Lumpy Cooper pairs in an iron-based superconductor

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Cooper pairs can tunnel through the vacuum barrier between two superconducting electrodes, known as a Josephson junction. One can extract the superconducting order parameter from the current-voltage curves close to zero bias. We use atomic-resolution Josephson scanning tunneling microscopy (STM) to visualize the spatial variations of the superfluid in the iron-based superconductor $FeTe_{0.55}Se_{0.45}$. To measure Cooper-pair tunneling, a Pb-coated tip was employed and its superconductivity was thoroughly verified by measuring noise enhancement induced by Andreev-reflection on Pb(111) surface. By simultaneously acquiring the topographic and electronic properties, we find that this inhomogeneity in the superfluid is not caused by structural disorder or strong inter-pocket scattering, and does not correlate with variations in the energy of the Cooper pair-breaking gap. Instead, we see a clear spatial correlation between superfluid density and the quasiparticle strength, defined as the height of the coherence peak, on a local scale. Our results shed light on the interplay between superconductivity and quasiparticle character that has been observed by photoemission experiments across the critical temperature in the unconventional superconductors.