# Atomically-resolved interlayer charge ordering and its interplay with superconductivity in $YBa_2Cu_3O_{6.81}$

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## Abstract

Charge order (CO) has been recognized as one of the most important competing order in superconductive cuprates. In $YBa_2Cu_3O_{6+x}$ (YBCO), CO could only be investigated by x-ray diffraction in under-doped YBCO with low critical temperatures ($T_C$), but not in highly-doped YBCO with high $T_C$ suitable for device applications, due to the competing superconductive phase. Therefore, the most fundamental physical mechanisms governing CO, for example, the role of so-called charge reservoir (Cu-O chain) layers in CO and the spatial interplay of CO and SC, in highly-doped YBCO are still unclear.

Here, we present the direct real-space cross-sectional scanning tunneling microscopy (XSTM) imaging with atomic resolution to characterize the atomically resolved electronic structure along the *c* [001] direction in high-temperature superconductive cuprates. We demonstrate that CO occurs on CuO plane and chain layers with an antiphase correlation along the *c*-axis direction governed by Coulomb repulsion rather than Josephson tunneling. Similarly, superconductive coherence is also observed in chain and plane layers. In addition, both phases exhibit a proximity-like boundary region mutually suppressing CO and SC.

The present atomically-resolved XSTM provides a detailed insight into the unexplored interlayer coupling and its spatial interplay with superconductivity and therefore offers a new approach to unravel the fundamental physical mechanisms of superconductivity in cuprates.[1]

## Reference

[1] Chun-Chih Hsu, Bo-Chao Huang, Michael Schnedler, Ming-Yu Lai, Yuh-Lin Wang, Rafal E. Dunin Borkowski, Chia-Seng Chang, Ting Kuo Lee, Philipp Ebert, and Ya-Ping Chiu, "Atomically-resolved interlayer charge ordering and its interplay with superconductivity in$YBa_2Cu_3O_{6.81}$", Nature Communications, 12, 3893 (2021).