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Project Number

S1720

Project Title

Topological Insulators: An Analysis of the Electron-Phonon Coupling Constant of Bi(2)Se(3) Using ARPES Data

Abstract

Objectives/Goals

Gapless surface states on topological insulators (TI#s) are protected from backscattering, making them promising candidates for quantum computing and spintronics applications. Verification of TI#s resistance to backscattering is found in the electron-phonon coupling constant, and the lower this value is, the less the TI is likely to have its spin current altered via scattering effects through interaction with its surroundings. The objective of this research is to verify and expand on the Gweon Group#s recently discovered lowest-ever recorded electron-phonon coupling constant (0.049 ±0.007) for Bi2Se3 on a different sample of the TI by using high resolution, angle-resolved photoemission spectroscopy (ARPES).

Methods/Materials

The Bi2Se3 sample was placed in an ultra high vacuum chamber inside ARPES at SSRL and cleaved using the tape method. Monochromatic UV light was fired at the cleaved sample to eject electrons from the topologically protected surface of the crystal, and the detector collected data on the energies and momenta of these ejected electrons. The incident photon angle was adjusted to get the clearest data on the ejected electrons, and this procedure was repeated from 50 K to 300 K at 50 K intervals. Lorentzian Momentum Distribution Curves were done to mathematically model this ARPES data, and from here, the Fermi velocities and Imaginary Self Energies of the crystal at the various temperatures were extracted to eventually solve for the electron-phonon coupling constant for Bi2Se3.

Results

The electron-phonon coupling constant is solved for as the slope of the best-fit line of the Imaginary Self-Energy vs. Temperature graph. However, unlike previous research of this kind, the slope from this research is negative, with the most recent coupling constant value being -0.203.

Conclusions/Discussion

From a purely mathematical standpoint, this negative value seems to be the lowest ever recorded electron-phonon coupling constant, even lower than the previous Gweon Group result. However, a negative value for this constant is anomalous in the field, and therefore the accuracy of this value must be further scrutinized with attention placed on the methods of coming to this value. Simultaneously, the research also brings up the inquiry of electron doping values varying per sample, and how that may lead to discrepancies between coupling constant values among different samples.

Summary Statement

Verifying and expanding research on the lowest ever recorded electron-phonon coupling constant for the topological insulator Bi2Se3 using ARPES data for possible future applications in spintronics and quantum computing.

Help Received

Participant in Summer Research Program at UC Santa Cruz under supervision of Prof. Gey-Hong Gweon and graduate student Ms. Ahram Kim