Neural-network and numerical analysis of self-energy and superconductivity in copper oxides

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Self-energy contains crucial information on superconductivity, and indeed a detailed analysis of self-energy by utilizing tunneling spectroscopy played an important role in the validation of the phonon mechanism for the Bardeen-Cooper-Schrieffer superconductors [1,2]. However, in strongly correlated superconductors, the self-energy analysis has been challenging [3,4].

Recently, we developed a regression scheme for self-energy based on artificial neural networks [5]. The neural network method is applied to the angle-resolved photoemission spectroscopy spectra of cuprate high-temperature superconductors, $Bi_2Sr_2CuO_{6+\delta}$ and $Bi_2Sr_2CaCuO_{8+\delta}$. We found prominent peak structures both in normal and anomalous self-energies. However, they cancel in the total self-energy making the structure apparently invisible while the peaks make universally dominant contributions to superconducting gap.

Further analysis of the self-energy revealed that, in addition to the super fluid density and effective attractive interactions among quasiparticles, the dissipative carrier relaxation controls the superconducting critical temperatures of the cuprates. We also discuss the combination of the extensive numerical simulation [6] and neural-network analyses on spectroscopy measurements and the future perspectives.

References

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