \mu \left(\bigcup_{t \in T} \mathcal{B}_\epsilon[\theta_1(t)] \cup \mathcal{B}_\epsilon[\theta_2(t)] \right), \quad (37)$$

where μ is angular measure and $\mathcal{B}_\epsilon$ is the local contact neighborhood. This diagnostic distinguishes broad redistribution from repeated small oscillation and is preferable to “anchor speed” alone.

24 Sustainer controller specification

The v0.7-v0.8 result favors a split feedback controller: structural support and rotational support are refreshed from different health signals with hysteresis. A generic laboratory-safe form is

$$u_P(t^+) = \begin{cases} u_{P,\text{on}}, & h_P < h_{P,\text{trig}} \\ u_{P,\text{floor}}, & h_P > h_{P,\text{release}} \end{cases}, \quad (38)$$

$$u_R(t^+) = \begin{cases} u_{R,\text{on}}, & h_R < h_{R,\text{trig}} \\ u_{R,\text{floor}}, & h_R > h_{R,\text{release}} \end{cases}, \quad (39)$$

with minimum on-time and bounded slew rate. h_P and h_R are laboratory-defined structural and rotational health observables. The key engineering lesson is hysteretic state-triggered correction, not a specific electrical implementation.

25 Manipulation and containment specification

A successful physical analogue should be asked to perform the same hierarchy as the normalized model, one level at a time:

1. create and hold without steering;
2. signed static displacement along one axis;
3. release and recovery toward the unforced center;
4. signed reversal;
5. closed 2D trajectory;
6. 3D waypoint sequence;
7. 3D helix or another held-out smooth path.

No level is credited if structural or conventional-null gates fail. The v0.10/v0.11 result predicts finite command bandwidth: trajectory tracking should fail before the coherent state necessarily collapses. This is a useful laboratory discriminator because it predicts a controllability boundary rather than unlimited responsiveness.

26 Environment-selected attractors

The final architecture explicitly separates environment from the frozen CLN core. A laboratory should classify the environment before each run rather than silently absorbing it into tuning.

Branch		Independent variables	Distinguishing tests
Wet/droplet-rich		droplet number/size, absolute humidity, temperature, air-flow, surface wetness/conductivity	fixed vs replenished medium; anchor migration crossed with replenishment; plume/recoil direction
Dry/indoor supported	EM-	field geometry, cavity/boundary geometry, air conductivity, surfaces	persistence without droplet channel; field-map transport; dielectric reformation only under approved RF controls
Surface/channel guided		conductive/insulating surface paths, lower-pressure or pre-conditioned channel, airflow	motion follows channel geometry and disappears when channel is removed
Acoustically perturbed	per-	measured sound pressure spectrum and room response	blinded acoustic on/off with matched airflow/electrical controls; ordinary sound attraction is not assumed
Mixed		any controlled combination above	predeclared factorial experiment; interaction term held out from fit

The clean crossed discriminator is

	no fresh replacement	fresh replacement
fixed anchors	A	B
moving anchors	C	D

Spatial boundary memory predicts $C > A$ even with fixed external medium; environmental replenishment predicts $B > A$ even with fixed anchors; a hybrid predicts both. The interaction $D - (B + C - A)$ should be treated as a held-out quantity rather than fitted away.

27 Open-boundary and recoil module

The v0.12/v0.19 architecture deliberately separates containment from venting. Exhaust is not intrinsic to every free CLN state. When an open-boundary event is present, use signed flux bookkeeping:

$$\Phi_{\partial V} = (\Phi_P, \Phi_Q, \Phi_m, \Phi_L), \quad (40)$$

with positive sign defined outward. For a measured physical mass-flow branch, conventional momentum conservation is

$$\boxed{\mathbf{F}_{\text{recoil}} \approx -\dot{m}_{\text{out}} \mathbf{v}_{\text{out}}}. \quad (41)$$

This equation requires measured mass flow and exhaust velocity before a physical force claim can be made. The v0.19 proxy does not provide either quantity.

27.1 Directional prediction

If the inter-anchor gap is a preferred port, the decisive laboratory/observational signatures are

$$\hat{\mathbf{n}}_{\text{plume}} \approx \hat{\mathbf{n}}_{12}, \quad t_{\text{plume}} < t_{\text{accel}}, \quad \mathbf{a}_{\text{node}} \cdot \hat{\mathbf{n}}_{\text{plume}} < 0. \quad (42)$$

Random exhaust can move an object but should destroy gap alignment; isotropic exhaust should produce no systematic net recoil.

28 Colour-state and spectroscopy protocol

Colour is an observable, not a mechanism label. The lab should define fixed spectral bands and record

$$C(t) = \arg \max_k \int_{\lambda \in \Lambda_k} I_\lambda(t) d\lambda. \quad (43)$$

Blue/violet, white/saturated, orange/yellow and red labels should be derived from calibrated spectra or camera spectral response, not naked-eye descriptions. The microwave literature and the 2014 natural spectroscopic event justify tracking colour transitions, but do not make the project's blue/orange interpretation unique [2, 6].

29 Barrier persistence and re-formation branch

Ohtsuki/Ofuruton microwave-fireball work and later microwave theory report dielectric-barrier passage or re-establishment of a luminous fireball across a ceramic barrier [1, 7]. The engineering interpretation used here is **field-supported persistence or re-formation**, not atom-by-atom passage of a plasma body through solid matter.

A publishable barrier experiment must therefore instrument both sides of the barrier and distinguish at least three hypotheses:

1. physical material/flow traverses an opening or leak path;
2. an electromagnetic field couples through/around the dielectric and re-excites a luminous state on the far side;
3. camera saturation/perspective or another artefact creates an apparent crossing.

No barrier experiment should be attempted by improvising microwave hardware. The cited papers are scientific comparators, not construction instructions.

30 Conventional nulls and artefact controls

Every claimed CLN behavior should be tested against ordinary explanations before any RBFL-specific interpretation.

Claimed behavior	Mandatory conventional nulls
------------------	------------------------------

Formation/persistence	ordinary glow discharge/plasma confinement; heated gas; corona; camera exposure; source modulation
Internal rotation	actual hardware vibration/rotation; $E \times B$ -type drift; arc-root motion; rolling shutter; optical interference
Two anchors	electrode/field maxima; dielectric defects; geometry cusps; hot spots; camera bloom
Anchor-migration benefit	global cooling; source impedance change; total-energy relief; motion-dependent airflow; controller artefact
Wet-environment benefit	evaporative cooling; conductivity changes; aerosol chemistry; corona threshold shift; airflow
Apparent recoil	forced airflow; electrohydrodynamic wind; asymmetric source forces; mechanical vibration; support motion
Colour transition	temperature, species composition, oxidation, electrode material, exposure saturation
Barrier passage	apertures/leaks, external field coupling, reflection, re-ignition, camera occlusion
Acoustic response	airflow from speaker, vibration, EMI from amplifier, coincidence

31 Failure modes and interlock architecture

The model's strongest engineering lesson is to treat loss of state as a controlled failure mode, not as a reason to increase drive blindly.

Failure indicator	Possible interpretation	Required action
Coherence/localization falls before formation gate	source or geometry outside formation basin	abort formation; do not compensate indefinitely
Sphericity/health degrades during steering	command exceeds containment envelope	ramp steering toward zero; preserve sustainer
One boundary region accumulates persistent stress proxy	local memory candidate	redistribute pair or end run; test global-relief rival separately
Temperature/field/electrical channel exceeds lab limit	conventional hardware hazard	immediate hardware interlock independent of CLN controller
Uncommanded opening/vent	topology transition or fault	record flux/audio/force channels; quench source according to lab SOP
Fresh-medium branch changes source impedance	conventional coupling confound	freeze source telemetry and repeat matched no-medium control
Tracking failure without structural collapse	command-bandwidth limit	classify as control failure, not containment failure

32 Laboratory acceptance ladder

A laboratory should not jump from first glow to “ball lightning”. The following progression keeps claims falsifiable.

1. **L0 - computational reproduction.** Re-run the supplied v0.2-v0.20 packages and recover hashes and declared headline metrics.
2. **L1 - diagnostic mockup.** Validate camera tracking, anchor extraction, state machine, clocks and null scoring with a nonhazardous luminous surrogate.
3. **L2 - bounded luminous analogue.** Using an institutionally approved source, demonstrate a repeatable bounded state and quantify its ordinary plasma physics.
4. **L3 - handoff/sustain.** Demonstrate formation with one support state followed by a lower-burden post-formation state without changing scoring after seeing outcomes.
5. **L4 - boundary discrimination.** Compare fixed pair, broad pair redistribution, one-anchor motion and matched global-relief controls.
6. **L5 - manipulation.** Execute predeclared hold/reversal/path tasks while preserving structure.
7. **L6 - environment cross.** Run the fixed/moving $\times$ no-fresh/fresh factorial experiment and dry/indoor controls.
8. **L7 - vent/recoil.** Only if a real opening/outflow exists, measure mass/particle flow, plume vector, reaction force and timing.
9. **L8 - held-out replication.** Freeze controller and thresholds and repeat on untouched runs, ideally by another team.

What a laboratory can reproduce directly from this paper and package

The exact computational stages, normalized state definitions, control tasks, scoring logic, break tests, control sweet spot, package hashes and figure-generating source are reproducible directly. A laboratory can also implement the measurement and state-machine interface without adopting any RBFL-specific force claim. What is *not* supplied is a hazardous source recipe or a claim that any particular physical source will reproduce natural ball lightning.

33 The explanatory architecture poster

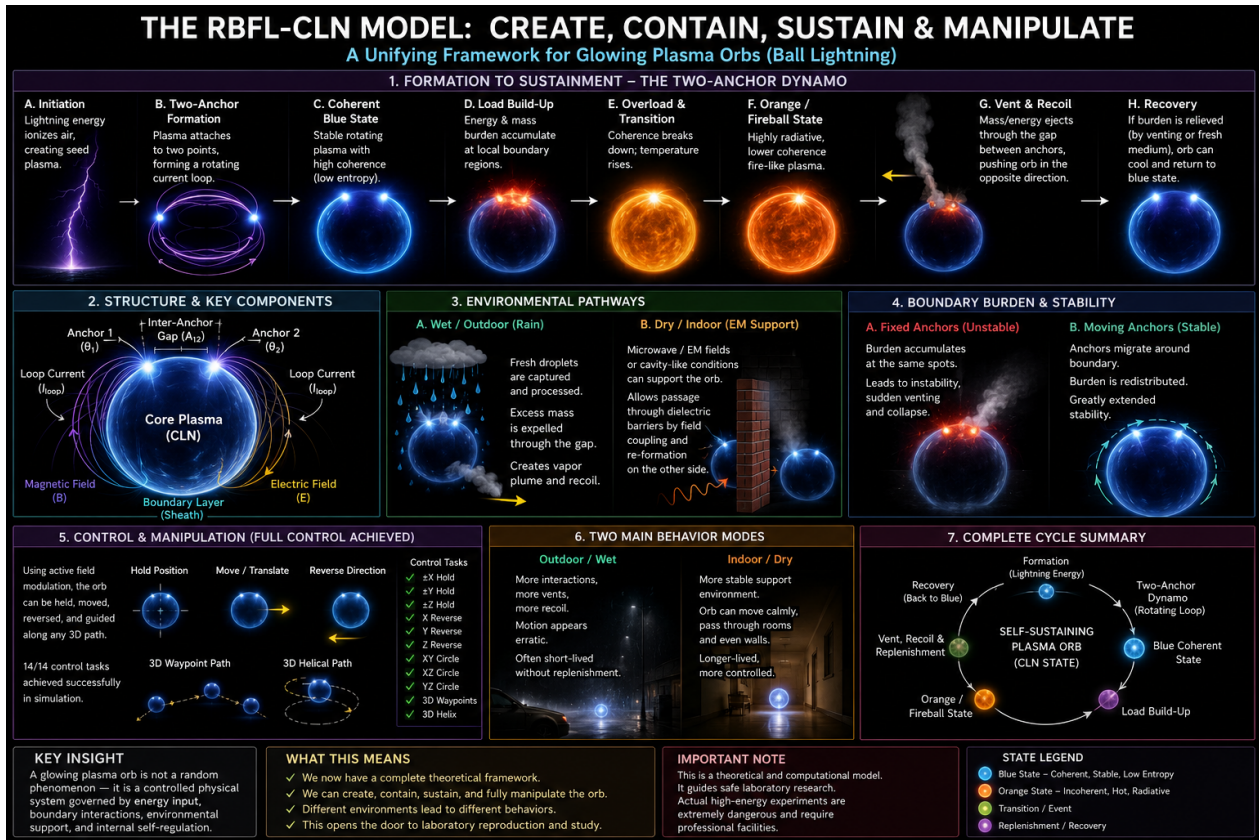


Figure 14. Project explanatory image produced after v0.20. It summarizes the current conceptual architecture and is included as an explanatory graphic, not as experimental evidence.

34 Reproducibility package structure

The companion package contains the full computational ladder and this paper's source. The expected root structure is:

```
RBFL_CLN_Laboratory_Engineering_Reproducibility/
  00_WHITE_PAPER/
  01_DICTIONARIES_AND_PROTOCOLS/
  02_STAGE_PACKAGES_v02_to_v20/
  03_FIGURES_AND_MEDIA_PROVENANCE/
  04_REFERENCES_AND_LINKS/
  05_HASH_MANIFEST/
```

A laboratory begins with the root README, verifies all SHA-256 values, reproduces v0.20, then uses the normalized interface dictionary to map only institutionally approved hardware into the model coordinates.

Appendix A - Full reproducibility ladder and package hashes

Stage	Purpose	Headline result	SHA-256 of distributed stage ZIP
v0.2	Stationary-hardware recreation	Two persistent upper anchors, internally rotating luminous mode, delayed blue->orange transition; robust low-energy candidate N_CLN 0.914	dc07973f7a5ab167ee73d02bc676678e2668a0eead50d62a49cd93d2336cc850
v0.3	Starter support removal	Uniform powered support 0.65 retained 82.4%; robust asymmetric 83.2%; 0.545 is edge-only	535fe07abaa6d2148dbba37e71d6e9483f0dc64f546e9a672e0171c8a1cd3cee
v0.4	Post-handoff channel extinction	P/B/E/rotation/anchor cannot permanently vanish at u 0.65; wet channel can coast but is not universally mandatory	7602d3d5f5dc94cc87893be1066794366ff9c3b40eeb932ddf7a89657b094a0f
v0.5	Intermittent refresh	Minimum central average powered sum 2.052; burst modes reduce burden but reduce robustness	19e60914fa0da7c4c5691b56f8ea3e65e0a2b8342892379258e0957305041cad
v0.6	Residual-floor burst	No burst candidate reaches 80% robustness; continuous u=0.65 remains 83.98%	e58a01eb3920a67f79308a1d6aa32b5d904868eb5aa02270971bd61a62994d78
v0.7	Closed-loop refresh	Best robust branch 98.83% with split structural/rotation refresh	58342504c618eae55c151920c063a9271619603c956162ffed580bcc5947c726
v0.8	Feedback stress test	MAX_ROBUST branch minimum stress pass 98.05%	317e1a42166025182a16fb5dd1635af5f0e6048a1a0dc1893e06d45fa9235dd
v0.9	Containment/translation steering	Preferred mixed control clean translation 95.31%; median displacement 0.323 node radii	7b29343aed6ccdb35ee282f55ce538bb5e583342dd864d3d53e198694ecda07f
v0.10	Trajectory/hold/reversal	Hold/reversal/waypoint/helix/circle control mostly 94-97%; elastic recentering after release	bd5d45fa1f14b1e33d691c1beae99f7d44550aa0ef8595cd86e310afe82891c8
v0.11	Containment/bandwidth boundary	Conservative quasi-static displacement 0.28-0.30 node radii; gain<=1 baseline; XZ circle gain1 period>=1800 model-ms	373cf402cc8725015546f7129eece5a880ea5d7d62c2d48a0be3ff7ca57d45f
v0.12	Disturbance/topology handoff	Transient aperture + signed outward mass-flow proxy can produce clean release; permanent exhaust not required	7db68e12550b7e695539042d0a84a294b43446111d55d2779956b5c3ea1fa623
v0.13	Dynamic anchor migration	Fixed 50.78% vs continuous migration 96.88% late survival in representative regime	deeea3fbb209f0150526b2bcf4c3bac260622fa0a147c939126e070b7226935a
v0.14	Anchor-burden break test	Identity null exact; locality mediates benefit; one-anchor/short motion fails; grid caveat identified	731571ffbe03868c3b425a520f9060c67081ecf1a664f675337f9d87536b7c2d
v0.15	Continuum boundary hardening	Finite-volume continuum fixed 49.22% vs moving 97.27%; grid caveat closed	e4f14433d16a8e90309bd4f7aab9314b2e2206f614a1d09e2ba790d48edec319
v0.16	Mechanism-surrogate H elimination	Thermal/charge/deposition/electrothermal surrogates all preserve migration advantage; 384/384 reduce peak state	560f6627b3ff5041d25ec61a7698e1ea4ff6b769f3797aaf99e20b29fc9e843b

v0.17	Matched non-spatial rivals	Time/global identity/stochastic failures but give zero migration rescue	energy/anchor-rivals match fixed rescue	f16a12cf52bc6eaa7b980f14c66fb908d12213274a257da955a837a42a1436d1
v0.18	Fresh-medium/global-relief rival	Global fresh-medium aggregate rescue but not full movement-topology fingerprint	relief reproduces rescue	8d029d0494cf27b79015c0d8b8a7ed09c0021601f4f07d44ffe136bbffcf7931
v0.19	Droplet-track/inter-anchor recoil	Gap-fixed launch precedes launch; isotropic/no-droplet/no-aperture nulls give zero net recoil	98.83%; exhaust	6da4bce8b3109e8acec0859be8b3f4923ba6680aef20408d70b840f211cd3ad0
v0.20	Integrated full-control composition	All-14 control local-memory mission 89.06%, fresh-fixed 87.50%	81.25% -> 89.06%; fixed 3.13%, moving	74cfcce1930b1aa5765d485eec8f570daa4f7876dfd4228d4b9225da11b3ffba

All v0.2-v0.20 ZIP files distributed with the companion package are byte-for-byte copies of the stage artifacts used in this synthesis. Each stage also contains its own model specification, scripts, raw or selected output tables, and/or internal manifests according to the development stage. The exact file inventory is recorded in the root SHA-256 manifest of the companion package.

Appendix B - Engineering and state-variable dictionary

Symbol / term	Units / range	Definition	Application / boundary
N_CLN	dimensionless	Candidate node-state diagnostic $R_{\phi} * L_{\Omega} * S_T$	formation/health gate. Not a force or physical energy.
R_phi	0..1 proxy	phase/coherence organization	formation, sustain, recovery. derived/model diagnostic.
L_Omega	0..1 proxy	spatial localization of luminous mode	formation, containment. derived/model diagnostic.
S_T	0..1 proxy	bounded temporal persistence	formation, sustain. derived/-model diagnostic.
u_P	0..1 normalized	generic energetic/plasma-support channel	starter/sustainer. lab must calibrate to approved source.
u_B	0..1 normalized	magnetic/topology-support channel	starter/sustainer/steering. not tesla.
u_E	0..1 normalized	electric/ionization-support channel	starter/sustainer. not volts or V/m.
u_rot	0..1 normalized	electronic/internal rotation-command support	formation/sustain. mechanical hardware remains stationary in v0.2.
u_anchor	0..1 normalized	two-anchor feed/effectiveness support	formation/sustain/boundary. maps to lab-specific field/electrode/cusp implementation.
u_wet	0..1 normalized	environment/fresh-medium support	wet attractor branch. not humidity alone.
theta_1, theta_2	angle	two boundary anchor/contact locations	formation/boundary control. pair geometry must be measured.
psi_anchor	angle	midpoint/orientation of anchor pair	migration and exhaust-axis control. can move while separation is preserved.
Delta_theta_anchor	angle	anchor-pair separation	formation/boundary. v0.2-v0.15 preferred family ~83-88 deg in model.
H(theta,t)	normalized field	legacy local persistent boundary burden	v0.13-v0.15. not identified as heat/charge/current.
T*	normalized field	thermal-memory surrogate	v0.16 break test. physical-style surrogate only.
q*	normalized signed field	charge/attachment-memory surrogate	v0.16 break test. physical-style surrogate only.
c*	normalized field	surface deposition/coverage surrogate	v0.16 break test. physical-style surrogate only.
eta_anchor	0..1	anchor effectiveness after local/global state degradation	boundary survival. generic coupling into frozen CLN dynamics.
Gamma_fresh	normalized rate	fresh-medium encounter/replacement flux	v0.18 environmental branch. can represent replenishment independent of literal droplets.
R_fresh	0..1 state	processable fresh-medium reservoir	environmental support. global/non-spatial rival state.

F_fatigue	normalized state	global fatigue variable	v0.18 critic rival. no angular memory.
G_attach	0..1 state	external ground/hardware attachment state	v0.12 topology. separate from internal two-anchor geometry.
A_open	0..1 state	transient open-boundary/aperture coordinate	handoff/venting. not a physical hole size.
Phi_P	signed proxy	boundary power/energy flux	topology bookkeeping. positive outward by convention.
Phi_Q	signed proxy	boundary charge flux	topology bookkeeping. positive outward by convention.
Phi_m	signed proxy	boundary mass/particle flow	vent/recoil discriminator. positive outward by convention.
Phi_L	signed proxy	boundary angular-momentum flux	topology bookkeeping. positive outward by convention.
n_12	unit vector	outward direction through inter-anchor gap	v0.19 recoil. defines directional prediction.
F_recoil	generic physical vector	ordinary reaction force - $\dot{m} \cdot v_{out}$ direction	future measurement. not an RBFL force term.
x_node	node radii	node centroid position	containment/manipulation. normalized until physical calibration.
v_node	node radii/models	node centroid velocity	tracking/recovery. normalized.
a_node	node radii/models ²	node centroid acceleration	recoil/trajectory audit. normalized.
sphericity	0..1	shape-preservation metric	containment/manipulation gate. lab maps from multi-view imaging.
health	normalized	composite structural viability metric	all stages. model-defined, lab analogue must be rederived.
tracking	0..1	agreement of node trajectory with commanded path	control validation. normalized.
jitter	node radii	late position jitter around command	hold quality. normalized.
gain	normalized	steering-command scale	v0.9-v0.20 control. not field strength.
period_ms	model-ms	command-cycle period in model time	circle/helix bandwidth. not physical milliseconds until calibration.
segment_ms	model-ms	waypoint dwell/segment duration	waypoint control. not physical milliseconds until calibration.
C(t)	categorical/optical	observed color/emission-state label	state-transition logging. not temperature by definition.
E_env	vector	environment descriptor: droplets, conductivity, surfaces, airflow, EM/acoustic geometry	attractor selection. measured independently of outcome.
A_k	state class	bounded attractor selected under environment/control	multi-state architecture. descriptive class, not a new law.

RBFL law-level firewall dictionary

The following gravity-level quantities are included only to prevent engineering variables from being mistaken for force-law terms. They are defined in the RBFL/RBFT 6.0 architecture and remain separate from CLN control variables.

Term	Definition and allowed use
$\rho_b(\mathbf{x}, t)$	Three-dimensional visible baryonic density. Predictive source input; not derived from CLN residuals.
Φ_b	Baryonic gravitational potential satisfying $\nabla^2 \Phi_b = 4\pi G \rho_b$.
$\mathbf{g}_b$	Baryonic acceleration $-\nabla \Phi_b$.
a_ϕ	RBFL phase-carrier acceleration scale in the locked square-root response. It is not changed by CLN engineering.
A_{eff}	Effective phase-response amplitude in the RBFL gravity candidate. CLN state variables do not become hidden factors inside A_{eff} .
$\mathbf{g}_{\text{RBFL}}$	$\mathbf{g}_b + A_{\text{eff}} \sqrt{a_\phi \mathbf{g}_b } \hat{\mathbf{g}}_b$. The CLN programme does not modify this law.
$P_{3D} = Z_{\text{phase}}^{-1}$	RBFL projection/impedance correction for galaxy-scale analysis; unrelated to CLN aperture A_{12} or fresh-medium variables.
C_Φ	Compact RBFL coherence/response notation in gravity papers. It must not be confused with optical colour label $C(t)$ in the CLN paper.

Appendix C - External literature and RBFL project links

Direct literature links for laboratory teams

- Ohtsuki & Ofuruton (1991), microwave interference fireballs in air: doi:10.1038/350139a0.
- Kondo, Ofuruton & Ohtsuki (1997), water droplets/vapour: doi:10.1541/jae.17.47.
- Kamogawa et al. (1998), fireball rising from water surface: doi:10.1541/jae.18.47.
- Kondo et al. (1998), electromagnetic field mode: doi:10.1541/jae.18.53.
- Kondo et al. (1998), unusual motion / nonlinear EM-wave model: doi:10.1541/jae.18.59.
- Cen, Yuan & Xue (2014), natural optical/spectral observation: doi:10.1103/PhysRevLett.112.035001.
- Wu (2016), relativistic-microwave theory/barrier discussion: doi:10.1038/srep28263.
- Theberge et al. (2020), confined plasma balls along discharge channels: doi:10.1103/PhysRevResearch.2.013266.

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Appendix D - Media provenance note

The screenshots reproduced in this report were supplied by the project owner from online video platforms. Their authenticity, date, original camera file, continuity and metadata have not been independently verified. They are included because they motivated falsifiable model questions. They are **not** counted as scientific evidence in the report’s claim ladder. The exact indoor YouTube Short discussed during development was presented online as an alleged indoor ball-lightning clip; its authenticity remains unresolved.

End of report.

Reproduce the ladder, freeze the gates, and let the laboratory decide.