

Provenance, credits, and AI disclosure. This expanded transcript was generated by OpenAI’s Astra-6 LLM, based on handwritten notes¹ by Luuk Stehouwer (as presented in a talk @ New York University Abu Dhabi on 7th Oct 2026²), with light editing for contextualization by Urs Schreiber and incorporating small corrections by Luuk Stehouwer.

EXPANDED TRANSCRIPT

A cobordism hypothesis for flagged TQFTs

Transcribed from handwritten talk notes by **Luuk Stehouwer** (presented @NYUAD 26-10-07).
on joint work with **Theo Johnson-Freyd**, **Cameron Krulewski**, and **Lukas Müller**.

The question

The ordinary cobordism hypothesis says that a fully extended topological field theory is determined by its value on a point, together with the appropriate duality and tangential-structure data. But a target higher category can identify objects more freely than a particular geometric or algebraic presentation intends. For example, the Morita bicategory identifies Morita-equivalent algebras, even when they are not isomorphic as algebras.

A flag records the finer information at each categorical level. The proposed refinement asks that duality, and the orthogonal-group actions expressing it, lift coherently to this flag. Its guiding formula replaces the ordinary space of fully dualizable objects by the selected space $\mathcal{C}_0$:

$$\text{flagged field theories} \simeq \text{structured points of } \mathcal{C}_0.$$

Route through the argument

We begin with ordinary TQFTs and the cobordism hypothesis, introduce flags and flagged duals, and examine the algebraic example that motivates the construction. We then formulate the announced classification and explain the two- and three-dimensional consequences.

Status of this text. This is an editorial reconstruction, not a verbatim transcript or an author-approved manuscript. It expands the five supplied pages, standardizes notation, and adds explanations. The announced theorem is stated at the informal level supported by the notes; no proof or complete coherence axioms are supplied there. The three-dimensional application retains the notes’ explicit conjectural qualification.

Editorial additions are identified where they materially go beyond transcription. Background references support the exposition; they are not presented as a published source for the announced flagged theorem.

¹ncatlab.org/nlab/files/Stehouwer-CQTS_26-10-07.pdf

²ncatlab.org/nlab/show/CQTS\#StehouwerOct2026

From bordisms to field theories

An n -dimensional TQFT is an axiomatization of the topological case of the Schrödinger picture of quantum field theory. A closed n -manifold has a partition function, a closed $(n - 1)$ -manifold has a state space, and a bordism gives a map between state spaces:

$$Z(M^n) \in \mathbb{C}, \quad Z(Y^{n-1}) \in \text{Vect}_{\mathbb{C}}, \quad Z(W) : Z(Y_0) \longrightarrow Z(Y_1).$$

Locality is encoded by two laws. Disjoint union becomes tensor product, and gluing becomes composition:

$$Z(Y \sqcup Y') \simeq Z(Y) \otimes Z(Y'), \quad Z(W_2 \circ W_1) \simeq Z(W_2) \circ Z(W_1).$$

A fully extended theory continues this assignment to lower-dimensional manifolds: codimension two can carry linear categories, and points carry objects of an appropriate higher category. The concise formulation is a symmetric monoidal functor

$$Z : (\text{Bord}_n^X, \sqcup) \longrightarrow (\mathcal{C}, \otimes).$$

Here $\mathcal{C}$ is a symmetric monoidal (∞, n) -category. The map $X \rightarrow BO(n)$ specifies a tangential structure: an X -structure on an n -manifold is a lift of its tangent-bundle classifying map. Framings, orientations, and spin structures correspond respectively to $* \rightarrow BO(n)$, $BSO(n) \rightarrow BO(n)$, and $B\text{Spin}(n) \rightarrow BO(n)$.

A one-dimensional test case

For an unoriented one-dimensional theory, put $V = Z(\text{pt})$. The cap and cup give evaluation and coevaluation. The snake identities force V to be finite-dimensional and the pairing to be nondegenerate. The symmetry exchanging the ends of the cap makes that pairing symmetric:

$$b : V \otimes V \longrightarrow \mathbb{C}, \quad b(v, w) = b(w, v).$$

Thus the space of such theories is the groupoid of finite-dimensional complex vector spaces with nondegenerate symmetric bilinear forms and their isometries. Equivalently, it is the homotopy fixed-point space for the duality action of $O(1) \cong \mathbb{Z}/2$ on the core of finite-dimensional vector spaces.

As usual, duality becomes a covariant action on the core by taking the inverse dual of an isomorphism. These are complex bilinear forms; no Hermitian or positivity condition is imposed in this example. [Source: handwritten pp. 1–2.]

A point, together with its symmetries

Write $\text{core}_k \mathcal{C}$ for the maximal (∞, k) -subcategory of $\mathcal{C}$: it retains all morphisms through degree k and only the invertible morphisms above that degree. In particular, $\text{core}_0 \mathcal{C}$ is a space, or equivalently an ∞ -groupoid.

The framed cobordism hypothesis. Evaluation at a framed point gives an equivalence between the space of fully extended framed theories with target $\mathcal{C}$ and the space of fully dualizable objects of $\mathcal{C}$.

$$\text{Fun}^\otimes(\text{Bord}_n^{\text{fr}}, \mathcal{C})^\simeq \simeq \text{core}_0(\mathcal{C}^{\text{fd}}).$$

Full dualizability means that the object has a dual and that the evaluation and coevaluation morphisms have the required adjoints, iteratively through the relevant dimensions. The notes subsequently assume a rigid target, so that these duality conditions are built into the setting. [1]

Changing the framing

The orthogonal group acts by changing a framing. Under the cobordism hypothesis this becomes an $O(n)$ -action on the space of fully dualizable objects. For a structure group $G \rightarrow O(n)$, the classification takes the form

$$\text{TQFT}_n^G(\mathcal{C}) \simeq (\text{core}_0(\mathcal{C}^{\text{fd}}))^{hG}.$$

The superscript hG means homotopy fixed points: an object equipped with coherent invariance under the action, not merely an invariant isomorphism class. Oriented theories use $G = SO(n)$; unoriented theories use $G = O(n)$.

Actions on higher cores

The next observation in the notes is a higher-level version. For a rigid symmetric monoidal (∞, n) -category there are orthogonal actions of the form

$$O(n - k) \curvearrowright \text{core}_k \mathcal{C} \quad (0 \leq k \leq n).$$

These actions follow from the lax-functor comparison of Theo Johnson-Freyd and Claudia Scheimbauer [6, Corollary 7.7], applied to

$$\text{core}_k \text{Fun}_\otimes^{\text{lax}}(\text{Bord}_{n-k}^{\text{fr}}, \mathcal{C}).$$

Precomposing by a change of framing supplies the orthogonal action. A flag must accommodate these actions coherently at its different levels.

For general foundations of categorical spectra and their tensor product, see Naruki Masuda [7]. His work also derives the cobordism hypothesis with singularities from the ordinary cobordism hypothesis, making precise their relationship.

Source: handwritten pp. 2–3, with attribution clarified by Stehouwer. The display remains schematic; precise conventions and hypotheses belong to the cited work.

Keeping track of finer equivalences

Definition. A flagged (∞, n) -category is a sequence $\mathcal{C}_0 \rightarrow \mathcal{C}_1 \rightarrow \cdots \rightarrow \mathcal{C}_n$, where $\mathcal{C}_i$ is an (∞, i) -category and each transition is essentially surjective on morphisms of degrees at most i .

The surjectivity condition is understood with compatible source and target data. It does not say that every transition is fully faithful. Thus two objects can become equivalent at a later stage without already being equivalent at an earlier one. This is the information a flag preserves. The definition agrees with the standard formulation of flagged higher categories. [2]

The canonical flag

Every (∞, n) -category has a canonical flag:

$$\mathrm{core}_0 \mathcal{C} \longrightarrow \mathrm{core}_1 \mathcal{C} \longrightarrow \cdots \longrightarrow \mathrm{core}_{n-1} \mathcal{C} \longrightarrow \mathcal{C}.$$

Here the flag is recovered from the final category. More interesting examples retain additional information that the final category alone does not determine.

The bordism flag

The geometric example organizes bordisms by dimension:

$$\mathrm{Bord}_0^{X_0} \longrightarrow \mathrm{Bord}_1^{X_1} \longrightarrow \cdots \longrightarrow \mathrm{Bord}_n^{X_n}.$$

Here $X_n = X$ is equipped with the original map to $BO(n)$, and $X_i \rightarrow BO(i)$ is its homotopy pullback along stabilization $BO(i) \rightarrow BO(n)$. This is the standard passage from higher- to lower-dimensional tangential structures, as clarified by Stehouwer. Mapping cylinders link the levels: geometric equivalences in one dimension become particular bordisms in the next. The notes announce that this flag has flagged duals.

Algebra isomorphism versus Morita equivalence

Let $\mathrm{Alg}(\mathrm{Vect}_{\mathbb{C}})$ be the category of algebras and algebra homomorphisms, and let $\mathrm{Bim}(\mathrm{Vect}_{\mathbb{C}})$ be the bicategory of algebras, bimodules, and bimodule maps. The algebraic flag in the notes is

$$\mathrm{core}_0 \mathrm{Alg}(\mathrm{Vect}_{\mathbb{C}}) \longrightarrow \mathrm{core}_1 \mathrm{Bim}(\mathrm{Vect}_{\mathbb{C}}) \longrightarrow \mathrm{Bim}(\mathrm{Vect}_{\mathbb{C}}).$$

An algebra map $\varphi : A \rightarrow B$ gives the bimodule ${}_B B_{\varphi}$, with right action $b \cdot a = b\varphi(a)$. At the first stage, equivalences are algebra isomorphisms. In the final bicategory, equivalences are invertible bimodules, hence Morita equivalences. For example, $\mathbb{C}$ and $M_r(\mathbb{C})$ are Morita equivalent but, for $r > 1$, are not isomorphic as algebras.

Source: handwritten p. 3. The matrix-algebra comparison is an editorial illustration. The algebraic flag is meaningful before imposing dualizability; its use as a rigid target needs the restrictions discussed below.

Lifting the orthogonal actions

Begin with a symmetric monoidal flagged $(\infty, 1)$ -category $\mathcal{C}_0 \rightarrow \mathcal{C}_1$, where $\mathcal{C}_1$ is rigid. Duality acts on $\text{core}_0 \mathcal{C}_1$. Essential surjectivity ensures that the dual of a represented object has some representative in $\mathcal{C}_0$. It does not choose representatives coherently.

A flagged duality must lift this operation to $\mathcal{C}_0$, including its involutivity and its compatibility with the map into $\mathcal{C}_1$. The distinction is between knowing that representatives exist and supplying a coherent duality on the chosen presentation.

Informal definition from the notes. Flagged duals on a rigid symmetric monoidal flag $\mathcal{C}_\bullet$ consist of compatible actions $O(n-k) \curvearrowright \mathcal{C}_k$ lifting the canonical actions on $\text{core}_k \mathcal{C}_n$, for $0 \leq k \leq n$.

$$\begin{array}{ccc} \mathcal{C}_k & \longrightarrow & \text{core}_k \mathcal{C}_n \\ O(n-k) \curvearrowright & & \curvearrowright O(n-k) \end{array}$$

The display says that the horizontal map is equivariant. Adjacent levels must also agree after restriction along the relevant inclusions of orthogonal groups, with higher coherence between these agreements. The source calls its definition informal and does not enumerate those coherence conditions.

Why this is the right kind of extra structure

An orthogonal transformation of the unused framing directions changes a local duality operation. If a field theory remembers a particular presentation of objects or morphisms, the transformed operation must still be expressible in that presentation. Flagged duals supply this compatibility.

For the canonical core flag, the relevant actions already come from the ambient rigid category, via the Johnson–Freyd–Scheimbauer comparison recalled in section 2 [6]. For a finer algebraic flag, however, a geometric rotation may be represented by a bimodule equivalence which is not yet presented by a specified algebra automorphism. The next example isolates exactly this issue.

Three assertions to keep separate

The notes distinguish the general notion of flagged duals, their existence for the bordism flag, and their construction on particular algebraic targets. Establishing the first two does not automatically provide the third. In particular, the later fusion-category example is explicitly introduced under conjectural assumptions.

Source: handwritten pp. 3–5. This section expands the motivation and explains the role of coherence, without claiming to reconstruct a missing formal definition. Related flagged constructions appear in [3], but that paper is not a source for the theorem announced here.

Rotation, Serre duality, and Frobenius forms

Consider the flag from algebra isomorphisms to the Morita bicategory. Reflection is relatively straightforward: it takes an algebra to its opposite, $A \mapsto A^{\text{op}}$, and reverses the relevant bimodule structures. This operation is already visible at the algebra level.

The connected rotation group is subtler. Since $SO(2) \simeq B\mathbb{Z}$, its fundamental loop acts on a fully dualizable algebra by its Serre automorphism. In the standard finite-dimensional Morita setting this is represented by the dual bimodule

$$S_A \simeq A^*, \quad A^* = \text{Hom}_{\mathbb{C}}(A, \mathbb{C}).$$

To lift this action to the algebra presentation, one wants to express A^* as a regular bimodule twisted by an algebra automorphism. A Frobenius form provides precisely that description.

Frobenius structure. A Frobenius form on a finite-dimensional algebra A is a linear functional $\lambda : A \rightarrow \mathbb{C}$ for which $(a, b) \mapsto \lambda(ab)$ is a nondegenerate bilinear pairing.

Following the convention written in the notes, the Nakayama automorphism φ is characterized by

$$\lambda(ab) = \lambda(\varphi(b)a).$$

Use the usual bimodule structure $(a \cdot f \cdot b)(x) = f(bxa)$ on A^* . Let ${}_{\varphi}A$ have left action $a \cdot c = \varphi(a)c$ and the ordinary right action. Then

$$\Theta : {}_{\varphi}A \xrightarrow{\cong} A^*, \quad \Theta(c)(x) = \lambda(cx).$$

Indeed, $\lambda(cxa) = \lambda(\varphi(a)cx)$ proves compatibility with the left action; compatibility with the right action is immediate. Nondegeneracy makes Θ invertible. Thus the rotation represented by the dual bimodule has an algebra-level representative supplied by φ .

Twist conventions matter: with a right-twisted regular bimodule, the same convention gives $A_{\varphi^{-1}} \cong A^*$. The notes write a twisted regular bimodule schematically. The explicit convention and verification here are editorial additions.

Dualizability qualification. The ordinary Morita bicategory of all algebras is not rigid. In its usual finite-dimensional version, fully dualizable algebras are separable, hence semisimple over $\mathbb{C}$. A Frobenius form alone does not imply full dualizability. The source suppresses this restriction. Background: [4].

What the Nakayama automorphism records

This worked example is added for explanation; it does not appear in the handwritten notes.

Let $A = M_r(\mathbb{C})$ and choose an invertible matrix D . Define

$$\lambda_D(a) = \text{Tr}(Da).$$

The trace pairing on matrices is nondegenerate, and multiplication by D is invertible, so λ_D is a Frobenius form. Cyclicity of the trace gives its Nakayama automorphism, in the convention of the preceding page:

$$\varphi_D(b) = D^{-1}bD, \quad \lambda_D(ab) = \lambda_D(\varphi_D(b)a).$$

For example, take $r = 2$ and $D = \text{diag}(1, 2)$. With E_{ij} denoting the matrix units,

$$\lambda_D(E_{12}E_{21}) = 1, \quad \lambda_D(E_{21}E_{12}) = 2, \quad \varphi_D(E_{12}) = 2E_{12}.$$

This Frobenius form is not symmetric. Its failure of symmetry is measured by a nontrivial algebra automorphism, even though that automorphism is inner and its associated twisted bimodule is isomorphic to the regular bimodule.

Symmetry and the orientation condition

A Frobenius form is symmetric when $\lambda(ab) = \lambda(ba)$ for all a, b . Nondegeneracy and the defining equation for φ show that

$$\lambda \text{ is symmetric} \iff \varphi = \text{id}_A.$$

In the matrix example, this happens precisely when D is a nonzero scalar matrix. Thus it is the chosen form, not only the underlying algebra, which controls the lifted rotation.

Why a flag can detect more

The core of the Morita bicategory contains bimodule isomorphisms as higher homotopies. It can therefore identify a twist by an inner automorphism with the identity bimodule. The groupoid of algebra presentations has no analogous higher morphism between two distinct algebra automorphisms.

This explains the refinement suggested by the red “FAs” annotation: retain Frobenius data at the first stage, so that the rotation is represented by the Nakayama automorphism. In such a groupoid model, an $SO(2)$ -fixed-point condition forces that lifted loop to be trivial, producing symmetric Frobenius data. This is the algebraic mechanism behind the announced two-dimensional example.

The source does not specify the full category of Frobenius presentations, its morphisms, or all equivariance coherences. The explanation identifies the intended mechanism; it is not a construction of the entire flagged target.

Respecting the levels of the flag

Let $\mathcal{C}_\bullet = (\mathcal{C}_0 \rightarrow \cdots \rightarrow \mathcal{C}_n)$ be a symmetric monoidal flagged target with flagged duals. A flagged field theory is a compatible symmetric monoidal system from the bordism flag to this target flag:

$$\begin{array}{ccccccc} \mathrm{Bord}_0^{X_0} & \longrightarrow & \mathrm{Bord}_1^{X_1} & \longrightarrow & \cdots & \longrightarrow & \mathrm{Bord}_n^{X_n} \\ \downarrow Z_0 & & \downarrow Z_1 & & & & \downarrow Z_n \\ \mathcal{C}_0 & \longrightarrow & \mathcal{C}_1 & \longrightarrow & \cdots & \longrightarrow & \mathcal{C}_n. \end{array}$$

The diagram commutes coherently, and the vertical functors respect the orthogonal actions associated to the unused directions. At level i , those directions carry an $O(n-i)$ -action.

What this means geometrically

An i -dimensional bordism is sent to an i -morphism in $\mathcal{C}_i$. An i -dimensional mapping cylinder is sent to an i -morphism already present in $\mathcal{C}_{i-1}$. Since $\mathcal{C}_{i-1}$ is an $(\infty, i-1)$ -category, this latter morphism is invertible.

More generally, the notes discuss k -fold mapping cylinders. Rotating their k additional directions is required to agree with the corresponding orthogonal action on the lower stage $\mathcal{C}_{i-k}$. This requirement relates the geometric origin of an equivalence to the level of the target flag where it is represented.

The extra information. An ordinary theory records the image of a bordism in $\mathcal{C}_n$. A flagged theory also records how that image is represented at the appropriate earlier stage, and how this representation interacts with duality.

Tangential-structure notation

As clarified by Stehouwer, write $X_n = X$ for the given tangential-structure space. The lower-dimensional structures are its homotopy pullbacks along stabilization:

$$X_i := BO(i) \times_{BO(n)}^h X_n, \quad V \longmapsto V \oplus \mathbb{R}^{n-i}.$$

Here $BO(i) \rightarrow BO(n)$ classifies the displayed stabilization of vector bundles, and $\xi : X_n \rightarrow BO(n)$ is the given structure map. In particular, X_0 is its homotopy fiber over the standard n -plane and carries an $O(n)$ -action.

Source: handwritten p. 5 and Stehouwer's clarification of 10 October 2026. The pullback convention is confirmed; the notes do not spell out the higher mapping-cylinder coherences.

The flagged cobordism hypothesis

Announced theorem · informal reconstruction. For an admissible rigid symmetric monoidal flagged target $\mathcal{C}_\bullet$ with flagged duals, the space of X -structured flagged field theories is equivalent to the space of X -structured points of $\mathcal{C}_0$.

$$\mathrm{TQFT}_{n,\mathrm{flag}}^X(\mathcal{C}_\bullet) \simeq \mathcal{C}_0^{X_n}.$$

This is the theorem as written in the notes, with its implicit admissibility and coherence requirements left implicit. The notation $\mathcal{C}_0^{X_n}$ needs interpretation: X_n is a space over $BO(n)$, not in general a group.

The tangential-structure superscript as a limit

Stehouwer’s intended definition is a limit in the ∞ -category Gpd_∞ of spaces. For an $O(n)$ -space Y , let $\rho_Y : BO(n) \rightarrow \mathrm{Gpd}_\infty$ be the functor taking the basepoint to Y , with the higher morphisms encoding its $O(n)$ -action. For any tangential structure $\xi : X \rightarrow BO(n)$, define

$$Y^X := \lim(X \xrightarrow{\xi} BO(n) \xrightarrow{\rho_Y} \mathrm{Gpd}_\infty).$$

In the ordinary hypothesis, $Y = \mathrm{core}_0(\mathcal{C}^{\mathrm{fd}})$; in the flagged hypothesis, $Y = \mathcal{C}_0$ with its lifted action. If $X = BG$ for $G \rightarrow O(n)$, this limit is Y^{hG} . Thus the notation generalizes homotopy fixed points without requiring X to be a classifying space of a group.

Three familiar special cases

$$\mathrm{TQFT}_{n,\mathrm{flag}}^{\mathrm{fr}}(\mathcal{C}_\bullet) \simeq \mathcal{C}_0,$$

$$\mathrm{TQFT}_{n,\mathrm{flag}}^{\mathrm{or}}(\mathcal{C}_\bullet) \simeq \mathcal{C}_0^{hSO(n)},$$

$$\mathrm{TQFT}_{n,\mathrm{flag}}^{\mathrm{un}}(\mathcal{C}_\bullet) \simeq \mathcal{C}_0^{hO(n)}.$$

The ordinary formula uses the core of fully dualizable objects in the final target. The flagged formula uses the chosen initial space $\mathcal{C}_0$, with the lifted action. Thus it retains the more restrictive notion of equivalence encoded by the flag. For the canonical core flag of a rigid target, it has the same form as the ordinary classification.

What is asserted, and what is not proved here

The claim is an equivalence of spaces, including automorphisms and higher homotopies, rather than a bijection of isomorphism classes. Conceptually, the value on a point generates the theory using duality, while equivariance accounts for changes of framing. Establishing existence, uniqueness, and all flag compatibilities is the content of the announced theorem. The five pages do not contain that proof.

Source: handwritten p. 5. “Admissible” is used here only to signal hypotheses missing from the abbreviated statement; it is not a new technical condition or a claimed reconstruction of the forthcoming paper’s axioms.

Frobenius algebras and fusion categories

Two dimensions

The closing line of the notes identifies oriented two-dimensional theories with symmetric Frobenius algebras. The preceding discussion explains why: the rotation is the Serre automorphism, its lift is a Nakayama automorphism, and the oriented fixed-point condition makes that lifted rotation trivial.

This must be read with the target and its equivalences specified. A flag built from algebra or Frobenius presentations retains algebra-level equivalences. Forgetting to the ordinary Morita target changes the comparison to Morita equivalence with the corresponding structure. The source crosses out “flagged” in the corollary and adds “up to Morita,” so it does not support a single unqualified classification statement covering both versions.

Scope of the algebraic statement. In the usual fully extended finite-dimensional Morita target, impose the separability/full-dualizability restriction. The associated symmetric Frobenius algebra need not be commutative. This is distinct from the familiar classification of ordinary, unextended oriented two-dimensional TQFTs by commutative Frobenius algebras, whose algebra is the value on a circle.

Three dimensions: the conditional example

The notes next replace algebras by fusion categories and bimodules by bimodule categories. Their abbreviated flag compares the core of the 2-category of fusion categories and tensor functors with the Morita 3-category of fusion categories, bimodule categories, bimodule functors, and natural transformations.

They explicitly introduce this example with “assuming conjectures.” Under the intended construction of flagged $O(3)$ -duals, the oriented fixed-point data are expected to recover spherical fusion categories. A spherical structure is a pivotal structure for which the left and right traces agree. The relation between dualizability, framing rotations, and tensor-category duality is standard background; the full flagged application is not established by these notes. [5]

The final blue annotation records

$$\tau_{\leq 2}O(3) \simeq \mathbb{Z}/2 \times B(\mathbb{Z}/2).$$

As a statement about the underlying homotopy 2-type, this reflects the two components of $O(3)$, the fundamental group $\pi_1 SO(3) \cong \mathbb{Z}/2$, and $\pi_2 SO(3) = 0$. It motivates low-dimensional coherence data; by itself it is not a proof of the claimed spherical classification or a specification of a coherent group action.

Source: handwritten pp. 4–5. The precise fusion versus multifusion scope, intermediate flag levels, normalization of spherical data, and equivalence relation all require the full statement. The conjectural qualification is retained rather than resolved by inference.

REFERENCES

Background and credits

- [1] Jacob Lurie. On the Classification of Topological Field Theories. arXiv:0905.0465. Ordinary cobordism hypothesis and tangential structures. <https://arxiv.org/abs/0905.0465>
- [2] David Ayala and John Francis. Flagged higher categories. arXiv:1801.08973, Definition 0.12. Formal definition of a flagged higher category. <https://arxiv.org/abs/1801.08973>
- [3] Giovanni Ferrer, Brett Hungar, Theo Johnson-Freyd, Cameron Krulewski, Lukas Müller, Nivedita, David Penneys, David Reutter, Claudia Scheimbauer, Luuk Stehouwer, and Chetan Vuppulury. Dagger n-categories. arXiv:2403.01651. Related flagged and equivariant higher-category constructions. <https://arxiv.org/abs/2403.01651>
- [4] Lukas Müller and Luuk Stehouwer. Reflection Structures and Spin Statistics in Low Dimensions. arXiv:2301.06664. Background on low-dimensional Morita targets and structured theories. <https://arxiv.org/abs/2301.06664>
- [5] Christopher L. Douglas, Christopher Schommer-Pries, and Noah Snyder. Dualizable tensor categories. arXiv:1312.7188. Dualizability of tensor categories and the expected relation of spherical structures to oriented theories. <https://arxiv.org/abs/1312.7188>
- [6] Theo Johnson-Freyd and Claudia Scheimbauer. (Op)lax natural transformations, twisted quantum field theories, and “even higher” Morita categories. arXiv:1502.06526. See especially Corollary 7.7 for the lax-functor comparison underlying the higher-core orthogonal actions in sections 2 and 4. <https://arxiv.org/abs/1502.06526>
- [7] Naruki Masuda. The Algebra of Categorical Spectra. PhD thesis, Johns Hopkins University, 2024; revised version arXiv:2605.03114. Foundations of categorical spectra and their tensor product; derivation of the cobordism hypothesis with singularities from the ordinary cobordism hypothesis. <https://arxiv.org/abs/2605.03114>