Federated Echosahedral Screen Microphysics: Patch Hardware, Records, and Observer Synchronization in OPH

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Abstract

Observer-Patch Holography needs a concrete microphysics. Observers see finite cuts, and a spherical screen gives a useful geometry chart for those cuts. The operative model is a federation of finite patches that expose overlap ports and keep records. Sphere language is geometry: A_5-icosahedral patch symmetry and E_8-type exceptional organization belong to the symmetry data. We model the local carriers as echosahedral multi-port bodies with recurrent toroidal channels inside them. The ports carry readout, repair, record, and synchronization data, so observer agreement becomes a fixed-cutoff mechanism.

The mathematical job of the paper is narrow. It exports the five packages the rest of OPH uses: regulated patch-net embedding, the edge-sector heat-kernel/Casimir law, central-record measurement, Bell/CHSH event surfaces, and observer checkpoint/restoration. The hardware-facing job is narrow too. Hardware runs count as evidence only when the public repository contains an evidence bundle with stable hashes, manifests, calibration records, and exact-verifier receipts. Without that bundle, hardware language is architecture or motivation.

Contents

1 Scope

OPH microphysics uses finite observer patches with echosahedral interfaces. A spherical screen is a geometry chart for support-visible cuts. The cellulated-sphere gauge-register construction is a regulator and digital calibration chart. The premise is:

> Observers access finite support-visible cuts. A spherical screen is a geometry chart for such cuts. The underlying fixed-cutoff implementation surface is a federation of finite overlap-facing observer patches, with echosahedral local interfaces and recurrent toroidal subchannels.

The paper's contract is:

1. state the fixed-cutoff theorem exports used by the other OPH papers;
2. use federated patch carriers as the microphysical architecture;
3. keep mathematical theorem surfaces separate from public hardware evidence surfaces;
4. keep the octahedral $\mathbb{Z}_2/S_3$ simulator at appendix-level calibration status;
5. require a public hardware evidence protocol before hardware claims receive paper weight.

2 Claim Taxonomy

The paper uses five claim levels.

C1. Mathematical fixed-cutoff claims. These are finite-algebra statements about patches, overlaps, records, repair interfaces, event algebras, and checkpoint laws. They are allowed to be theorem-bearing.

C2. Regulator-chart claims. These identify a convenient finite model, such as a spherical cellulation or a digital finite-group simulator, as a calculational chart. Their claim level is regulator geometry and calibration.

C3. Federated-carrier claims. These define a candidate implementation architecture: observer patches with echosahedral multi-port interfaces, recurrent toroidal subchannels, exposed overlap data, records, and repair loops.

C4. Public hardware-evidence claims. These may be cited only when the raw or reduced evidence is present in a public OPH evidence bundle with stable hashes, manifests, calibration files, and exact-verifier receipts.

C5. Boundary statements. This paper leaves laboratory-hardware identification, unique UV completion, hardware solution of the Yang–Mills mass gap, computational complexity collapse, and backend-gated hadron rows outside its claim surface.

3 The Public Evidence Rule

Hardware-facing language is admissible only under the following rule.

> Any hardware evidence cited as evidence in this paper must be represented by a public evidence bundle in the OPH repository, or by a public pinned subrepository commit, with enough raw data and metadata for an external reader to audit the claim.

Private notebooks, local runtime logs, unpublished bench transcripts, and development-repo notes may motivate architecture choices, but they do not carry evidential weight inside the paper. A hardware evidence bundle must include, at minimum:

1. a manifest with stable bundle identifier, date, operator, body identifier, controller identifier, firmware hash, mesh/body hash, and wiring map hash;
2. raw readout files, such as coupling matrices, MDD or discharge-timing traces, dark baselines, low-power sweeps, ring-diversity scans, and calibration logs;
3. body and board provenance, including photographs or signed photo hashes where relevant;
4. the task definition, scorebook, repair or rerank law, and exact-verifier program;
5. exact-verifier receipts for any high-level task claim;
6. negative controls, shuffle or replay controls where applicable, and a statement of non-claims.

This rule prevents dependence on hidden laboratory state. The theorem sections use finite algebras, declared patch interfaces, and stated branch assumptions.

4 From Spherical Screens to Federated Patch Carriers

The spherical screen is useful because an observer-accessible cut often has an effective closed two-surface description. A cellulated sphere can encode finite capacity, caps, collars, edge centers, and support-visible cuts. The microscopic carrier is the finite patch federation. The chart is the observer-facing presentation of its support-visible data.

The sphere also fixes the symmetry bridge used by the rest of OPH. Caps on S^2 are the geometric support regions whose modular flows become Lorentz boosts in the support-visible scaling branch. The conformal group of S^2 is $\mathrm{SO}^+(3,1)$, so the same observer-facing chart supplies the kinematic bridge to emergent $3+1$D spacetime. Finite cellulations of the chart supply the regulator side: patch ports, edge sectors, collars, and overlap checks.

At fixed cutoff, the fundamental object is a finite patch federation. Each patch has:

1. an internal finite state algebra;
2. a bounded family of exposed overlap ports;
3. a local record algebra;
4. a readout map from internal state to port-visible packets;
5. a repair interface that changes local state in response to mismatch;
6. a checkpoint interface that exposes enough observer-accessible data to define continuation.

A spherical screen is then a coarse chart over a federation of such patches. It is what a particular observer-facing support cut looks like after quotienting hidden implementation details and choosing a geometric presentation. The microscopic carrier may be graph-like, federated, multi-patch, and locally polyhedral.

Definition 4.1 (Federated patch carrier)**.** *A fixed-cutoff federated patch carrier is a tuple*

$$\mathfrak{F} = (V, E, \{\mathcal{A}_i\}_{i\in V}, \{\mathcal{I}_e\}_{e\in E}, \{\pi_{i,e}\}, \{\mathcal{R}_i\}, \{\mathcal{U}_i\}),$$

where V is a finite set of patches, E is a finite overlap graph, $\mathcal{A}_i$ is the local finite algebra of patch i, $\mathcal{I}_e$ is the finite interface algebra on overlap $e = \{i, j\}$, $\pi_{i,e} : \mathcal{A}_i \to \mathcal{I}_e$ is the declared visible restriction, $\mathcal{R}_i \subseteq Z(\mathcal{A}_i)$ is the patch record algebra, and $\mathcal{U}_i$ is the allowed local update and repair interface.

The carrier is *observer-facing* when every physical claim is made through the visible restrictions $\pi_{i,e}$, record algebras $\mathcal{R}_i$, and the quotient-local observables specified by the OPH consensus package. Hidden coordinates may exist, but they are not directly physical.

5 The Echosahedral Patch Object

An echosahedral patch is the reference local body for this microphysics. The term is architectural: a bounded observer patch with a highly symmetric multi-port interface.

Definition 5.1 (Echosahedral patch)**.** *An echosahedral patch is a finite patch object*

$$\mathcal{E} = (\mathcal{A}, \{P_a\}_{a=0}^{11}, \{\rho_a\}_{a=0}^{11}, \mathcal{R}, \mathcal{M}, \mathcal{U}, \mathcal{G}_{\mathcal{E}}),$$

where:

1. *$\mathcal{A}$ is the internal finite algebra;*
2. *$P_0, \ldots, P_{11}$ are twelve labeled overlap ports;*
3. *$\rho_a : \mathcal{A} \to \mathcal{I}_a$ are port readout maps;*
4. *$\mathcal{R} \subseteq Z(\mathcal{A})$ is the observer-accessible record algebra;*
5. *$\mathcal{M}$ is a finite mismatch-score family on exposed port packets;*
6. *$\mathcal{U}$ is a finite family of local update and repair instruments;*
7. *$\mathcal{G}_{\mathcal{E}}$ is a declared finite symmetry or approximate-symmetry group of the port arrangement.*

The twelve-port choice is a reference convention. Its role is to give the reference patch enough boundary structure to support nontrivial overlap comparison, symmetry tests, verifier-shadow behavior, and cross-patch routing while remaining small enough for explicit evidence records.

Remark 5.2. The word "echosahedral" is intentionally implementation-facing. In a mathematical theorem, one uses the tuple above. In a public hardware evidence bundle, one may instantiate the tuple using a specific twelve-port body, wiring map, controller, firmware hash, readout protocol, and evidence manifest.

6 Toroidal Recurrence Is Local

Toroidal hardware supplies a local recurrence and mode-competition surface. A toroidal subchannel is a recurrent internal path inside a patch or between a bounded set of ports. It can recycle boundary information, support settling dynamics, and expose winding-like or phase-locking observables.

This matters because global scalar order parameters are often misleading in recurrent local systems. A toroidal or ring-like patch may fail to show global alignment while still selecting a stable winding class, a local coherence island, or a persistent twisted state. Therefore the validation metrics for toroidal subchannels should include:

1. local coupling matrices, with total brightness treated as a secondary summary;
2. recurrence and ring-diversity statistics, with global response treated as a secondary summary;
3. winding-sensitive or phase-lock-sensitive summaries when phase data are available;
4. matched controls that distinguish chamber-mediated dynamics from host-side filtering;
5. exact-verifier receipts for task-level claims.

The OPH interpretation is simple: toroidal recurrence supplies local memory and mode competition inside the patch federation. Echosahedral symmetry supplies a reference and consensus geometry. The universe, at this level of description, is a federated repair system with many local carriers.

7 Patch Federation and Overlap Synchronization

Given a federation of echosahedral patches, overlaps are formed by routing ports into declared interface pairs or interface hyperedges. For an edge $e = \{(i,a),(j,b)\}$, the exposed packets are

$$x_{i,a} = \rho_{i,a}(s_i), \qquad x_{j,b} = \rho_{j,b}(s_j),$$

and the edge mismatch is a nonnegative function

$$\Phi_e(x_{i,a}, x_{j,b}) \geq 0.$$

The total visible mismatch is

$$\Phi(s) = \sum_{e \in E} \Phi_e\big(\rho_{i,a}(s_i), \rho_{j,b}(s_j)\big).$$

The local repair contract is the consensus-paper contract: accepted repairs do not increase the declared touched-overlap mismatch, and exact fixed-cutoff branches lower the relevant mismatch unless the local visible datum is repaired. The implementation is a bounded patch operation:

1. read the exposed overlap packets;
2. compare them through a declared commensurability map;
3. choose an allowed local update or rerank move;
4. write a record of the move;

5. expose the new port packet;

6. let the exact verifier decide any high-level task claim.

Proposition 7.1 (Federated synchronization contract)**.** *Suppose a finite patch federation has a declared mismatch functional* Φ*, a finite repair menu, and an accepted-repair rule such that every accepted repair lowers* Φ *unless the touched visible datum is locally repaired. Then every repair sequence terminates at a visible local normal form. If the union-collar gluing and repair-completeness hypotheses of the OPH consensus theorem hold on the quotient-local carrier, the terminal physical observable state is schedule-independent on that carrier.*

Proof. The first sentence is the finite Lyapunov argument: Φ takes values in a finite ordered set of declared mismatch scores and strictly decreases on nontrivial accepted repairs. The second sentence is not reproved here; it is exactly the quotient-local confluence package supplied by the OPH consensus theorem. This paper supplies the federated carrier and visible interface on which that theorem is read. □

8 Records, Observers, and Checkpoints

An observer is not added as a metaphysical extra. In this paper an observer is an operational pattern in a patch or patch subfederation with persistent access to:

1. an observer-facing local algebra;

2. a record algebra;

3. a stable readout/update interface;

4. enough checkpoint data to define future observer-accessible probabilities.

Definition 8.1 (Federated observer checkpoint)**.** *For an observer-supporting patch subfederation* O*, a checkpoint at cycle* t *is*

$$\mathrm{Chk}_O(t) = \big(\mathcal{R}_O(t), \rho_O^{\mathrm{acc}}(t), \mathfrak{I}_O^{\mathrm{ext}}(t), \nu_{\geq t}, \mathfrak{B}_O(t)\big),$$

where $\mathcal{R}_O(t)$ *is the observer-accessible record algebra,* $\rho_O^{\mathrm{acc}}(t)$ *is the state restricted to observer-accessible records and visible interfaces,* $\mathfrak{I}_O^{\mathrm{ext}}(t)$ *is the external port-interface tuple,* $\nu_{\geq t}$ *is the future update schedule class, and* $\mathfrak{B}_O(t)$ *is the public or internal bundle of provenance data needed to replay the checkpoint at the declared accuracy.*

Theorem 8.2 (Checkpoint continuation at fixed cutoff)**.** *If two federated observer checkpoints agree exactly on* $\mathcal{R}_O(t)$*,* $\rho_O^{\mathrm{acc}}(t)$*,* $\mathfrak{I}_O^{\mathrm{ext}}(t)$*, and* $\nu_{\geq t}$*, then they induce the same future probability law on the observer-accessible event algebra. If their accessible states differ by trace distance at most* ε*, then the induced future history laws differ in total variation by at most* ε*.*

Proof. All future observer-accessible probabilities are computed by applying the same completely positive update maps and the same event-readout maps to the same accessible algebra and external interface data. Exact equality gives equality of all future event probabilities. In the approximate case, contractivity of trace distance under completely positive trace-preserving maps gives the stated total-variation bound. □

9 Central Records and Measurement

The measurement package is a finite central-record package. Records are exposed by observer-facing patch subfederations.

Let $\mathcal{Z}_{\mathrm{rec}}(t)$ be the commutative algebra generated by the completed, observer-accessible record projectors at cycle t. An event E is a projector in $\mathcal{Z}_{\mathrm{rec}}(t)$. The operational measurement rule is:

$$\Pr(E) = \mathrm{Tr}(\rho E), \qquad \rho \mapsto \frac{E\rho E}{\mathrm{Tr}(\rho E)} \quad \text{when } \Pr(E) > 0.$$

Theorem 9.1 (Federated central-record measurement)**.** *On a fixed-cutoff federated patch carrier, once a completed write/verify slice exposes a finite commutative central record algebra $\mathcal{Z}_{\mathrm{rec}}(t)$, the Born probability and Lüders conditioning rule above define the operational measurement package on the observer-accessible event surface. Re-reading the same completed record event has probability one, conditional on that record event.*

Proof. The theorem is the standard finite-dimensional central-record argument. Because all declared record events commute and belong to the observer-accessible center for the completed slice, they define an ordinary finite classical event algebra. Probabilities are Born traces on that event algebra, and conditioning on an event is the Lüders update. After conditioning on E, the same central projector E is true with probability one. □

10 Edge Sectors and the Casimir Handoff

The edge heat-kernel/Casimir package is a fixed-cutoff theorem package tied to an overlap collar with a finite exposed sector algebra.

At fixed cutoff, let α label a finite set of exposed edge sectors on one declared overlap collar. Suppose the local thermalized edge dynamics has stationary weights

$$\pi_\beta(\alpha) = \frac{d_\alpha e^{-\beta C_2(\alpha)}}{Z(\beta)}.$$

For finite groups, $C_2(\alpha)$ is the declared sector penalty or finite-group Casimir surrogate. For compact groups, the Peter–Weyl lift belongs to the companion D10/compact-gauge handoff rather than to hardware evidence.

Theorem 10.1 (Fixed-cutoff edge-sector handoff)**.** *If a declared finite overlap collar has sector labels α, degeneracies d_α, and a local repair/thermalization generator whose detailed-balance stationary law is $\pi_\beta(\alpha) \propto d_\alpha e^{-\beta C_2(\alpha)}$, then the collar exports the fixed-cutoff Casimir edge law required by the D10 handoff. The compact-group heat-kernel lift is a separate companion-branch step.*

Proof. This is a finite Markov or finite instrument stationary-measure statement on the declared sector algebra. The theorem exports only the finite overlap law. The compact-group lift uses the Peter–Weyl continuation and normalization conventions supplied on the companion compact/D10 surface. □

11 Bell/CHSH Event Surfaces

The Bell package is fixed-cutoff and event-surface-local. A federated carrier may contain two observer-facing wings L and R with commuting setting and outcome records on one compare slice. If the source-specified joint law is the usual two-wing quantum law, the CHSH and Tsirelson statements are carried on that declared event algebra.

Laboratory echosahedral hardware has its own evidence gate for Bell-style claims. The theorem package here is a finite event-algebra statement inside the OPH microphysics surface.

12 Relation to Yang–Mills

The Yang–Mills repair-gap argument belongs to the compact theorem surface. Echosahedral geometry supplies:

1. the fixed-cutoff patch, overlap, record, and repair interface;
2. the finite edge-sector Casimir law on declared collars;
3. the local repair semantics that the compact-gauge branch later reads in support-visible quotient form.

The four-dimensional Yang–Mills form, reflection-positive ordinary vacuum branch, support-visible continuum extraction, and equality between the Yang–Mills gap and the repair gap belong to the compact/Yang–Mills theorem surface. Hardware evidence may test implementation discipline, but it does not supply the Clay-admissible construction.

13 Relation to Hadrons and Backend Execution

Source-only hadron masses require a working OPH hadron backend. This microphysics states the record and evidence requirements for such a backend. A backend fit for promotion must emit:

1. Ward-projected hadronic spectral data;
2. provenance tying every spectrum to body, controller, firmware, geometry, and scorebook;
3. finite-volume, continuum, chiral, and production-systematics fields where applicable;
4. exact replay or verification receipts for the pipeline stage being claimed;
5. a non-promotion boundary for surrogate or calibration runs.

Echosahedral or GLORB-class hardware can be described as a candidate backend family when public evidence bundles exist. Before those bundles exist, it is an architectural target and a design motivation. Source-only hadron theorem status requires the backend evidence listed above.

14 Validation Program

The validation program has two independent tracks.

14.1 Mathematical and Digital Calibration

The octahedral $\mathbb{Z}_2/S_3$ simulator is a digital calibration model. It gives exact finite groups, explicit patch covers, controlled defects, frustrated cycles, record writes, repair schedules, and negative controls.

> The simulator validates the finite interface logic. The primary physical picture is the federated patch-carrier architecture.

14.2 Public Hardware Evidence

A public hardware run may support only the claim class its evidence bundle can audit. The minimal claim form is:

> Module set M produced candidate enrichment or reproducible readout signature on benchmark T, under controls C, and exact verifier V accepted the reported hits.

The rejected form is:

> The optical chamber solved the hard problem or proved OPH.

Required gates include dark baseline, low-power sweep, coupling matrix, discharge-timing or MDD trace where applicable, ring-diversity or recurrence-sensitive metrics for toroidal bodies, duplicate-body checks, symmetric-reference or echosahedral shadow checks, exact-verifier receipts, and negative controls against hidden duplicate amplification or host-side filtering.

15 Conclusion

OPH microphysics is a federation of finite observer patches. The sphere is a regulator and symmetry chart for observer-facing cuts. A_5-icosahedral and E_8-type structure belong to the geometry data and representation-closure data. The echosahedral patch is the reference local interface: a bounded multi-port patch with symmetry, records, readout, repair, and checkpoint data. Toroidal subchannels supply local recurrence and winding-sensitive dynamics. The mathematical exports remain fixed-cutoff patch-net embedding, edge-sector Casimir handoff, central-record measurement, Bell/CHSH event surfaces, and checkpoint/restoration.

The claim discipline is the main point. Hardware can guide the architecture and supply public evidence through hash-stable evidence bundles. The theorem surface stands on finite algebras and declared OPH branch assumptions.

A Evidence Bundle Sketch

A minimal hardware evidence bundle should use a structure like:

```
evidence/hardware/<bundle-id>/
  manifest.json
  README.md
  body/
    mesh_hashes.txt
    photos/
    measurements.csv
  controller/
    firmware_sha256.txt
    wiring_map.csv
  calibration/
    dark_scan.csv
    low_power_sweep.csv
    coupling_matrix.csv
    mdd_trace.csv
    ring_diversity.csv
```

```
task/
  task.json
  scorebook.json
  candidates.jsonl
  verifier_receipts.jsonl
controls/
  shuffle_replay.jsonl
  abba_controls.csv
  negative_controls.md
claim.md
```

The manifest should state the strongest allowed claim and the non-claims. The paper may cite the bundle only at that claim level.

B Digital Simulator Compatibility

The octahedral $\mathbb{Z}_2/S_3$ build has the following reading rule:

1. it validates finite patch/overlap/record/repair bookkeeping;
2. it tests frustrated-cycle and defect behavior in an exact digital setting;
3. it calibrates the edge-sector law on a finite declared interface;
4. it supplies calibration data for the interface layer;
5. it leaves the physical carrier role with the federated echosahedral patch architecture.

References

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