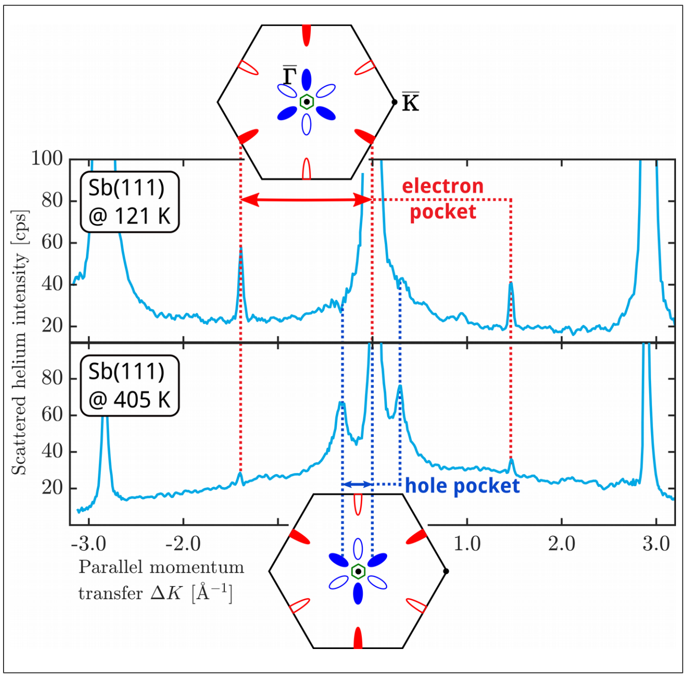
Surface phonons and charge density wave excitations at topological semimetal and insulator surfaces

Anton Tamtögl[1], Patrick Kraus[1], Michael Mayrhofer-Reinhartshuber[1], Adrian Ruckhofer[1], Giorgio Benedek[2], Marco Bernasconi[3], Daniele Dragoni[3], Davide Campi[4], Marco Bianchi[5], Philip Hofmann[5] and Wolfgang E. Ernst[1]

[1]*Institute of Experimental Physics, Graz University of Technology, Graz, Austria*
[2]*Donostia International Physics Center (DIPC), Donostia-San Sebastián, Spain*
[3]*Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca, Milano, Italy*
[4]*École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*
[5]*Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark*
tamtoegl@tugraz.at

Charge density waves (CDWs), periodic modulations of the electron density, are ubiquitous phenomena in crystalline metals [1]. They appear often in systems with reduced dimensionality such as quasi-two-dimensional materials. CDW order is usually stabilised by coupling to the crystal lattice via electron-phonon interaction [2]. Since helium atom scattering (HAS) has been recently recognised as a powerful tool to investigate the electron-phonon interaction at surfaces [3-6], the question arises whether the energy and parallel momentum provided by the He atom can be retained by low-energy surface electronic excitations, rather than being transmitted to phonons.

A positive answer comes from our present study of the Sb(111) surface, a topological semimetal with layered structure. HAS diffraction spectra of Sb(111) show a superstructure whose peculiar temperature dependence permits to associate it with the surface electron and hole pocket states, due to the non-trivial surface electronic band structure. The corresponding low energy excitations of the CDW, could be identified by phonon dispersion measurements which show two low-energy branches below the typical surface acoustic waves.



Moreover, elastic HAS measurements of the topological insulator $Bi_2Te_2Se(111)$ [7] show a number of particularly sharp satellite peaks, aside the diffraction peaks, which are likely to correspond to electronic transitions across the Dirac ring. Hence our results suggest that HAS may be capable of mapping the surface electronic states at the Fermi level, in the case of narrow electron/hole pockets in reciprocal space as well as the Dirac states of topological insulator surfaces.

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