

CLAIMS

1. A superconducting coupling device comprising:
 - a resonator structure (200, 300, 500, 600) having a resonator center conductor (202, 302, 506, 706) constructed of a superconducting material, the resonator structure (200, 300, 500, 600) having a first end configured to be coupled to a first device and a second end configured to be coupled to a second device; and
 - a gate positioned proximal to the resonator center conductor (202, 302, 506, 706) of the resonator structure (200, 300, 500, 600), the gate configured to receive a gate voltage and vary a kinetic inductance of the resonator center conductor (202, 302, 506, 706) of the resonator structure (200, 300, 500, 600) based upon the gate voltage, the varying of the kinetic inductance inducing the resonator structure (200, 300, 500, 600) to vary a strength of coupling between the first device and the second device.
2. The superconducting coupling device of claim 1, wherein the varying of the kinetic inductance is a result of the gate varying a superfluid density of the resonator center conductor (202, 302, 506, 706) of the resonator structure (200, 300, 500, 600).
3. The superconducting coupling device of any one of the preceding claims, wherein the varying of the kinetic inductance induces a varying of a characteristic frequency of the resonator structure (200, 300, 500, 600).
4. The superconducting coupling device of claim 3, wherein the varying of the characteristic frequency of the resonator structure (200, 300, 500, 600) enables the varying of the strength of coupling between the first device and the second device.
5. The superconducting coupling device of any one of the preceding claims, wherein the resonator center conductor (202, 302, 506) of the resonator structure (200, 300, 500, 600) is formed of magic angle twisted bilayer graphene, WTe_2 , or $\text{Sn}_{1-\delta-\text{x}}\text{In}_\text{x}\text{Te}$.
6. The superconducting coupling device of any one of the preceding claims, wherein the gate is formed of a metal material or of a superconducting material.

7. The superconducting coupling device of any one of the preceding claims, wherein the first device is capacitively coupled to the first end of the resonator structure (200, 300, 500, 600), and the second device is capacitively coupled to the second end of the resonator structure (200, 300, 500, 600).
8. The superconducting coupling device of any one of the preceding claims, further comprising a ground plane connected to the resonator structure (200, 300, 500, 600).
9. The superconducting coupling device of claim 8, wherein the ground plane is connected to the resonator structure (200, 300, 500, 600) by a shunt portion of the resonator structure (200, 300, 500, 600).
10. The superconducting coupling device of any one of the preceding claims, further comprising a substrate structure, wherein the resonator structure (200, 300, 500, 600) is disposed upon a surface of the substrate structure.
11. The superconducting coupling device of any one of the preceding claims, further comprising an insulator disposed upon the resonator structure (200, 300, 500, 600), wherein the gate is disposed upon the insulator.
12. The superconducting coupling device of claim 10, further comprising a ground plane disposed upon the surface of the substrate structure proximate to the resonator structure (200, 300, 500, 600).
13. The superconducting coupling device of any one of the preceding claims, wherein the first device is a first qubit and the second device is a second qubit.
14. The superconducting coupling device of any one of claims 1 to 12, wherein the first device is a qubit and the second device includes readout measurement circuitry of a quantum computing device.
15. The superconducting coupling device of any one of claims 1 to 13, wherein the first device is a first transmon and the second device is a second transmon, and wherein the resonator

structure (200, 300, 500, 600) and the gate provide tunable coupling between the first transmon and the second transmon.

16. A method comprising:

- coupling a first end of a resonator structure (200, 300, 500, 600) to a first device;
- coupling a second end of the resonator structure (200, 300, 500, 600) to a second device;
- positioning a gate proximal to a resonator center conductor (202, 302, 506, 706) constructed of a superconducting material of the resonator structure (200, 300, 500, 600);
- receiving a gate voltage by the gate; and
- varying a kinetic inductance of the resonator center conductor (202, 302, 506, 706) of the resonator structure (200, 300, 500, 600) based upon the gate voltage, the varying of the kinetic inductance inducing the resonator structure (200, 300, 500, 600) to vary a strength of coupling between the first device and the second device.

17. The method of claim 16, wherein the varying of the kinetic inductance is a result of the gate varying a superfluid density of the portion of the resonator structure.

18. The method of any one of claim 16 or 17, wherein the varying of the kinetic inductance induces a varying of a characteristic frequency of the resonator structure.

19. The method of claim 18, wherein the varying of the characteristic frequency of the resonator structure (200, 300, 500, 600) enables the varying of the strength of coupling between the first device and the second device.

20. The method of any one of claims 16 to 19, wherein the resonator center conductor (202, 302, 506) of the resonator structure (200, 300, 500, 600) is formed of magic angle twisted bilayer graphene, WTe_2 , or $\text{Sn}_{1-\delta-x}\text{In}_x\text{Te}$.

21. A superconductor fabrication system comprising a lithography component, the superconductor fabrication system when operated on a die to fabricate a superconductor device performing operations comprising:

- coupling a first end of a resonator structure (200, 300, 500, 600) to a first device;
- coupling a second end of the resonator structure (200, 300, 500, 600) to a second device;
- positioning a gate proximal to a resonator center conductor (202, 302, 506, 706) constructed of a superconducting material of the resonator structure (200, 300, 500, 600);

receiving a gate voltage by the gate; and

varying a kinetic inductance of the resonator center conductor (202, 302, 506, 706) of the resonator structure (200, 300, 500, 600) based upon the gate voltage, the varying of the kinetic inductance inducing the resonator structure (200, 300, 500, 600) to vary a strength of coupling between the first device and the second device.

22. The superconductor fabrication system of claim 21, wherein the varying of the kinetic inductance is a result of the gate varying a superfluid density of the portion of the resonator structure (200, 300, 500, 600).

23. The superconductor fabrication system of any one of claim 21 or 22, wherein the varying of the kinetic inductance induces a varying of a characteristic frequency of the resonator structure (200, 300, 500, 600).

24. The superconductor fabrication system of claim 23, wherein the varying of the characteristic frequency of the resonator structure (200, 300, 500, 600) enables the varying of the strength of coupling between the first device and the second device.

25. The superconductor fabrication system of any one of claims 21 to 24, wherein the resonator center conductor (202, 302, 506) of the resonator structure (200, 300, 500, 600) is formed of magic angle twisted bilayer graphene, WTe_2 , or $\text{Sn}_{1-\delta-x}\text{In}_x\text{Te}$.