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Significant Tc enhancement in FeSe films on SrTiO3 due to interfacial mode coupling

ROBERT MOORE, SLAC National Accelerator Laboratory

The enhanced superconductivity in monolayer FeSe films grown on SrTiO3 (STO) substrates has generated a lot of attention. Several previous studies have shown a dramatic difference between the superconducting monolayer and non-superconducting bilayer films suggesting the substrate or interface plays a critical role in the enhancement of superconductivity. Utilizing Molecular Beam Epitaxy (MBE) and in situ Angle Resolved Photoemission Spectroscopy (ARPES), we explore the role of the substrate on the electronic structure of superconducting monolayer FeSe films. The electronic structure at the Fermi surface of the monolayer film consists of two electron pockets at the M point of the Brillouin zone, in contrast to bilayer and thicker films that show an electronic structure similar to bulk FeSe. The orbital character of the two pockets has been resolved which shows two distinct gaps and places strict constraints on the possible pairing symmetry. Surprisingly, we observe exact replicas of the FeSe bands which are attributed quantum shakeoffs arising from strong electron phonon coupling. Shakeoff bands have never been resolved with such clarity in a solid before and are only observed in the monolayer films. The coupling is between a high energy oxygen phonon in the STO substrate and electrons in the FeSe monolayer. Oxide MBE has been used to grow STO with oxygen 18 to explore the isotope effect on the electron phonon coupled shakeoff bands and will be discussed. Theoretical investigations show how these distinct features result from strong forward scattering which enhances superconductivity. This enhancement does not depend on the origins of superconductivity as it exists in all channels and is responsible for the increase in Tc. These results suggest a possible avenue for engineering superconductors with higher Tc.