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Nonequilibrium corrections and Higgs mode in superconducting devices: unraveling the pronounced Anti-Q slope in high-frequency regime and current-dependent kinetic inductance

Thursday 25 September 2025 10:10 (20 minutes)

The anti-Q-slope observed in superconducting RF (SRF) cavities has been a longstanding puzzle. Previous studies by Gurevich [1] and Kubo-Gurevich [2] linked this phenomenon to the smearing of the density of states under high RF current. However, the experimentally observed trend of a more pronounced anti-Q-slope with increasing frequency remains unexplained. Recent theoretical investigations using the Keldysh formalism of nonequilibrium superconductivity have provided new insights [3,4]. They revealed that in superconductors exposed to a perturbative RF field on a bias dc, nonequilibrium corrections to the current-carrying state, including the Higgs mode—previously overlooked—significantly influence Q-values and kinetic inductance, even in the RF region. Notably, over 40 % of the current dependence of kinetic inductance is attributed to the Higgs mode. Moreover, the anti-Q-slope as a function of dc bias becomes more pronounced at higher frequencies. These findings suggest that the anti-Q-slope under strong RF fields arises from these nonequilibrium corrections in addition to DOS smearing. Such corrections, including the Higgs mode, are crucial in superconducting devices under strong currents, whether dc or RF, affecting not only SRF cavities but also devices like single photon detectors and kinetic inductance detectors. This presentation highlights key physical mechanisms and their impact on superconducting devices, including SRF cavities.

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Yes

Footnotes

[1] A. Gurevich, Phys. Rev. Lett. 113, 087001 (2014).
[2] T. Kubo and A. Gurevich, Phys. Rev. B 100, 064522 (2019).
[3] T. Kubo, Phys. Rev. Applied 22, 044042 (2024).
[4] T. Kubo, arXiv:2502.05914.

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