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Fermion Pairs and Loners in the Attractive Hubbard Gas

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The Hubbard model of attractively interacting fermions provides a paradigmatic setting for fermion pairing, featuring a crossover between Bose-Einstein condensation (BEC) of tightly bound pairs and Bardeen-Cooper-Schrieffer (BCS) superfluidity of long-range Cooper pairs, and a "pseudo-gap" region where pairs form already above the superfluid critical temperature. We directly observe the non-local nature of fermion pairing in a Hubbard lattice gas, employing spin- and density-resolved imaging of ~1000 fermionic 40K atoms under a bilayer microscope. In the strongly correlated regime, the fermion pair size is found to be on the order of the average interparticle spacing. We resolve polaronic correlations around individual spins, resulting from the interplay of non-local pair fluctuations and charge-density-wave order. In the presence of spin imbalance, correlations reveal a crossover from polarons to a Fermi liquid coexisting with repulsive bosons. Our methods open the door towards the in-situ observation of superfluids, FFLO states and spin density waves in a Hubbard lattice gas.

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