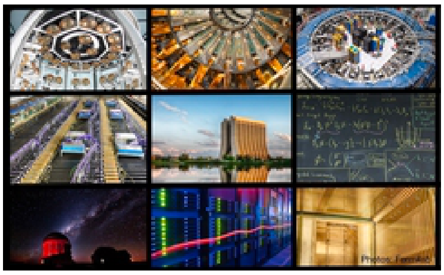

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Non-Boolean Quantum Amplitude Amplification and Quantum Mean Estimation

This paper generalizes the quantum amplitude amplification and amplitude estimation algorithms to work with non-boolean oracles. The action of a non-boolean oracle $U\varphi$ on an eigenstate $|x\rangle$ is to apply a state-dependent phase-shift $\varphi(x)$. Unlike boolean oracles, the eigenvalues $\exp(i\varphi(x))$ of a non-boolean oracle are not restricted to be ± 1. Two new oracular algorithms based on such non-boolean oracles are introduced. The first is the non-boolean amplitude amplification algorithm, which preferentially amplifies the amplitudes of the eigenstates based on the value of $\varphi(x)$. Starting from a given initial superposition state $|\psi 0\rangle$, the basis states with lower values of $\cos(\varphi)$ are amplified at the expense of the basis states with higher values of $\cos(\varphi)$. The second algorithm is the quantum mean estimation algorithm, which uses quantum phase estimation to estimate the expectation $\langle\psi 0|U\varphi|\psi 0\rangle$, i.e., the expected value of $\exp(i\varphi(x))$ for a random x sampled by making a measurement on $|\psi 0\rangle$. It is shown that the quantum mean estimation algorithm offers a quadratic speedup over the corresponding classical algorithm. Both algorithms are demonstrated using simulations for a toy example. Potential applications of the algorithms are briefly discussed.

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