Bound-State in the continuum in a fluxonium qutrit

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Quantum excitations generally decay when coupled to a band of states with a continuous spectrum, however, there are some exceptions to those decay processes where a confined state lying at the continuum part of the spectrum lives forever. Those bound states in the continuum (BIC) were predicted long ago and have appeared on several platforms as solid-state devices or photonic devices. Some recent works have found BICs modes in typical quantum-information set-ups, such as superconducting circuits, and argue their usefulness for quantum information applications. In this case, BICs correspond to plasma excitations spatially localized in a superconducting waveguide, while a qubit is used to enforce the necessary boundary conditions.

In this work, we show how to construct a BIC state [1], more precisely a quasi-BIC state, localized within a fluxonium device when it is capacitively coupled to a waveguide [2]. First, we introduce an effective model for the Hamiltonian, flux, and charge operators of the fluxonium qutrit. Then, we analyze the capacitive coupling to a waveguide, finding that the second excited state becomes a quasi-bound state in the continuum (quasi-BIC) when the fluxonium is heavily shunted. In the case without noise, we find BIC lifetimes T_1 that can be much larger than seconds, being typical device frequencies on the order of gigahertz. While in presence of noise, we find BIC lifetimes T_1 of the order of 10^{-1} ms.

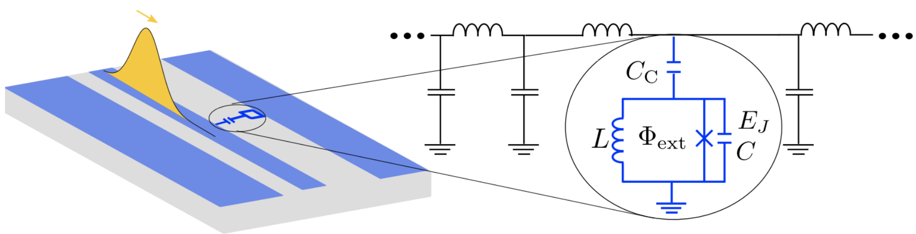

Figure 1. Fluxonium qubit capacitively coupled to a superconducting waveguide.

[1] M. Hita-Pérez, P. Orellana, J.J. García-Ripoll, and M. Pino, *Phys. Rev. A* **106**, 062602 (2022).
[2] V.E. Manucharyan, J. Koch, L.I. Glazman, and M.H. Devoret, *Science* **326**, 113 (2009).

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