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Sensing the quantum limit in scanning tunneling spectroscopy BERTHOLD JAECK¹, CHRISTIAN R. AST, JACOB SENKPIEL, MATTHIAS ELTSCHKA, MARKUS ETZKORN, Max-Planck-Institute for Solid State Research, JOACHIM ANKERHOLD, University of Ulm, KLAUS KERN, Max-Planck-Institute for Solid State Research — The tunneling current in scanning tunneling spectroscopy (STS) is typically modeled by a continuous and homogeneous charge flow. If the charging energy of a single-charge quantum sufficiently exceeds the thermal energy, however, the granularity of the current becomes non-negligible. In this quantum limit, the capacitance of the tunnel junction mediates an interaction of the tunneling charges with the surrounding electromagnetic environment and becomes a source of noise itself. Using a scanning tunneling microscope operating at 15_{-mK}, we show that we operate in this quantum limit, which determines the ultimate energy resolution in STS. In general, P(E)-theory describes the probability for a tunneling electron to exchange energy with the environment. In the context of STS, the P(E)-function can be regarded as the energy resolution function. We experimentally demonstrate this effect with a superconducting aluminum tip and sample, where it is most pronounced. We expect the P(E)-broadening to be most significant on intrinsically sharp features, such as superconducting coherence peaks, Yu-Shiba-Rusinov states or Kondo peaks, and to become observable at temperatures of 1 K or below.

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