Edge-Induced Excitations in Bi_2Te_3 from Spatially-Resolved Electron Energy-Gain Spectroscopy

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Abstract

Topological insulators (TIs)are promising materials for developing novel tunable plasmonics at THz and mid-infrared frequencies, with potential applications in quantum computing, THz detectors and spintronic devices. However, to fully utilize the unique physical properties of TI's it is essential to understand the intricate relationship between their nanoscale crystal structure and the resulting physical properties. Here, we deploy spatially resolved electron energy-gain spectroscopy to investigate collective excitations in Bi_2Te_3 and correlate them to the underlying crystalline properties at the nanoscale. Specifically, we use the Monte Carlo replica method implemented in our Python machine learning framework, EELSFitter [1,2], to process spectral images for the removal of the zero-loss peak and the identification of the gain-energy features. We demonstrate the presence of an energy-gain peak located around -1.0 eV, in agreement with a predicted plasmonic resonance of Bi_2Te_3, which exhibits enhanced intensity at the edge-rich regions of the specimen. Our approach to the automated detection of energy-gain peaks makes it possible to stablish clean correlations with the associated local crystal properties. This approach, combined with temperature-dependent EELS measurements, could make possible the determination of estimate the local temperature of specimens with nanoscale-level spatial resolution.[3]

References

[1] A. Brokkelkamp et al., J. Phys. Chem. A., 126 (2022) 1255-1262

[2] L. I. Roest et al., Ultramicroscopy, 222 (2021) 113202

[3] J. C. Idrobo et al., PhysRevLett., 120 (2018) 095901

Figures

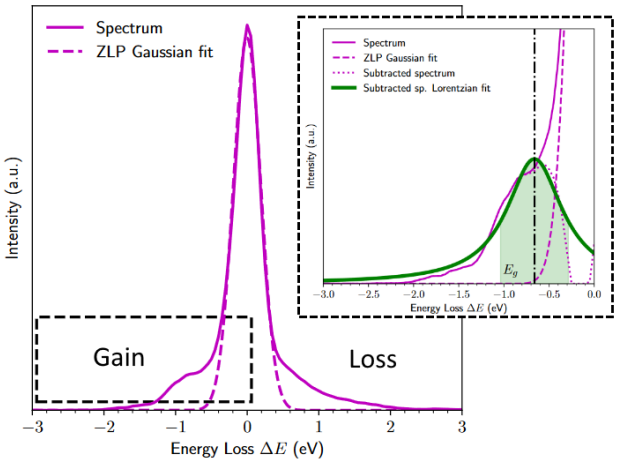

Figure 1: Plot of the zero-loss peak (ZLP) centered around 0 eV. In the energy gain region, an unusual broadening of the ZLP is present. The inset shows a Lorentzian fit of this energy gain feature.