Vortex Energy barriers in Meandering Superconducting Nanowires: Controlling Jitter in SNSPDs via Magnetic Field and Bias Currents

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We present a theoretical and computational study of vortex dynamics in meandering superconducting nanowires (e.g., SNSPDs). Building upon established methods for computing vortex energies in non-conventional geometries [1, 2], our work incorporates the effect of screening currents induced by an external magnetic field. We calculate the total Gibbs free energy landscape to determine sets of parameters (B_z , I_{bias}) to engineer a tunable energy barrier for vortex crossing events. We seek barriers high enough to suppress spontaneous vortex-crossing yet remain low enough to permit crossing upon localized perturbations (e.g., a hotspot following single-photon absorption [3]).
This analytical approach is benchmarked against a heuristic approach via simulations of the generalized time-dependent Ginzburg- Landau (gTDGL), performed using the open-source package py-TDGL [4]. Our findings offer a design principle for optimizing operating conditions of SNSPDs to achieve maximal timing resolution and dark-count suppression.

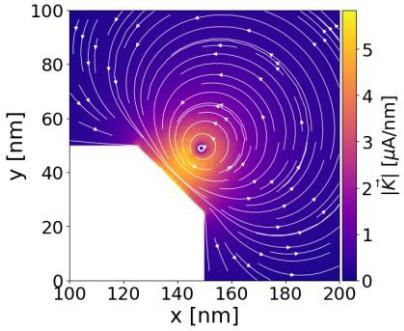

Fig. 1: *Current density of a single vortex close to the inner boundary of a meandering wire at its bend.*

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References

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