Hidden order in '122' class of Fe-based superconductors

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Abstract

Among high-temperature superconductors, Fe-based compounds have attracted much attention during past decade, where the parent compounds are metals exhibiting spin density wave (SDW) phase in the ground state and charge carrier doping leads to superconductivity via suppression of magnetic order. We studied the evolution of complex Fermiology of $CaFe_2As_2$ with temperature using Angle Resolved Photoemission (ARPES) spectroscopy. $CaFe_2As_2$ undergoes a transition from tetragonal paramagnetic to orthorhombic spin density wave (SDW) state at 170 K. Application of small pressure (>0.35 GPa) leads the system to non-magnetic collapsed tetragonal (cT) phase (c axis length is compressed) in the ground state [1,2]. The high Tc (> 45 K) in $CaFe_2As_2$ under pressure and/or chemical substitution was often attributed to cT phase [2], despite the belief that superconductivity and correlated antiferromagnetic fluctuations are closely related in Fe-based compounds making cT phase unfavourable for unconventional superconductivity.

ARPES measurements were carried out at the Electron Spectroscopy Lab, TIFR, India and VUV beamline, Elettra, Trieste using VG Scienta R4000 analyzer at an energy resolution better than 15 meV. Valence band spectra at different conditions reveal importance of the interplay between covalency and correlation induced effects in the electronic structure [3-5]. ARPES data [3, 6] show signatures of Fermi surface nesting due to SDW transition and an evolution from 2D to 3D Fermi surface consistent with earlier results [7]. Curiously, the signature of the Fermi surface reconstructions appears at temperatures much lower than 170 K, which is unusual. Moreover, some of the hole pockets appear to expand with the decrease in temperature. The spectra at 30 K are even more complex with distinct signature of an additional contribution due to cT phase indicating coexistence of the cT phase hidden within the orthorhombic phase although all the bulk studies do not show signature of such scenario [6]. Clearly, application of pressure helps to manifest such hidden phases and it appears difficult to rule out the role of cT phase in superconductivity in these materials although cT phase is non-magnetic.

References

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