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Effects of electron-phonon coupling on the superconductivity of FeSe/SrTiO3 interface

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The maximal Tc in iron-based high temperature superconductors has remained around 55K since 2008. In 2012 a Chinese group reported STS evidences of enhanced superconductivity of one-unit-cell FeSe film on SrTiO3 substrate, with an estimate of Tc over 77K [1]. Similarly large gaps were later observed in ARPES experiments [2,3] and a recent transport measurement directly confirmed the superconductivity at this FeSe/STO interface [4]. These exciting progresses call for a better understanding of the mechanism of high Tc in this and other iron-based materials. In this talk I will discuss our work on the possible role of electron-phonon coupling in the FeSe/STO system [5]. We propose that electron-phonon coupling, which is largely overlooked in the studies of bulk Fe-based superconductors, can play a significant role here due to the soft ferroelectric phonon modes in SrTiO3. We generalize the phenomenological Eliashberg theory to this multiple-band case, and obtain generalized McMillan formula of Tc for conventional and unconventional s-wave pairing states. We can therefore demonstrate that moderate electron-phonon coupling will be able to produce the observed large enhancement of pairing gap. This result is further confirmed by a microscopic functional renormalization group calculation. We will also discuss the experimental signatures of electron-phonon coupling, and propose other substrate materials to utilize this mechanism. This work could foster further experimental and theoretical studies of Fe-based superconductivity, and may eventually lead to the discovery of even higher Tc systems.

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[3] S.Y. Tan et al. Nat. Mater. 12, 634 (2012).
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[5] Y.-Y. Xiang, F. Wang, D. Wang, Q.-H. Wang, D.-H. Lee, Phys. Rev. B 86, 134508 (2012).