CLAIMS

1. A quantum information processing (QIP) system comprising:

a data qubit; and

an ancilla qubit with an asymmetric error channel, the data qubit coupled to the ancilla qubit,

wherein an error channel of the ancilla qubit is dominated by phase-flip errors and not bit-flip errors.

2. The QIP system according to claim 1, further comprising a measurement device configured to measure a property of the data qubit using the ancilla qubit and using a quantum non-demolition measurement by:

causing the data qubit and the ancilla qubit to interact such that a state of the ancilla qubit is based on the property of the data qubit; and

measuring the state of the ancilla qubit to determine the state of the data qubit.

3. The QIP system according to claim 2, wherein the measurement device comprises:

a readout cavity coupled to the ancilla qubit; and

a cavity state detector configured to measure the state of the readout cavity.

4. The QIP system according to claim 2, further comprising a microwave field source configured to cause the data qubit and the ancilla qubit to interact such that a z-component of a state of the ancilla qubit is based on the property of the data qubit.

5. The QIP system according to claim 4, wherein:

the ancilla qubit is an ancilla superconducting nonlinear asymmetric inductive element (SNAIL) with a resonance frequency; and

the microwave field source is configured to apply a pump microwave field to the ancilla SNAIL at a pump frequency that is twice the resonance frequency of the SNAIL.

6. The QIP system according to claim 5, wherein the microwave field source is configured to:

apply at least one initialization microwave field to the ancilla qubit to initialize the ancilla qubit in a cat state along the x-axis of a Bloch sphere; and

apply at least one drive microwave field to at least one of the data qubit and the ancilla qubit to create an interaction between the data qubit and the ancilla qubit.

7. The QIP system according to claim 6, wherein the microwave field source is configured to apply the at least one initialization microwave field to the ancilla qubit by adiabatically increasing an amplitude of a pump microwave field of the ancilla SNAIL, prepared in a vacuum state, from 0 to a pump amplitude value equal to $K|\alpha|^2$, where K is a strength of a Kerr nonlinearity of the ancilla SNAIL and α is a coherent state amplitude associated with the cat state.

8. The QIP system according to claim 5, wherein:

the data qubit is a transmon;

the property of the data qubit is σ_Z of the transmon; and

the microwave field source is further configured to apply a drive microwave field to the transmon at the resonance frequency of the SNAIL and in phase with the pump microwave field to cause the data qubit and the ancilla qubit to interact such that a z-component of the state of the ancilla qubit is dependent on σ_Z of the data qubit.

9. The QIP system according to claim 5, wherein:

the data qubit comprises a cat state in a linear oscillator;

the property of the data qubit is a photon number parity of the cat state; and

the microwave field source is further configured to apply a drive microwave field to the cat state in the linear oscillator at the resonance frequency of the SNAIL and in phase with the pump microwave field to cause the data qubit and the ancilla qubit to interact such that a z-component of the state of the ancilla qubit is dependent on the photon number parity of the data qubit.

10. The QIP system according to claim 5, wherein:

the data qubit comprises a Gottesman-Kitaev-Preskill (GKP) state in a linear oscillator;

the property of the data qubit is a stabilizer of the GKP state; and

the microwave field source is further configured to apply a drive microwave field to the ancilla SNAIL at a drive frequency equal to a difference between the resonance frequency of the SNAIL and a resonance frequency of the linear oscillator to cause the data qubit and the ancilla qubit to interact such that a z-component of the state of the ancilla qubit is dependent on a stabilizer of the GKP state of the data qubit.

11. The QIP system according to claim 1, further comprising a microwave field source configured to apply a stabilizing microwave field to the ancilla qubit to create the asymmetric error channel.

12. A method of performing quantum information processing (QIP) in a system comprising a data qubit coupled to an ancilla qubit, the method comprising:

driving the ancilla qubit with a stabilizing microwave field to create an asymmetric error channel.

13. The method according to claim 12, further comprising measuring a property of the data qubit using the ancilla qubitby performing a quantum non-demolition measurement, wherein performing the quantum non-demolition measurement comprises:

causing the data qubit and the ancilla qubit to interact such that a state of the ancilla qubit is based on the property of the data qubit; and

measuring the state of the ancilla qubit to determine the state of the data qubit.

14. The method according to claim 13, further comprising causing the data qubit and the ancilla qubit to interact such that a z-component of a state of the ancilla qubit is based on the property of the data qubit.

15. The method according to claim 14, further comprising:

applying at least one initialization microwave field to the ancilla qubit to initialize the ancilla qubit in a cat state along the x-axis of a Bloch sphere; and

applying at least one drive microwave field to at least one of the data qubit and the ancilla qubit to create an interaction between the data qubit and the ancilla qubit.

16. The method according to claim 12, further comprising implementing a quantum data gate between the data qubit and the ancilla qubit.

17. The method according to claim 16, wherein the quantum data gate is a CNOT gate, the data qubit is a target qubit of the CNOT gate, and the ancilla qubit is a control qubit of the CNOT gate, and wherein the control qubit comprises a first cat state and the target qubit comprises a second cat state.

18. The method of claim 17, further comprising rotating the first cat state in phase space to implement the CNOT gate.

19. The method according to claim 18, further comprising:

applying a first microwave field with a frequency $2\omega_c$ to the control qubit, wherein ω_c is a resonance frequency of the control qubit;

applying a second microwave field with a frequency $2\omega_t$ to the target qubit, wherein ω_t is a resonance frequency of the target qubit;

applying a third microwave field with a frequency $2\omega_t - \omega_c$ to the target qubit;

applying a fourth microwave field with a frequency ω_c to the control qubit; and

applying a fifth microwave field with a frequency ω_c to the target qubit.

20. The method according to claim 19, wherein:

an amplitude of the first microwave field is constant over the gate time duration;

an amplitude of the second microwave field is time-varying over the gate time duration;

an amplitude of the third microwave field is time-varying over the gate time duration;

an amplitude of the fourth microwave field is time-varying over the gate time duration; and

an amplitude of the fifth microwave field is constant over the gate time duration.