

WHAT IS CLAIMED IS:

1. A quantum computing device comprising:
 - a plurality of co-planar waveguide flux qubits;
 - at least one coupler element arranged such that each co-planar waveguide flux
 - 5 qubit, of the plurality of co-planar waveguide flux qubits, is operatively couplable to each other co-planar waveguide flux qubit, of the plurality of co-planar waveguide flux qubits, of the quantum computing device; and
 - a tuning quantum device, wherein the tuning quantum device is in electrical
 - contact with a first co-planar waveguide flux qubit of the plurality of co-planar waveguide
 - 10 flux qubits and with a second co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, wherein each co-planar waveguide flux qubit, of the plurality of co-planar waveguide flux qubits, comprises (a) a qubit quantum device and (b) an elongated thin film superconductor waveguide electrically coupled in parallel with the qubit quantum
 - device.
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2. The quantum computing device of claim 1, wherein for each co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, the qubit quantum device comprises a superconducting quantum interference device (SQUID).
- 20 3. The quantum computing device of claim 2, wherein each coupler element is arranged to operatively couple two different co-planar waveguide flux qubits.
4. The quantum computing device of claim 3, wherein each coupler element is arranged to operatively couple an elongated thin film superconductor waveguide of one of
- 25 the plurality of co-planar waveguide flux qubits to an elongated thin film superconductor waveguide of another one of the plurality of co-planar waveguide flux qubits.
5. The quantum computing device of claim 2, wherein the tuning quantum device is a superconducting quantum interference device (SQUID).
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6. The quantum computing device of claim 5, wherein the SQUID of the tuning quantum device is a DC-SQUID.

5 7. The quantum computing device of claim 5, wherein a first end of the SQUID of the tuning quantum device is in electrical contact with the first co-planar waveguide flux qubit between the qubit quantum device and the elongated thin film waveguide of the first co-planar waveguide flux qubit, and a second end of the SQUID of the tuning quantum device is in electrical contact with the second co-planar waveguide flux qubit between the qubit quantum device and the elongated thin film waveguide of the second co-planar
10 waveguide flux qubit.

8. The quantum computing device of claim 2, wherein, for each co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, a first end of the elongated thin film superconductor waveguide is in electrical contact with the qubit quantum
15 device and a second end of the elongated thin film superconductor waveguide is in electrical contact with a co-planar ground plane.

9. The quantum computing device of claim 8, wherein, for each co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, a first elongated
20 side and a second opposite elongated side of the thin film superconductor waveguide are spaced apart from and co-extensive with the co-planar ground plane.

10. The quantum computing device of claim 9, wherein, for the tuning quantum device, a first end of the tuning quantum device is in electrical contact with the first co-planar
25 waveguide flux qubit between the qubit quantum device and the elongated thin film waveguide of the first co-planar waveguide flux qubit, and a second end of the tuning quantum device is in electrical contact with the second flux qubit between the qubit quantum device and the elongated thin film waveguide of the second co-planar waveguide flux qubit.
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11. The quantum computing device of claim 10, wherein the tuning quantum device and each qubit quantum device of each co-planar waveguide flux qubit of the plurality of co-

planar waveguide flux qubits comprises a superconducting quantum interference device (SQUID).

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12. The quantum computing device of claim 2, wherein, for each co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, the SQUID of the qubit quantum device is a DC-SQUID.

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13. The quantum computing device of claim 2, wherein each coupler element comprises a thin film superconductor, and wherein, for each coupler element, the thin film superconductor is spaced apart from a corresponding first elongated thin film superconductor waveguide of a first one of the plurality of co-planar waveguide flux qubits and from a
15 corresponding second elongated thin film superconductor waveguide of a second one of the co-planar waveguide flux qubits to allow inductive coupling between the first corresponding elongated thin film superconductor waveguide and the second corresponding elongated thin film superconductor waveguide.

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14. The quantum computing device of claim 2, further comprising, for each co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, a corresponding qubit readout device operatively couplable to the elongated thin film superconductor
25 waveguide of the co-planar waveguide flux qubit.

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15. The quantum computing device of claim 14, wherein, for each co-planar waveguide flux qubit of the plurality of co-planar waveguide flux qubits, the corresponding qubit readout device comprises a serpentine-shaped thin film superconductor spaced apart from a side of the elongated thin film superconductor waveguide of the co-planar waveguide flux qubit to enable inductive coupling between the qubit readout device and the elongated

thin film superconductor waveguide.

5 16. The quantum computing device of claim 2, wherein the plurality of co-planar waveguide flux qubits, the at least one coupler, and the tuning quantum device are arranged on a dielectric substrate.

17. The quantum computing device of claim 2, wherein the quantum computing device is represented by the Hamiltonian: $H = \sum_i^N h_i \sigma_z^i + \sum_{i,j}^N (J_{ij} \sigma_z^i \sigma_z^j + K_{ij} \sigma_x^i \sigma_x^j)$, for $i = 1 \dots N, j = 1 \dots N$, wherein

10 N is the number of co-planar waveguide flux qubits in the quantum computing device, h_i is the local bias on co-planar waveguide flux qubit i , σ_z and σ_x represent the Pauli matrices, and J_{ij} and K_{ij} are the coupling strength between co-planar waveguide flux qubits i and j .

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