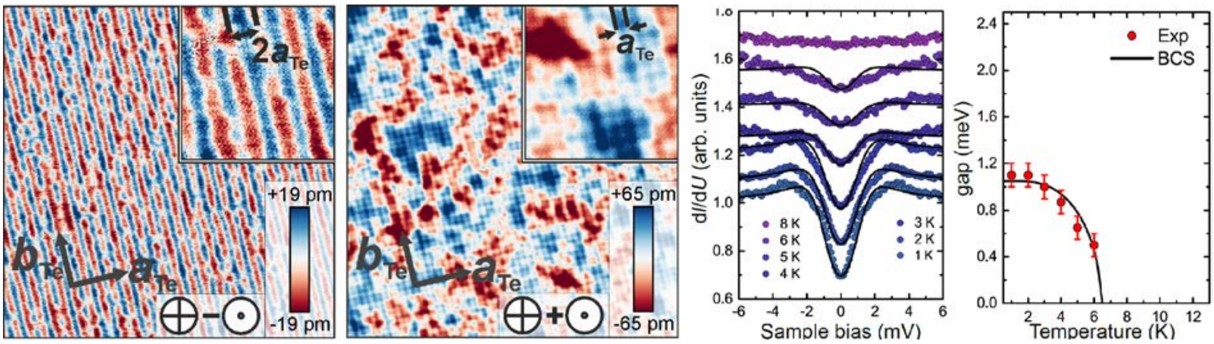
Coexistence of magnetism and superconductivity in iron-based superconductors on the atomic scale

Jens Wiebe

Institute for Nanostructure and Solid State Physics, Universität Hamburg, Germany

Topological insulators and interfacial superconductors are both topics of intense current interest in modern condensed matter physics. The combination of both materials is expected to reveal novel physics such as, e.g., Majorana Fermions arising in heterostructures of topological insulators and s-wave superconductors by including magnetic fields. Interestingly, it was recently shown by transport measurements, that superconductivity can emerge at the interface of two inherently non-superconducting materials, a topological insulator (Bi_2Te_3) and the magnetic parent compound $Fe_{1+y}Se_{1-x}Te_x$ (x=1) of the Fe-chalcogenide superconductors [1]. It was proposed that the topological surface state may dope the FeTe layers and suppress the long-range diagonal double-stripe antiferromagnetic spin-structure at the interface, which thereby induces the observed interfacial superconductivity. However, the spin-structure of the interface layer was not experimentally studied so far, and thus a coexistence of superconductivity and magnetism has not been disproven.



Here, I will review our recent investigation of the local superconducting and magnetic properties of single-layer thin films of $Fe_{1+y}Te_xSe_{1-x}$ (x=0, 0.5, 1) grown on $Bi_2Te_xSe_{3-x}$ (x=0, 2, 3) by low-temperature spin-resolved scanning tunneling spectroscopy [2-5]. While there is no indication for superconductivity in FeSe on Bi_2Se_3 down to T = 6 K [2], $FeTe_{0.5}Se_{0.5}$ on Bi_2Te_2Se shows a fully developed, temperature dependent gap suggesting a superconducting transition at a critical temperature of T_c = 12 K, close to the bulk T_C value [3]. Most notably, FeTe on Bi_2Te_3 shows a temperature dependent gap indicating superconducting correlations below T_c = 6 K which spatially coexist with a long-range antiferromagnetic spin-structure [4], that is different from the bulk spin-order (see the figure) [5].

[1] Q. L. He *et al.*, Nature comm. **5**, 4247 (2014); [2] U. R. Singh *et al.*, *Journal of Physics: Condensed Matter* **29**, 025004 (2017); [3] A. Kamlapure *et al.*, **arXiv:1608.03827** [cond-mat.supr-con] (2016); [4] S. Manna *et al.*, *Nature Communications* **8**, 14074 (2017); [5] T. Hänke *et al.*, *Nature Communications* **8**, 13939 (2017).