The Logics of Quantum Computation: Results and Open Problems

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The theory of logical gates in quantum computation has suggested new forms of quantum logic, called *quantum computational logics*. The basic semantic idea is the following: the meaning of a sentence α is identified with a *quantum information quantity*, represented by a density operator ρ of a Hilbert space $\otimes^n C^2$, where n depends on the logical complexity of α. At the same time, the logical connectives of the language are interpreted as operations that are defined, in terms of logical gates, on the set $\mathfrak{D} = \bigcup \mathfrak{D}(\otimes^n C^2)$ (which contains all density operators of all spaces $\otimes^n C^2$). We study different kinds of *reversible* and *irreversible quantum computational structures*. We introduce the notion of *quantum computational MV algebra* that permits one to prove a completeness theorem for a fragment of *Łukasiewicz quantum computational logic* (an irreversible form of quantum computational logic).