Current-induced breakdown of the quantum anomalous Hall effect

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The quantum anomalous Hall (QAH) effect is characterized by zero longitudinal resistivity and quantized Hall resistance without the need of an external magnetic field, see Fig. 1(a). However, when reducing the device dimensions or increasing the current density, an abrupt breakdown of the dissipationless state occurs, see Fig. 1(b). In this poster, the mechanism of breakdown will be addressed, and the electric field created between opposing chiral edge states will be shown to lie at its origin. Electric-field-driven percolation of two-dimensional charge puddles in the gapped surface states of compensated topological-insulator films is proposed as the most likely cause of the breakdown [1]. Moreover, it was recently reported that the interplay between the 1D chiral edge state and the 2D surface state can give rise to nonreciprocity in the longitudinal resistance [2]. In this poster, it will be shown that the onset of 2D conduction due to breakdown is sufficient to create the nonreciprocal effect, allowing for efficient switching between the dissipationless and nonreciprocal transport regime of the QAH state.

References

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[2] K. Yasuda, T. Morimoto, R. Yoshimi, M. Mogi, A. Tsukazaki, M. Kawamura, K. S. Takahashi, M. Kawasaki, N. Nagaosa, and Y. Tokura, Nat. Nanotechnol., 15 (2020) 831-835

Figures

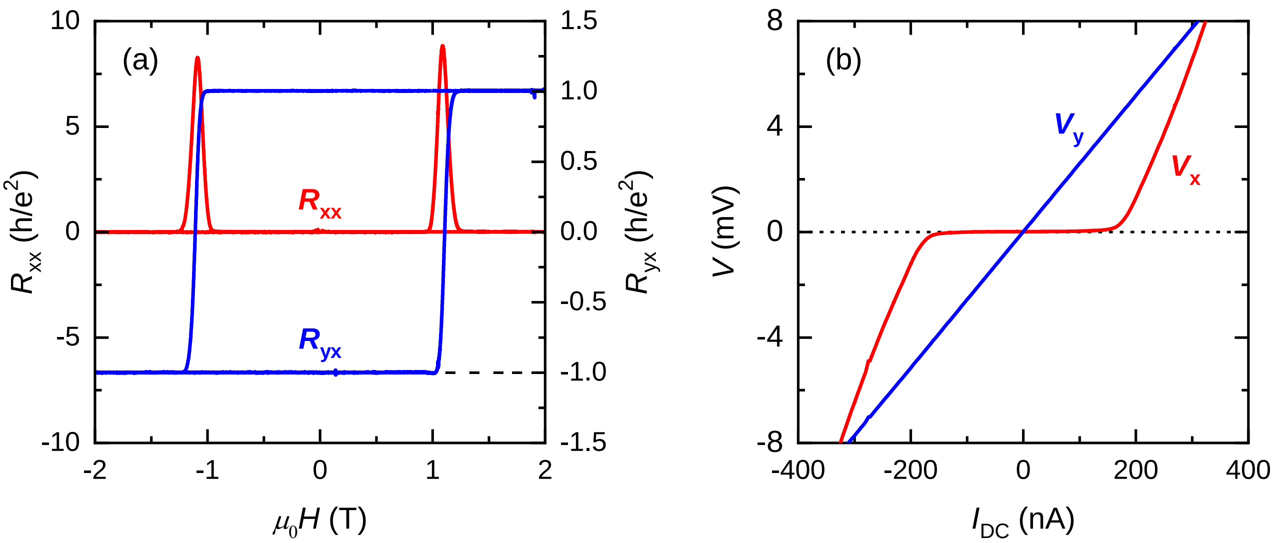

Figure 1: (a) The longitudinal and transverse resistance as a function of the applied magnetic field, showing the quantum anomalous Hall effect. (b) The current-induced breakdown of the QAH effect for a 100-µm-wide Hall-bar device.