Topological insulator 2D nanoflakes – A Raman investigation on electron-phonon coupling

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Topological insulators (TIs) are a highly discussed new phase of quantum matter, which gained a lot of scientific interest due to their topologically protected surface states [1,2]. While the bulk is insulating those surface states remain conductive even under structural disorder and are protected against backscattering [3] making them promising materials for applications in possible spintronic devices [4]. Two suitable candidates that were identified as 3D topological insulators are Bi_2Se_3 and Bi_2Te_3 [5].
To explicitly study the properties of the conducting surface states and reduce contributions from the bulk we investigated ultrathin Bi_2X_3 (X=Se, Te) 2D nanoflakes with a highly increased surface to volume ratio. With regard to TI based applications, it is crucial to investigate the fundamental limits of the conducting surface states due to electron-phonon interactions. A unique technique to simultaneously study the intrinsic phononic and electronic properties of a material is Raman spectroscopy.
We have studied TI nanoflakes by means of temperature and magnetic field dependent Raman spectroscopy. For Bi_2Se_3 we observe unexpected changes in the phonon self-energies at low temperatures and high magnetic fields indicative for a coupling to electronic states. Since the conductive surface states are known to be sensitive to an applied magnetic field [6], we explain our phonon anomalies by a gap opening in the Dirac cone that enables electron-phonon coupling.

References

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Figures

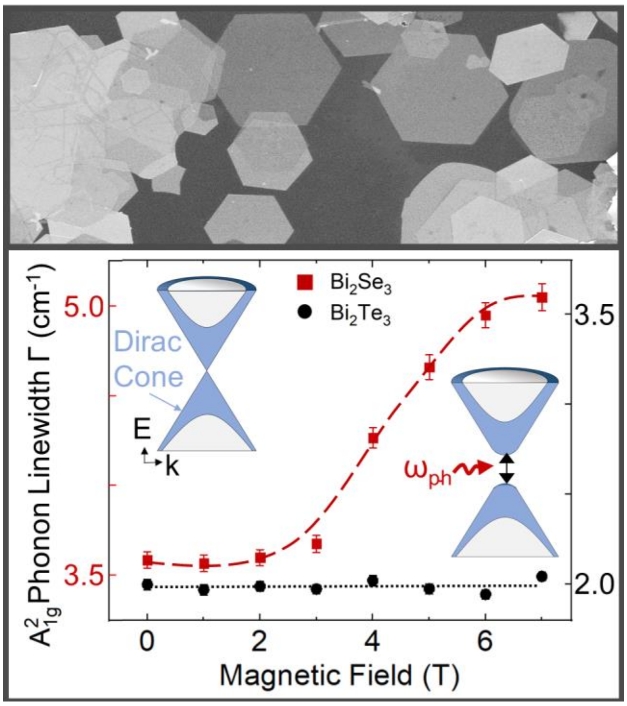

Figure 1: Upper panel: SEM micrograph of Bi_2Se_3 nanoflakes. Lower panel: Linewidth dependence of the A^2_{1g} phonon of both materials as a function of magnetic field showing a larger effect of the field on the Bi_2Se_3 phonon. The inset cartoons show the change in the energy dispersion of a TI with applied magnetic field. The linewidth changes in the Bi_2Se_3 phonon above 3 T are explained by a coupling to an electronic transition from the lower to the upper gapped Dirac Cone.