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Lattice, spin, and charge excitations in cuprates[1]

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Tracking doping evolution of elementary excitations is a crucial approach to understand the complex phenomena exhibited in cuprates. In the first part of my talk, I will discuss the role of the lattice in the quasi-one-dimensional edge-sharing cuprate $Y_{2+x}Ca_{2-x}Cu_5O_{10}$ [1]. Using O K-edge RIXS, we resolve site-dependent harmonic phonon excitations of a 70 meV mode. Coupled with theory, this provides a direct measurement of electron-lattice coupling strength. We show that such electron-lattice coupling causes doping-dependent distortions of the Cu-O-Cu bond angle, which sets the intra-chain spin exchange interactions. In the second part of my talk, I will discuss collective excitations in the electron-doped superconducting cuprate, $Nd_{2-x}Ce_xCuO_4$ [2] observed using Cu L-edge RIXS. Surprisingly, despite the fact that the spin stiffness is zero and the AFM correlations are short-ranged, magnetic excitations harden significantly across the AFM-HTSC phase boundary, in stark contrast with the hole-doped cuprates. Furthermore, we found an unexpected and highly dispersive mode emanating from the zone center in superconducting NCCO that is undetected in the hole-doped compounds. This may signal a quantum phase distinct from superconductivity. Thus, our results indicate an asymmetry of the collective excitations in electron- and hole-doped cuprates, providing a new perspective on the doping evolution of the cuprate ground state.

[1] W. S. Lee *et al.,* Phys. Rev. Lett. **110**, 265502 (2013).
[2] W. S. Lee *et al.,* arXiv: 1308. 4740.

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