Electron-phonon coupling and atom-surface interaction of topological insulators from helium atom scattering

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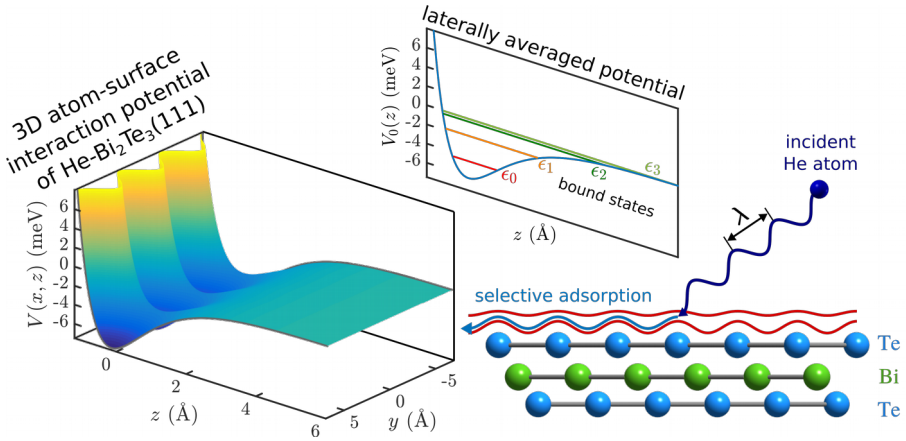
Materials with peculiar electronic surface effects such as the novel group of topological insulators are particularly interesting for truly surface sensitive measurement methods such as helium atom scattering (HAS). Using HAS we are able to obtain an accurate He−Bi_2Te_3(111) atom-surface interaction profile by analysing ultrahigh resolution measurements of selective adsorption resonances[1]. Following an initial free-particle model analysis, we use elastic close-coupling calculations to obtain a three-dimensional potential. Close-coupling calculations provide a quantum mechanically accurate way of testing a provided interaction profile against measured data[1,2]. The optimised He−Bi_2Te_3(111) interaction potential fully reproduces the experimental data and can be described by a corrugated Morse potential with a well a depth D=(6.22±0.05) meV, a stiffness κ=(0.92±0.01) 1/Å and a surface electronic corrugation of (9.6±0.2)% of the lattice constant.

Moreover, we are able to extract the electron-phonon (e-ph) coupling λ of Bi_2Te_3(111) by adapting a recently developed quantum-theoretical derivation of the helium scattering probabilities to the case of degenerate semiconductors[3,4]. Based on the Debye-Waller attenuation of the elastic diffraction peaks of Bi_2Te_3(111), measured at surface temperatures between 110 and 355 K, we find λ to be in the range of 0.04-0.11. This method allows us to extract a correctly averaged λ and to address the discrepancy between previous studies. The relatively modest value of λ is not surprising even though some individual phonons may provide a larger electron-phonon interaction[5]. The obtained weak electron-phonon coupling indicates that the Bi_2Te_3 system may be useful in achieving high electron mobilities.



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