CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus comprising at least one processor and at least one memory having computer-coded instructions stored thereon that, in execution with the at least one processor, configure the apparatus to:

receive an initial quantum program;

identify, from the initial quantum program, an initial output qubit set;

determine, based on the initial quantum program and the initial output qubit set, one or more causal cones associated with the initial quantum program; and

generate an optimized quantum program based on the initial quantum program, the initial output qubit set, and the one or more causal cones, wherein the optimized quantum program minimizes a number of qubits needed for execution of the optimized quantum program.

2. The apparatus according to claim 1, wherein the optimized quantum program is associated with an optimized input qubit set that includes one or more fewer qubits than an initial input qubit set required for execution of the initial quantum program.

3. The apparatus according to claim 1, wherein the optimized quantum program includes at least one of a measurement operation or a reset operation.

4. The apparatus according to claim 1, wherein the optimized quantum program includes the same gating operations as the initial quantum program.

5. The apparatus according to claim 1, wherein the apparatus is further configured to:

execute the optimized quantum program on a quantum computer.

6. The apparatus according to claim 1, wherein the apparatus is further configured to:

determine a dual of the initial quantum program;

determine, based on the dual of the initial quantum program, one or more causal cones associated with the dual of the initial quantum program; and

generate an optimized dual quantum program based on the dual of the initial quantum program, and the one or more causal cones associated with the dual of the initial quantum program.

7. The apparatus according to claim 6, wherein the apparatus is further configured to:

determine a first reduced number of qubits corresponding to the optimized quantum program;

determine a second reduced number of qubits corresponding to the optimized dual quantum program;

when the first reduced number of qubits is smaller than or equal to the second reduced number of qubits, compile and cause execution of the optimized quantum program; and

when the second reduced number of qubits smaller than the first reduced number of qubits, compile and cause execution of a dual of the optimized dual quantum program.

8. A computer-implemented method comprising:

receiving, at a controller of a quantum computer, an initial quantum program;

identifying, by the controller, and from the initial quantum program, an initial output qubit set;

determining, by the controller, based on the initial quantum program and the initial output qubit set, one or more causal cones associated with the initial quantum program; and

generating, by the controller, an optimized quantum program based on the initial quantum program, the initial output qubit set, and the one or more causal cones, wherein the optimized quantum program minimizes a number of qubits needed for execution of the optimized quantum program.

9. The computer-implemented method according to claim 8, wherein the optimized quantum program is associated with an optimized input qubit set that includes one or more fewer qubits than an initial input qubit set required for execution of the initial quantum program.

10. The computer-implemented method according to claim 8, wherein the optimized quantum program includes at least one of a measurement operation or a reset operation.

11. The computer-implemented method according to claim 8, wherein the optimized quantum program includes the same gating operations as the initial quantum program.

12. The computer-implemented method according to claim 8, the computer-implemented method further comprising:

executing the optimized quantum program on the quantum computer.

13. The computer-implemented method according to claim 8, further comprising:

determining a dual of the initial quantum program;

determining based on the dual of the initial quantum program, one or more causal cones associated with the dual of the initial quantum program; and

generating an optimized dual quantum program based on the dual of the initial quantum program, and the one or more causal cones associated with the dual of the initial quantum program.

14. The computer-implemented method according to claim 13, further comprising:

determining a first reduced number of qubits corresponding to the optimized quantum program;

determining a second reduced number of qubits corresponding to the optimized dual quantum program;

when the first reduced number of qubits is smaller than or equal to the second reduced number of qubits, compiling and causing execution of the optimized quantum program; and

when the second reduced number of qubits smaller than the first reduced number of qubits, compiling and causing execution of a dual of the optimized dual quantum program.

15. A computer program product comprising at least one non-transitory computer-readable storage medium having computer program code stored thereon that, in execution with at least one processor, is configured for:

receiving an initial quantum program;

identifying, from the initial quantum program, an initial output qubit set;

determining based on the initial quantum program and the initial output qubit set, one or more causal cones associated with the initial quantum program; and

generating an optimized quantum program based on the initial quantum program, the initial output qubit set, and the one or more causal cones, wherein the optimized quantum program minimizes a number of qubits needed for execution of the optimized quantum program.

16. The computer program product according to claim 15, wherein the optimized quantum program is associated with an optimized input qubit set that includes one or more fewer qubits than an initial input qubit set required for execution of the initial quantum program.

17. The computer program product according to claim 15, wherein the optimized quantum program includes at least one of a measurement operation or a reset operation.

18. The computer program product according to claim 15, wherein the optimized quantum program includes the same gating operations as the initial quantum program.

19. The computer program product according to claim 15, wherein the computer program code, when executed by the at least one processor, is further configured for:

determining a dual of the initial quantum program;

determining based on the dual of the initial quantum program, one or more causal cones associated with the dual of the initial quantum program; and

generating an optimized dual quantum program based on the dual of the initial quantum program, and the one or more causal cones associated with the dual of the initial quantum program.

20. The computer program product according to claim 19, wherein the computer program code, when executed by the at least one processor, is further configured for:

determining a first reduced number of qubits corresponding to the optimized quantum program;

determining a second reduced number of qubits corresponding to the optimized dual quantum program;

when the first reduced number of qubits is smaller than or equal to the second reduced number of qubits, compiling and causing execution of the optimized quantum program; and

when the second reduced number of qubits smaller than the first reduced number of qubits, compiling and causing execution of a dual of the optimized dual quantum program.