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Visualizing nodal superconductivity and heavy fermion formation in $CeCoIn_5$

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In solids containing elements with $f-$orbitals, the interaction between f-electron spins and those of itinerant electrons leads to the development of low-energy excitations with heavy effective mass. Previously, we used the scanning tunneling microscope (STM) to visualize the scattering of quasiparticles and detect their mass enhancement with the lowering of temperature in the prototypical Ce-115 heavy fermion family. Tunneling into different surface terminations revealed the composite nature of these heavy excitations, arising from the entanglement of conduction and f electrons [1]. Here, by extending our techniques to milli-Kelvin temperature and high magnetic field, we first observe a spectroscopic pseudogap in the tunneling density of states of the heavy quasiparticles both prior to superconductivity and also above the critical field, indicating the development of further correlations from which the unconventional superconducting state arises. Quasiparticle interference (QPI) measurements in the superconducting and normal states demonstrate the onset of strong particle-hole asymmetry in the superconducting state, dissimilar from previous STM QPI studies of gap symmetry. Nevertheless, we can directly pinpoint the d-wave nature of Cooper pairing through visualizing the spatial symmetry of quasi-particle bound states in the vicinity of atomic scale defects [2]. Work done in the collaboration with R. E. Baumbach, J. D. Thompson, E. D. Bauer, and A. Yazdani. Primary financial support from DOE-BES.

[1] P. Aynajian, E. da Silva Neto, et al., Nature, 486, 201 (2012).
[2] B. B. Zhou, S. Misra, et al. Nature Phys., 9, 474 (2013).