世纪物理情·系列讲座

Pair density wave state and higher charge superconductivity in low dimensional superconductors

【报告人】

王健

北京大学

【 时间 】

2024/ 01 / 03（周三）

下午 4:00

【 地点 】

清华大学高等研究院

科学馆104报告厅

【摘要】

The pair density wave (PDW) is an extraordinary superconducting state where Cooper pairs carry nonzero momentum. Theoretically, the PDW order is hypothesized to play a fundamental role in high-temperature superconductors. Here, using scanning tunneling microscopy/spectroscopy, we report the discovery of the PDW state in monolayer iron-based high-Tc Fe(Te,Se) films grown on SrTiO3(001) substrates [1]. The PDW state with a period of λ ~ 3.6aFe (aFe is the distance between neighboring Fe atoms) is observed at the domain walls by the spatial electronic modulations of the local density of states, superconducting coherence peak height and gap energy. Moreover, the π-phase shift boundaries of the PDW state are observed near the vortices of the induced secondary charge density wave state, further demonstrating that the PDW state at the domain wall is a primary state. The discovery of the primary PDW state in the monolayer Fe(Te,Se) film provides a low-dimensional platform to study the PDW state and its interplay with the topological electronic states and unconventional high-Tc superconductivity.

Despite of the various forms of superconductivity, conventional or unconventional, topologically trivial or nontrivial, the condensation of charge-2e Cooper pairs has remained the origin and character of all superconductivity, as described by the BCS theory. We report our experimental discoveries of the charge-4e and charge-6e superconductivity in nanopatterned ring devices fabricated using the new kagome superconductor CsV3Sb5 [2]. These new macroscopic phase coherent states are discovered by the observation of the quantized magnetic flux in units of h/4e and h/6e in systematic magneto-transport measurements. Our observations provide direct experimental evidence for the existence of macroscopic phase coherent paired quantum matter beyond the charge-2e superconductors, and provide ground work for exploring the physical properties of the charge-4e and charge-6e superconductivity as unprecedented phases of matter beyond the condensation of Cooper pairs described by the BCS theory.

【报告人简介】

Dr. Jian Wang is a Boya Distinguished Professor of Physics at Peking University. He developed two laboratories at Peking University to perform ultralow temperature-high magnetic field transport measurements and low temperature scanning tunneling microscopy/spectroscopy-molecular beam epitaxy investigations. Dr. Jian Wang's current research interests are quantum transport properties of low dimensional superconductors and topological materials. He has discovered a series of emergent quantum phase transitions and quantum states in both low dimensional superconductors and topological materials, including quantum Griffiths singularity, bosonic anomalous (quantum) metal state, topological zero energy bound states and pair density wave states in two dimensional superconductors, as well as log-periodic quantum oscillations, high Chern number and high temperature Chern insulator states in topological materials. Dr. Jian Wang authored more than 130 papers in Science, Nature, Nature Physics, Nature Materials, Nature Nanotechnology, Science Advances, Nature Communications, PNAS, Physical Review X, Physical Review Letters, etc. He has given more than 100 invited talks and was awarded Sir Martin Wood China Prize in 2015, Changjiang Distinguished Professor of China's Ministry of Education in 2016, Outstanding Achievement Award for Research in Institutes of Higher Education of China (Young Scientists) in 2019, and the Achievement in Asia Award (Robert T. Poe Prize) in 2022.

主办单位:清华大学高等研究院