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TQFTs and Quantum Computing

Quantum computing is captured in the formalism of the monoidal subcategory M of the category $\mathrm{Vect}_{\mathbb{C}}$ of complex vector spaces generated under tensor products by $\mathbb{C}^2$ — in particular, quantum circuits can be seen as diagrams in this category — while topological quantum field theories, in the sense of Atiyah, are diagrams in $\mathrm{Vect}_{\mathbb{C}}$ indexed by a cobordism category. We outline a program to formalize a connection between these two scenarios. In doing so, we first equip cobordisms with machinery for producing $\mathbb{C}$–linear maps by parallel transport along curves under a connection and then assemble these structures into a higher category. The category M above is also given a suitable higher categorical structure which we call $\mathbb{F}\mathrm{Vect}_{\mathbb{C}}$. Finally, we realize quantum circuits as images of these cobordisms with additional structure under a higher monoidal functor to $\mathbb{F}\mathrm{Vect}_{\mathbb{C}}$, which are computed by taking parallel transports of vectors and then combining the results in a pattern encoded in the domain of the functor. This talk reports on joint work with Steven Rayan.