Superconductivity mediated by charged phonons

Dirk van der Marel, Francesco Barantani, Willem Rischau, Adrien Stucky, Gernot Scheerer, Dorota Pulmannova, and Enrico Giannini

Department of Quantum Matter Physics, University of Geneva, 24 Quai Ernest-Ansermet, 1211 Geneva 4, Switzerland

Strontium titanate is a semiconducting material, which can be tuned to become ferro-electric by substituting the heavier ^{18}O isotope for the natural ^{16}O isotope. When doped, the material becomes superconducting already at extremely low carrier densities [1, 2]. The proximity to a ferro-electric instability is peculiar and has lead to the suggestion that the pairing is mediated by ferro-electric soft modes. This model has lead to the prediction of a strong increase of the superconducting T_c with ^{18}O isotope substitution [3], which has been confirmed by our experimental studies and those from a group in Tokyo [4–6]. From our optical studies we can moreover show that the main channel for pairing is the exchange of pairs of ferro-electric modes. Using the optical sumrule for coupling to charged phonons, and another one relating the electronic polarizability to interband transitions, we can determine the strength of the pairing interaction [7], which is consistent with the T_c of these materials. Applying the same arguments to doped $KTaO_3$ [8], the coupling is even stronger in this material, for which T_c has recently been found to be 5 times higher than in doped $SrTiO_3$. These observations imply an interesting possibility, namely that superconducting pairing can be mediated by pairs of so-called "charged phonons", i.e. optical phonons coupled to electronic modes. This type of pairing is particularly relevant when the carrier concentration is low and may be relevant in other cases of interest such as twisted bilayer graphene.

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