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Electronic Excitations of Quantum Materials Probed with RIXS

by

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ALL INTERESTED ARE WELCOME
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Abstract

Recent advancements in synchrotron instrumentation have rendered resonant inelastic X-ray scattering (RIXS) a powerful technique for probing elementary excitations and providing direct information about the dynamics of spin, charge, and orbital degrees of freedom. This talk will begin with a review of the advances in high-resolution RIXS instrumentation, followed by examples of RIXS studies on quantum materials such as cuprate superconductors and chiral magnets.

The cuprate superconductivity has remained a mystery since its discovery decades ago. Above T_c, various physical quantities show an enigmatic pseudogap. One approach to resolving the puzzle of pseudogap is based on the scenario of quantum phase transition, which is driven by non-thermal fluctuations at zero temperature, playing a crucial role in shaping the phase diagram of cuprate superconductors. We have investigated the temperature- and doping-dependent RIXS of $La_{2-x}Sr_xCuO_4$ to unravel the quantum fluctuations of charge-density waves. Our findings provide the spectroscopic signature of quantum critical scaling in cuprates, and show that the QCP belongs to the universality class characterized by the O(3) symmetry, a new type of QCP. Remarkably, while the QCP is manifested through the charge-density wave, our analysis indicates that the pair-density wave also participates, revealing the intertwined nature of quantum fluctuations.

In addition, we show that excitonic excitations of cuprate $Bi_2Sr_2CaCu_2O_{8+\delta}$ with energy far above the superconducting-gap energy scale, about 1 eV, are unusually enhanced by the onset of superconductivity. Our findings prove the involvement of such high-energy excitons in superconductivity. Therefore, the observed enhancement in the spectral weight of excitons imposes a crucial constraint on theories for the pseudogap and superconducting. Lastly, using RIXS with circularly polarized X-rays, we demonstrate that chiral phonons can be significantly enhanced by helical spins in a polar and chiral magnet.

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