

Pseudogap and nematicity in a Fermi-Hubbard simulator

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Abstract

Understanding the nature of the pseudogap phase and its connection to high- T_c superconductivity in cuprate materials remains an outstanding problem in condensed matter physics, since unbiased numerical simulations are unfeasible in this regime due to the low temperatures, strong interactions, and competing orders. Quantum simulation at low temperatures offers a promising route to making progress here, allowing the study of large system sizes with microscopic control and measurements, both in and out of equilibrium. Leveraging a recent breakthrough in our lab reaching significantly lower temperatures in a cold atom Fermi-Hubbard simulator[1], we are for the first time able to perform quantum simulation of the pseudogap phase of the Hubbard model[2]. We observe the opening of a spectral gap in the Raman response at low temperatures which is non-uniform in the Brillouin zone, indicating the formation of a pseudogap. We observe two novel signatures coinciding with the onset of this pseudogap – a maximum in the charge compressibility, and an enhanced rotational-symmetry breaking tendency (nematicity) versus doping. We further observe a suppression of the nematic response in the presence of an added disorder potential which suppresses charge ordering, establishing a link between nematicity, charge order, and the

pseudogap. This work furthermore paves the way for experiment-theory feedback in understanding frontier problems in correlated electron physics.

References

- [1] M. Xu, L. H Kendrick, A. Kale et al, Nature 642, 909-915 (2025).
- [2] L. H Kendrick, A. Kale, Y. Gang et al, arXiv:2509.18075 (2025).

Figures

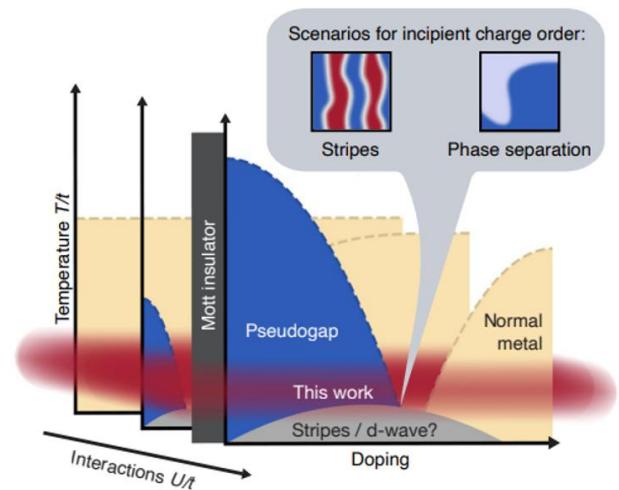


Figure 1: Schematic phase diagram of the Hubbard model versus temperature, interaction strength, and doping, showing Fermi liquid, pseudogap, and Mott insulating regions, together with conjectured stripe or d-wave superconducting regions. Figure adapted from [2].