

Anisotropic second-harmonic generation in superconducting nanostructures

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Superconducting nanostructure-based circuits are widely regarded as leading candidates for next-generation quantum computing architectures [1]. A key challenge in this context is clarifying how device geometry influences the statics [2] and nonlinear dynamics of superconducting state, in the presence of the microwave driving field.

Previous studies have predominantly focused on systems where static and time-dependent magnetic fields are collinearly aligned [3]. In contrast, the present work [4] explores the electrodynamic response of a superconducting nanocube subjected to simultaneous static and microwave magnetic fields with a general, noncollinear orientation. The analysis reveals that, under such excitation, the magnetization component parallel to the static field exhibits a pronounced second-harmonic response when driven by microwave fields.

Remarkably, this nonlinear signal is strongly enhanced at static magnetic fields just below the onset of successive Abrikosov vortex nucleation, where Meissner currents approach saturation. Time-dependent Ginzburg–Landau simulations demonstrate that the observed behavior arises from the interplay between Meissner-current saturation and nonlinear oscillations of normal-phase indentations. As a result, an anisotropic second-harmonic response emerges, spatially separated from the first-harmonic magnetization and therefore not masked by it. These results highlight new opportunities for engineering controllable high-frequency nonlinearities in superconducting devices.

References:

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