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Visualizing surface states of topological insulators using spectroscopic mapping with the scanning tunneling microscope[1]

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In topological insulators, the spin texture of the surface states makes them distinct from conventional two-dimensional electron states, and leads to novel properties for these states. These surface states are expected to be immune to localization and to overcome barriers caused by material imperfections. We have used scanning tunneling microscopy and spectroscopy to study the topological surface states in $Bi_{0.9}Sb_{0.1}$, Sb, and Bi_2Te_3. By mapping the interference of the surface states scattering off random alloying disorder in $Bi_{0.9}Sb_{0.1}$, we have demonstrated that despite strong atomic scale disorder, backscattering between states of opposite momentum and opposite spin is absent, resulting from the spin texture [1]. Furthermore, we have measured the transmission and reflection of topological surface states of Sb through atomic terraces [2]. In contrast to Schottky surface states of noble metals, these surface states penetrate such barriers with high probability. To examine the possibility of disorder induced localization, we investigated the surface states of $\mathrm{Bi_2Te_3}$ in the presence of local defects. In the presence of magnetic dopants, we have observed an interference pattern throughout a broad range of energies, even in the region of linear dispersion near the Dirac point [3]. We discuss the results of a statistical analysis of these patterns which can help to learn about the tendency toward localization for these surface states and how this trend is affected as the energy is tuned to the Dirac point. *Work was done in collaboration with J. Seo, H. Beidenkopf, L. Gorman, Y. S. Hor, C. Parker, D. Hsieh, and A. Richardella, M. Z. Hasan, R. Cava, and A. Yazdani.

[1] P. Roushan *et al.* Nature 460, 1106 (2009).
[2] J. Seo *et al.* Nature 466, 343 (2010).
[3] H. Beidenkopf *et al.* (2010).

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