

Magnetically mediated hole pairing in fermionic ladders of ultracold atoms

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Conventional superconductivity emerges from pairing of charge carriers mediated by phonons. In many unconventional superconductors, the pairing mechanism is conjectured to be mediated by magnetic correlations, as captured by models of mobile charges in doped antiferromagnets. However, a precise understanding of the underlying mechanism in real materials is still lacking and has been driving experimental and theoretical research for the past 40 years.

Quantum gas microscopes pose an ideal platform to study the interplay between spin and charge degrees of freedom on the level of single dopants. In the poster, I present the direct observation of hole pairing due to magnetic correlations in a system of ultracold fermions in optical lattices [1]. By engineering doped antiferromagnetic ladders with mixed-dimensional couplings, where charge motion is confined to one dimension, while spin-exchange takes place along two directions, we suppress Pauli blocking of holes at short length scales. This results in a marked increase in binding energy and a decrease in pair size, enabling us to observe pairs of holes predominantly occupying the same rung of the ladder. We find a hole-hole binding energy of the order of the superexchange energy and, upon increased doping, we observe spatial structures in the pair distribution, indicating repulsion between bound hole pairs.

[1] Hirthe et al., Nature (2023)

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