PAPER-Δ

The Structural Architecture of Physical Reality

A Minimal Ontological Constitution for the DCQ–FBT Framework

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December 2023

Version v3.0

Abstract

We present a minimal ontological constitution for the DCQ–FBT programme. Rather than proposing a complete dynamical model, this paper identifies the structural conditions under which a physical theory may count as admissible within the present framework.

The central claim is that physical reality is not fundamentally object-based or field-based, but is instead grounded in invariant geometric and algebraic structure. Within this view, phase space, observables, dynamical histories, and discrete physical sectors arise as constrained readouts of a deeper symplectic and topological substrate.

We formulate four postulates that define this constitutional layer: (i) *Structural Realism*, specifying the ontological primacy of invariant structure; (ii) *Symplectic Admissibility*, defining the criterion of physical observability; (iii) *Modal Determinism*, characterizing the structural selection of realized histories; and (iv) *Topological Locking*, explaining the stability of discrete, integer-valued, and quantized sectors.

These postulates do not by themselves constitute a finished physical theory. Their role is to delimit the admissible form of any realization in which emergent spacetime, admissible phase space, and topologically protected observables arise from an underlying geometric parent.

Keywords: structural realism; symplectic geometry; ontological architecture; topological invariants; emergent spacetime; admissibility criteria; geometric quantization; DCQ–FBT framework

*Preprint archived at Zenodo: https://doi.org/10.5281/zenodo.18359933. DOI: 10.5281/zenodo.18359933.

Contents

1 Introduction: Beyond Objects, Fields, and Laws

A persistent feature of modern theoretical physics is the tendency to treat certain mathematical structures as primitive. Classical mechanics presupposes the existence of phase space and canonical conjugate variables. Quantum theory presupposes Hilbert spaces, operators, and probability amplitudes. Field theory presupposes spacetime manifolds equipped with dynamical fields and symmetry groups.

In most foundational programs, these elements are taken as given and then combined into increasingly sophisticated dynamical frameworks. The deeper question of why such structures should exist at all, and why they should take precisely the forms required by physical law, is often left implicit.

The DCQ–FBT programme inverts this perspective. Rather than beginning with particles, fields, or even spacetime, it treats *structure itself* as the primary ontological category. Physical reality is understood as an emergent, constrained representation of an underlying geometric and algebraic architecture.

This paper does not introduce a new model of interaction, cosmology, or quantum dynamics. Instead, it proposes a minimal *constitutional layer*: a small set of postulates that specify what kinds of mathematical structures are permitted to count as physically meaningful, what kinds of degrees of freedom may be observed, how dynamical histories are selected, and why certain numerical features of nature appear discrete and stable.

The role of these postulates is analogous to that of axioms in geometry or admissibility criteria in variational calculus. They do not generate specific solutions; they delimit the space within which any physically acceptable solution must reside.

Principle DELTA-1.1 (The Blind-Spot Principle)**.** The primary purpose of an architectural framework is not to outperform established effective theories inside the regimes where they are already operationally complete. Rather, it is to identify the structural conditions under which such theories *emerge*, *coexist*, and ultimately *fail* as readouts of a deeper geometric parent.

Accordingly, the DCQ–FBT programme does not aim to replace the Standard Model or General Relativity as calculational tools for their respective domains. It aims to characterise the admissibility, selection, and locking criteria that define the common overlap structure of these theories, and to isolate the "blind spots" where both descriptions cease to be valid as effective representations. Such blind-spot regimes—where comparability, convergence, or topological locking breaks down—form the natural domain of genuinely new physics (dark sectors, quantum gravity, and pre-spacetime phases).

Remark DELTA-1.2 (From precedent to programme: unification as boundary-finding)**.** Once a common architectural layer underlying GR and the Standard Model is identified, the decisive scientific task is no longer to re-derive their already successful predictions in their native regimes, but to map the *boundary loci* where their effective descriptions cease to be admissible readouts—i.e. where comparability, convergence, or topological locking fails and genuinely new sectors can emerge.

The next question is therefore not yet mathematical in the narrow technical sense, but constitutional: *what kind of statement is an ontological postulate, and what role does it play within a structural research programme?*

2 Relativity as a Precedent for Architectural Physics

Modern theoretical physics has repeatedly advanced by identifying *principle layers* that constrain the admissible form of physical law prior to the specification of any particular dynamical model. The present framework situates itself within this tradition and extends it to a higher, explicitly ontological level.

2.1 Einstein: Principle before Dynamics

Special and general relativity mark a decisive shift from mechanism–based modeling to principle–based architecture. Rather than postulating specific forces or microscopic interactions, Einstein imposed global constraints on the form of admissible physical descriptions: relativity of inertial frames, invariance of the speed of light, equivalence of inertial and gravitational mass, and general covariance.

The resulting field equations are not primitive assumptions but *closure conditions*—the simplest dynamical realization compatible with these principles. In this sense, relativity establishes a paradigm in which geometry is not a stage on which physics unfolds, but a structural condition that selects which physical laws are even admissible.

2.2 Noether: Symmetry as a Structural Constraint

Noether's theorems further elevated this architectural perspective by demonstrating that conservation laws are not independent postulates but necessary consequences of symmetry at the level of the action functional.

This result repositions dynamical invariants as *structural correlates* of admissible transformations rather than as empirical regularities. Energy, momentum, and charge are thus understood as measures of how physical descriptions remain invariant under time translation, spatial translation, and internal phase rotation.

Within the present framework, this marks the transition from geometry–based admissibility to algebra–based admissibility, in which the space of allowed physical processes is constrained by group and symmetry structure.

Berry: Geometry in the Space of States

Berry's discovery of geometric phase reveals that geometry operates not only in spacetime but also in the space of physical states. Adiabatic evolution around closed loops in parameter space produces observable phase shifts determined by curvature on a fiber bundle over state space.

This result generalizes the role of connection and curvature from spacetime manifolds to abstract configuration spaces. Physical effects are shown to depend on global geometric features of representation spaces rather than solely on local dynamical equations.

In architectural terms, Berry curvature provides a bridge between admissible representations and physically observable quantities, linking abstract structure to measurable phase information.

[6].

2.3 Topological Phases: Stability beyond Dynamics

The theory of topological phases extends this perspective by demonstrating that entire classes of physical behavior are protected by topological invariants rather than by energetic or dynamical details. Quantized conductance, protected edge modes, and robust degeneracies arise from global properties of the underlying state space.

Here, physical law acquires a new layer of architectural constraint: continuous deformation of microscopic parameters cannot alter discrete, integer–valued observables as long as topological class is preserved.

This development establishes topology as an organizing principle for physical stability, independent of local dynamics.

2.4 DCQ–FBT: Ontological Architecture

The DCQ–FBT framework may be viewed as a continuation of this principle–driven lineage. It extends the architectural role of geometry, symmetry, and topology from the level of physical law to the level of physical ontology.

Rather than asking which dynamical equations govern a given set of fields on a spacetime manifold, the framework asks which geometric and algebraic structures are permitted to count as physically meaningful representations in the first place.

In this sense, DCQ–FBT does not propose a new interaction or force. It proposes a *constitutional layer* that constrains the form of any admissible physical theory in which phase space, observability, and discrete structure are required to emerge from a higher–level geometric parent.

2.5 From Law to Architecture

The historical progression from Einstein to modern topological classification illustrates a consistent shift in the foundational role of mathematics in physics:

$$\text{Dynamics} \longrightarrow \text{Symmetry} \longrightarrow \text{Geometry} \longrightarrow \text{Topology} \longrightarrow \text{Architecture.}$$

Within this progression, the present framework occupies the final position. It treats the space of physical theories itself as a structured object, subject to admissibility, stability, and representational constraints.

Remark DELTA-2.1. The purpose of this architectural perspective is not to replace established physical theories, but to provide a unifying principle layer in which their common structural features—symplectic form, gauge redundancy, geometric phase, and topological protection—appear as coordinated expressions of a single underlying constraint system.

3 The Role of Ontological Postulates

An ontological postulate is not a hypothesis about a particular mechanism or interaction. It is a constraint on what *counts as a possible description of reality.*

In the present framework, the postulates serve three functions:

(i) **Ontological delimitation:** They specify the fundamental category of existence.

(ii) **Physical admissibility:** They define what distinguishes physical degrees of freedom from redundant, gauge, or purely descriptive variables.

(iii) **Structural stability:** They explain why certain features of physical law are discrete, integer–valued, or resistant to continuous deformation.

The guiding principle is minimality. Each postulate is designed to subsume a wide class of conventional assumptions—about observables, quantization, symmetry breaking, and topological protection—into a single structural criterion.

The constitutional ambition of the present paper is therefore sharply limited but also precise: it does not seek to derive a finished physical theory, but to identify the minimal ontological conditions that any admissible realization of the DCQ–FBT programme must satisfy.

We now present the four postulates that define the minimal ontological architecture of the DCQ–FBT framework.

3.1 Postulate A: Structural Realism

Postulate DELTA-3.1 (Structural Realism)**.** Physical reality is constituted by invariant geometric and algebraic structures rather than by primitive objects, particles, or fields. All physical entities, laws, and observables arise as admissible representations of these underlying structures.

Remark DELTA-3.2. This postulate replaces substance–based or field–based ontologies with a structural ontology. What is physically real is that which remains invariant under the class of admissible transformations defined by the underlying geometry and algebra.

Remark DELTA-3.3 (Readout and Representation Layer)**.** The present framework distinguishes sharply between *structural reality* and its *physical readout*. Quantities such as units, dimensional scales, fields, and even spacetime coordinates are not taken as ontological primitives, but as elements of a *representation map*

$$\mathcal{R} : \ \mathsf{Structure} \ \longrightarrow \ \mathsf{Observable\ Physics}.$$

Gauge redundancy and normalization freedom are interpreted as inequivalent descriptions of the same underlying structure within the kernel of $\mathcal{R}$, rather than as physical degrees of freedom.

3.2 Postulate B: Symplectic Admissibility

Postulate DELTA-3.4 (Symplectic Admissibility)**.** A degree of freedom is physically admissible if and only if it preserves a non–degenerate symplectic form under all structural constraints. Directions annihilated by the restricted symplectic form correspond to unobservable, redundant, or gauge degrees of freedom.

Remark DELTA-3.5. This criterion elevates the symplectic form from a kinematical input to an ontological filter. Canonical conjugacy, quantization, and physical observability are not assumed but emerge as consequences of admissibility.

3.3 Postulate C: Modal Determinism

Postulate DELTA-3.6 (Modal Determinism)**.** The underlying structure uniquely determines the space of physically admissible processes. The realized physical history corresponds to a selection among structurally stable and dynamically consistent paths within this space.

Remark DELTA-3.7. This postulate separates determinism at the level of admissible structure from contingency at the level of realized history. It formalizes the role of stability, consistency, and selection without invoking fundamental randomness or anthropic criteria.

Remark DELTA-3.8 (Probability as Structural Selection Statistics)**.** Within this architecture, probability does not represent fundamental ontological randomness. It encodes the relative measure of structurally admissible and stable paths in the space of representations. Statistical laws therefore arise from coarse–graining over basins of structural stability, rather than from indeterminacy at the level of the underlying geometric substrate.

3.4 Postulate D: Topological Locking

Postulate DELTA-3.9 (Topological Locking)**.** Discrete and integer components of physical constants, interaction structures, and admissible sectors originate from topological invariants of the underlying geometry and are protected against continuous deformation.

Remark DELTA-3.10. This postulate does not assert that all physical constants are purely topological. It asserts that their discrete and integer–valued components must admit a topological interpretation if they are to remain stable under continuous variation of dynamical or geometric parameters.

The four postulates above define the minimal ontological core of the programme. Their significance, however, lies not only in their separate content but in the fact that they form a closed architectural loop.

3.5 Logical Architecture and Closure

The four postulates form a closed logical architecture rather than a linear hierarchy.

$$\begin{tikzcd}
\text{Structure (A)} \arrow[r] & \text{Admissibility (B)} \arrow[r] & \text{Selection (C)} \arrow[r] & \text{Stability (D)} \arrow[d] \\
 & & & \text{Constraint on Structure (A)}
\end{tikzcd}$$

Principle DELTA-3.11 (Architectural Closure)**.** The admissible space of physical theories is defined by a closed loop: structure determines admissibility, admissibility constrains possible histories, selection stabilizes discrete features, and topological stability restricts the class of allowable underlying structures.

This closure condition ensures that no postulate functions as an external or ad hoc rule. Each postulate both constrains and is constrained by the others.

The constitutional layer is therefore logically self-supporting. What remains is to ask how this layer is *realized* in the actual mathematical development of the programme. We begin with the FBT side, whose minimal mathematical core can be stated independently of later dynamical elaborations.

4 Minimal Mathematical Core of the FBT Framework

The constitutional role of the present paper is to articulate the minimal ontological conditions under which a physical theory may count as admissible. These conditions, however, do not by themselves identify the concrete mathematical structures through which the Fracture–Berry–Tension (FBT) framework is realized.

For clarity, we therefore record the *minimal mathematical core* of the FBT framework. This core should not be confused with a complete dynamical theory. It is the smallest family of structures from which the later FBT constructions are built and to which the ontological postulates of the present paper apply.

4.1 Foundational status

Within the broader DCQ–FBT programme, the FBT framework does not begin from the Grassmannian construction of the DCQ series. The DCQ route starts from a discrete binary configuration space and its phase–encoded embedding into $\mathrm{Gr}(3,6)$, and only subsequently develops the geometric, spectral, and topological structures that can later be related to the FBT arena.

By contrast, the FBT framework proper begins from its own foundational structural principles—in the internal terminology of the series, FP1 and FP2—which require: (i) the existence of a minimal noncommutative structural generator, and (ii) finite structural distinguishability. From these inputs, the six-dimensional symplectic arena is reconstructed directly and serves as the primary geometric parent of the framework.

4.2 Core objects

At the structural level, the FBT framework is organized around the following objects:

(i) a six-dimensional symplectic manifold

$$(\mathcal{B}_6, \omega),$$

serving as the primary geometric parent of the framework;

(ii) a canonical horizontal–vertical decomposition

$$T\mathcal{B}_6 = \mathrm{Hor} \oplus \mathrm{Vert}, \qquad \mathrm{Hor} \cong T\mathcal{M}_4, \qquad \mathrm{Vert} \cong T\Sigma_2,$$

which defines the characteristic 4+2 splitting of the FBT system;

(iii) an effective four-dimensional readout sector

$$\mathcal{M}_4,$$

interpreted in later papers as the emergent spacetime layer of the framework;

(iv) a compact dual-phase surface

$$\Sigma_2 \simeq T^2,$$

which carries the phase geometry, locking structure, and vertical topological data of the theory;

(v) a Berry line bundle

$$\mathcal{L} \to \Sigma_2,$$

with Berry connection A_{Berry} and curvature

$$\Omega_{\text{Berry}} = dA_{\text{Berry}},$$

subject to the integrality condition

$$\frac{1}{2\pi} \int_{\Sigma_2} \Omega_{\text{Berry}} \in \mathbb{Z};$$

(vi) a minimal transport algebra

$$\mathfrak{g}_T = \text{span}\{X, Y, Z, S\} \cong \mathfrak{su}(2) \oplus \mathbb{R},$$

called the four-gate tension algebra, whose generators organize the irreducible transport and readout channels;

(vii) a unified tension connection

$$\mathcal{D} = d + \mathcal{A}, \qquad \mathcal{A} \in \Omega^1(\mathcal{B}_6, \mathfrak{g}_T),$$

with curvature

$$\mathcal{F} = \mathcal{D}^2,$$

providing the field-level carrier of the gate structure;

(viii) an admissibility operator

$$\mathcal{O}_{\text{adm}},$$

which selects the physically meaningful curvature sector

$$\Omega_{\text{read}} := \mathcal{O}_{\text{adm}}(\mathcal{F}),$$

thereby implementing the distinction between total geometric content and admissible physical readout;

(ix) an internal–external covariance principle, formulated in later FBT papers as *S-Covariant Internal–External Correspondence* (SCIEC), which relates internal symmetry and external geometric readout as two compatible manifestations of the same structural parent.

4.3 Interpretive role of the core

These objects should not be interpreted as independent axioms. They form a minimal structural package.

The symplectic manifold $(\mathcal{B}_6, \omega)$ provides the primary geometric arena. The 4+2 decomposition identifies the distinction between the effective horizontal readout sector $\mathcal{M}_4$ and the compact dual-phase sector Σ_2. The Berry bundle on Σ_2 introduces geometric phase, topological quantization, and the locking mechanism responsible for discrete stability. The four-gate tension algebra organizes the admissible transport channels. The unified tension connection gives these channels field-level expression. The admissibility operator separates physically meaningful structure from redundant or unreadable geometric content. Finally, SCIEC states that internal symmetry and external geometry are not primitive independent sectors, but two constrained readouts of one common structural substrate.

In this sense, the mathematical core provides the *realization layer* of the ontological postulates introduced in the present paper: Postulate A identifies the primacy of structure, Postulate B is implemented by the symplectic and admissibility conditions, Postulate C governs the selection of admissible histories within this core, and Postulate D is realized through Berry quantization, phase locking, and the topological protection of discrete sectors.

4.4 Minimality claim

The present paper does not claim that the above structures are already sufficient to derive a full dynamical theory. Rather, it claims that the later constructions of the FBT series can be reduced to this minimal core.

Remark DELTA-4.1 (Constitutional vs. dynamical status)**.** The objects listed above define the minimal mathematical constitution of the FBT framework, not its final physical content. A complete dynamical theory would additionally require: (i) a specified action functional, (ii) a variational or path-integral selection principle in explicit form, (iii) a matter representation sector, and (iv) concrete observational or phenomenological consequences. These belong to the realization layer, not to the constitutional layer itself.

The broader programme, however, contains more than one route to its higher structures. To understand the standing of the present paper, one must therefore distinguish carefully between the DCQ route and the FBT route.

5 Relation Between the DCQ Route and the FBT Route

The broader programme developed in this series contains two distinct but ultimately convergent routes: the *DCQ route* and the *FBT route*. They should not be identified at the level of their starting points, even though later papers reveal strong structural overlap and eventual compatibility.

5.1 The DCQ route

The DCQ route begins from a discrete binary configuration space

$$\mathcal{H}_6 = \{\pm 1\}^6$$

and its phase–encoded embedding into the complex Grassmannian

$$\iota : \mathcal{H}_6 \hookrightarrow \mathrm{Gr}(3, 6).$$

Its first task is to establish a rigorous discrete–continuous–quantum correspondence: metric compatibility between the discrete and Grassmannian structures, representation-theoretic boson–fermion splitting, Berry curvature and topological quantization, and the emergence of mutual-phase orbit geometry. In this route, the Grassmannian construction is primary, and the later appearance of higher-dimensional geometric structures is obtained through successive geometric, spectral, and categorical developments.

5.2 The FBT route

The FBT route does not begin from $\mathrm{Gr}(3, 6)$. It begins instead from its own foundational structural principles (FP1 and FP2 in the internal terminology of the series), which require: (i) the existence of a minimal noncommutative structural generator, and (ii) finite structural distinguishability. From these inputs, the six-dimensional symplectic arena

$$(\mathcal{B}_6, \omega)$$

is reconstructed directly, together with its canonical 4+2 splitting, dual-phase sector, Berry structure, admissibility layer, and gate-based transport/readout architecture. In this route, the six-dimensional symplectic manifold is primary, and later physical sectors are read out from it.

5.3 Convergence and distinction

The two routes therefore differ in direction:

- the DCQ route proceeds

  $$\text{discrete binary structure} \longrightarrow \mathrm{Gr}(3, 6) \longrightarrow \text{phase geometry, quantization, and higher structural}$$

- the FBT route proceeds

  $$\text{structural postulates} \longrightarrow (\mathcal{B}_6, \omega) \longrightarrow \text{admissible readout, dual-phase structure, and effective p}$$

Thus DCQ and FBT are not identical formulations of the same starting point. They are two non-equivalent entry routes into a broader architectural programme.

Nevertheless, they are not unrelated. Both routes converge toward a common family of structural themes: phase geometry, Berry curvature, topological quantization, boson–fermion differentiation, admissibility constraints, and the emergence of physically meaningful readout from a deeper geometric substrate. For this reason, the two routes should be understood neither as independent theories nor as simple reformulations of each other, but as *structurally convergent developments within one wider research programme.*

Remark DELTA-5.1 (Methodological significance). The distinction between the two routes is important for both conceptual and expository reasons. Conceptually, it prevents the mistaken impression that the FBT framework is merely a continuation of the Grassmannian construction, or that the DCQ series already presupposes the full FBT symplectic arena. Expositorily, it clarifies why some later structures may admit both a DCQ realization and an FBT realization while still arising from different foundational pathways.

Once this distinction is made, the next task is to record what has in fact already been achieved across the current programme.

6 Established Structural Results of the Current Programme

The present paper is constitutional rather than constructive. Its primary task is to articulate the ontological and architectural conditions under which a physical theory may count as admissible within the broader DCQ–FBT programme.

At the same time, the programme is not purely programmatic. A nontrivial body of structural results has already been obtained in the existing DCQ and FBT papers. The purpose of the present section is not to reproduce proofs, but to record, in compressed form, the principal realized structures that now define the current state of the programme.

6.1 I. Established results on the DCQ route

Along the DCQ route, the following structural results have been established.

(D1) **Discrete binary starting space and phase encoding.** A finite binary configuration space

$$\mathcal{H}_6 = \{\pm 1\}^6$$

was identified as the minimal discrete arena supporting pairing structure, phase encoding, and a nontrivial global boson–fermion differentiation, together with a phase–encoded embedding

$$\iota : \mathcal{H}_6 \hookrightarrow \mathrm{Gr}(3, 6).$$

(D2) **Discrete–continuous metric correspondence.** The discrete pairwise metric on $\mathcal{H}_6$ was shown to coincide with the induced geodesic distance on the image of the Grassmannian embedding, thereby establishing a rigorous metric compatibility between the discrete and continuous descriptions.

(D3) **Quantum state-space decomposition.** The induced quantum state space was shown to admit a natural representation-theoretic decomposition into bosonic and fermionic sectors with total effective dimension

$$20 + 4 = 24,$$

providing the structural origin of the 24-fold degeneracy appearing throughout the DCQ development.

(D4) **Berry geometry and topological quantization.** The determinant line bundle over $\mathrm{Gr}(3,6)$ was shown to carry a Berry connection whose curvature defines an integral cohomology class, yielding topological quantization of the associated geometric phase.

(D5) **Mutual-phase orbit geometry.** The Grassmannian construction was refined into a mutual-phase orbit geometry and corresponding orbit-space description adapted to the phase structure induced by the binary embedding.

(D6) **Categorical and statistical refinement.** The later DCQ development organized the bosonic and fermionic sectors into a neutral double-space structure with categorical statistics, homological differentiation, and a nontrivial double-space path-integral framework.

(D7) **Measure factorization and convergence framework.** An explicit double-space path-integral construction was introduced in which the total measure factorizes into bosonic, fermionic, and Berry-curvature contributions, including a finite-dimensional non-perturbative integral over the relevant bosonic orbit space and fermionic fracture sector together with a structural convergence analysis.

(D8) **Structural entropy and spectral-topological invariants.** The DCQ route further identified a distinguished structural entropy

$$S_{\text{struct}} = \ln 24$$

and a spectrum–Chern duality of the form

$$X_{\text{fracture}} = \chi_{\text{fracture}} = 6,$$

thereby linking discrete state multiplicity, categorical statistics, spectral structure, and topological invariants.

(D9) **Double-space construction and emergent dimensionality.** The DCQ route developed a double-space framework in which the emergent geometry is organized into a bosonic orbit sector and a fermionic fracture/statistical sector, later refined into a neutral double-space description. At the geometric level, the phase-orbit submanifold

$$\mathcal{N} \simeq (\mathbb{C}P^1)^3$$

was shown to undergo a nontrivial dimensional reduction: despite the 18-dimensional ambient Grassmannian structure and the 6-dimensional phase manifold, Berry-induced phase-locking together with symplectic reduction produce an effective configuration space

$$\mathcal{C}_\delta$$

of real dimension 4. This result provides one of the first explicit realizations, within the DCQ route, of how a lower-dimensional physical readout space can emerge from a higher-dimensional discrete–geometric parent.

(D10) **Symmetry breaking to a six-dimensional symplectic** $4{+}2$ **structure.** A later step in the DCQ route proposed a controlled symmetry-breaking pathway from the projective Grassmannian $\mathrm{Gr}(3,6)$ to a six-dimensional symplectic manifold carrying canonical Darboux structure. At the intermediate stage, the relevant constrained sector is organized as

$$(\mathbb{C}P^1)^3,$$

and a subsequent collective phase-locking/condensation mechanism yields a distinguished decomposition into an effective four-dimensional sector and a residual two-dimensional dual-phase sector. While this construction belongs to the realization layer rather than to a finalized low-energy physical theory, it marks an important structural completion of the DCQ route: the emergence of a six-dimensional symplectic parent with an explicit 4+2 organization.

6.2 II. Established results on the FBT route

Along the FBT route, the following structural results have been developed at the realization level.

(F1) **Direct reconstruction of the six-dimensional symplectic arena.** Starting from the foundational structural principles of the FBT series, the programme reconstructs a six-dimensional symplectic manifold

$$(\mathcal{B}_6, \omega)$$

as the primary geometric parent of the framework, rather than taking spacetime, matter, or field variables as primitive inputs.

(F2) **Canonical 4+2 splitting.** The six-dimensional arena was shown to admit a canonical horizontal–vertical decomposition

$$T\mathcal{B}_6 = \mathrm{Hor} \oplus \mathrm{Vert}, \qquad \mathrm{Hor} \cong T\mathcal{M}_4, \qquad \mathrm{Vert} \cong T\Sigma_2,$$

thereby isolating an effective four-dimensional readout sector together with a compact dual-phase sector.

(F3) **Dual-phase compact sector and Berry geometry.** The vertical sector was identified with a compact dual-phase surface

$$\Sigma_2 \simeq T^2,$$

equipped with Berry connection, phase-locking structure, and topological quantization data. This sector supplies the geometric carrier of phase information and discrete stability within the framework.

(F4) **Four-gate tension algebra.** A minimal transport algebra

$$\mathfrak{g}_T = \mathrm{span}\{X, Y, Z, S\} \cong \mathfrak{su}(2) \oplus \mathbb{R}$$

was isolated as the irreducible gate structure organizing the basic transport and readout channels of the theory.

(F5) **Unified tension connection and field language.** The gate structure was lifted to field level through a unified tension connection and, in later formulations, a unified tension-field description. This provided a common geometric language for curvature, transport, coupling, and readout across the FBT framework.

(F6) **Admissibility framework for physical readout.** A distinction was introduced between total geometric curvature and physically admissible readout through an admissibility operator

$$\mathcal{O}_{\text{adm}}, \qquad \Omega_{\text{read}} = \mathcal{O}_{\text{adm}}(\mathcal{F}),$$

thereby formalizing the separation between structural possibility and physical realizability.

(F7) **Internal–external covariance.** The relation between internal symmetry and external geometric readout was formulated as a structural covariance principle, later named *S-Covariant Internal–External Correspondence* (SCIEC). This principle expresses the claim that internal and external sectors are not independent primitives, but compatible readouts of one common structural parent.

(F8) ***S*-channel condensation and geometric readout.** The central gate S was identified as a distinguished channel through which low-energy geometric readout may occur, leading to the S-condensation mechanism and, at the realization level, to an effective vierbein- or metric-like description of emergent geometry.

(F9) **Path-integral, measure-theoretic, and thimble convergence programme.** Beyond the geometric kinematics, the FBT route developed a systematic programme for the treatment of path-integral and measure-theoretic difficulties in the noncommutative setting. This includes admissible fracture measures, Berry-compatible integration schemes, convergence analysis for complexified integration domains, and the identification of an A_3-induced three-branch thimble structure in the relevant convergence region.

(F10) **Structural entropy, logarithmic mass ladder, and mass fits.** Within the FBT development, the number 24 and its logarithm

$$\ln 24$$

were promoted from degeneracy data to structural quantities governing admissible hierarchy. In particular, $\ln 24$ was interpreted as a logarithmic mass-ladder parameter, and the programme developed nontrivial structural fits to observed fermionic and bosonic mass hierarchies. At present, these fits are best understood as evidence of internal structural coherence and phenomenological plausibility rather than as a fully finalized unique derivation of all mass data.

(F11) **Relativistic, quantum, and Standard-Model emergence routes.** In later FBT work, the programme was further extended toward three higher-level realization themes: first, a structural route to effective special-relativistic kinematics and Lorentz-signature readout; second, a geometric reconstruction of quantum-theoretic features from Berry, symplectic, and admissibility structures; and third, an emergence route toward Standard-Model-like physics, including gauge-readout patterns, matter-sector organization, and interaction-channel structure. These developments should be read as major realization claims of the programme, though not yet as a universally finalized derivation of the full relativistic, quantum, and phenomenological closure of the theory.

6.3 III. Convergent themes across the programme

Although the DCQ and FBT routes begin from different mathematical starting points, they already converge toward a recognizably common structural vocabulary. Among the most significant recurring themes are:

- phase geometry and Berry curvature;
- topological quantization;
- boson–fermion differentiation;
- admissibility and readout constraints;
- path-integral selection and convergence structure;
- effective lower-dimensional readout emerging from a richer higher structural parent;
- and the repeated appearance of distinguished invariants such as 24, $\ln 24$, and 6.

These recurrent motifs do not yet prove a full equivalence of the two routes. They do, however, justify treating them as structurally convergent realizations within one wider programme rather than as merely unrelated constructions.

Remark DELTA-6.1 (Interpretive status of the present map)**.** The function of the present section is diagnostic. It records what the programme can already claim at the level of realized structure. Questions concerning the logical status of these claims—whether they belong to the constitutional layer, the realization layer, or the still-open forward agenda—are separated out in the following section.

The map above records what the programme can already claim at the level of realized structure. A different but complementary question concerns the *status* of those claims: which belong to the constitutional layer, which to the realization layer, and which remain explicitly open.

7 Status of Claims: Constitution, Realization, and Open Tasks

A recurrent difficulty in foundational programmes is the tendency to mix different levels of assertion: constitutional principles, realized structural constructions, interpretive proposals, and open technical ambitions are often stated in the same register. To avoid this ambiguity, we explicitly distinguish the status of claims within the present DCQ–FBT programme.

The distinction is threefold:

(i) **Constitutional claims:** claims concerning the ontological and architectural conditions that define admissibility at the programme level;

(ii) **Realization claims:** claims concerning structural constructions and partial technical closure already achieved within the existing papers;

(iii) **Open tasks:** claims that remain incomplete, provisional, or only partially realized, and therefore belong to the forward research agenda rather than to the established architectural core.

7.1 I. Constitutional claims

At the constitutional level, the programme asserts:

- that physical reality is to be understood structurally rather than in terms of primitive objects or fields;
- that physical observability is constrained by symplectic admissibility rather than granted a priori;
- that realized histories are selected from a space of admissible processes by structural stability and consistency conditions;
- and that discrete, quantized, or integer-valued physical sectors require a topological locking mechanism in order to remain stable under continuous deformation.

These claims are architectural rather than empirical. They define the admissibility conditions under which any realization of the programme must operate.

7.2 II. Realization claims

At the realization level, the programme can already claim explicit geometric, topological, spectral, and path-integral constructions.

On the DCQ side, this includes: the discrete binary starting space, the phase–encoded embedding into $\mathrm{Gr}(3,6)$, metric compatibility, representation-theoretic boson–fermion decomposition, Berry curvature and topological quantization, mutual-phase orbit geometry, double-space categorical refinement, measure-factorized path-integral constructions, and the identification of invariants such as $\ln 24$ and $X_{\text{fracture}} = \chi_{\text{fracture}} = 6$.

On the FBT side, this includes: the direct reconstruction of the six-dimensional symplectic arena, the canonical 4+2 splitting, the compact dual-phase sector, the four-gate tension algebra, the unified tension connection and field language, the admissibility framework, SCIEC, S-channel geometric readout, regularization schemes for path-integral and measure-theoretic difficulties, the identification of an A_3-induced three-branch thimble configuration, and the promotion of $\ln 24$ to a logarithmic mass-ladder parameter together with corresponding structural mass fits.

These claims are stronger than constitutional postulates because they involve explicit constructions, but they remain weaker than a completed predictive physical theory.

7.3 III. Interpretive intermediate claims

Between constitution and full closure lies an intermediate class of claims: interpretive claims supported by structural constructions but not yet reduced to full theorem-level or phenomenological closure.

Examples include: the interpretation of the dual-phase sector as a physically meaningful readout kernel, the reading of S-condensation as a low-energy geometric channel of emergent spacetime, the interpretation of $\ln 24$ as both structural entropy and mass hierarchy parameter, the role of A_3-type singularity structure in selecting convergent thimble sectors, and the claim that the DCQ and FBT routes are convergent rather than merely parallel.

These should be read as structurally grounded bridges between explicit constructions and the still-open dynamical theory.

7.4 IV. Open technical tasks

Several major tasks remain open and should not be mistaken for already completed parts of the programme.

(O1) **Fully stabilized action functionals.** Although action principles and path-integral structures have been proposed in multiple places, the programme has not yet produced a fully stabilized action functional closing the entire DCQ–FBT architecture in one definitive form.

(O2) **Complete dynamical derivation.** The programme has not yet reached a final derivation of the full dynamical equations governing the unified geometric parent together with its effective low-energy readout sectors.

(O3) **Matter-sector completion and anomaly control.** A complete matter representation sector, together with a systematic treatment of anomaly cancellation or anomaly control, remains to be formulated in final form.

(O4) **Observation-level extraction.** Although structural fits and phenomenological correspondences have been developed, the programme has not yet completed a systematic extraction of sharply testable observational predictions in standardized form.

(O5) **Comparison of the DCQ and FBT routes at derived level.** The structural convergence of the two routes has been identified, but a full derived-level comparison—showing precisely how one route maps into, reconstructs, or constrains the other—remains unfinished.

(O6) **Siegel-theta-based mass matrix.** Although mass hierarchies and logarithmic ladder structures have been developed, the programme has not yet produced a finalized mass-matrix construction explicitly grounded in Siegel theta functions.

(O7) **Perfect fusion of tension algebra and thimble convergence.** The programme has identified both a nontrivial tension algebra and a structured thimble convergence sector, including A_3-induced three-branch splitting. However, these two structures have not yet been fused into a single fully closed formalism in which the gate/tension algebra directly governs the geometry of the convergent thimble region.

7.5 V. Present standing of the programme

The current DCQ–FBT programme is therefore best described as a *partially realized architectural framework*.

It is not merely a philosophical manifesto, because it already contains a substantial body of explicit geometric, topological, spectral, and path-integral constructions. It is not yet a completed physical theory, because major dynamical, modular, and phenomenological closure tasks remain open.

Remark DELTA-7.1 (Why this distinction matters)**.** The distinction between constitutional claims, realization claims, and open tasks is methodologically necessary. Without it, the programme risks being misunderstood either as a purely philosophical declaration with no mathematical body, or as a completed physical theory claiming more finality than has actually been achieved.

8 Relation to Established Frameworks

Although formulated independently, the postulates resonate with well–established principles across mathematical physics:

- **Structural Realism** aligns with ontic structural realism and with category–theoretic and functorial approaches to physics.
- **Symplectic Admissibility** generalizes Dirac's theory of constraints and the Marsden–Weinstein framework of symplectic reduction [4, 5].
- **Modal Determinism** is compatible with stability theory, variational principles, and Picard–Lefschetz theory in complexified path integrals [10].
- **Topological Locking** reflects the role of Chern numbers, index theorems, and topological phases in quantum and condensed–matter systems [7, 8, 9].

The present framework does not replace these results. It provides a unifying ontological interpretation in which they appear as manifestations of a single architectural constraint.

This relation to established frameworks should not, however, be read as a claim of completed reduction or completed derivation. The present paper remains constitutional in scope.

9 Scope and Limitations

This paper does not claim to derive physical couplings, interaction strengths, or dynamical laws from first principles in the sense of a complete predictive theory.

Its purpose is classificatory and constitutional. It identifies a set of structural conditions that any theory must satisfy if physical phase space, observability, dynamical selection, and discrete stability are to emerge from a higher–level geometric parent.

The mathematical notions invoked—symplectic non–degeneracy, structural stability, and topological invariance—are standard. The physical interpretation that elevates them to ontological criteria remains a structural hypothesis.

Future work is required to construct explicit dynamical measures and quantitative models that realize these postulates in concrete physical settings. Only at that stage can the present architectural framework be promoted from an organizing principle to a predictive theory.

10 Conclusion

We have proposed a minimal ontological constitution for the DCQ–FBT framework based on four postulates: Structural Realism, Symplectic Admissibility, Modal Determinism, and Topological Locking.

Together, these postulates define a closed architectural loop that specifies what is real, what is physical, how histories are selected, and why discrete structures remain stable. They do not prescribe a particular physical model. They delimit the class of models that may coherently claim to describe a reality in which phase space, interaction structure, and physical constants emerge from a deeper geometric substrate.

The paper has also clarified the relation between the constitutional layer and the realization layer of the current programme. In particular, it has distinguished the DCQ and FBT routes, recorded the minimal mathematical core of the FBT framework, and summarized the established structural results and open closure tasks of the wider programme.

In this sense, the framework is not a theory of nature but a theory of *theories of nature*. It functions as a constitutional layer that any admissible dynamical model must implicitly or explicitly satisfy.

The ultimate test of this architectural approach will be its capacity to guide the construction of concrete models that connect geometric structure to measurable physical phenomena without introducing external constants or ad hoc dynamical rules.

Acknowledgements

AI Tool Usage: The author used large language models during the manuscript preparation for brainstorming, text refinement, and improving exposition. **All central ideas, mathematical constructions, proofs, and conclusions are the sole intellectual product and responsibility of the author.**

References

References

[1] J. Worrall, "Structural Realism: The Best of Both Worlds?" *Dialectica* **43** (1989), 99–124.

[2] J. Ladyman, "What is Structural Realism?" *Studies in History and Philosophy of Science Part A* **29** (1998), 409–424.

[3] J. Bain, "Category Theory and the Foundations of Physics," in *The Oxford Handbook of Philosophy of Mathematics and Logic*, Oxford University Press, 2011.

[4] P. A. M. Dirac, *Lectures on Quantum Mechanics*, Yeshiva University, 1964.

[5] J. Marsden and A. Weinstein, "Reduction of Symplectic Manifolds with Symmetry," *Reports on Mathematical Physics* **5** (1974), 121–130.

[6] M. V. Berry, "Quantal Phase Factors Accompanying Adiabatic Changes," *Proc. Roy. Soc. Lond. A* **392** (1984), 45–57.

[7] J. W. Milnor and J. D. Stasheff, *Characteristic Classes*, Princeton University Press, 1974.

[8] M. F. Atiyah and I. M. Singer, "The Index of Elliptic Operators on Compact Manifolds," *Bull. Amer. Math. Soc.* **69** (1963), 422–433.

[9] D. J. Thouless, M. Kohmoto, M. P. Nightingale, and M. den Nijs, "Quantized Hall Conductance in a Two–Dimensional Periodic Potential," *Phys. Rev. Lett.* **49** (1982), 405–408.

[10] E. Witten, "Analytic Continuation of Chern–Simons Theory," *Amer. J. Math.* **133** (2011), 235–271. (Originally circulated as arXiv:1001.2933, 2010.)

[11] H. B. Lawson and M.-L. Michelsohn, *Spin Geometry*, Princeton University Press, 1989.

[12] A. D. Sakharov, "Vacuum Quantum Fluctuations in Curved Space and the Theory of Gravitation," *Soviet Physics Doklady* **12** (1968), 1040–1041.

[13] T. Regge and C. Teitelboim, "General Relativity à la String: A Progress Report," in *Proceedings of the First Marcel Grossmann Meeting*, (1975–1976 work; published 1977).

A Concrete Physical Instantiations

This appendix illustrates how the four postulates of the DCQ–FBT framework can be recognized in two foundational pillars of modern physics: relativity and quantum theory. It does not provide derivations of these theories from the postulates. Rather, it classifies them as *instances* that satisfy the architectural constraints articulated in the main text.

Remark DELTA-A.1 (Interpretive status)**.** This appendix is classificatory rather than constructive. Its purpose is to identify established physical frameworks as realizations of the architectural postulates, not as consequences uniquely implied by them.

A.1 Relativity as a Consequence of Structural Constraints

Relativity, in both its special and general formulations, may be understood as a theory that satisfies the four postulates within a Lorentzian geometric setting.

From Structural Realism to Spacetime Geometry

Postulate A (Structural Realism) asserts that physical reality is constituted by invariant geometric structures. In relativity, this role is played by a four–dimensional differentiable manifold $\mathcal{M}$ equipped with a Lorentzian metric $g_{\mu\nu}$. The physically meaningful entities are spacetime intervals, causal relations, and curvature tensors, rather than coordinate values or observer–dependent descriptions.

Different coordinate charts, tetrads, and reference frames correspond to different representations of the same underlying geometric structure. Diffeomorphisms and local Lorentz transformations act as admissible symmetries that leave the structural content invariant, reflecting the kernel of the representation map.

Symplectic Admissibility and Kinematical Invariance

For a relativistic particle or field, the phase space carries a natural symplectic structure, locally of the form

$$\omega = dp_\mu \wedge dx^\mu.$$

Admissible transformations of the physical degrees of freedom must preserve this structure.

The requirement that the restricted symplectic form remain non–degenerate on the physically admissible subspace is naturally aligned with transformations that preserve both the causal and metric structure of spacetime. When combined with the empirical constraint of an invariant characteristic speed, this admissibility condition selects a class of transformations consistent with the Lorentz group.

In this sense, Lorentz invariance may be interpreted as a kinematical compatibility condition between causal structure and symplectic admissibility, rather than as an independent postulate.

Modal Determinism and Variational Selection

In general relativity, the space of admissible processes is the space of Lorentzian metrics on $\mathcal{M}$ subject to appropriate boundary and regularity conditions. The Einstein field equations arise from a variational principle based on the Einstein–Hilbert action, which selects realized spacetime geometries as stationary points within this admissible space.

This reflects Postulate C (Modal Determinism): the underlying geometric structure determines the space of consistent histories, while the realized physical history corresponds to a structurally stable extremal within that space.

Topological Locking and Global Stability

Topological and global invariants play a stabilizing role in relativistic physics. Examples include conserved charges associated with asymptotic symmetries, horizon topology in black hole spacetimes, and index–type quantities that constrain the existence of certain field configurations.

Some global quantities, such as electric charge, admit direct topological characterizations (e.g. through Chern classes), while others, such as mass and angular momentum, are associated with geometric and symmetry–based conservation laws. Their robustness under continuous deformation of the spacetime geometry reflects the stabilizing role emphasized in Postulate D (Topological Locking).

Thus, the four postulates provide an architectural interpretation of relativity:

- Structural Realism $\longrightarrow$ spacetime geometry as the ontological carrier.
- Symplectic Admissibility $\longrightarrow$ kinematical compatibility with Lorentz–type invariance.
- Modal Determinism $\longrightarrow$ variational selection of physical geometries.
- Topological Locking $\longrightarrow$ stability of global and conserved quantities.

A.2 Quantum Mechanics as an Emergent Representation

Quantum mechanics may be interpreted as a particular representation of an underlying geometric and algebraic structure that satisfies the four postulates.

Structural Realism and State Space Geometry

In quantum theory, the physically meaningful structure is not the Hilbert space itself but its associated projective space, which encodes the rays of physical states. Observable quantities correspond to algebraic relations among operators, typically formalized as a C^*–algebra, rather than to individual state vectors.

Different representational choices, such as the Schrödinger and Heisenberg pictures, are related by unitary transformations that leave the underlying projective and algebraic structure invariant.

Symplectic Admissibility and Canonical Structure

The quantum state space carries a natural Kähler structure, whose imaginary part defines a symplectic form. In geometric formulations of quantum mechanics, this form governs the admissible transformations of physical states.

Postulate B requires that physically meaningful transformations preserve this symplectic structure. Within geometric quantization and related frameworks, this condition is compatible with the emergence of the canonical commutation relations, such as

$$[\hat{x}, \hat{p}] = i\hbar,$$

as structural features of admissible representations rather than as independent axioms.

Modal Determinism and Path–Integral Selection

In the path–integral formulation, the space of admissible processes is the space of all paths in configuration or field space. Physical predictions arise from a weighted sum over these paths, with weights determined by the action functional.

From the perspective of Modal Determinism, the classical limit corresponds to the selection of structurally stable paths by the principle of stationary phase, while quantum fluctuations correspond to admissible but non–extremal contributions. The measure and phase structure of the path integral reflect both the symplectic geometry (Postulate B) and the topology of the underlying configuration space (Postulate D).

Topological Locking and Quantized Observables

The discreteness of quantum numbers, such as angular momentum and topological response coefficients, admits a natural interpretation in terms of topological invariants.

For example, the integer quantization of Hall conductance is governed by a Chern number associated with the Berry curvature over the Brillouin zone. Similarly, the distinction between integer and half–integer spin is linked to the topology of the rotation group and its double cover.

These phenomena exemplify Postulate D: discrete physical sectors remain stable under continuous deformation because they are anchored in topological properties of the underlying state space.

Probability and Representation

In this architectural perspective, quantum probabilities may be interpreted as measures on the space of admissible representations rather than as fundamental physical propensities. Decoherence and measurement correspond to changes in the effective representation of the underlying structure induced by coupling to an environment, rather than to dynamical collapse processes.

Thus, quantum mechanics may be viewed as a representational layer built on a structurally constrained geometric substrate:

- Structural Realism $\longrightarrow$ projective state space and operator algebra.
- Symplectic Admissibility $\longrightarrow$ unitary and canonical transformations.
- Modal Determinism $\longrightarrow$ variational and path–integral selection.
- Topological Locking $\longrightarrow$ quantized and topologically protected observables.

A.3 Synthesis: Toward a Unified Architectural View

The preceding examples suggest that both relativity and quantum mechanics may be understood as specific realizations of a common architectural pattern defined by the four postulates.

A candidate theory of quantum gravity, within this perspective, would be expected to:

1. Identify ontologically fundamental geometric and algebraic structures (Postulate A).
2. Derive physical degrees of freedom through a principled reduction of redundant or gauge structure based on symplectic admissibility (Postulate B).
3. Provide a coherent selection principle for realized physical histories, possibly in variational or generalized path–integral form (Postulate C).
4. Explain the discreteness and stability of physical constants and sectors through topological invariants of the underlying geometry (Postulate D).

The DCQ–FBT framework does not itself constitute such a theory. It provides a constitutional layer that constrains the form any such theory must take if it is to coherently unify geometric structure, physical observability, dynamical selection, and topological stability.

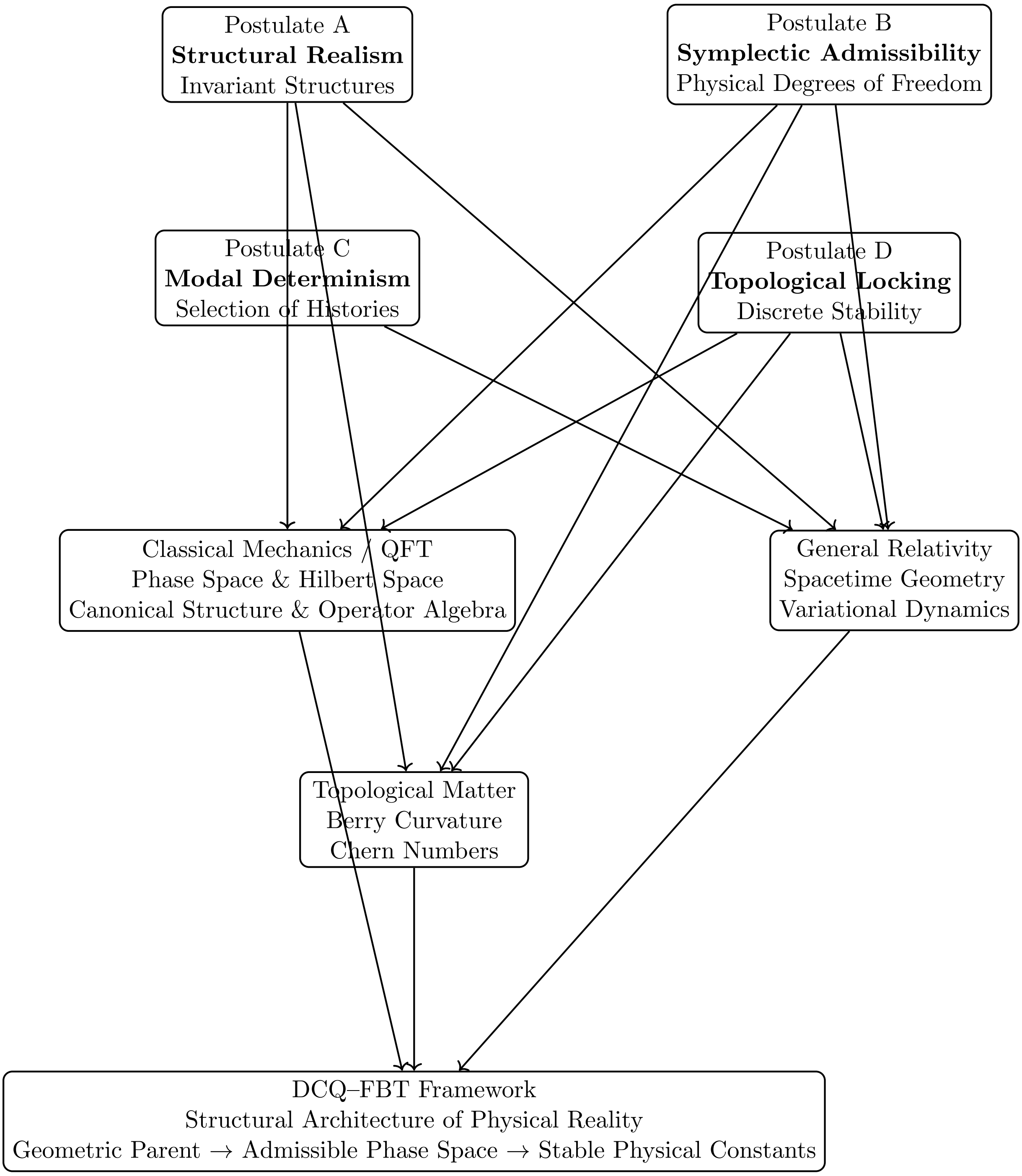

Table 1: Architectural Map of Physics. The four ontological postulates define a constitutional layer that constrains admissible physical frameworks. Classical mechanics, quantum field theory, general relativity, and topological phases appear as structural realizations satisfying different subsets of the postulates. The DCQ–FBT framework is positioned as an integrative architectural closure, relating these realizations to a common geometric parent structure.

B Philosophical Context and Implications

This appendix situates the DCQ–FBT framework within contemporary philosophical debates, clarifying its relationship to structural realism, emergence, reduction, and related concepts.

B.1 Structural Realism: Ontic vs. Epistemic

The term "structural realism" encompasses two distinct but related positions: *epistemic structural realism* (ESR) and *ontic structural realism* (OSR). The DCQ–FBT framework aligns with and extends the latter.

Epistemic Structural Realism (ESR)

ESR, associated primarily with John Worrall [1], asserts that our scientific knowledge is limited to the structural aspects of reality. We can know the mathematical relations that govern physical phenomena, but not the intrinsic nature of the relata. In ESR, structures are epistemological tools—they describe what we can know, not necessarily what exists.

Ontic Structural Realism (OSR)

OSR, developed by James Ladyman [2], Steven French, and others, makes a stronger claim: structure is all that exists. There are no objects with intrinsic properties "behind" the relations; rather, objects are constituted by their relational properties within a structure. OSR comes in several variants, from moderate (objects exist but are secondary to structures) to radical (objects are eliminated in favor of pure structures).

The DCQ–FBT Position

Postulate A (Structural Realism) explicitly adopts a strong ontic stance:

1. **Primacy of structure:** Geometric and algebraic structures are ontologically primitive, not derived from or dependent on objects or fields.

2. **Eliminativism toward objects:** The framework does not merely claim that we only know structures (epistemic), but that structures are what exist (ontic). Physical entities such as particles and fields are "admissible representations" of the underlying structure—they are how structure appears, not what structure is.

3. **Mathematical realism:** The structures in question are mathematical in nature, but they are not mere descriptions; they are constitutive of physical reality.

Thus, the DCQ–FBT framework aligns with a *radical ontic structural realism* that is also *mathematically realist*. It goes beyond traditional OSR by specifying the precise architectural constraints (Postulates B–D) that govern which structures are physically admissible and how they give rise to observable phenomena.

Relation to Category–Theoretic Structuralism

The framework is compatible with category–theoretic approaches to structural realism [3], where physical theories are understood as functors between categories of mathematical structures. In the DCQ–FBT view, the "admissible representations" of Postulate A can be formalized as natural transformations between functors, and the closed architectural loop of Section 3.5 corresponds to the commutativity of certain diagrams in a category of physical theories.

B.2 Emergence vs. Reduction

The DCQ–FBT framework challenges the traditional dichotomy between reductionism and emergence by introducing a third possibility: *structural constitution*.

Reductionism

Traditional reductionism assumes a hierarchy of levels (e.g., particle physics, chemistry, biology), where the laws and entities at higher levels can be derived from those at lower levels. In physics, this often takes the form of deriving macroscopic laws from microscopic dynamics, or obtaining classical mechanics as a limit of quantum mechanics.

Emergence

Emergentism asserts that higher-level phenomena possess novel properties that are not reducible to, nor predictable from, lower-level laws. Strong emergence claims causal powers that are not determined by the micro-level; weak emergence allows that higher-level phenomena are determined by but not reducible to lower-level laws due to complexity.

Structural Constitution in DCQ–FBT

The DCQ–FBT framework proposes a different picture:

1. **No fundamental level:** There is no "bottom level" of particles or fields from which everything else is constructed. Instead, there is a structural substrate that is not itself physical in the usual sense (it does not consist of entities interacting in spacetime).

2. **Representational emergence:** Physical entities, laws, and observables *emerge* as representations of the underlying structure (Postulate A and Remark DELTA-3.3). This emergence is not from a lower physical level to a higher one, but from a non-physical structural level to the physical world.

3. **Constrained emergence:** The form of emergence is tightly constrained by the architectural postulates. Not any representation is admissible—only those that preserve symplectic structure (Postulate B), are selected by modal determinism (Postulate C), and exhibit topological stability (Postulate D) can correspond to physical reality.

4. **Explanatory reduction without ontological reduction:** The framework allows for *explanatory reduction* in the sense that physical phenomena can be explained by reference to the underlying structural constraints. However, this is not

an *ontological reduction* because the structural substrate is not composed of physical entities.

Thus, the DCQ–FBT framework advocates for what might be called *structural constitutionalism*: physical reality is constituted by structures, not composed of particles, and the apparent "levels" of reality (quantum, classical, cosmological) are different representational regimes of the same structural substrate.

B.3 Relation to Other Philosophical Positions

Platonism and Mathematical Realism

The framework is compatible with a moderate form of mathematical Platonism: mathematical structures exist independently of human minds, and physical reality instantiates (or is constituted by) some of these structures. However, it adds an important constraint: not all mathematical structures are physically admissible—only those satisfying the four postulates can be realized as physical reality.

The Physicality Filter: Why Not All Mathematical Structures Are Real

A natural objection to any form of mathematical or ontic structural realism is the apparent overgeneration problem: if mathematical structures exist independently, what distinguishes those that are physically real from those that remain purely abstract?

The DCQ–FBT framework addresses this concern by introducing a *physicality filter* in the form of its architectural postulates. Not every mathematical structure qualifies as physically admissible. Only those structures that simultaneously satisfy:

1. the preservation of a non–degenerate symplectic form (Postulate B),
2. the existence of structurally stable histories (Postulate C), and
3. the presence of topologically protected discrete invariants (Postulate D),

can be represented as physical reality.

In this sense, the framework does not identify physical reality with the totality of mathematical structures, but with a sharply constrained subclass of them. Physical existence is thus not equivalent to mathematical existence; it is equivalent to *structural admissibility under geometric, dynamical, and topological constraints.*

Nominalism and Conventionalism

The framework opposes strict nominalism (which denies the existence of abstract objects) and radical conventionalism (which claims that physical laws are merely human conventions). While the representation map (Remark DELTA-3.3) allows for conventional choices (coordinates, units, gauge), the underlying structure and the constraints on admissible representations are objective and mind-independent.

Process Philosophy

In process philosophy (e.g., Whitehead), reality is fundamentally constituted by processes rather than substances. The DCQ–FBT framework shares this emphasis on dynamics: Postulate C (Modal Determinism) gives primacy to processes (admissible histories) over static entities. However, it grounds these processes in geometric and algebraic structures rather than in experiential events.

Information–Theoretic Approaches

Some recent approaches to physics (e.g., "it from bit") propose that information is fundamental. The DCQ–FBT framework can accommodate an informational interpretation: the underlying geometric structures encode information, and physical laws emerge from constraints on how this information can be processed. However, information in this sense would be structural and geometric, not merely Shannon–theoretic.

B.4 Implications for the Philosophy of Physics

The DCQ–FBT framework has several implications for ongoing debates in the philosophy of physics:

- **The interpretation of quantum mechanics:** By treating quantum states as representations of an underlying geometric structure (Appendix A.2), the framework offers a realist interpretation that avoids both the measurement problem and the need for hidden variables. Probability is reinterpreted as structural selection statistics (Remark DELTA-3.8).
- **The nature of spacetime:** Spacetime is not fundamental but emerges from the representation of structural constraints (Appendix A.1). This provides a philosophical foundation for approaches to quantum gravity that seek to derive spacetime from more fundamental structures.
- **The status of physical laws:** Laws are not imposed on nature from outside, nor are they mere regularities. They are necessary features of the way structural constraints manifest in admissible representations. This aligns with a *necessitarian* view of laws.
- **The unity of physics:** The framework suggests that the apparent disunity of physical theories (classical vs. quantum, relativistic vs. non-relativistic) reflects different representational regimes of a single structural substrate. The search for a theory of quantum gravity is thus the search for the common structural origin of these representations.

B.5 Conclusion: A New Philosophical Synthesis

The DCQ–FBT framework does not merely adopt existing philosophical positions; it synthesizes them into a novel perspective:

- **From OSR to architectural realism:** It extends ontic structural realism by adding specific architectural constraints that determine which structures are physically admissible.

- **From emergence to constitutional emergence:** It reconfigures the emergence debate by proposing that physical reality emergently represents a non-physical structural substrate, with the form of emergence tightly constrained by architectural principles.
- **From mathematical realism to physically constrained mathematical realism:** It agrees that mathematical structures are real, but adds that only a subset of these structures can be physically realized—those satisfying the four postulates.

This synthesis provides a coherent philosophical foundation for a research program that seeks to derive the fundamental laws of physics from geometric and algebraic constraints, rather than from dynamical principles governing microscopic entities.

C Notation and Core Terminology

This appendix records the principal notations and core terminology used throughout the paper. Its purpose is not to replace the formal definitions in the main text, but to provide a stable reference map for the structural language of the Fracture–Berry–Tension framework.

A. Core geometric structures

$(\mathcal{B}_6, \omega)$ — The fundamental six-dimensional symplectic manifold of the FBT framework. It is the primary geometric arena on which the unified tension structure is defined.

FBT six-dimensional symplectic manifold — A shorthand designation for the foundational symplectic geometry $(\mathcal{B}_6, \omega)$ together with the structural constraints imposed by the FBT framework.

canonical 4+2 splitting — The canonical horizontal–vertical decomposition

$$T\mathcal{B}_6 = \mathrm{Hor} \oplus \mathrm{Vert}, \qquad \mathrm{Hor} \cong T\mathcal{M}_4, \qquad \mathrm{Vert} \cong T\Sigma_2,$$

which separates the effective four-dimensional readout sector from the compact dual-phase sector.

$\mathcal{M}_4$ — The effective four-dimensional horizontal sector. In the low-energy regime it is interpreted as emergent spacetime.

Σ_2 — The compact dual-phase surface, typically taken to satisfy

$$\Sigma_2 \simeq T^2.$$

It carries the Berry geometric structure and forms the vertical sector of the 4+2 decomposition.

dual-phase sector — The compact phase-geometric sector represented by Σ_2. It supports phase locking, Berry curvature, and the topological data entering the readout structure.

dual-phase surface — The concrete geometric realisation of the dual-phase sector, namely the oriented compact surface Σ_2.

$\pi : \mathcal{B}_6 \to \mathcal{M}_4$ — The projection from the six-dimensional symplectic manifold to the effective horizontal sector.

horizontal sector / vertical sector — The horizontal sector refers to $\mathrm{Hor} \cong T\mathcal{M}_4$; the vertical sector refers to $\mathrm{Vert} \cong T\Sigma_2$.

B. Berry structure, phase geometry, and structural entropy

$\mathcal{L} \to \Sigma_2$ — The Berry line bundle over the dual-phase surface.

A_{Berry} — A Berry connection on the line bundle $\mathcal{L} \to \Sigma_2$.

Ω_{Berry} — The Berry curvature two-form associated with A_{Berry}:

$$\Omega_{\mathrm{Berry}} = \mathrm{d}A_{\mathrm{Berry}}.$$

phase locking — The structural locking condition that removes unphysical phase redundancy and stabilises the admissible geometric readout on the dual-phase sector.

dual-phase locking — A more specific term for phase locking when the locking mechanism is explicitly understood as acting on the compact dual-phase surface Σ_2.

Chern quantisation — The integrality condition

$$\frac{1}{2\pi}\int_{\Sigma_2} \Omega_{\mathrm{Berry}} \in \mathbb{Z},$$

ensuring topological quantisation of the relevant Berry curvature sector.

ln 24 structural entropy — The distinguished structural entropy associated with the minimal stable configuration count 24 in the FBT/DCQ framework. It is interpreted not as a generic thermodynamic entropy, but as a discrete structural entropy measuring the logarithmic complexity of the minimally admissible configuration class:

$$S_{\mathrm{struct}} := \ln 24.$$

structural entropy — A logarithmic measure of irreducible structural multiplicity. In the present framework it usually refers to $\ln 24$, which records the minimal stable degeneracy emerging from the underlying discrete-geometric architecture.

24-structure — A shorthand expression for the minimal twenty-fourfold structural multiplicity appearing in the boson–fermion decomposition, entropy counting, and related topological readout sectors.

C. Tension algebra and transport structure

$\mathfrak{g}_T$ — The tension algebra of the FBT framework.

four-gate tension algebra — The minimal gate algebra

$$\mathfrak{g}_T = \mathrm{span}\{X, Y, Z, S\} \cong \mathfrak{su}(2) \oplus \mathbb{R}$$

(or, at the compact readout level, $\mathfrak{su}(2) \oplus \mathfrak{u}(1)$), which organises the irreducible transport and readout channels.

X, Y, Z, S — The four tension gates. The generators X, Y, Z form the non-abelian triad, while S is the central generator.

S-channel — The central channel associated with the generator S. It plays a distinguished role in causal orientation, universal phase structure, and the low-energy geometric readout.

gate sector — The transport sector governed by the four-gate algebra $\mathfrak{g}_T$.

$\mathcal{A}$ — A $\mathfrak{g}_T$-valued connection one-form on $\mathcal{B}_6$, often interpreted as the unified tension connection:

$$\mathcal{D} = \mathrm{d} + \mathcal{A}.$$

$\mathcal{D}$ — The unified tension covariant derivative or connection operator.

$\mathcal{F}$ — The curvature of the unified tension connection:

$$\mathcal{F} = \mathcal{D}^2.$$

transport/readout channels — The four structurally distinguished channels through which curvature is organised and becomes physically legible in the FBT framework.

D. Unified field language

$\mathbf{T}$ — The unified tension field, written schematically as

$$\mathbf{T} = \sum_{A=X,Y,Z,S} \mathcal{T}_\mu^A \, T_A \, \mathrm{d}x^\mu.$$

unified tension field — The field-level object whose gate components encode the distinct tension channels. It provides the common structural source from which gauge and gravitational readouts emerge.

$\mathcal{T}_\mu^A$ — The component fields of the unified tension field along the gate direction $A \in \{X, Y, Z, S\}$.

$\mathcal{A}^S$ or $\mathcal{T}^S$ — The S-component of the unified tension connection or unified tension field.

E. Admissibility and physical readout

$\mathcal{O}_{\mathrm{adm}}$ — The admissibility operator acting on the total curvature sector.

admissibility operator — The structural filter that selects physically realisable curvature components from the total geometric curvature.

admissible readout — The physically meaningful curvature/readout sector selected by admissibility.

Ω_{read} — The admissible curvature defined by

$$\Omega_{\mathrm{read}} := \mathcal{O}_{\mathrm{adm}}(\mathcal{F}).$$

$\mathcal{H}_{\mathrm{phys}}$ — The physical Hilbert subspace selected by the admissibility constraints.

F. Internal symmetry and correspondence language

$\mathfrak{g}_{\mathrm{eff}}$ — The effective internal symmetry algebra acting on the admissible matter sector.

$\mathfrak{su}(3)_c \oplus \mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y$ — The Standard Model gauge algebra as it appears in the effective readout layer of the FBT framework.

V_{int} — The internal matter space carrying the effective gauge representation.

internal symmetry — The admissible gauge symmetry acting on the matter degrees of freedom.

external geometric readout — The effective spacetime/geometric sector read out from the unified tension geometry.

SCIEC — Abbreviation for *S-Covariant Internal–External Correspondence.*

S-Covariant Internal–External Correspondence — The structural principle stating that internal gauge symmetry and external geometric readout are not independent primitives, but two covariant and mutually constrained readouts of one unified tension geometry, with the S-channel ensuring the covariance relation.

internal–external covariance — A descriptive phrase referring to the SCIEC principle.

gate–gauge compatibility — The compatibility condition stating that the gate transport structure and the effective internal gauge structure act coherently on the same matter sector.

G. Gravitational readout and low-energy structure

S-condensation — The low-energy condensation of the central S-channel.

S-gate condensation — An equivalent term for S-condensation, used when the gate interpretation is emphasised.

$\langle \mathcal{T}_\mu^S \rangle = \kappa^{-1} e_\mu^a$ — The basic condensation ansatz identifying the background S-sector with a vierbein readout.

e_μ^a — The vierbein field obtained as the low-energy readout of the condensed S-sector.

$g_{\mu\nu}$ — The effective spacetime metric,

$$g_{\mu\nu} = \eta_{ab} e_\mu^a e_\nu^b.$$

gravitational readout — The effective geometric sector induced by the condensed or macroscopic behaviour of the S-channel.

causal phase — The universal phase structure associated with the central S direction.

H. Spectral and topological invariants

X_{fracture} — The spectral or fracture invariant associated with the fermionic fracture sector. Depending on context, it is interpreted as the corresponding spectral, Hausdorff, or effective fracture dimension read from the double-space geometry.

χ_{fracture} — The topological fracture invariant, typically defined through a Chern–Weil integral over the relevant bosonic and fermionic sectors.

spectrum–Chern duality — The structural duality equating the spectral fracture invariant with the topological Chern invariant:

$$X_{\text{fracture}} = \chi_{\text{fracture}}.$$

It expresses the principle that the effective spectral complexity of the fracture sector is topologically controlled.

$X_{\text{fracture}} = \chi_{\text{fracture}} = 6$ — The distinguished quantized value of the spectrum–Chern duality in the DCQ construction. In this form, the spectral fracture invariant and the topological fracture index coincide and are fixed to

$$X_{\text{fracture}} = \chi_{\text{fracture}} = 6.$$

spectral invariant $X = 6$
: A shorthand expression indicating that the relevant spectral fracture index is fixed to the quantized value 6.

fracture index
: A descriptive expression for the invariant value carried by the fracture sector. In DCQ language this is often identified with $\chi_{\text{fracture}} = 6$.

topological protection of 6
: The statement that the value 6 appearing in the fracture/spectral/Chern sector is not accidental, but stable under admissible continuous deformations because it is fixed by topological data.

I. Terminological summary

For clarity, the following terms should be treated as stable core expressions of the FBT framework:

Framework name:	Fracture–Berry–Tension (FBT) Framework
Primary arena:	FBT six-dimensional symplectic manifold
Structural split:	canonical 4+2 splitting
Vertical phase geometry:	dual-phase sector / dual-phase surface Σ_2
Core algebra:	four-gate tension algebra
Field-level object:	unified tension field
Selection mechanism:	admissibility operator / admissible readout
Correspondence principle:	SCIEC
Low-energy metric mechanism:	S-condensation
Stabilisation mechanism:	phase locking / dual-phase locking
Structural entropy:	$\ln 24$ structural entropy
Spectral-topological invariant:	spectrum–Chern duality
Quantized fracture value:	$X_{\text{fracture}} = \chi_{\text{fracture}} = 6$

Remark DELTA-C.1. When possible, these terms should be used with stable spelling across the paper series, so that the FBT vocabulary remains internally coherent and externally recognisable.