Concept Paper

Not peer-reviewed version

Entropic Projection in Diagrammatic Hilbert Space as a Concrete Realization of Generative Projection Architectures

Borros Arneth *

Posted Date: 27 February 2026

doi: 10.20944/preprints202602.1690.v1

Keywords: Diagram-Hilbert Space; DHS; entropy originated topological framework; EOTF; generative projection

Concept Paper

Entropic Projection in Diagrammatic Hilbert Space as a Concrete Realization of Generative Projection Architectures

Borros Arneth

Philipps University Marburg, Justus Liebig University Giessen, Germany, borros.arneth@staff.uni-marburg.de

Abstract

Foundational physics increasingly investigates whether spacetime geometry, quantum fields, and even the apparent universality of physical laws might be emergent from deeper informational or relational structures. In parallel, recent "generative projection" approaches in philosophy of physics propose that established theories can be interpreted as invariant-preserving projected domains arising from a deeper generative level, while remaining agnostic about the latter's mathematical realization. This paper develops a synthesis in which the Diagram–Hilbert Space (DHS) and Entropy-Originated Topological Projection / Entropic Ontological Transfer Framework (EOTF) are treated as a concrete candidate realization of such an architecture. We provide a compact mathematical formalism for diagrammatic state spaces, symmetry-defined equivalence classes, and entropy-constrained projection maps, and we introduce a stability criterion that selects "physical" projected sectors as fixed points of repeated entropic projection while preserving designated invariants. Within this perspective, quantum mechanics, gauge structure, and emergent geometry correspond to distinct stable projection regimes rather than competing fundamental ontologies. We conclude with a classification program for invariant-stable projection sectors and discuss how this reframes unification: from seeking a single universal formalism to identifying universal invariants and stability mechanisms that render effective theories robust.

Keywords: Diagram-Hilbert Space; DHS; entropy originated topological framework; EOTF; generative projection

---

1. Introduction

The contemporary landscape of fundamental physics is dominated by extraordinarily successful but conceptually heterogeneous frameworks. Quantum field theory (QFT) provides the standard language for matter and interactions, while general relativity (GR) models gravitation as spacetime geometry; both are empirically supported, yet their mutual interpretation remains unsettled in regimes where quantum and gravitational effects intertwine. This methodological tension is often presented as a technical obstacle to quantization or unification, but it also has an irreducibly ontological dimension: what, exactly, is the "world" that these theories describe? Classic expositions of QFT and quantum gravity already make clear how deeply the interpretation of theory-structure influences the direction of research, especially in regimes where measurement, locality, and background structure are nontrivial. [1,2]

Over the last three decades, a family of results has strengthened the case that spacetime and geometry may be emergent rather than primitive. The AdS/CFT correspondence suggests that a gravitational bulk can be dual to a non-gravitational quantum system, challenging the naive primacy of spacetime description. [3,4] The Ryu–Takayanagi relation and subsequent work connects geometric quantities to entanglement structure, implying that aspects of geometry might be reconstructed from quantum-informational features of the underlying state. [5,6] A complementary thermodynamic line of reasoning derives gravitational dynamics from local horizon

 doi:10.20944/preprints202602.1690.v1

thermodynamics, hinting that Einstein's equations can be read as an equation of state rather than a fundamental dynamical law. [7] Entropic approaches, while controversial, similarly propose that gravitational interaction can be interpreted through information and entropy gradients under broad assumptions. [8]

These developments resonate with black-hole thermodynamics, where entropy appears as a structural constraint linking information and geometry. [9,10] At the same time, the "information-theoretic turn" in statistical physics—particularly the maximum-entropy tradition—has supplied a powerful framework for understanding effective laws as inference under constraints. [11] A mature and technically precise body of information theory further clarifies which features are universal and which are model-dependent when entropy is used as a selection principle. [12] In quantum foundations, decoherence and "environment-induced selection" offer a mechanism for the stability of classical structures emerging from quantum systems, again emphasizing robustness and redundancy rather than primitive classicality. [13]

In philosophy of physics, these trends have encouraged structural and relational positions that treat invariants and symmetries as ontologically primary relative to objects, and that treat theory plurality as potentially legitimate rather than as an embarrassment requiring immediate reduction. [14,15] Related work on emergence and reduction argues that novelty and robustness can coexist with precise limiting or projection relations between theories, implying that "less fundamental" does not mean "less real." [16] Relational interpretations of quantum theory push in a similar direction by treating state attribution as framework-relative and insisting that some classical ontological expectations (absolute properties, observer-independent states) may be misplaced. [17]

Against this backdrop, Axelkrans' Generative Projection Framework (GPF) proposes an explicitly architectural ontology: projected physical descriptions are legitimate and internally coherent, but their apparent fundamentality should not be read off from formal scope or empirical dominance. Instead, admissibility is tied to the preservation of designated invariant structures across projection. [18,19] GPF is intentionally neutral about what the generative level "is," and it does not propose new physical postulates in the usual sense. This neutrality is philosophically disciplined, but it also raises a natural question: can one supply a mathematically concrete generative structure and projection scheme that implements the GPF architectural commitments while remaining compatible with established physics?

This paper argues that the DHS/EOTF research program by Borros Arneth can be interpreted as one such candidate realization, because it explicitly constructs a diagrammatic Hilbert space, defines projection operators and entropic selection principles, and aims to recover gravitational and gauge structures as emergent projections within a single operator framework. [20–24] Our goal here is not to reproduce the full technical claims of DHS/EOTF, nor to add new physical postulates; rather, it is to develop a journal-style synthesis with enough mathematical formalism to make the architecture precise, and to articulate how "invariance" and "entropic stability" together can function as a selection principle for effective physical sectors.

To motivate the choice of a diagrammatic Hilbert space as a generative candidate, it is helpful to recall that diagrammatic methods are not an exotic departure from standard physics: Feynman diagrams were introduced as computational and conceptual tools in QED, and perturbative expansions in QFT naturally organize themselves diagrammatically. [25,26] Diagrammatics became even more structurally prominent with large-N expansions and planar limits. [27] Independently, Penrose's early work on spin networks anticipated the use of combinatorial structures as carriers of quantum-geometric information, and spin-network bases later became central in loop quantum gravity. [28,29] Reviews of loop quantum gravity further demonstrate how graph- and network-based kinematics can encode geometric observables. [30] In condensed matter and quantum information, tensor networks and entanglement renormalization provide a mature Hilbert-space formalism where geometry-like structures emerge from entanglement organization. [31,32] The relationship between entanglement renormalization and holography strengthens the intuition that coarse-graining and network geometry can be deeply linked. [33]

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 February 2026 doi:10.20944/preprints202602.1690.v1

Finally, modern diagrammatic reasoning has been generalized and clarified using category-theoretic approaches that treat diagrams as representations of compositional processes, with precise correspondence between graphical calculus and algebraic structure. [34,35] Since invariance and symmetry are central to the selection of admissible physical structures, it is also natural to recall Noether's theorem as the canonical bridge between invariance and conservation, and Weyl's broader perspective on symmetry as an organizing principle. [36,37] Gauge theory itself is historically rooted in the demand for local symmetry. [38] String theory's conceptual toolkit, especially duality, further legitimizes the view that multiple formalisms can represent the same underlying content, reinforcing the architectural motivation. [39] With these threads in place, we now formalize a minimal "invariance + entropic stability" projection scheme in a diagrammatic Hilbert space, and we then interpret DHS/EOTF as a concrete instantiation of the generative component and its projection mechanisms.

2. Architectural Setting: Invariance-Preserving Projection

We adopt the GPF distinction between (i) a generative descriptive level and (ii) projected effective domains. [18,19] In the present synthesis, the generative level is realized as a diagrammatic Hilbert space $\mathcal{H}_D$, and projected domains correspond to effective subspaces $\mathcal{H}_{\mathrm{eff}}$ equipped with domain-appropriate invariants. The key architectural constraint is that projection is not understood as a time evolution in spacetime, but as a relation that selects stable representational regimes from the generative structure.

Let $\mathcal{I}$ denote a set of invariants that define the identity of an effective domain; depending on the target domain these may include unitarity structure, gauge equivalence, diffeomorphism-type redundancy, or more general relational invariants. The central admissibility requirement is that an admissible projection Π from the generative level to a projected domain preserves $\mathcal{I}$ in the relevant sense. In practice, this means that if O denotes a representative set of invariant-defining operators or relations, then the image under Π must remain within the same equivalence class or satisfy the same constraints.

This view is aligned with the physical centrality of invariance: conservation laws and stable interaction structures are commonly understood to be determined by symmetry constraints rather than introduced ad hoc. [36–38] The novelty here is not the importance of invariance, but its role as a criterion for "ontological admissibility of projected description," rather than as a marker of fundamentality.

3. Diagrammatic Hilbert Space: Kinematics and Equivalence

We define a diagrammatic configuration space $\mathcal{D}$ of labeled diagrams d. A diagram may be represented as a finite combinatorial structure $d = (V, E, \ell)$, where V is a set of vertices, $E \subseteq V \times V$ a set of edges (directed or undirected as needed), and ℓ a labeling map assigning types, weights, or representations to vertices and edges. Diagrammatic reasoning in QFT and quantum gravity motivates such structures as natural carriers of compositional and interaction information. [25–30]

A central move, compatible with DHS/EOTF, is to treat physically indistinguishable diagrammatic configurations as members of an equivalence class. [20,21] Let G be a group (or groupoid) acting on diagrams by relabeling, local rewriting, or symmetry transformation. We write $d \sim d'$ if $d^{'} = g \cdot d$ for some $g \in G$, or if d and d' are connected by a sequence of admissible rewrite moves preserving the designated invariants. The "microstates" are then equivalence classes $[d] \in \mathcal{D}/\sim$.

The diagrammatic Hilbert space is defined as

$$\mathcal{H}_D = \overline{\mathrm{span}}\{\, |[d]\rangle : [d] \in \mathcal{D} \nsim \},$$

with inner product initially taken as $\langle [d] \mid [d'] \rangle = \delta_{[d],[d']}$ for an orthonormal basis of equivalence classes, though weighted or kernel-based inner products may be used to encode similarity or overlap.

The use of Hilbert structure for combinatorial objects is consistent with both spin-network kinematics and tensor-network formalisms, even though the details differ. [29–32]

A symmetry action becomes a unitary representation $U(g)$ acting by $U(g)\mid[d]\rangle=\mid[g\cdot d]\rangle$. Invariant subspaces are then defined by

$$\mathcal{H}_D^G = \{\,|\,\psi\rangle \in \mathcal{H}_D: U(g)\,|\,\psi\rangle = |\,\psi\rangle \text{ for all } g\in G\,\},$$

or more generally by appropriate covariance conditions if the relevant invariants are not strict fixed-point conditions.

This already expresses a key GPF idea: ontological admissibility is not tied to a privileged object ontology, but to the persistence of structure under transformation. [18,19] It also aligns with structural realism's insistence that the primary ontological commitment is to structure, not to individuated objects. [14,15]

4. Entropic Projection as Constrained Selection

DHS/EOTF emphasizes entropy and topology as selection principles for effective physics. [20–24] To formalize this in a way that cleanly separates architecture from dynamics, we treat projection as a constrained selection map on state space rather than as a time evolution operator in spacetime.

Let a generic generative state be

$$|\,\Psi\rangle = \sum_{[d]} c_{[d]}\ \,|\,[d]\rangle, \sum_{[d]} |\,c_{[d]}\,|^2 = 1.$$

A natural probability distribution over diagram classes is $p_{[d]} = |\,c_{[d]}\,|^2$. We then define a Shannon–von Neumann–type entropy functional on the distribution,

$$S(|\,\Psi\rangle) = -\sum_{[d]} p_{[d]} \log\, p_{[d]},$$

in the spirit of maximum-entropy reasoning in statistical mechanics. [11] The information-theoretic meaning of such functionals and their constraint-based optimization is standard. [12]

Projection is modeled as selecting an effective representative $|\,\Phi\rangle$ in a target subspace $\mathcal{H}_{\mathrm{eff}} \subseteq \mathcal{H}_D$ by optimizing an entropy-regularized objective subject to invariant constraints. One flexible form is

$$\Pi_\lambda(|\,\Psi\rangle) = \text{arg min } |\,\Phi\rangle \in \text{Heff}(S(|\,\Phi\rangle) + \lambda\, D(|\,\Psi\rangle, |\,\Phi\rangle)),$$

where D is a divergence or distance functional on states (for example, relative entropy or a fidelity-based distance), and where the admissible set $\mathcal{H}_{\mathrm{eff}}$ is implicitly defined by the invariants $\mathcal{I}$ that the effective domain must preserve. The point is not to claim that Nature "computes" this optimization in time, but to encode a principle of selection: the effective domain is the stable, invariant-admissible representational regime singled out by an entropic criterion under constraints. This generalizes the inferential logic of maximum entropy into an ontological selection principle, while remaining compatible with the idea that physical laws appear robust because they correspond to stable structures under selection. [11,12,18]

The connection to decoherence is conceptual but instructive: decoherence theory explains the stability of certain classical structures as redundancy-selected "pointer states" produced by interaction with an environment, emphasizing robustness and selection rather than fundamental classicality. [13] In the present setting, "environment" is not required; instead, the selection is encoded at the level of admissible projected domains and entropic stability, but the methodological lesson—robustness as selection of stable structures—remains relevant. [13]

5. Invariant-Stable Sectors as Effective Physical Domains

The key technical notion connecting GPF's invariance criterion with DHS/EOTF's entropic selection is stability under repeated projection. Define an effective sector $\mathcal{H}_\alpha \subseteq \mathcal{H}_D$ to be invariant-admissible if it satisfies the invariant constraints $\mathcal{I}_\alpha$, and entropically stable if repeated application

 doi:10.20944/preprints202602.1690.v1

of the projection returns the state to the same sector (up to equivalence in $\sim$). One convenient formulation is the fixed-point condition

$$\Pi_\lambda(\mathcal{H}_\alpha) \subseteq \mathcal{H}_\alpha, \text{ and ideally } \Pi_\lambda \restriction_{\mathcal{H}_\alpha} \approx \mathrm{id}_{\mathcal{H}_\alpha}.$$

In words: once the generative state has been "projected" into a stable admissible domain, further projection does not drive it out of that domain. This is the formal analogue of a stable rendered interface in a generative architecture: the world we observe is the set of stable projections, not the full generative state space. This captures the architectural GPF claim that projected theories are not approximations of a hidden physical substrate but coherent domains of description stabilized by invariant structure. [18,19]

At this point, it becomes natural to interpret different effective theories as different invariant-stable sectors. The reason quantum theory, quantum fields, and geometry can appear mutually dissonant is then not that one is "wrong," but that each is a stable projection regime governed by a different invariant profile. This corresponds to the pluralist compatibility motif in GPF and aligns with philosophical arguments that emergent novelty and robustness can be consistent with precise inter-theory relations. [16]

6. Emergent Quantum Dynamics Inside a Stable Sector

Once a stable sector $\mathcal{H}_Q$ is identified, effective quantum dynamics can be introduced as unitary evolution internal to that sector, in the standard form

$$i\hbar \frac{d}{dt} \mid \psi(t)\rangle = H_{\text{eff}} \mid \psi(t)\rangle, \mid \psi(t)\rangle \in \mathcal{H}_Q.$$

The architectural point is not that Π_λ supplies H_{eff} uniquely, but that unitary structure is an invariant that defines admissibility for a quantum-mechanical effective domain. This is consistent with viewing quantum mechanics relationally: the meaning of the quantum state and its attribution may be sector-relative, while the unitary structure remains the stable invariant content. [17]

Diagrammatic and compositional viewpoints reinforce this reading. Feynman's diagrammatic calculus is not merely a computational trick; it encodes compositional structure of processes. [25,26] Category-theoretic treatments show how diagrammatic reasoning can be made rigorous as a calculus of morphisms in symmetric monoidal categories, which is useful when the underlying degrees of freedom are inherently compositional and relational. [34,35] In this sense, DHS-style "diagram states" can be viewed as generative carriers of compositional quantum structure, with effective unitary dynamics emerging in those stable sectors that preserve the relevant invariants.

7. Emergent Geometry from Correlations and Entanglement Organization

To connect diagrammatic structure to emergent geometry, it is useful to recall that in holography and related programs, geometric quantities are often reconstructed from entanglement or correlation data. [3–6] A minimal way to express this within a diagrammatic Hilbert space is to define an effective distance function from correlators of suitable operators associated to substructures of diagrams. If O_i denotes an operator associated with a subgraph, region, or algebra element, one can define a correlation-based distance such as

$$d(i,j) \;=\; -\log \mid \langle O_i O_j \rangle - \langle O_i \rangle \langle O_j \rangle \mid.$$

The specific choice is not unique, but the conceptual role is: a geometry can be induced from relational/correlation structure, and stable low-entropy sectors may correspond to approximately classical geometries, while higher-entropy sectors correspond to fluctuating or non-geometric regimes. This is consonant with the entanglement-geometry perspective and with thermodynamic derivations of gravitational dynamics as emergent. [5–8]

Tensor-network methods make this intuition technically concrete in many-body physics: network geometry tracks entanglement structure, and renormalization procedures organize degrees of freedom across scales. [31,32] Swingle's proposal relating entanglement renormalization to holography further strengthens the idea that a network-organized Hilbert space can underwrite

 doi:10.20944/preprints202602.1690.v1

emergent geometry. [33] These results do not prove that any specific diagrammatic Hilbert space yields spacetime, but they strongly motivate the plausibility of geometry emerging as an effective invariant-stable projection regime within a larger relational state space.

8. Gauge Structure as Redundancy and Automorphism in Diagram Space

Gauge invariance is historically and conceptually tied to local symmetry requirements. [38] In a diagrammatic setting, gauge redundancy can be modeled as an automorphism structure of diagram classes: local relabelings that preserve adjacency and interaction constraints correspond to gauge transformations. More formally, if $\mathrm{Aut}([d])$ denotes the automorphism group of the equivalence class $[d]$, then an effective gauge group can be identified as a subgroup of automorphisms that preserve the invariant content defining the sector. The emergence of gauge fields can then be interpreted as the need to compare local representatives across equivalence, which in turn suggests connection-like data as effective variables internal to the projected domain.

This viewpoint is compatible with the deep link between invariance and conservation articulated by Noether. [36] It also reflects Weyl's broader stance that symmetry principles often organize physical law more deeply than mechanistic pictures of "forces" acting between primitive objects. [37] In the present synthesis, gauge structure is not added as a separate ontological ingredient; rather, it is interpreted as a structural invariant that defines admissible effective sectors and is preserved under projection.

9. DHS/EOTF as a Concrete Realization of the Generative Component

Up to this point, we have described a general synthesis: a diagrammatic Hilbert space provides a concrete generative level; projection is modeled as entropy-constrained invariant-admissible selection; physical domains correspond to invariant-stable projection sectors. The DHS/EOTF program can be read as a specific instantiation of this architecture, because it explicitly proposes (i) a unified Hilbert space of topological/diagrammatic states, (ii) projection operators selecting particle and field subsectors, and (iii) an entropic assignment connecting topological invariants, partition functions, and effective physical parameters. [20–24]

From the GPF standpoint, the key gain is architectural clarity. GPF's neutrality about the generative structure makes it broadly applicable but also empirically noncommittal; DHS/EOTF turns this into a concrete hypothesis space by specifying a candidate generative Hilbert space and concrete projectors. [18–21] Conversely, DHS/EOTF gains from the GPF perspective by being interpretable not merely as "another unification attempt," but as an explicit proposal for how multiple effective theories can be ontologically legitimate as stable projections from one generative structure. This shift in framing is particularly relevant given how modern dualities undermine naive demands that unification must produce a single privileged set of fundamental variables; string-theoretic duality is the canonical example. [39]

10. Unification Reframed as Classification of Invariant-Stable Sectors

The synthesis suggests that "unification" should be understood less as the derivation of all physics from one privileged formalism, and more as the identification of (a) the invariant constraints defining admissible effective domains and (b) the stability/selection mechanism that makes those domains robust. This does not eliminate the need for technical derivations; rather, it reorganizes what counts as a fundamental question. Under this perspective, the core tasks become (i) specifying invariants that characterize physically meaningful sectors, (ii) defining entropic (or complexity-like) functionals that implement stability selection, and (iii) classifying fixed points and flows induced by repeated projection in $\mathcal{H}_D$.

This program is naturally aligned with the idea that emergent regimes can be both novel and robust while remaining compatible with precise inter-theory relations, rather than requiring eliminative reduction. [16] It also aligns with the methodological lessons of decoherence, where

 doi:10.20944/preprints202602.1690.v1

classicality is an emergent stability phenomenon. [13] The point is not to claim that entropy alone "explains everything," but to argue that entropy, when paired with invariance constraints, is a principled candidate for why some effective structures persist as stable projected realities.

11. Conclusion

We have provided a journal-style synthesis connecting the Generative Projection Framework's architectural commitments to a concrete generative realization in terms of diagrammatic Hilbert space and entropy-constrained projection, with DHS/EOTF as an explicit candidate instantiation. The essential conceptual move is to treat physical laws and effective theories as invariant-stable projection sectors rather than as competing claims to fundamentality. The essential formal move is to define diagrammatic equivalence classes, symmetry-admissible subspaces, and entropic projections whose fixed points correspond to robust effective domains. This reframes unification as a classification problem over invariant-stable sectors and stability mechanisms, a perspective strongly motivated by holography, emergent gravity arguments, tensor-network geometry, and structural-realist ontology. [3–8,14,15,18–21,31–33]

References

1. S. Weinberg, The Quantum Theory of Fields, Vol. I: Foundations, Cambridge University Press, 1995.
2. C. Rovelli, *Quantum Gravity*, Cambridge University Press, 2004.
3. J. M. Maldacena, "The Large N Limit of Superconformal Field Theories and Supergravity," *Advances in Theoretical and Mathematical Physics* **2** (1998) 231–252.
4. E. Witten, "Anti–de Sitter Space and Holography," *Advances in Theoretical and Mathematical Physics* **2** (1998) 253–290.
5. S. Ryu and T. Takayanagi, "Holographic Derivation of Entanglement Entropy from AdS/CFT," *Physical Review Letters* **96** (2006) 181602. doi:10.1103/PhysRevLett.96.181602.
6. M. Van Raamsdonk, "Building up spacetime with quantum entanglement," *General Relativity and Gravitation* **42**(2010) 2323–2329.
7. T. Jacobson, "Thermodynamics of Spacetime: The Einstein Equation of State," *Physical Review Letters* **75** (1995) 1260–1263. doi:10.1103/PhysRevLett.75.1260.
8. E. P. Verlinde, "On the Origin of Gravity and the Laws of Newton," *Journal of High Energy Physics* **2011**:029 (2011). doi:10.1007/JHEP04(2011)029.
9. J. D. Bekenstein, "Black Holes and Entropy," *Physical Review D* **7** (1973) 2333–2346. doi:10.1103/PhysRevD.7.2333.
10. S. W. Hawking, "Particle Creation by Black Holes," *Communications in Mathematical Physics* **43** (1975) 199–220. doi:10.1007/BF02345020.
11. E. T. Jaynes, "Information Theory and Statistical Mechanics," *Physical Review* **106** (1957) 620–630. doi:10.1103/PhysRev.106.620.
12. T. M. Cover and J. A. Thomas, *Elements of Information Theory*, 2nd ed., Wiley-Interscience, 2006 (Print ISBN 978-0-471-24195-9).
13. W. H. Zurek, "Decoherence, einselection, and the quantum origins of the classical," *Reviews of Modern Physics* **75**(2003) 715–775. doi:10.1103/RevModPhys.75.715.
14. J. Ladyman and D. Ross, *Every Thing Must Go: Metaphysics Naturalized*, Oxford University Press, 2007.
15. S. French and J. Ladyman, "Remodelling Structural Realism: Quantum Physics and the Metaphysics of Structure," *Synthese* **136**(1) (2003) 31–56. doi:10.1023/A:1024156116636.
16. J. Butterfield, "Less is Different: Emergence and Reduction Reconciled," *Foundations of Physics* **41** (2011) 1065–1135. doi:10.1007/s10701-010-9516-1.
17. C. Rovelli, "Relational Quantum Mechanics," *International Journal of Theoretical Physics* **35** (1996) 1637–1678. doi:10.1007/BF02302261.
18. E. Axelkrans, "The Generative Projection Framework in Fundamental Physics: A Conceptual and Ontological Overview," preprint (submitted December 2025). PhilArchive.

 doi:10.20944/preprints202602.1690.v1

19. E. Axelkrans, "The Generative Projection Framework: A Generative Projection Ontology of Physical and Consciousness Projection," preprint (2025). PhilArchive.
20. Borros Arneth, "Entropy-Originated Topological Framework for a Unified Description of Gravity and Gauge Dynamics," Zenodo preprint (2025).
21. Borros Arneth, "A Diagram-Hilbert-Space Framework: Mathematical Foundations and Projection-Entropy Variational Principles," Zenodo preprint (2025).
22. Borros Arneth, "A Unified Framework for the Standard Model and Gravity," Zenodo preprint (2025).
23. Borros Arneth, "Entropic and Topological Origins of Quantum Fields," Zenodo preprint (2025).
24. Borros Arneth, "Diagram–Hilbert Space (DHS) with Entropy-Originated Topological Projection (EOTF): Unified kinematics, projected partition functions, and …," Zenodo preprint (2026).
25. R. P. Feynman, "Space-Time Approach to Quantum Electrodynamics," *Physical Review* **76** (1949) 769–789. doi:10.1103/PhysRev.76.769.
26. F. J. Dyson, "The Radiation Theories of Tomonaga, Schwinger, and Feynman," *Physical Review* **75** (1949) 486–502. doi:10.1103/PhysRev.75.486.
27. G. 't Hooft, "A Planar Diagram Theory for Strong Interactions," *Nuclear Physics B* **72** (1974) 461–473. doi:10.1016/0550-3213(74)90154-0.
28. R. Penrose, "Angular Momentum: An Approach to Combinatorial Space-Time," in: T. Bastin (ed.), *Quantum Theory and Beyond*, Cambridge University Press, 1971, pp. 151–180.
29. C. Rovelli and L. Smolin, "Spin Networks and Quantum Gravity," *Physical Review D* **52** (1995) 5743–5759. doi:10.1103/PhysRevD.52.5743.
30. A. Ashtekar and J. Lewandowski, "Background Independent Quantum Gravity: A Status Report," *Classical and Quantum Gravity* **21** (2004) R53–R152. doi:10.1088/0264-9381/21/15/R01.
31. G. Vidal, "Entanglement Renormalization," *Physical Review Letters* **99** (2007) 220405. doi:10.1103/PhysRevLett.99.220405.
32. R. Orús, "A Practical Introduction to Tensor Networks: Matrix Product States and Projected Entangled Pair States," *Annals of Physics* **349** (2014) 117–158. doi:10.1016/j.aop.2014.06.013.
33. B. Swingle, "Entanglement Renormalization and Holography," *Physical Review D* **86** (2012) 065007. doi:10.1103/PhysRevD.86.065007.
34. J. C. Baez and M. Stay, "Physics, Topology, Logic and Computation: A Rosetta Stone," *Lecture Notes in Physics***813** (2010) 95–172. doi:10.1007/978-3-642-12821-9_2.
35. B. Coecke and A. Kissinger, Picturing Quantum Processes: A First Course in Quantum Theory and Diagrammatic Reasoning, Cambridge University Press, 2017.
36. E. Noether, "Invariante Variationsprobleme," Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse (1918) 235–257.
37. H. Weyl, *Symmetry*, Princeton University Press, 1952.
38. C. N. Yang and R. L. Mills, "Conservation of Isotopic Spin and Isotopic Gauge Invariance," *Physical Review* **96**(1954) 191–195. doi:10.1103/PhysRev.96.191.
39. J. Polchinski, String Theory, Vol. 1: An Introduction to the Bosonic String, Cambridge University Press, 1998.
40. J. Polchinski, String Theory, Vol. 2: Superstring Theory and Beyond, Cambridge University Press, 1998.