Angle-resolved photoemission spectroscopy of iron-based superconductors

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Angle-resolved photoemission spectroscopy (ARPES) gives a unique insight into the evolution of the electronic structure of iron-based superconductors. By varying the temperature and doping of the sample, one can investigate all regions of their phase diagrams, including the high temperature normal state, the magnetic ground state, the so-called nematic state where four-fold symmetry is broken without magnetic order, and the superconducting state.

For example, ARPES measurements of FeSe give an exclusive opportunity to investigate the electronic structure in nematic phase without magnetic order. In our measurements, we found substantial shifts of both the electron and hole bands associated with the onset of the nematic order, however the interpretation of these data has caused some controversy due to the formation of the twin orthorhombic domains in the samples. Our high resolution ARPES results obtained on FeSe crystals detwinned by application of mechanical strain, reveal remarkable anisotropies hidden in the measurements of the twinned samples. We observe that in the nematic phase the Fermi surface consists of one elliptical hole-like pocket and only one orthogonally oriented electron-like pocket.

Moreover, we find the same effect in detwinned NaFeAs samples where the spectral weight from only one elliptical electron pocket is detected in the nematic phase.

Finally, we use synchrotron-based high-resolution ARPES to map the 3D momentum dependence of the superconducting gap in FeSe. We find that on both the hole and electron Fermi surfaces, the gap is highly anisotropic, with its magnitude following the distribution of d orbital weight on each pocket. We show that this anisotropic gap structure can be reproduced from theoretical calculations only when the one-electron pocket state, observed in the nematic phase, is taken into account. These results support the spin fluctuation mediated mechanism of superconductivity in FeSe.