

Simultaneous imaging of the electrostatic potential and current density of flowing electrons in two-dimensional systems

Electron transport in nanoscale devices can often result in nontrivial spatial patterns of voltage and current that reflect a variety of physical phenomena, particularly in nonlocal transport regimes. While numerous techniques have been devised to image electron flows, the need remains for a nanoscale probe capable of simultaneously imaging current and voltage distributions with high sensitivity and minimal invasiveness, in magnetic field, across a broad range of temperatures, and beneath an insulating surface. Here we present such a technique for spatially mapping electron flows based on a nanotube single-electron transistor, which achieves high sensitivity for both voltage and current imaging. In a series of experiments using high-mobility graphene devices, we demonstrate the ability of our technique to visualize local aspects of intrinsically nonlocal transport, as in ballistic flows, which are not easily resolvable via existing methods. This technique should both aid in understanding the physics of two-dimensional electronic devices, as well as enable new classes of experiments that image electron flow through buried nanostructures in the quantum and interaction-dominated regimes.