Masterarbeit
Probing the magnetoresistance effects in a 3D topological insulator HgTe
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Three-dimensional topological insulators (TIs) host topologically protected surface state, where spin and k-vector (momentum) are perpendicularly locked to each other (see Fig. 1a). The Zeeman coupling between the spin states in TI and external magnetic field is expected to produce two kinds of magnetoresistance effects:

I) Even two-fold magnetoresistance, i.e., $R_{xx}(0^\circ) = R_{xx}(180^\circ) \neq R_{xx}(90^\circ)$, which is similar to the anisotropic magnetoresistance effect in ferromagnetic materials.

II) Odd unidirectional magnetoresistance, i.e., $R_{xx}(0^\circ) \neq R_{xx}(180^\circ)$, which is a current non-linear effect. The resistance is higher in one magnetic-field direction and lower in the other. This unidirectional magnetoresistance could also provide a new scheme to probe topological surface states.

In this Master thesis, the above magnetoresistance effects will be investigated using a thoroughly investigated three-dimensional topological insulator HgTe. The device is field-effect structure with a top-gate (see Fig. 1b). Both $1\omega$ and $2\omega$ signal will be measured with Lock-In-Amplifier under the application of an external magnetic field. And the corresponding magnetoresistances will be measured as a function of gate voltage and current. Finally, the experimental results will be compared with theory.

Fig. 1 . (a) Illustration of the spin texture of topological surface states in k-space. (b) Schematic of experimental set up. AC current $I(t) = I_0 \sin \omega t$ 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.