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Unconventional isotope effects in cuprate high-temperature superconductors

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A brief review on unconventional oxygen-isotope ($^{16}O/^{18}O$) effects (OIE) in cuprate high-temperature superconductors (HTS) is presented. First the doping dependence of the OIE on the superconducting transition temperature T_c in various H TS is discussed. For all cuprate HTS families the OIE exponent of T_c (α_O) shows a generic trend: In the underdoped regime α_O is large ($\alpha_O > 0.5$) and becomes small in the optimally doped and overdoped re gime. Magnetization, magnetic torque, and muon-spin rotation (μSR) studies of the OIE on the in-plane penetration depth $\lambda_{ab}(0)$ in $La_{2-x}Sr_xCuO_4$ and $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ indicate a substantial oxygen-mass dependence of $\lambda_{ab}(0)$ which increases with reduced doping. It is remarkable that even in optimally doped $YBa_2Cu_3O_{7-\delta}$ and $La_{2-x}Sr_xCuO_4$ a substantial OIE on $\lambda_{ab}(0)$ is observed, although the OIE o n T_c is rather small. The oxygen-isotope shifts of T_c and $\lambda_{ab}(0)$ exhibit a correlation that appears to be generic for various families of HTS. Furthermore, site-selective OIE investigations of $Y_{1-x}Pr_xBa_2Cu_3O_{7-\ delta}$ clearly reveal that the planar oxygen atoms mainly contribute to the total OIE on T_c as well as on $\lambda_{ab}(0)$ at all doping levels. These unusual OIE, which are beyond the scheme of BCS theory, may be explained with a polaron theory.[1] It is found that the coupling of the electronic degrees of freedom to the Jahn-Teller Q_2-type mode is the origin of these isotope effects.

[1] A. Bussmann-Holder and H. Keller, cond-mat/0409738.