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Evidence for superfluidity of ultracold fermions in an optical lattice

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Ultracold fermions in periodic potentials hold promise for studies of quantum order in crystalline materials, since the observables and the parameter regime accessed differ greatly from traditional condensed-matter systems. Condensation of fermion pairs is an example of macroscopic phase ordering, and is a first step towards the realization of more exotic orderings. Starting with a pure superfluid of ^{6}Li pairs in the BEC-BCS crossover, we adiabatically ramp up an optical lattice potential and allow the system to equilibrate. Upon release, the atom cloud expands and self-interferes, revealing the phase-relation across the different lattice sites. The appearance of sharp momentum peaks corresponding to momenta $2\hbar k$ carried by ^{6}Li pairs of mass $2m$ implies long-range phase coherence in the system. Such observations have traditionally been taken as an experimental indicator of superfluidity in an optical lattice, where the transport of atoms occurs by quantum mechanical tunneling and not by simple propagation. The effect of deep lattice depths and the role of interactions on the phase ordering and detection across the entire crossover are also explored.

[1] J. K. Chin, D. E. Miller, Y. Liu, C. Stan, W. Setiawan, C. Sanner, K. Xu, W. Ketterle, Nature **443**, 961, (2006).