Abstract Submitted
for the MAR07 Meeting of
The American Physical Society

Quantum spin Hall phase and surface spin current in Bi and Sb

SHUICHI MURAKAMI, Department of Applied Physics, University of Tokyo — In the quantum spin Hall (QSH) phase, the bulk is gapped while edge states are gapless and carry spin currents. Experimental studies for the QSH phase are called for. To search for candidates of the 2D QSH phase, we relate the spin Hall conductivity in insulators with magnetic response of the orbital magnetization to the Zeeman field. In this respect, bismuth is promising since it is a strong diamagnet enhanced by spin-orbit coupling. For a 2D (111)-bilayer bismuth, we calculate the Z_2 topological number, the band structure for the strip geometry, the spin Chern number, and the parity at the time-reversal symmetric wavenumbers. We predict that the (111)-bilayer bismuth will be a QSH phase [1]. On the other hand, it was proposed recently that 3D bismuth is a simple insulator, and not the QSH phase, by parity consideration [2]. Transition from the 2D QSH topological phase to the 3D simple insulator phase is described by gradually increasing inter-bilayer hopping, thereby band-touching occurs at high- symmetry points and parities of the wavefunctions are exchanged. Similar discussion applies for Sb, where 2D bilayer is a simple insulator and 3D bulk is the QSH phase. Finally, we compare the theory with the ARPES data showing surface spin-splitting (spin current) for various surfaces of Bi and Sb. [1] S. Murakami, cond-mat/0607001 (to appear in Phys. Rev. Lett.). [2] L. Fu, C. L. Kane, cond-mat/0611341.

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Date submitted: 16 Nov 2006 Electronic form version 1.4