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Dirac Fermions in HgTe Quantum Wells

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Replace this text with your abstract. Narrow gap HgTe quantum wells exhibit a band structure with linear dispersion at low energies and thus are very suitable to study the physics of the Dirac Hamiltonian in a solid state system. In comparison with graphene, they boast higher mobilities and, moreover, by changing the well width one can tune the effective Dirac mass from positive, through zero, to negative. Negative Dirac mass HgTe quantum wells are 2-dimensional topological insulators and, as a result, exhibit the quantum spin Hall effect. In this novel quantum state of matter, a pair of spin polarized helical edge channels develops when the bulk of the material is insulating, leading to a quantized conductance. I will present transport data provide very direct evidence for the existence of this third quantum Hall effect: when the bulk of the material is insulating, we observe a quantized electrical conductance. Apart from the conductance quantization, there are some further aspects of the quantum spin Hall state that warrant experimental investigation. Using non-local transport measurements, we can show that the charge transport occurs through edge channels - similar to the situation in the quantum Hall effect. However, due to the helical character of the quantum spin Hall edge channels, inhomogeneities in the potential profile of the experimental devices have a much stronger effect on the transport properties. Moreover, the quantum spin Hall edge channels are spin polarized. We can prove this fact in split gate devices that are partially in the insulating and partly in the metallic regime, making use of the occurrence of the metallic spin Hall effect to convert the magnetic spin signal into an electrical one. Finally, I will address another aspect of Dirac Fermion physics: HgTe quantum wells at a critical thickness of 6.3 nm are zero gap systems and exhibit transport physics that is very similar to that observed over the past few years in graphene. However, zero gap HgTe wells have a higher mobility than graphene, and also have only a single Dirac valley. This makes them especially suitable to study quantum interference effects under a Dirac Hamiltonian.