

Evidence of polaronic charge carriers in oxide superconductors

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Abstract. The analysis of photoemission and femtosecond optical absorption spectroscopy in oxide superconductors supports the view that the charge carriers are polaronic in nature. These carriers are found to exist in the (Ba/Sr)–O planes and are coupled to B_{1g} vibrations of the apical oxygen.

Keywords. Optical properties of high T_c compounds; polaronic charge carriers.

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1. Introduction

The nature of the charge carriers in high T_c superconductors has been a subject of extensive investigations [1–4]. We have proposed that the normal state properties of copper-oxide superconductors can be understood on the polaronic model of the charge carrier [5]. Recently Zhao *et al* [2] through the study of isotope effect of the number density and London penetration depth have found evidence of polaronic charge carriers in $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$. Shen and Schrieffer [3] have observed two types of excitations in their angle resolved photoemission spectroscopy (ARPES) of Bi(2212), one has a nearly Lorentzian shape and is attributed to a quasi-particle and the other has a broad feature with an edge type opening near the Fermi surface which they attribute to a collective mode of excitation. These line shapes of the excitations are dependent on the temperature, level of doping, and momentum of the excitations. Campuzano *et al* [6] have carried out ARPES studies on $\text{YBa}_2\text{Cu}_3\text{O}_{6.9}$ and have mapped the Fermi surfaces which are in agreement with the calculations made using the local-density approximation. Similar measurements have been made for Bi (2212) by Marshall *et al* [7] and they find hole pockets centred at (π, π) . The underdoped sample with less hole has Fermi level crossings over a small portion compared to the overdoped sample and its Fermi surface does not extend to the Brillouin zone (BZ) edge. The lowest binding energy edge is shifted from the Fermi surface by about 20–30 meV as in ref. [3]. There exist several femtosecond pump-probe optical absorption studies on high T_c superconducting and nonsuperconducting compounds [8, 9]. The results for $\text{YBa}_2\text{Cu}_3\text{O}_7$, $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10+\delta}$ and nonsuperconducting $\text{YBa}_2\text{Cu}_3\text{O}_{6+y}$ ($y < 0.4$) have been discussed by Chwalek *et al* [8]. They report a dramatic increase in the relaxation time as the sample temperature is lowered