Scilight

5 January 2022

Developing low cost, efficient magnetic refrigeration down to 0.2 K

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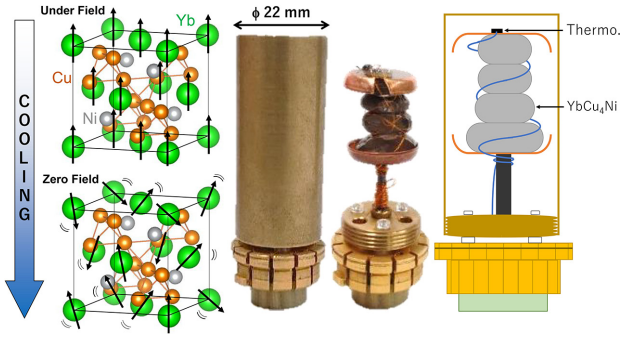
Magnetic refrigerators made of YbCu4Ni could be used for condensed matter physics, superconducting circuits, cosmic ray detectors.



Temperatures below 1 K are useful for studying condensed matter physics, like exotic superconductivity, quantum spin liquids, and the quantum Hall effect. These temperatures can cool superconducting circuits in quantum computers and devices used in space to detect cosmic rays. Standard techniques for these applications use 3He, which is precious and expensive, and do not work under zero gravity conditions.

Magnetic refrigeration takes advantage of electronic spin and addresses the above issues. A magnetic field aligns spins in one direction and is then switched off, causing material to cool as the directions of spin in its constituent electrons become random and dynamic.

Shimura et al. developed a magnetic refrigeration system using YbCu4Ni metal that reached 0.2 K. The material is low cost, stable, highly heat conductive, and has a large specific heat, which is essential for magnetic refrigeration.

“Ytterbium is one of the few rare-earth elements that can form the heavy electron state,” said author Yasuyuki Shimura. “The heaviness of the electrons in YbCu4Ni is 1,000 to 10,000 times larger than that in normal metals. Heaviness of the electrons corresponds to the magnitude of the specific heat, and large specific heat at zero magnetic field results in the high performance of the magnetic refrigerator.”

The team demonstrated the magnetic refrigeration by first installing their system in a commercial 4He refrigerator, applying an external magnetic field, and precooling down to 1.8 K. At that temperature, the magnetic field was turned off, and the thermometer directly mounted on the YbCu4Ni showed a decrease to 0.2 K in less than 20 minutes.

In the future, the researchers plan to make magnetic refrigeration materials for cooling below 0.1 K.

Source: “Magnetic refrigeration down to 0.2 K by heavy fermion metal YbCu4Ni,” by Yasuyuki Shimura, Kanta Watanabe, Takanori Taniguchi, Kotaro Osato, Rikako Yamamoto, Yuka Kusanose, Kazunori Umeo, Masaki Fujita, Takahiro Onimaru, and Toshiro Takabatake, *Journal of Applied Physics* (2021). The article can be accessed at https://doi.org/10.1063/5.0064355.

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