Talk Proposal

QPL 2026

Title: Beyond Wigner – How Non-Invertible Symmetries Preserve Probabilities

Speaker: Thomas Bartsch (University of Oxford)

Based on: arXiv:2602.07110

Dear Members of the Organizing Committee,

I am pleased to submit a proposal for a contributed talk at the *23rd International Conference on Quantum Physics and Logic (QPL 2026)* in Amsterdam. The proposed talk is based on our recent manuscript "Beyond Wigner: Non-Invertible Symmetries Preserve Probabilities" which is linked above. Below, I provide a summary of the context, outline, and scope of the talk.

Context: Symmetries play a foundational role in quantum theory. They act on and thereby organize the spectrum of physical observables, leading to selection rules and robust constraints on the dynamics of a quantum system. According to Wigner's theorem, every symmetry transformation must be implemented by a unitary or anti-unitary operator on the Hilbert space in order to preserve transition amplitudes between physical states. In particular, every symmetry transformation is invertible. The appropriate mathematical framework to describe symmetries is therefore given by the theory of groups and their representations. Recent years, however, have seen the expansion of the traditional notion of symmetry in quantum theory to so-called *generalized* or *categorical symmetries*, which correspond to operators / defects that are "topological" in an appropriate sense. An example is the two-dimensional critical Ising CFT, which in addition to the invertible spin-flip symmetry η hosts the so-called *Kramers-Wannier duality defect* D with non-invertible fusion rule

$$\mathrm{D} \otimes \mathrm{D} = 1 \oplus \eta \,.$$

In general, we refer to topological defects that have no inverse as *non-invertible symmetries.* However, the latter seem to stand in direct conflict with Wigner's theorem, which raises the following natural question:

Are non-invertible symmetries compatible with Wigner's theorem and the preservation of quantum transition amplitudes?

The aim of the proposed talk is to resolve this question for a broad class of generalized symmetries that are described by so-called (higher) fusion categories.

Outline: I propose the following structure for the talk:

1. *Introduction:* After reviewing the traditional notion of symmetries in quantum theory, I will motivate and introduce the notion of generalized and non-invertible symmetries. I will discuss the precise sense in which the latter generalize the traditional notion of symmetry and highlight their apparent tension with the preservation of quantum transition amplitudes in the sense of Wigner's theorem.
2. *Mathematical Background:* While ordinary symmetries can be described by groups G, the appropriate mathematical framework for the description of generalized symmetries is more elusive. The primary focus of this talk will be on generalized symmetries in two spacetime dimensions that can be captured by so-called fusion categories C. I will provide a pedagogical overview of the latter that includes a discussion of the associated mathematical structures as well as their physical significance.
3. *Symmetry Actions:* Traditionally, the action of a symmetry group G on physical states is described by a linear representation of G on a Hilbert space. I will discuss the analogue of this statement for generalized fusion category symmetries C by showing that the latter act via linear representations of the so-called *tube algebra* associated to C. Crucially, the latter acts on states living in an enlarged Hilbert space that includes so-called *twisted sectors* for the symmetry C, which I will review in detail.
4. *Probability Preservation:* I will present the main result of our work by proposing a resolution to the apparent tension between non-invertible symmetries and Wigner's theorem. This is formulated as the so-called *Categorical Probability Preservation (CPP) Theorem*, which asserts that, in order for non-invertible symmetries to preserve quantum transition amplitudes, one has to consider their action on all possible twisted sectors together with all possible *transition channels* thereinto. In this case, one naturally obtains a probability-preserving isometry (or, equivalently, a trace-preserving quantum channel) associated to the action of each symmetry generator in C. I will provide a detailed explanation of the above concepts and terminology during the talk.
5. *Examples:* I will illustrate our construction through concrete examples of non-invertible symmetries that include Tambara-Yamagami symmetries (which capture e.g. the Kramers-Wannier duality defect in the critical Ising CFT) as well as more exotic symmetries such as the Fibonacci symmetry. In particular, I show that our construction reduces to unitary actions in the case of invertible (group-like) symmetries as required by Wigner's theorem.
6. *Generalizations:* I will discuss generalizations of the CPP Theorem to quantum systems in higher spacetime dimensions and systems with boundaries.

Scope: Our results resolve a conceptual tension at the heart of quantum theory: the relationship between (generalized) symmetries and the preservation of transition amplitudes. By allowing symmetry defects to act on an enlarged Hilbert space incorporating all twisted sectors, we show that their action can be formulated in terms of isometries and, more generally, trace-preserving quantum channels. In this way, probability preservation remains compatible with non-invertible structures.

More broadly, our construction highlights structural connections between generalized symmetry and quantum-information–theoretic notions. The natural appearance of completely positive, trace-preserving maps suggests parallels between defect-based symmetry operations and the operational language of quantum channels. While these connections remain to be explored further, they indicate a shared mathematical framework that may facilitate interaction between categorical approaches to symmetry and quantum information theory.

I hope that this proposed talk would be of interest to participants working across quantum foundations, category theory, and quantum information, and I would be very happy to contribute to the scientific programme of QPL 2026.

Sincerely,

Thomas Bartsch