1 μm wavelength, and an expected band narrowing of a factor of 10.

ROSALIA SERNA

Nanoclusters of Niobium Display Nonmetallic Properties at Ultracold Temperatures

While searching for signs of superconductivity in nanometer-scale clusters of the metal niobium, researchers at the Georgia Institute of Technology found that the material stops behaving as a metal when the clusters—of up to 200 niobium atoms—are cooled to low temperature. The electrical charges in the clusters suddenly shift, forming dipoles, as the temperature is lowered below a transition temperature that depends on cluster size.

"This is very strange, because no metal is supposed to be able to do this," said Walter de Heer, a professor in the School of Physics at the Georgia Institute of Technology. "These clusters become spontaneously polarized, with electrons moving to one side of the cluster for no apparent reason. One side of each cluster becomes negatively charged, and the other side becomes positively charged. The clusters lock into that behavior." In bulk metals—including niobium clusters at room temperature—electrical charge is normally distributed equally throughout the sample unless an electric field is applied to them.

This ferroelectric phenomenon has so far been observed in clusters of niobium, vanadium, and tantalum—three transition metals that in bulk form become superconducting at about the same temperature that the researchers observe formation of dipoles in the tiny clusters. De Heer believes this discovery will provide insights into superconductivity.

For the smallest clusters, as reported in the May 23 issue of *Science* by de Heer and collaborators R. Moro, X. Xu, and S. Yin, the strength of the dipole effect varies dramatically according to size. Clusters composed of 14 atoms display strong effects, while those made up of 15 atoms show little effect. Above 30 atoms, clusters with even numbers of atoms display stronger dipole effects than clusters with odd numbers of atoms.

De Heer attributes the size sensitivity to the quantum size regime, which is related to restrictions on how electrons can move in very small clusters.

To produce and study the clusters, the researchers use a custom-built apparatus that includes a detector able to count and characterize several million particles per hour. First, a laser beam is used to vaporize the niobium, creating a cloud of metallic vapor. A stream of ultracold helium gas is then injected into a vacuum chamber housing the vapor, causing the niobium gas to condense into particles of varying sizes. Under pressure from the helium, the particles exit through a small hole in the chamber's wall, creating a 1-mm-wide jet of particles that passes between two metal plates before hitting the detector.

At intervals 1 min apart, the metal plates are energized with 15,000 V, creating a strong electrical field. The field interacts with the polarized niobium nanoclusters, causing them to be deflected away from the detector. Unpolarized clusters remain in the beam and are counted by the detector.

By comparing detector readings while the plates are energized against the readings when no field is applied, the researchers learn which clusters carry the dipole. By varying the temperature and voltage, the research team can study the impact of these changes on the effect.

"By studying several different metals, we found that those that are superconducting in bulk have this effect, and those that are not superconducting do not have it. That strengthens our belief that this is connected to superconductivity in some way that we don't yet understand," de Heer said.

Radiotracer Diffusion Measurements of Isotope Motion in a Metal Alloy above the Glass-Transition Temperature Support Mode-Coupling Theory

The discovery of alloys formed from bulk metallic glass has offered a host of applications ranging from casings for mobile phones to golf clubs. Like conventional glasses, these alloys are processed by supercooling the melt though the glass transition. Much effort has been made into understanding the atomic motion in the supercooled melt and the dynamics of the glass transition. Recently, researchers at Kiel University have measured diffusion and the isotope effect in a Pd-based metallic alloy from the glassy state to the equilibrium liquid. The scientists said that the results, reported by V. Zöllmer, K. Rätzke, F. Faupel, and A. Meyer in the May 16 issue of *Physical Review Letters*, provide direct evidence of the decay of activation barriers due to the onset of liquidlike motion.

According to Faupel, who holds the Chair for Multicomponent Materials at Kiel, the most striking result is that the onset of liquidlike motion upon heating the metallic glass is not observed at the caloric glass-transition temperature,

https://doi.org/10.1557/mrs2003.159 Published online by Cambridge University Press