Probing the unidirectional magnetoresistance in topological insulators

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The discovery of three-dimensional topological insulators (TIs) has triggered an outburst of research activities aimed at understanding their physical properties, especially about its topologically protected surface state, where spin and k-vector (momentum) are perpendicularly locked to each other (see Fig. 1a). As a consequence, the resistance measured in the presence of an in-plane magnetic-field is expected to depend on the current direction. For fixed current direction the resistance is higher in one magnetic-field direction and lower in the other. This so called unidirectional magnetoresistance (UMR) provides a new scheme to probe topological surface states\(^1,2\).

This project aims at probing the unidirectional magnetoresistance in topological insulators by measuring the second harmonic of the voltage drop when an ac current is driven through the device (see Fig. 1b). The samples will be grown in University of Regensburg (Bi\(_2\)Se\(_3\)) and the Chinese Academy of Sciences (Cd\(_2\)As\(_3\)). Going beyond existing experiments\(^1,2\) we will take thermal effects into account.

![Fig. 1](image_url)  
*Fig. 1 | Probing UMR in topological insulators.* (a) Illustration of the spin texture of topological surface states in k-space. (b) Schematic of experimental set up. AC current \(I(t) = I\sin(\omega t)\) with circular frequency \(\omega\) and amplitude \(I\) is driven through a topological insulator, and the out-of-phase \(2\omega\) voltage \(V_{2\omega}\) is detected by sweeping the direction of external magnetic field. (c) Typical measurements of \(2\omega\) resistance \(R_{2\omega} (V_{2\omega}/I)\) as a function of magnetic-field angle \(\theta\). Due to the interplay between surface states and external magnetic field, the high resistance state is realized for \(B /\perp y\), while the low resistance state occurs for \(B /\parallel y\).

References