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Multiband superconductivity in n-doped $SrTiO_3$

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The superconducting state of n-doped $SrTiO_3$ occupies a singular place in the history of superconductivity. Besides being the first oxide superconductor, it was one of the earliest "semiconducting superconductors," the first experimentally-detected multi-gap superconductor and the first case of a superconducting dome. Half a century after its discovery, it remains the most dilute superconductor [1]. We present a systematic study of quantum oscillations and superconducting transition in doped $SrTiO_3$, over a wide range of carrier concentration from 10^{17} to 10^{20} cm^{-3} [2]. Mobile carriers were introduced either by removing oxygen or by substituting Ti by Nb. Superconductivity was found to persists down to an exceptionally low concentration of mobile electrons (n=3 10^{17} cm^{-3} and T_c =34 mK). At this concentration range, with the Fermi temperature below 10 K, the narrowness of the relevant energy window severely restricts possible pairing scenarios. We identify two critical doping levels, which are the filling thresholds of the upper conduction bands. This clarifies the limits of single-band, two-band and three-band superconducting regimes. We find that the exceptionally-wide superconducting dome of $SrTiO_3$ has a structure with two distinct domes, each peaking near a critical doping level. Thermal conductivity measurements uncover the existence of multiple nodeless superconducting gaps at optimal doping [3].

[1] X. Lin *et al.,* Phys. Rev. X 3, 021002 (2013).
[2] X. Lin *et al.,* Phys. Rev. Lett. **112**, 207002 (2014)
[3] X. Lin et al., Phys. Rev. B **90**, 140508(R) (2014).