PHONON MECHANISM IN THE MOST DILUTE SUPERCONDUCTOR: n-TYPE $SrTiO_3$

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Superconductivity of doped $SrTiO_3$, remaining enigmatic for half a century, is proven to be a particular case of the non-adiabatic pairing. We argue that, for carrier concentrations exceeding that of the mobility edge, the superconductivity of doped $SrTiO_3$ is mediated by interaction of electrons with several longitudinal (LO) optical polar phonons with frequency much larger than the Fermi energy. The electronic spectrum of $SrTiO_3$ consists at low temperatures of three conduction bands which are successively doped. Each band contributes to the Cooper instability and exhibits a superconducting gap in the energy spectrum. The theory predicts maxima in dependence of the transition temperature $T_C(n)$ on n, the number of electrons owing to the following mechanism. Doping by electrons increases the density of states at the Fermi surface and $T_C(n)$ initially grows up. At the same time, screening on the part of accumulating charges tends to reduce amplitude of the electrical fields inherent in LO phonon modes and at larger concentrations the matrix element of interaction between electrons and LO phonons decreases. The compromise between the two tendencies leads to maxima in the $T_C(n)$-dependence, providing interpretation to one of the most intriguing experimental findings in Xiao Lin *et al.* [Phys. Rev. Lett. 112, 207002 (2014)]. Having reached a maximum in the third band, the superconducting transition finally decreases, rounding out the $T_C(n)$-dome, the three maxima in $T_C(n)$ with accompanying superconducting gaps emerging consecutively as electrons fill successive bands. This arises from attributes of the LO optical phonon pairing mechanism. More generally, the mechanism opens prospect of increasing temperature of the superconducting transition in transition-metals oxides and other polar crystals.