Resistively Detected NMR as Probe of Topological Insulators

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Introduction

Topological insulators (TIs) are new states of quantum matter that embody a state of bulk matter characterized by spin-momentum-locked surface states that span the bulk bandgap [1-3]. Our work focuses on study of these topological states of matter. In particular, we investigated two classes of 3D topological insulators subject to a magnetic field, time-reversal-breaking perturbation. The goal is to determine microscopic nature of the exotic quantum states that can arise as a consequence time-reversal symmetry breaking.

Experimental -

We performed resistively detected NMR (RDNMR) measurements at temperatures in the vicinity of 50 mK on Bi_2Se_3 sample with low mobility, in order to achieve the quantum limit in relatively low fields below 10 T for bulk 3D electrons. Both low temperature and high field environment are necessary for the success of our experiment, performed using the top-loading $^3He/^4He$ dilution refrigerator and 18 T magnet at the miliKelvin facility at NHMFL. The near field RF excitation was generated by a surface coil that was placed on the top surface of the sample between the leads used for 4-probe transport measurements.

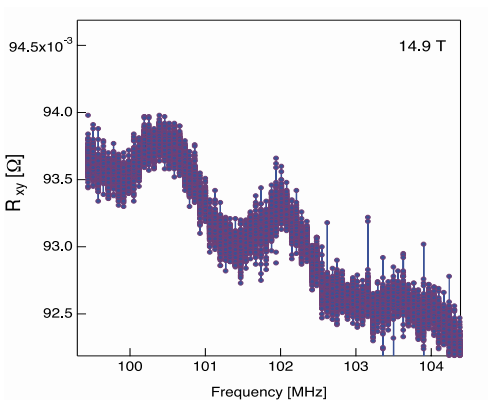

Fig.1 Longitudinal resistance measured at fixed applied field, 14.9 T, at 50 mK for Bi_2Se_3. The resistance was recorded for total of 1 minute (60 point total) after an RF excitation pulse at a given frequency.

Results and Discussion

We were able to detect measurable changes in sample resistance subject to the resonant RF field, as shown in Fig. 1. Longitudinal resistance measured at fixed applied field at 50 mK shows an enhancement in resistance over a frequency range that approximately corresponds to the FWHM of ^{209}Bi NMR spectra in the same field orientations.

Conclusions

Our results indicate that an appropriate RF field can be used to manipulate the electronic spin of topological surface states.

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