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Experimental observation of the quantum spin Hall state in HgTe quantum wells

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Spin-orbit interaction in semiconductors causes many interesting and potentially useful transport effects, such as e.g. the presently very topical spin-Hall effect[1]. So far no direct evidence for a ballistic, intrinsic SHE (i.e. resulting from the band structure) has been obtained by transport experiments. Here, we demonstrate that in specially designed nanostructures[2], which are based on narrow gap HgTe type-III quantum wells, a detection of the spin signal is possible via non-local voltage measurements. Recently, it was pointed out that such HgTe quantum wells, that exhibit an inverted band structure where the ordering of electron- and hole-like states is interchanged, are topologically non-trivial insulators[3], in which the quantum spin Hall insulator state[4] should occur. 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 electric conductance[5]. Finally, we demonstrate how a combination of the techniques used in the above experiments allows us to verify that the transport in the quantum spin Hall insulator state indeed occurs through spin-polarized helical edge channels.

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