Materials Engineering Program
Texas Center for Superconductivity at Univ. of Houston
Center for Integrated Bio and Nano Systems
10:00 am, Friday, Sept. 1, 2023

This seminar will be held in hybrid mode: in person at HSC 102

Achievements and Challenges on Superconductivity in Copper Oxides

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Abstract: Superconductivity has been widely studied since its discovery in 1911, and superconductors are poised to bring about a technological revolution akin to light bulbs and telephones. Five Nobel Prizes in Physics have been awarded in related research to date. The superconductivity in copper oxide material was discovered by Swiss IBM scientists in 1986 and they were awarded the Nobel Prize in the following year. So far, the mechanism of how the superconducting electrons of this type of material are paired is still unclear, which was listed twice by Science Magazine as one of the most important key scientific issues. In this report, I will briefly introduce the history, achievements, current situation, and unresolved scientific problems of superconductivity research in copper oxides. Then I will introduce our explorations and efforts in the study of the mechanism of superconductivity in copper oxides, including the theoretical models we proposed, and the methods applied to generate the experimentally observed doping and critical temperatures. I will show how to understand why each superconducting family of copper oxide has different critical temperature and isotope effect and how the critical temperature varies the number of CuO_2 layers in the unit cell in a homologous family. I will talk about how to understand the effects on the critical temperature from the isotopic external pressure and anisotropic uniaxial pressure in bulk materials, and the epitaxial strain in thin film materials. I will also present the latest results to illustrate which phonon is most likely to participate in the superconductivity, and pairing with electrons is responsible for its high-temperature superconducting behavior. The possible relationships between the superconductivity and various orders such as antiferromagnetic order, pseudogap, and charge density wave will be introduced. The possible routes to further increase the critical temperature in cuprates will be discussed.

Bio: Xiao-Jia Chen joined University of Houston as a professor in Department of Physics and a principal investigator of Texas Center for Superconductivity in June 2023. Prior to these appointments, he worked in academic institutions such as Harbin Institute of Technology at Shenzhen, High-Pressure Science and Technology Advanced Research at Shanghai of China, Carnegie Institution of Washington in the United States, and Max-Planck Institute for Solid State Research in Germany. He earned his Ph.D, degree in condensed matter physics in 1997 from Zhejiang University. He has expertise in the experimental and theoretical study of superconductivity in many materials spanning 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.