Probing interaction induced quantum Hall states

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Progress in graphene sample quality starts to disclose rich physics related to Coulomb interactions as well as interaction induced lifting of symmetries associated with the spin and pseudospin degrees of freedom. A key requirement to observe these fragile states in transport has so far been the fabrication of better quality samples. This has been accomplished by placing graphene on BN, or by suspending graphene. In the quest for observing fragile or novel incompressible states, probing a smaller area may be an alternative to circumvent the challenges of producing even higher mobility samples, since the sample may be much cleaner on the nanometer scale. However, to obtain such microscopic information we are usually forced to resort to sophisticated local probe methods which prevent the blurring by disorder induced averaging. Here we demonstrate that fluctuations in the transconductance of a graphene field effect transistor reflect processes that occur very locally. They are a manifestation of charge localization. A systematic study allows observing higher order fractional quantum Hall and broken symmetry states even if these do not show up as quantized states in the Hall or longitudinal resistance traces. They make phenomena on the nanometer scale visible in a macroscopic transport experiment despite significant disorder. Alternatively, it is possible to detect such fragile quantum Hall states locally by measuring with a single electron transistor. Fractional quantum Hall states of unprecedented high order in graphene are disclosed.

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