One dimensional hot electrons regain coherence in semiconducting nanowires

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Electrons confined to one dimension exhibit various counter-intuitive phenomena such as charge fractionalization, spin-charge separation, and Majorana end modes induced at nanowires rendered topologically superconducting. We study the phase coherence of hot electrons in semiconducting InAs nanowires through scanning tunneling spectroscopic imaging. By maintaining the MBE grown nanowires under ultra-high vacuum we are able to atomically resolve their facets and spectroscopically investigate the quasi-one-dimensional electronic states in them. We visualize the confined nature of these states both through the Van Hove singularities in their spectrum as well as through direct mapping of the quantized channels via quasi-particle interference. We thus identify a new relaxation regime of electrons in one-dimension. Above a certain energy threshold the relaxation rate turns non-monotonic where the higher the injection energy of the hot electron is, the more stable it becomes against relaxation. We detect this behavior both in the decay length of the quasi-particle interference patterns at the nanowire end as well as via the finite life-time of the hot electrons within Fabry-Perot resonators formed by adjacent stacking faults. The origin of this unusual energy-evolution of coherence lies in the form of the Coulomb interaction in quasi-one-dimension as well as the non-linear dispersion over the energy scale probed.

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