Lattice dynamics of high-T_c-superconductors and related materials

BRADEN M.[1], REICHARDT W.[2], PINTSCHOVIUS L.[2], SENFF D.[1], FRIEDT O.[1,3]

1 II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany

2 Forschungszentrum Karlsruhe, IFP, Postfach 3640, 76021 Karlsruhe, Germany

3 Laboratoire Léon Brillouin, CE-Saclay, 91191 Gif sur Yvette, Cedex, France

Evidence for electron phonon coupling in the high-T_c-cuprates superconductors has been found very early but its role in the pairing mechanism is still matter of controversy. Strong anomalies in the dispersion of the longitudinal Cu-O bond stretching modes were reported by inelastic neutron scattering for $La_{2-x}Sr_xCuO_4$ and $YBa_2Cu_3O_{6+\delta}$. In the metallic samples of these series there is strong frequency renormalization of the linear zone boundary breathing mode. More recently, evidence for a similar anomaly has been observed in inelastic x-ray experiments on $Nd_{2-x}Ce_xCuO_4$. Due to the availability of large single crystals, superconducting $Nd_{2-x}Ce_xCuO_4$ has now been studied by inelastic neutron scattering too, confirming that these three systems of superconducting cuprates exhibit essentially similar electron phonon anomalies. Some minor differences may point to the distinct character of the charge carriers.

However, these phonon anomalies are not a particularity of the superconducting cuprates. In many other oxide perovskite systems, even stronger anomalies were found. For example in some manganates the frequency renormalization amounts to about 25meV and the high-temperature superconductor $Ba_{1-x}K_xBiO_3$ (T_c~35K) exhibits frequency renormalization of the order of 40% compared to an insulating reference system. Furthermore, in these materials the anomalous behaviour extends over a much larger part of the Brillouin-zone than in the cuprates. We conclude that the families $La_{1-x}Sr_xMnO_3$, $(La/Sr/Ca)_3Mn_2O_7$, $La_{1-x}Sr_{1+x}MnO_4$, $La_2NiO_{4+\delta}$, $La_{2-x}Sr_xNiO_4$, $Ba_{1-x}K_xBiO_3$, $BaPb_{1-x}Bi_xO_3$ and the cuprates all present somehow related charge carrier induced frequency renormalisation in the bond stretching phonon dispersion. The only metallic oxide perovskite studied so far which does not exhibit comparable anomalies is Sr_2RuO_4 in spite of its excellent metallic properties. We discuss the phonon anomalies in all these systems as related to tendencies towards charge ordering.