Shining Light on High T_c Cooper Pairs Dancing with Lattice

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A fundamental issue for the cuprate high temperature superconductors is how various degrees of freedom, e.g. lattice and spin, compete or cooperate as basic ingredients of the superconductivity. I will discuss unique insights obtained on this issue by the first use of the combination of two well-known methods for investigating superconductivity: angle resolved photoemission spectroscopy (ARPES) and isotope substitution. By studying the change of ARPES spectra induced by oxygen isotope substitution on optimally doped Bi2212, we are able to extract information regarding the influence of the lattice on the single electron dynamics in the cuprates, directly and unambiguously. In particular, the observed momentum and temperature dependences of the isotope induced change reveal a strong correlation between the electron-phonon interaction and the superconducting order parameter, providing the first direct evidence for a significant role that phonons play in the high temperature superconductivity. I will discuss a cooperative role between the lattice and the spin in the Cooper pairing of superconducting electrons, as suggested by our data. In addition, our data show that the electron-phonon interaction in the cuprates is relevant for explaining the so-called dispersion “kink” observed in ARPES, providing a new clue to a long-standing debate, but they also prove that the explanation should go well beyond the conventional Migdal-Eliashberg theory of the electron-phonon interaction.