THE CHINESE UNIVERSITY OF HONG KONG
Department of Physics
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The Interplay Between Superconductivity and Other Orders in Complex Oxides

by

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ALL INTERESTED ARE WELCOME
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Abstract

Complex oxides exhibit many intriguing phenomena, including ferroelectricity, ferromagnetism, charge order, and superconductivity. In particular, superconductivity may coexist or compete with other phases. The interplay between superconductivity and other orders is a subject of intensive study in condensed matter physics. In this talk, I will discuss two such examples in the context of complex oxides. In the first example, we study doped strong ferroelectrics (taking BaTiO3 as a prototype). We find a strong coupling between itinerant electrons and soft polar phonons in doped BaTiO3, contrary to Anderson/Blount's weakly coupled electron mechanism for "ferroelectric-like metals". As a consequence, across a polar-to-centrosymmetric phase transition in doped BaTiO3, the total electron-phonon coupling is increased to about 0.6 around the critical concentration, which is sufficient to induce phonon-mediated superconductivity of about 2 K. Lowering the crystal symmetry of doped BaTiO3 by imposing epitaxial strain can further increase the superconducting temperature via a sizable coupling between itinerant electrons and acoustic phonons. Our work demonstrates a viable approach to modulating electron-phonon coupling and inducing phonon-mediated superconductivity in doped strong ferroelectrics and potentially in polar metals. In the second example, we study the recently observed q=(1/3, 0, 0) charge order (CO) in infinite-layer nickelates, which exhibit unconventional superconductivity upon Sr doping. We use first-principles calculations to reveal a special charge-transfer-driven CO mechanism in infinite-layer nickelates, which leads to a characteristic Ni1+-Ni2+-Ni1+ stripe state. For every three Ni atoms, due to the presence of near-Fermi-level conduction bands, Hubbard interaction on Ni-d orbitals transfers electrons on one Ni atom to conduction bands and leaves electrons on the other two Ni atoms to become more localized. We further derive a low-energy effective model to elucidate that the CO state arises from a delicate competition between Hubbard interaction on Ni-d orbitals and charge transfer energy between Ni-d orbitals and conduction bands. With physically reasonable parameters, q=(1/3, 0, 0) CO state is more stable than the usual paramagnetic state and checkerboard antiferromagnetic state. Our work highlights the multi-band nature of infinite-layer nickelates, which leads to some distinctive correlated properties that are not found in cuprates.