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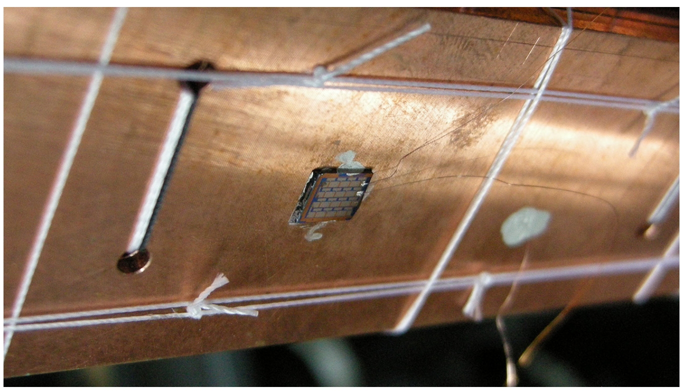
Applying demagnetization cooling in a new way to Coulomb blockade thermometers reduces heat leaks and achieves a record cooling temperature.



The production of ultra-low temperature devices continues to hold promise for the field of physics beyond the major fundamental advances already made with supercooled helium and optical cooling. Overcoming temperature as a limiting factor in experimental studies, and devices involving electron transport would open doors to better observe new phenomena occurring in nuclear spin phases, quantum Hall states, phase transitions and low temperature quantum coherence. In a study published in *Applied Physics Letters*, cooling temperatures of a Coulomb blockade thermometer (CBT) reached 2.8 (+/− 0.1) millikelvin by using adiabatic demagnetization of the CBT's electronic leads and metallic islands.

Adiabatic nuclear demagnetization (AND), or magnetic cooling, achieves refrigeration through the magnetocaloric effect by lowering an external magnetic field to decrease a material's magnetic energy while it simultaneously decouples thermally. The process, adapted here for CBTs, cooled both the leads and their large copper islands.

Performing AND in both the leads and islands combined direct on-chip cooling with a reduced external heat leak from the leads. The CBTs rested on cryo-free platforms supporting 16 leads, each of which was equipped with 2 moles of copper that could be cooled as low as 150 microkelvin. Each CBT consisted of 16 metallic islands with tunnel barriers in between them that provided a small enough charging energy to allow for accurate thermometry down to approximately 2 millikelvin.

The large volume of the metallic Cu islands acted as the spin reservoir for the AND refrigerator. Adiabatic magnetic cooling was accomplished by applying a 9T magnetic field with the CBT and copper plates coupled to the cryo-platform. They were then decoupled and the field was ramped down slowly to 0.375T. This combination improved the final cooling by a factor of 8.6 to achieve the 2.8 millikelvin temperature. It also improved the cold time of the system, where the low temperatures lasted for hours instead of minutes.

Source: "On-and-off chip cooling of a Coulomb blockade thermometer down to 2.8 mK," by M. Palma, C. P. Scheller, D. Maradan, A. V. Feshchenko, M. Meschke, and D. M. Zumbühl, *Applied Physics Letter* (2017). The article can be accessed at https://doi.org/10.1063/1.5002565.