Freie Universität Berlin

Colloquium
Dahlem Center for Complex Quantum Systems

Imaging currents in HgTe quantum wells in the quantum spin Hall regime

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Time: Wednesday, August 14th, 2013, 11:00 c.t.

Location: Hörsaal A (1.3.14)

Abstract:

Conducting edge channels at the sample boundaries are a key feature of the quantum spin Hall (QSH) state, which was predicted [1] and experimentally demonstrated [2] to be realized in HgTe quantum wells. The existence of the edge channels has been inferred from transport measurements on sufficiently small devices, which find local [2] and non-local [3] conductance values close to the quantized values expected for ballistic edge channels. In this talk I will show images of how the current flows in large Hall bars made from HgTe quantum wells, directly confirming the existence of the edge channels [4]. The images are obtained by probing the magnetic fields produced by the current using a scanning superconducting interference devic e (SQUID). From the magnetic images we reconstruct the current density in the device with several micron spatial resolution. These images distinguish between current that passes through each edge and the bulk. Upon tuning the bulk conductivity by gating or raising the temperature, we observe a regime in which the edge channels clearly coexist with the conducting bulk, providing input to the question of how ballistic transport may be limited in the edge channels. Our results represent a versatile method for studying new quantum spin Hall materials systems. To this end I will show images we have recently obtained on devices made from InAs/GaSb quantum wells.

[1] B. A. Bernevig, T. L. Hughes & S. C. Zhang, Science 314, 1757–1761 (2006)
[2] M. Koenig et al., Science 318, 766–770 (2007)
[3] A. Roth et al., Science 325, 294–297 (2009)
[4] K. C. Nowack et al., Nature Materials, doi:10.1038/nmat3682 (2013)