

Full control of a single vortex in a superconducting nanodevice

Maciej Zgirski*

CoolPhon Group, International Research Centre MagTop,
Institute of Physics, Polish Academy of Sciences, Warsaw

<http://coolphongroup.ifpan.edu.pl>

*zgirski@ifpan.edu.pl

We introduce the **Single Vortex Box** (SVB) – a nanodevice that allows to treat a single superconducting vortex as a macroscopic, yet quantized, “particle” that can be created and annihilated on demand using electrical current pulses [1]. By applying fast, nanosecond-resolving switching thermometry [2], we measure the temperature rise and the subsequent thermal relaxation resulting from the expulsion of just a single magnetic vortex from the aluminum SVB. Our experiment provides a calorimetric estimation of the energy dissipated in a superconductor due to a single moving vortex – a fundamentally important measurement that has never been accomplished before due to the lack of appropriate tools. We experimentally determine the range of magnetic fields and applied electric currents for which the vortex remains trapped in the box. On the applied side, we demonstrate a single-vortex memory cell, superconducting diode, and heat valve.

References

- [1] M. Foltyn, K. Norowski, A. Savin, M. Zgirski, *Quantum thermodynamics with a single superconducting vortex*, **Science Advances** 10, eado4032 (2024).
- [2] M. Zgirski, M. Foltyn, A. Savin, A. Naumov, K. Norowski, *Heat Hunting in a Freezer: Direct Measurement of Quasiparticle Diffusion in Superconducting Nanowire*, **Phys. Rev. Applied** 14, 044024 (2020).