Cutting corners to make superconductors work better

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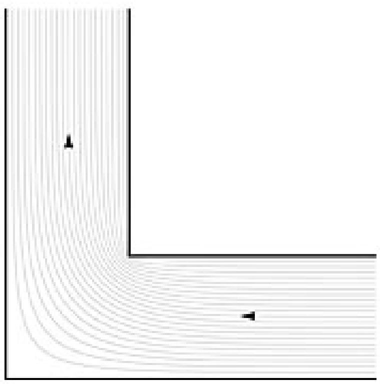

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Making superconducting nanocircuits with rounded corners will improve their performance, according to John R. Clem, a physicist at the U.S. Department of Energy's Ames Laboratory, and Karl K. Berggren, an associate professor of electrical engineering at the Massachusetts Institute of Technology.

Clem and Berggren calculated the critical current in thin and narrow superconducting strips with sharp right-angle turns, 180-degree turnarounds, and more complicated geometries. They found that current crowding, which occurs at the inner corners when the current rounds sharp turns, significantly reduces the current where a voltage first appears, called the critical current. Rounded corners, according to Clem and Berggren, will significantly improve critical currents.

The new theoretical work explains existing experimental measurements of critical currents that had previously not been understood.

"These results may help improve fundamental measurements of the critical currents of thin and narrow strips, because many previous experiments, which used samples with sharp corners, are likely to have yielded anomalously low values of the critical current because of current crowding," said Clem.

The results may also have applications in the design of the meander lines in superconducting nanowire single-photon detectors, which perform best when the lines have the highest possible critical currents, as well as in quantum gates for quantum computers, terahertz detectors for astronomy, and SQUID magnetometers used to measure extremely small magnetic fields.

"We've known for some time that patterns with extremely sharp hairpin turns exhibit reduced critical current," said Berggren, "but now we finally understand why this happens, and can eliminate this problem in our future detector designs. The result is likely to be detectors with improved efficiency and reduced noise."

The research was done while Berggren was on sabbatical at the Technical University of Delft in the Netherlands.The work at Ames Laboratory was funded by the DOE's Office of Science's Office of Basic Energy Sciences.

More information: A paper describing both the theoretical calculations and a comparison with experiment recently appeared in *Physical Review B*: link.aps.org/doi/10.1103/PhysRevB.84.174510 .

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