TcSUH Special Seminar

Superconductivity in Alkali Metal (K, Rb, Cs) Fullerides

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ABSTRACT: The discovery of superconductivity in potassium-doped C_{60} in 1991 was an important event soon after the birth of the new form of carbon called `buckminsterfullerene' or, in short, fullerene. However, many issues remain unsettled. Here I will talk about the recent progresses in the studies of superconductivity in (K[1,3,4], Rb[2,5], Cs[6])-doped C_{60}. The experimental evidence for the superconductivity was firmly provided from the observations of the zero-resistance state and Meissner effect for these compounds by using the same samples. The superconductivity is found to result from the suppression of the competing order, such as the orientational ordering[1] or antiferromagnetic state[6]. The electron-phonon interaction is evaluated for K_3C_{60} at ambient[1] and high pressure[3]. The study also reveals that Rb_3C_{60} is the only superconducting phase with the nearly constant transition temperature regardless of the doping level[5]. Many important superconducting parameters, such as the upper critical field, lower critical field, coherence length, penetration depth, carrier concentration, and energy gap, are determined for K-[1,3,4], Rb-[2,5], and Cs-doped[6] C_{60} superconductors.

Meanwhile, we discover the superconducting phase of Cs_3C_{60} at atmosphere pressure[6]. The established universal phase diagram of superconductivity for all phases of Cs_3C_{60} suggests that the collaboration between the electron-phonon coupling and electron correlations accounts for the superconductivity in fullerene superconductors. Most interestingly, we observe pressure-driven crossover between weakly coupled Bardeen–Cooper–Schrieffer (BCS) and strongly coupled Bose–Einstein-condensate (BEC) in K_3C_{60}. These new results and findings based on high-quality samples and developed experimental techniques indicate that alkali metal (K, Rb, Cs) fulleride superconductors possess rather rich physics beyond the earlier thinking.

References

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[6] D. Peng, R. S. Wang, L. N. Zong, and X. J. Chen, axXiv: 2208.09429 (2022).

BIO: Prof. Xiao-Jia Chen is currently a chair professor in physics of Harbin Institute of Technology at Shenzhen and a staff scientist of High-Pressure Science and Technology Advanced Research at Shanghai. He earned his Ph. D degree in condensed matter physics in 1997 from Zhejiang University. After moving to Germany and USA, he spent most his academic time in Max-Planck Institute for Solid State Research and Carnegie Institution of Washington. He has expertise in the experimental and theoretical study of superconductivity in many materials covering from cuprates, iron-based compounds, organic compounds, and hydrogen-bearing materials. His current research focuses on the discovery of new superconductors and the improvement of the performance of known superconductors by understanding the fundamental physics of superconductivity through high-pressure study. He is also making efforts to improve the thermoelectric performance through pressure tuning in the existing thermoelectric materials and to understand the intrinsic relationship between the topology and thermoelectricity.

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