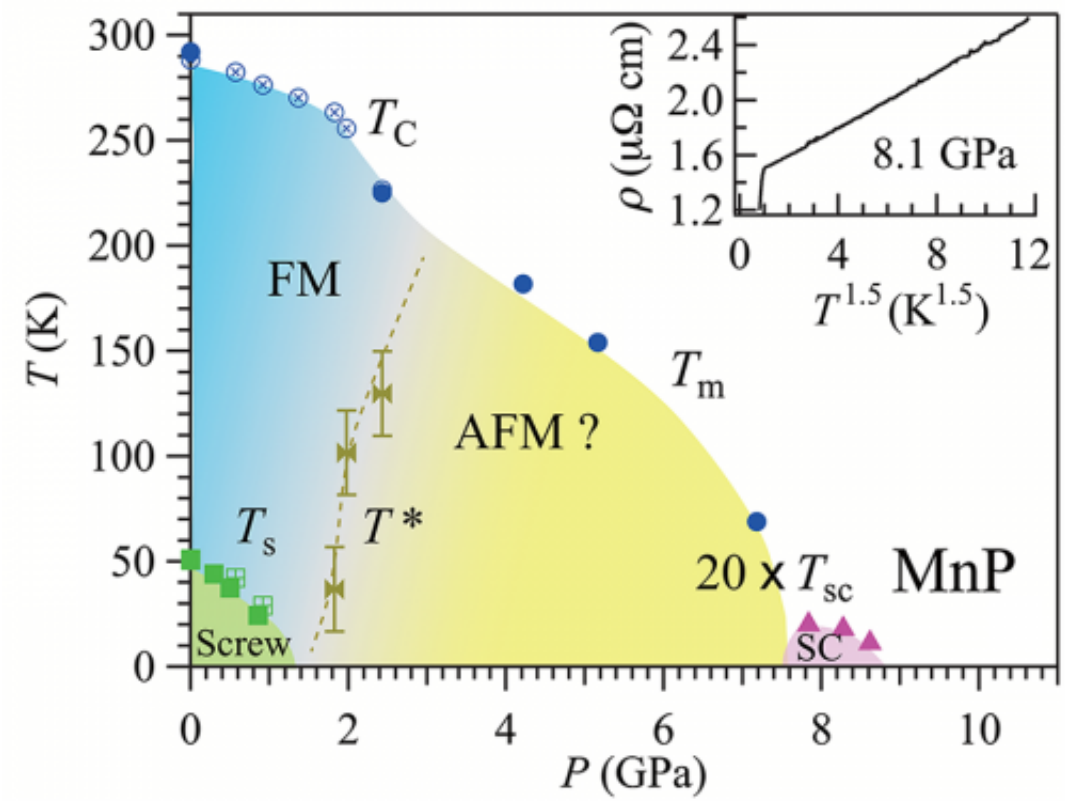
Researchers discover first manganese based superconductor

March 19 2015, by Bob Yirka



Pressure-temperature phase diagram of the helical magnet MnP [8]. Although several different magnetic phases are indicated—helical (Screw), ferromagnetic (FM), and antiferromagnetic (AFM)—all are likely to be variants of the helical phase. Suppression of the magnetism by pressure gives rise to a superconducting phase, similar to what is observed in the related helical magnet CrAs [5, 6], as seen in the inset, where the resistivity versus temperature at a pressure of 8.1 GPa is plotted. Credit: Jin-Guang Cheng/Beijing National Laboratory

(Phys.org)—A combined team of researchers from the Institute of Physics in China and the University of Tokyo has found the first instance of a manganese based superconductor. In their paper published in the journal *Physical Review Letters*, the team describes the technique they used to discover the superconductor properties in the material which many had thought would not be possible due to its high degree of magnetism.

Until recently, the idea that a material such as manganese phosphide could have a superconducting state, was ruled out because conventional superconductors have a property where electrons formed couplets known as Cooper pairs—and magnetism disrupted them. But then it was found that using magnetism suppression techniques allowed researchers to discover superconductor states in some organic or even iron based materials where it wasn't driven by Cooper pairs. In this new effort, the researchers worked backwards, subjecting materials to both a range of temperatures and varying degrees of pressure. That allowed them to test the properties of materials over a whole range of scenarios that might be likely to allow for a superconducting state to exist and to create phase diagrams. In so doing, they found that putting a sample of manganese phosphide in a freezer at 1K and then increasing pressure to 8 gigapascals suppressed its magnetism which led to a sudden drop in resistivity and thus a superconducting state. Also, because of the high percentage of volume fraction, the researchers were able to rule out the chance that the property was localized.

Manganese phosphide is a helical magnet, the researchers note—which suggests that other materials with a magnetic spin that is shaped like a spiral might exist. But that isn't the end of study for manganese phosphide, thus far nothing else is known about its superconducting state—that means more research will have to be done learn more about it in general and to find out if it might be useful for some applications. But meanwhile, because their technique worked so well, the researchers plan

to carry out similar experiments on a wide variety of other materials to find out if some of them might have superconducting properties under certain conditions as well.

More information: Pressure Induced Superconductivity on the border of Magnetic Order in MnP, J.-G. Cheng, K. Matsubayashi, W. Wu, J. P. Sun, F. K. Lin, J. L. Luo, and Y. Uwatoko, *Phys. Rev. Lett.* 114, 117001 – Published 16 March 2015 . journals.aps.org/prl/abstract/ … ysRevLett.114.117001 . On *Arxiv*: arxiv.org/abs/1412.7883

ABSTRACT

We report the discovery of superconductivity on the border of long-range magnetic order in the itinerant-electron helimagnet MnP via the application of high pressure. Superconductivity with Tsc≈1 K emerges and exists merely near the critical pressure Pc≈8 GPa, where the long-range magnetic order just vanishes. The present finding makes MnP the first Mn-based superconductor. The close proximity of superconductivity to a magnetic instability suggests an unconventional pairing mechanism. Moreover, the detailed analysis of the normal-state transport properties evidenced non-Fermi-liquid behavior and the dramatic enhancement of the quasiparticle effective mass near Pc associated with the magnetic quantum fluctuations.

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