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Axion insulators and surface quantum point junctions

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Axion insulators are materials in which inversion, or another magnetic symmetry other than simple time reversal, quantizes the formal Chern-Simons magnetoelectric coupling to a half-quantum value of pi. The surfaces of axion insulators need not be metallic, and when gapped, they exhibit a half-quantized surface anomalous Hall conductivity (AHC) and dissipationless chiral edge channels at 1D boundaries between surfaces of different sign of the AHC. While 3D materials realizations are still an object of active search, I will look ahead to discuss future opportunities presented by such materials. In particular, I will focus on the fact that chiral channels can be associated either with steps or with antiferromagnetic domain walls, opening the opportunity to form novel quantum point junctions at the intersections of the chiral channels. I will also show how the quantum scattering at the junction can be mapped, in principle, onto the physics of qubits, and point out how such gates might be controlled by surface scanning probe tips.

Nicodemos Varnava, Justin H. Wilson, J. H. Pixley, and David Vanderbilt, "Controlling a quantum point junction on the surface of an antiferromagnetic topological insulator," Nature Communications 12, 3998 (2021).

In collaboration with Nicodemos Varnava, Justin Wilson, and Jedediah Pixley from Rutgers University.