Calculating Transition Amplitudes of an Observable Using the Rodeo Algorithm for Quantum Computing

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Existing quantum computing algorithms for measuring and preparing quantum systems are able to prepare a system in a single given energy eigenstate or measure the energy of said eigenstate. We introduce a new quantum computing method called the two-state rodeo algorithm, capable of preparing an arbitrary system in a superposition of energy eigenstates. To demonstrate the algorithm's effectiveness, we calculate transition matrix elements produced by a quantum operator. We demonstrate several examples using classical simulation and then implement the algorithm on the IBM quantum device Perth. We obtain accurate estimates for the transition matrix elements from the classical simulation (<1% error) and from the results from IBM quantum device Perth (<5% error).

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