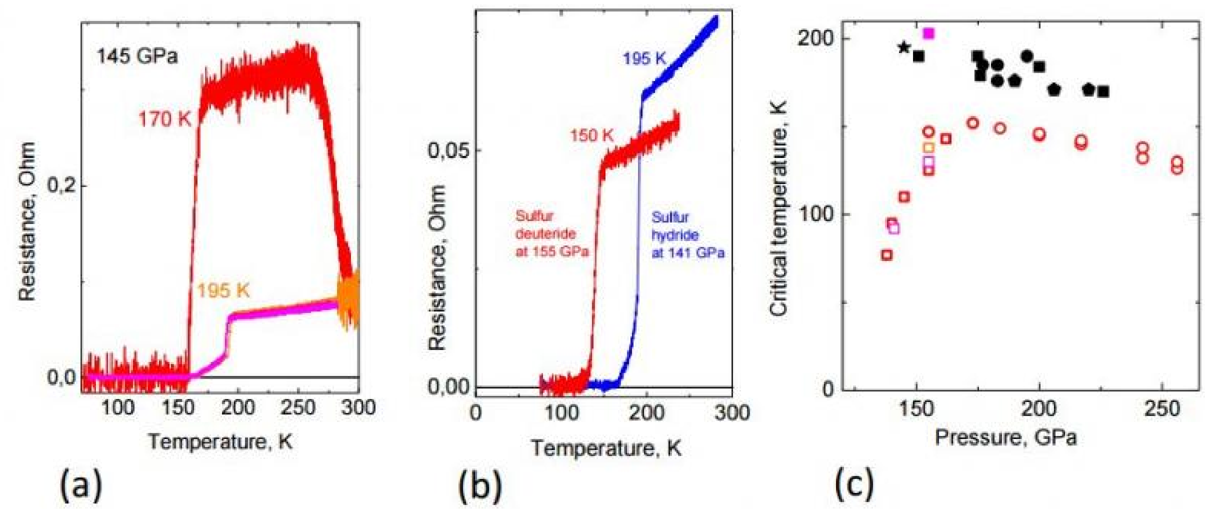
New test of hydrogen sulfide backs up superconducting claim

July 2 2015, by Bob Yirka



Pressure and temperature effects on Tc in sulfur hydride and sulfur deuteride. Credit: arXiv:1506.08190 [cond-mat.supr-con]

(Phys.org)—A combined team of researchers from the Max Planck Institute and Johannes Gutenberg University, both in Germany has backed up the findings of prior research indicating hydrogen sulfide becomes a superconductor at high pressure and a temperature of 190K. In their paper they have uploaded to the preprint server *arXiv*, the team describes their latest experiment and what it might mean for eventually finding a superconductor that works at room temperature.

Ever since 1986 following the discovery of superconductivity in cuprates, which showed that superconducting materials could be made, scientists have been looking to find one that would work at room temperature—should they succeed it would revolutionize electronics. Up till now, progress has been constant but no material has been found that could be used in everyday products. Last December, a team with some of the same members as this new group, announced that they had found that putting hydrogen sulfide under high pressure (150GPa) caused it to exhibit signs of being a superconductor at 190K—but they were not able to get it to demonstrate the Meissner effect—where a material expels a magnetic field—a key test of a superconductor. In this new effort, the researchers tested a sample in a different way, and this time, did get it to demonstrate the Meissner effect.

To make it happen, the team built a non-magnetic cell and used an ultrasensitive SQUID magnetometer. A tiny sample of hydrogen sulfide was then exposed to two million atmospheres of pressure while the temperature was raised very slowly from just above absolute zero—at 203K they got their magnetization signal indicating that the material did indeed demonstrate the Meissner effect.

The researchers propose that the reason for the superconductivity is vibrations in its crystal lattice which occur due to compression. If that turns out to be the case, other hydrogen materials might be superconductors as well, perhaps at different temperatures, some maybe as high as room temperature. As to why there was a small temperature difference this go round, the team suggests it was likely due to differences in crystal structure between the samples used in this latest effort versus that used last December.

More information: Conventional superconductivity at 203 K at high pressures, arXiv:1506.08190 [cond-mat.supr-con] arxiv.org/abs/1506.08190

Abstract
A superconductor is a material that can conduct electricity with no resistance below its critical temperature (Tc). The highest Tc that has been achieved in cuprates1 is 133 K at ambient pressure2 and 164 K at high pressures3. As the nature of superconductivity in these materials has still not been explained, the prospects for a higher Tc are not clear. In contrast, the Bardeen-Cooper-Schrieffer (BCS) theory gives a guide for achieving high Tc and does not put bounds on Tc, all that is needed is a favorable combination of high frequency phonons, strong electron-phonon coupling, and a high density of states. These conditions can be fulfilled for metallic hydrogen and covalent compounds dominated by hydrogen4,5. Numerous calculations support this idea and predict Tc of 50-235 K for many hydrides6 but only moderate Tc=17 K has been observed experimentally7. Here we studied sulfur hydride8 where a Tc~80 K was predicted9. We found that it transforms to a metal at pressure ~90 GPa. With cooling superconductivity was found deduced from a sharp drop of the resistivity to zero and a decrease of Tc with magnetic field. The pronounce isotope shift of Tc in D2S is evidence of an electron-phonon mechanism of superconductivity that is consistent with the BCS scenario. The superconductivity has been confirmed by magnetic susceptibility measurements with Tc=203K. The high Tc superconductivity most likely is due to H3S which is formed from H2S under its decomposition under pressure. Even higher Tc, room temperature superconductivity, can be expected in other hydrogen-based materials since hydrogen atoms provide the high frequency phonon modes as well as the strong electron-phonon coupling.

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