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The Quantum Spin Hall Effect

CHARLES KANE, University of Pennsylvania

We show that the intrinsic spin orbit interaction in a single plane of graphene converts the ideal two dimensional semi metallic groundstate of graphene into a quantum spin Hall (QSH) state [1]. This novel electronic phase shares many similarities with the quantum Hall effect. It has a bulk excitation gap, but supports the transport of spin and charge in gapless "spin filtered" edge states on the sample boundary. We show that the QSH phase is associated with a Z_2 topological invariant, which distinguishes it from an ordinary insulator [2]. The Z_2 classification, which is defined for any time reversal invariant Hamiltonian with a bulk excitation gap, is analogous to the Chern number classification of the quantum Hall effect. We argue that the QSH phase is topologically stable with respect to weak interactions and disorder. The QSH phase exhibits a finite (though not quantized) dissipationless spin Hall conductance even in the presence of weak disorder, providing a new direction for realizing dissipationless spin transport.

1. C.L. Kane and E.J. Mele, Phys. Rev. Lett. **95**, 226801 (2005).
2. C.L. Kane and E.J. Mele, Phys. Rev. Lett. **95**, 146802 (2005).