Coherence-Incoherence and Dimensional Crossover in Layered Strongly Correlated Metals

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Many “quasi-low-dimensional” materials consist of 1D or 2D building blocks, loosely connected into a 3D whole. Their physical properties are therefore highly anisotropic. Within the Fermi liquid picture, the currents are carried by quasiparticles (QP) and resistivity is proportional to the QP scattering rate. The anisotropy is then a consequence of different hopping integrals for different directions and is usually small and essentially T-independent. Problems with this picture appear when conductivities become uncoupled, i.e. when the anisotropy is strongly T-dependent. We have studied single-particle excitations in ARPES in several layered systems (Sr₂RuO₄, NaCo₂O₄ and (Bi, Pb)₂Ba₃Co₂O₉) that display a crossover in the c-axis transport, from insulating-like, at high temperatures, to metallic-like at low temperatures, while being metallic over the whole temperature range in the plane. We have found sharp, QP-like excitations in the low-temperature, 3D-like \((\rho_{c}(T) \propto \rho_{ab}(T))\) phase, and their absence in the effectively 2D, high-temperature phase. Similar dimensional crossovers to coherent, 3D low-temperature states have been identified in some other layered materials. The high temperature superconductors, showing a sharp transition from an incoherent 2D-like \((\rho_{ab}(T) > 0, \rho_{c}(T) < 0)\) normal state into the coherent 3D superconducting state will be discussed.