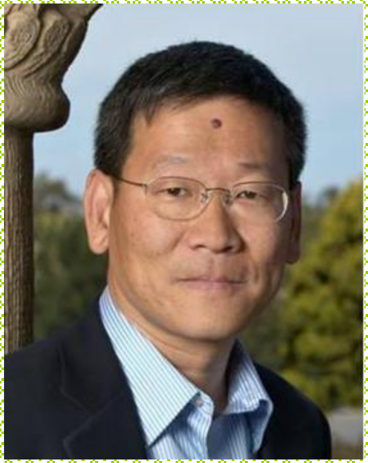
Columbia University
Department of Physics Colloquium

"Bridging the Gap in High Temperature Superconductor"



It is now over 100 years since superconductivity was discovered and it took 45 years before a complete theory was formulated by Bardeen-Cooper-Schrieffer. Once understood, the impact has been felt far behind superconductivity itself, and superconductivity became a prime example of emerging properties in quantum system. High-Tc superconductivity in cuprate oxides was discovered 25 years ago and it remains a major unsolved physics problem today. The challenge of the cuprate research is symbolized by its complex phase diagram consists of intertwined states with extreme and unconventional properties in addition to unconventional superconductivity – such as Mott Hubbard insulating state, the peculiar pseudogap state with an anisotropic gap above Tc, and the so-called strange metal state. None of them are understood by conventional theory, thus compounding the difficulty to understand high-Tc superconductivity itself as these states are different manifestations of the same underlying physical system, making an integrated understanding a necessity.

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Angle-resolved photoemission spectroscopy (ARPES) has emerged as a leading experimental tool to address this problem. Over the last two decades, substantial progress towards understanding the cuprate problem has been made in concert with breathtaking progresses in ARPES technique. In this talk, I will use ARPES derived energy gap as a bridge to link the relationship between the different parts of the phase diagram, with focus on the complex relationship between pseudogap state and superconductivity. In addition to exhibiting a different doping and temperature dependence from superconductivity, the pseudogap also has a momentum structure implying a distinct electronic symmetry. This pseudogap is entangled with superconductivity, resulting in two or more phenomenologically-distinct superconducting ground states in the cuprate phase diagram, with quantum phase transitions inside the superconducting dome. Detailed temperature dependence across the pseudogap temperature and T_c reinforces the picture of two intertwined, dynamically competing states, providing an explanation for many seemingly contradicting experiments.

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