Oxygen Isotope Effect in High Temperature Superconductors - Phonons or Magnons?

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The oxygen isotope effect displayed in the critical temperature, T_c, by high temperature superconducting (HTS) cuprates was studied using polycrystalline samples of $YBa_2Cu_3O_6$. The dominant perspective within the community is that this isotope effect is resultant from lattice vibrations or 'phonons'. In contrast, our treatment assesses the viability of explaining this effect by an indirectly acting magnetic mechanism. This proposed mechanism involves an increase in the anti-ferromagnetic super-exchange interaction energy, J, between adjacent Cu(2) ions as a result of decreasing unit cell basal area from a decrease in lattice vibration magnitudes.

Polycrystalline YBa2Cu3O6 samples of similar mass were synthesised under identical conditions, then co-annealed under ^{16}O and ^{18}O gas respectively. Neutron diffraction experiments were performed on these samples at 3K, 50K and 100K to accurately determine structural parameters.

Rietveld refinement produced inferred critical temperature isotope exponents, α=..., of $\alpha(3K)=(3.6\pm0.4)\times10^{-3}$, $\alpha(50K)=(4.3\pm0.6)\times10^{-3}$ and $\alpha(100K)=(7.2\pm0.9)\times10^{-3}$. Comparison with the experimentally measured isotope effect of $\alpha=0.06$ in the overdoped region indicates that our mechanism is unlikely to be sufficient to account for the isotope effect in T_c. We note, however, that there remains a possibility of a secondary contribution from this mechanism. This project plans for further back-exchange and repeated diffraction measurements, which will aid in confirming and comparing these results.