New unconventional superconductors and Weyl semi-metal dynamics

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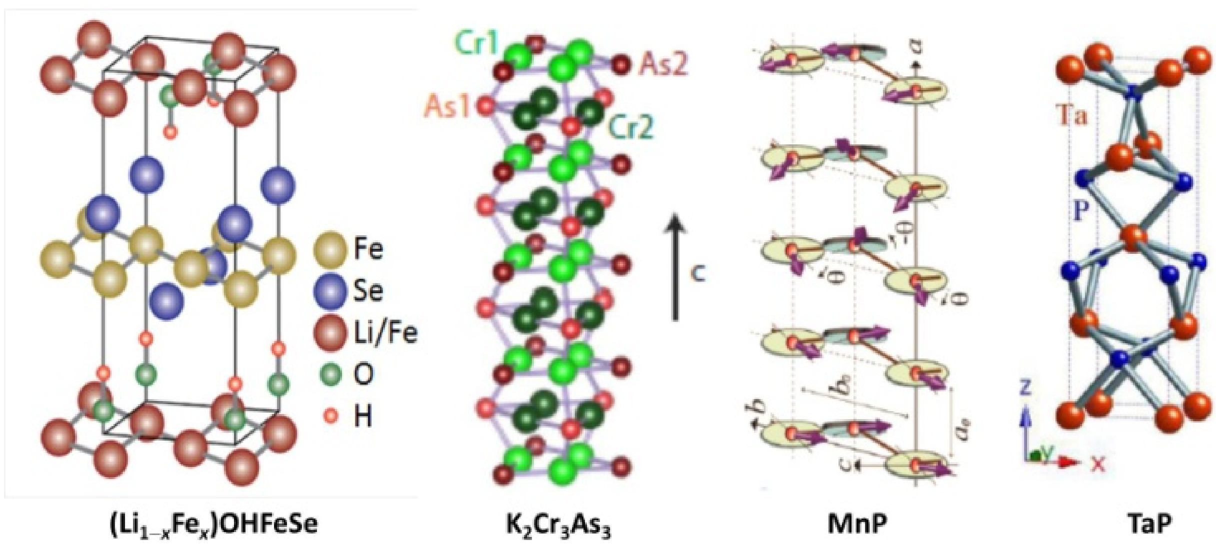

Four schematic structures investigated in this special topic. Credit: ©Science China Press

Unconventional superconductivity and topological quantum phenomena are two frontier research directions of condensed matter physics. A special topic published in a recent issue of *Science China Physics, Mechanics & Astronomy* collected several articles covering important progress in these two directions.

Superconductivity was discovered in mercury in 1911 by the group of

Kamerling Onnes in Leiden (Holland). But the mystery of superconductivity was unresolved until 1957, when Bardeen-Cooper-Schrieffer (BCS) proposed the electron-phonon coupling model. In the BCS model, two electrons near the Fermi surface with opposite momentum and spins form a bound state by exchanging phonons. Such charge carriers are called as Cooper pairs. Cooper pairs condense into a low-energy state, which exhibits macroscopic phase coherence with the presence of a superfluid. The validity of this theory is, however, quite limited, and it cannot explain superconductivity in many unconventional superconductors, such as cuprates, iron pnictides, and iron selenides.

Four works on unconventional superconductivity were presented in this special collection. The first work concerns the effect of impurity scattering on superconductivity in $K_2Cr_3As_3$, an unconventional superconductor discovered in 2015 by the same group. This superconductor may contain a one-dimensional superfluid channel and exhibit rarely reported triplet superconductivity. The report, by the group of Prof. Guang-Han Cao from Zhejiang University, deals with the effect of impurity resulting from dopants, which may reveal a fundamental feature of the manner of pairing. They found the suppression of superconductivity by non-magnetic impurities, which is consistent with a possible novel pairing gap with, for example, gap nodes.

The second work, by the group of Prof. JianLin Luo of the Chinese Academy of Sciences, involves NMR studies of the recently discovered superconductor MnP under pressure, which was discovered by the same group. The chiral magnetic state is essential to the superconductivity in that system. Here, the authors put new efforts into this issue. The third work is by Prof. Hai-Hu Wen's group from Nanjing University. Since the discovery of the superconductor $(Li_{1-x}Fex)OHFeSe$, researchers have questioned whether the superconductivity is robust and has a full volume. Clearly, the authors report robust superconductivity and anisotropy of the newly discovered superconductor $(Li_{1-x}Fex)OHFeSe$. Using well-documented data and analysis, they concluded a full volume of superconductivity in this new superconductor. The fourth work is by the group of Prof. ShiYan Li from Fudan University. They use elegant thermal transport measurements at very low temperatures to detect the superconducting gap structure of the new superconductor $Ca_{10}(Pt_{4-\delta}As_8)((Fe_{1-x}Ptx)2As_2)_5$ (Tc=22 K). They find strong evidence of a fully gapped feature, the gap structure of which is common with many other iron-based superconductors.

Finally, the special topic includes a paper by the group of Prof. MingHu Fang from Zhejiang University on the transport properties of the theoretically predicted Weyl semi-metal TaP. Weyl semi-metals are a very hot topic involving interesting physics. The detailed and careful transport measurements reveal not only the features of a semi-metal, but also some evidence of the chiral feature of the electrons, such as the huge positive and negative magnetoresistance. This discovery will trigger further studies on the Weyl semimetal state.

More information: Yi Liu et al. Effect of impurity scattering on superconductivity in K2Cr3As3, *Science China Physics, Mechanics & Astronomy* (2016). DOI: 10.1007/s11433-016-5788-6

GuoZhi Fan et al. 31P NMR study of magnetic phase transitions of MnP single crystal under 2 GPa pressure, *Science China Physics, Mechanics & Astronomy* (2016). DOI: 10.1007/s11433-016-5783-y

Hai Lin et al. Robust superconductivity and transport properties in (Li1-x Fe x)OHFeSe single crystals, *Science China Physics, Mechanics & Astronomy* (2016). DOI: 10.1007/s11433-016-5782-z

Xun Qiu et al. Nodeless superconducting gaps in Ca10(Pt4-δ As8)((Fe1-x Pt x)2As2)5 probed by quasiparticle heat transport, *Science*

China Physics, Mechanics & Astronomy (2016). DOI: 10.1007/s11433-016-5780-1

JianHua Du et al. Large unsaturated positive and negative magnetoresistance in Weyl semimetal TaP, *Science China Physics, Mechanics & Astronomy* (2016). DOI: 10.1007/s11433-016-5798-4

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