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A categorical model for a quantum circuit description language

Quipper is a practical programming language for describing families of quantum circuits. In this talk, we formalize a small, but useful fragment of Quipper called Proto-Quipper-M. Unlike its parent Quipper, this language is type-safe and has a formal denotational and operational semantics. Proto-Quipper-M is also more general than Quipper, in that it can describe families of morphisms in any symmetric monoidal category, of which quantum circuits are but one example. We design Proto-Quipper-M from the ground up, by first giving a general categorical model of parameters and states. After finding some interesting categorical structures in the model, we then define the programming language to fit the model. We cement the connection between the language and the model by proving type safety, soundness, and adequacy properties.

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