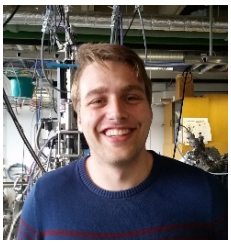
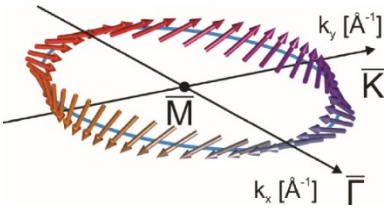
Montag, 23.05.2016 um 15.15 Uhr
Ort: Seminarraum 87, Wilhelm-Klemm-Straße 10

Spin-split surface states in the unoccupied electronic structure of Tl/Ge(111) and Tl/Si(111)



Philipp Eickholt
AG Donath
Physikalisches Institut



Since the beginnings of quantum mechanics it has been known that spin-orbit interaction (SOI), i.e., the coupling of the electron spin to its orbital momentum, can affect the splitting of energy levels in atoms, molecules and solids. At a crystalline surface, the translational symmetry of the crystal is broken and SOI can lead to spin-polarized electronic surface states even in the absence of magnetic fields. This may open the way for promising spintronic applications such as the spin field-effect transistor [1]. To integrate spintronic devices in today's silicon-based electronics, thin films of heavy metals with high SOI on semiconductor substrates are particularly interesting.
Prototypical systems of such kind are Tl/Si(111) [2-4] and Tl/Ge(111) [5]. With the help of our setup for spin- and angle-resolved inverse photoemission we studied the spin texture of the unoccupied spin-split surface states of these systems.
Interestingly, we identified surface states close to the Fermi energy with a valley-like dispersion around $\bar{K}$. They are fully out-of-plane spin-polarized and exhibit a giant energetic splitting at the $\bar{K}$ point. In contrast, the spin-polarization vector for states along $\bar{\Gamma}\,\bar{M}$ is forced to lie in the surface plane and perpendicular to the momentum vector of the electronic state. As a consequence, spin chirality is found in momentum space around the $\bar{M}$ point.
Comparing our results for Tl/Si(111) with isoelectronic Tl/Ge(111), we see surprising differences in their unoccupied electronic structure. These differences are explained with the help of a tight-binding model based on *ab initio* calculations as a peculiar effect of hybridization and SOI. Understanding the fundamental mechanisms for the formation of SOI-induced spin-polarized surface states is important to find suitable materials for future spintronic applications.

[1] S. Datta and B. Das, Appl. Phys. Lett. **56**, 665 (1990)
[2] S.D. Stolwijk et al., Phys. Rev. Lett. **111**, 176402 (2013)
[3] S.D. Stolwijk et al., Phys. Rev. B **90**, 161109(R) (2014)
[4] S.D. Stolwijk et al., Phys. Rev. B **91**, 245420 (2015)
[5] P. Eickholt et al., Phys. Rev. B **93**, 085412 (2016)