Title	Spin Hall effects in HgTe Quantum Well Structures(Topological Aspects of Solid State Physics)
Author(s)	Molenkamp, Laurens
Citation	物性研究 (2009), 91(6): 682-682
Issue Date	2009-03-20
URL	http://hdl.handle.net/2433/142908
Right	
Type	Departmental Bulletin Paper
Textversion	publisher

DAY 4: 9:00 – 9:40

Spin Hall effects in HgTe Quantum Well Structures

Laurens Molenkamp
Physikalisches Institut (EP3) der Universität Würzburg

Spin-orbit interaction (SOI) in 2DEGs causes many interesting and potentially useful effects, such as the generation of an intrinsic spin accumulation polarized normal to the 2DEG at the edges, caused by the presently very topical spin-Hall effect [1]. So far no direct evidence for the intrinsic SHE 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 (QW), a detection of the spin signal is possible via voltage measurements.
Recently, it was pointed out that inverted HgTe QW structurescan be regarded as non-trivial insulators[3], in which the quantum spin Hall insulator state[4] should occur. In this state, a pair of spin polarized helical edge channels develops when the bulk of the material is insulating, leading to a quantized conductance. We will discuss our recent transport measurements on gated low density HgTe QWs that yield a first evidence for the existence of this effect[5].

[1] S. Murakami et al., Science 301 (2003) 1348;
J. Sinova et al., Phys. Rev. Lett. 92 (2004) 126603;
Y. Kato et al., Science 306 (2004) 1910 .
[2] E.M. Hankiewicz, et al., Phys. Rev. B 70 (2004) 241301(R)
[3] B.A. Bernevig et al., Science 314 (2006) 1757
[4] C.L. Kane and E.J. Mele, Phys. Rev. Lett. 95 (2005) 146802.
[5] M. K ‡ nig et al., Science 318, 766 (2007).

DAY 4: 9:40 – 10:20

Universal phase diagram for the quantum spin Hall systems

Shuichi Murakami
Tokyo Institute of Technology

Spin Hall effect has been attracting interest, because it can produce a spin current without a magnetic field or a magnet [1]. One of the recent interesting issues is the quantum spin Hall (QSH) effect. In the QSH system, the bulk is gapped and insulating, while there are gapless states on the edge (in 2D) or on the surface (in 3D) carrying a spin current. This phase is characterized by a nontrivial Z_2 topological number.
In the presentation we explain our recent theory on universal phase diagrams describing the QSH phase and the ordinary insulator (I) phase, both in 2D and in 3D [2] for systems without impurities. In particular, in 3D, a gapless phase appears between the QSH and insulator phases by changing an external parameter, when the inversion symmetry is broken. This gapless phase comes from the topological nature of the QSH-I phase transition in 3D. At the phase transition the bulk gap closes, and the gap-closing points in the 3D k space are monopoles and antimonopoles, which can be created and annhihilated only by pair-creation/annihilation. This topological consideration is confirmed by a model calculation using the tight-binding model on the diamond lattice proposed by Fu, Kane and Mele. If time allows, we also mention my recent theoretical results on candidate materials for the QSH phase, in particular on the bismuth ultrathin film [3]. The band structure calculation has been done for the bismuth ultrathin film, and is used for the calculation of the Z_2 topological number.

[1] S. Murakami, N. Nagaosa, and S.-C. Zhang, Science 301, 1348 (2003).
[2] S. Murakami et al., Phys. Rev. B76, 205304 (2007); S. Murakami, New J. Phys. 9, 356 (2007).
[3] S. Murakami, Phys. Rev. Lett. 97, 236805 (2006).