

CLAIMS

1. A method for fidelity benchmarking for quantum hardware comprising:
accessing a universal set of quantum gates from the quantum hardware;
sampling a plurality of subsets of quantum gates from the universal set of
5 quantum gates, wherein each sampled subset of quantum gates defines a respective
quantum circuit; wherein
each gate in the universal set of quantum gates is associated with a respective
quantum gate fidelity, and each sampled subset of quantum gates comprises a same
number of quantum gates of comparable respective quantum gate fidelity;
10 wherein, for each sampled subset of quantum gates, the method comprises:
applying the respective quantum circuit to a quantum device and performing
measurements on the quantum device to determine output information of the quantum
device;
calculating output information of the quantum device based on application of the
15 respective quantum circuit to the quantum device; and
estimating a fidelity of the respective quantum circuit based on the determined
output information and the calculated output information of the quantum device.
2. The method of claim 1, wherein estimating a fidelity of the quantum device
20 comprises fitting the determined output information of the quantum device to the
calculated output information of the quantum device.
3. The method of claim 2, wherein fitting the determined output information of the
quantum device to the calculated output information of the quantum device to estimate
25 the fidelity of the quantum circuit comprises:
defining a convex combination of the calculated output information of the
quantum device and a totally mixed quantum state; and
estimating the fidelity of the quantum circuit by comparing the defined convex
combination with the determined output information of the quantum device.

4. The method of claim 3, wherein the convex combination is given by

$$\rho = \alpha |\psi\rangle\langle\psi| + (1 - \alpha) \frac{\mathbb{I}}{N}$$

wherein α represents the fidelity of the quantum circuit, $|\psi\rangle$ represents a calculated quantum state of the quantum device based on application of the quantum circuit to the quantum device, and $\mathbb{I}/N$ represents the totally mixed state.

5. The method of claim 1, further comprising:

repeatedly sampling each subset of quantum gates from the universal set of quantum gates until completion of an event.

6. The method of claim 5, wherein the completion of the event occurs when an uncertainty of an estimated fidelity is below a predetermined threshold.

7. The method of claim 1, wherein the set of quantum gates comprise single qubit quantum gates and two qubit quantum gates.

8. An apparatus comprising:

quantum hardware comprising:

one or more qubits;

a universal set of one or more quantum gates;

one or more measurement devices;

one or more classical processors in data communication with the quantum hardware;

wherein the quantum hardware and one or more classical processors are configured to perform operations comprising:

sampling a plurality of subsets of quantum gates from the universal set of quantum gates, wherein each subset of quantum gates defines a respective quantum circuit;

wherein each gate in the universal set of quantum gates is associated with a respective quantum gate fidelity and each sampled subset of quantum gates comprises a

same number of quantum gates of comparable respective quantum gate fidelity;

wherein, for each sampled subset of quantum gates, the quantum hardware and one or more classical processors are configured to:

5 apply the quantum circuit to a quantum device and perform measurements on the quantum device to determine output information of the quantum device;

 calculate output information of the quantum device based on application of the quantum circuit to the quantum device; and

 estimate a fidelity of the quantum circuit based on the determined output information and the calculated output information of the quantum device.

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9. The apparatus of claim 8, wherein the one or more qubits are superconducting qubits.

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10. The apparatus of claim 8, wherein the one or more qubits form a one dimensional array.

11. The apparatus of claim 8, wherein the one or more qubits form a two dimensional array.

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12. The apparatus of claim 8, wherein each of the one or more qubits are subject to nearest neighbor interactions.