

A quieter microscope

For years, scanning tunneling microscopes (STMs) have imaged surfaces at the atomic scale. Such studies are often performed in ultrahigh vacuum systems at millikelvin temperatures. Although the typical helium dilution refrigeration technique easily brings the temperature below 100 mK, the continuous circulation of cryogenic liquids produces a substantial level of mechanical noise. This picture shows a different STM whose cooling unit maintains a temperature range of 30 mK to 1 K using adiabatic demagnetization refrigeration. Designed by Ruslan Temirov of the Jülich Research Center in Germany and his colleagues, the solid-state refrigerator is quieter than other refrigerators with mechanical pumps. Among other possibilities, the new STM could be used to study the entanglement of individual electron spins in artificially created atomic and molecular structures.

The sample is treated in the preparation chamber (top right), inserted into the STM (top left), and then transferred to the large blue flask (bottom). A paramagnetic material, in contact with the flask, cools the system via a superconducting magnet that applies a strong magnetic field, which entrains the magnetic dipoles of the paramagnet. A helium bath acts as a heat sink during the magnetization, effectively holding the temperature at 1 K as the paramagnet's entropy decreases. After the researchers remove the thermal link to the bath, they decrease the magnetic field strength, causing the paramagnet to regain its entropy. Because the STM is decoupled from the 1 K environment yet anchored to the paramagnet, it cools adiabatically. From there, the sample is precisely imaged at millikelvin temperatures. (T. Esat et al., *Rev. Sci. Instrum.* **92**, 063701, 2021; image courtesy of Forschungszentrum Jülich/Sascha Kreklau.)

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