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Quantum Measurement with the Josephson Bifurcation Amplifier

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The Josephson tunnel junction is a unique dipolar circuit element which can be both non-linear and non-dissipative. This combination makes it well suited to measuring quantum systems since non-linearity enables fast, sensitive detection while the absence of dissipation reduces loss of coherence. When the junction is driven close to a bifurcation point with a sufficiently intense microwave drive, then two metastable states exist which differ in oscillation amplitude and phase. The junction remains confined to a single well of its sinusoidal potential in both of these states and no DC voltage is generated. The oscillation state of the junction can be determined by measuring either the reflected or transmitted AC microwave drive signal. The transition between these dynamical states is a sensitive function of the junction critical current. Therefore, the critical current serves as the input variable of the amplifier and can be modulated by the application of a magnetic flux, electric charge, or a superconducting phase. The bifurcation amplifier has been successfully used for the state readout of superconducting qubits, and has many potential applications including the coherent detection of magnetic nanostructures such as single molecule magnets.