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Charge order beyond pairing in mix-dimensional Fermi-Hubbard systems

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The Fermi-Hubbard model is an iconic model of solid state physics that is believed to capture the intricate physics of strongly correlated phases of matter, including high-Tc superconductivity. Such a state of matter is supposedly achieved upon doping a cold antiferromagnetic Mott insulator, and magnetically mediated charge ordering in the form of pairing of dopants (holes), in particular, is considered to be a key mechanism for the occurrence of unconventional superconductivity. The low temperature phase diagram of the Fermi-Hubbard model, however, features other partially understood charge-ordered states which may compete or enhance the superconducting state. The stripe phase, corresponding to the formation of a charge density wave in combination with incommensurate antiferromagnetism, is believed to be dominant in the ground state of the plain Fermi-Hubbard model in typical parameter regimes.

Here, I will present our experimental observation of charge ordering beyond pairing with our lithium quantum gas microscope. We use superlattices to engineer mix-dimensional Fermi-Hubbard systems in which tunneling is enforced to be 1D while spin super-exchange in maintained in 2D, extending our recent work on ladder systems [1]. We observe pairing of dopants beyond nearest neighbors, as well as larger structures of more than two holes, reminiscent of stripe formation. We furthermore observe signatures of a phase shift of the underlying antiferromagnetic ordering, compatible with incommensurate magnetism and the onset of a charge density wave.

[1] S. Hirthe *et. al.*, *Magnetically mediated hole pairing in fermionic ladders of ultracold atoms*, Nature **613**, 463-467 (2023)

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