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Spatial fluctuations of helical Dirac fermions on the surface of topological insulators[1]

HAIM BEIDENKOPF, Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot 76100, Israel

Strong topological insulators are materials that host exotic states on their surfaces due to a topological band inversion in their bulk band structure. These surface states have Dirac dispersion as if they were massless relativistic particles, and are assured to remain metallic by time reversal symmetry. The helical spin texture associated with the Dirac dispersion prohibits backscattering, which we have imaged using scanning tunneling microscopy (STM) and spectroscopic mappings [1,2]. This topological protection can be lifted by time-reversal breaking perturbations that induce a gap at the Dirac point and cant the helical spin texture. Massive Dirac electrons had been visualized by angular resolved photo emission spectroscopy in magnetically doped topological insulators. While we do not identify a gapped spectrum in our STM measurements of similar compounds, we do find a dominating electrostatic response to the charged content of those dopants [3]. In their presence the Dirac spectrum exhibits strong spatial fluctuations. As a result translational invariance is broken over a characteristic length scale and the Dirac-point energy is only locally defined. Possible global manifestations of these local fluctuations will be discussed, as well as alternative avenues for breaking time reversal symmetry while maintaining the integrity of the Dirac spectrum.

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[3] H. Beidenkopf, P. Roushan, J. Seo, L. Gorman, I. Drozdov, Y. S. Hor, R. J. Cava, A. Yazdani, Nat. Phys. 7, 939 (2011).

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