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Nanoscale thermal imaging: Glimpse into dissipation in quantum systems down to atomic scale

Energy dissipation is a fundamental process governing the dynamics of classical and quantum systems. Despite its vital importance, direct imaging and microscopy of dissipation in quantum systems is currently mostly inaccessible because the existing thermal imaging methods lack the necessary sensitivity and are unsuitable for low temperature operation. We developed a scanning nanoSQUID that resides at the apex of a sharp pipette acting simultaneously as nanomagnetometer with single spin sensitivity and as nanothermometer providing cryogenic thermal imaging with four orders of magnitude improved thermal sensitivity of below 1 μK [1]. The non-contact non-invasive thermometry enables direct visualization and control of the minute heat generated by electrons scattering off a single atomic defect in graphene [2]. By further combining the scanning nanothermometry with simultaneous scanning gate microscopy we demonstrate independent imaging of work and dissipation and reveal the microscopic mechanisms that conceal the true topological protection in the quantum Hall state in graphene [3].

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