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Visualizing heavy fermions emerging in a quantum critical Kondo lattice[1]

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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 fermionic excitations with a heavy effective mass. These excitations are fundamental to the appearance of unconventional superconductivity and non-Fermi-liquid behavior observed in actinide- and lanthanide-based compounds. We use spectroscopic mapping with the scanning tunneling microscope to detect the emergence of heavy excitations with lowering of temperature in a prototypical family of cerium-based heavy-fermion compounds. We demonstrate the sensitivity of the tunneling process to the composite nature of these heavy quasiparticles, which arises from quantum entanglement of itinerant conduction and f electrons. Scattering and interference of the composite quasiparticles is used to resolve their energy–momentum structure and to extract their mass enhancement, which develops with decreasing temperature. The lifetime of the emergent heavy quasiparticles reveals signatures of enhanced scattering and their spectral lineshape shows evidence of energy–temperature scaling. These findings demonstrate that proximity to a quantum critical point results in critical damping of the emergent heavy excitation of our Kondo lattice system.

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