Heterogeneous charge localization and percolative superconductivity in the high-T_c cuprates

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The cuprate high-temperature superconductors are among the most intensively studied quantum materials, yet pivotal questions regarding their principal phases and the transitions between them remain unanswered. Generally thought of as doped charge-transfer insulators, these complex lamellar oxides exhibit pseudogap, strange-metal, superconducting and Fermi-liquid behaviour with increasing hole-dopant concentration. We consider an inhomogeneous Mott-like (de)localization model wherein exactly one hole per copper-oxygen unit is gradually delocalized with increasing doping and temperature [1]. The model is percolative in nature, with parameters that are consistent with experiment. It comprehensively captures pivotal unconventional experimental results, including the temperature and doping dependence of the pseudogap phenomenon, the strange-metal linear temperature dependence of the planar resistivity, and the doping dependence of the superfluid density. The success and simplicity of our model greatly demystify the cuprate phase diagram and point to a local superconducting pairing mechanism involving the (de)localized hole. The spatial inhomogeneity of the localization gap is thus expected to cause a distribution of superconducting gaps as well, leading to superconducting percolation. Accordingly, we find for several representative cuprates that the superconducting diamagnetism [2], the nonlinear conductivity [3] and the paracondcutivity [4] exhibit robust, unconventional exponential temperature dependence above T_c that is captured by a simple percolation model. Our results show that that intrinsic, universal gap disorder is highly relevant to understanding the properties of the cuprates.

References

[1] D. Pelc, Popčević, M. Požek, M. Greven, N. Barišić, D. Pelc, P. Popčević, G. Yu, M. Požek, M. Greven, and N. Barišić. https://arxiv.org/abs/1710.10221

[2] G. Yu, D. D. Xia, D. Pelc, R.-H. He, N. Kaneko, T. Sasagawa, Y. Li, X. Zhao, N. Barišić, A. Shekhter, and M. Greven. https://arxiv.org/abs/1710.10957

[3] D. Pelc, M. Vučković, M. S. Grbić, M. Požek, G. Yu, T. Sasagawa, M. Greven, and N. Barišić. https://arxiv.org/abs/1710.10219

[4] P. Popčević, D. Pelc, Y. Tang, K. Velebit, Z. Anderson, V. Nagarajan, G. Yu, M. Požek, N. Barišić, and M. Greven. https://arxiv.org/abs/1710.10220