# NOVEL INTERFACE-INDUCED ELECTRONIC AND SPIN STATES REVEALED BY SPIN-RESOLVED SCANNING TUNNELING SPECTROSCOPY


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Recently, exotic states of ultrathin films resulting from interfacial interactions have become of great interest in various fields of nanoscience research. As first example, nanoscale magnetic knots, called skyrmions, will be discussed which represent novel types of localized non-collinear spin textures offering great potential for future energy-efficient magnetic memory and logic devices [1]. The twisting in the skyrmions' magnetization profile leads to a gain in energy with respect to a homogeneously magnetized, ferromagnetic state. As a result of this magnetization twisting, skyrmions have non-trivial topological properties. The energetics of skyrmionic states in ultrathin films is explained by the interfacial Dzyaloshinskii-Moriya interaction [2] being relevant in material systems exhibiting large spin-orbit coupling and a lack of inversion symmetry. By using atomic-resolution spin-polarized scanning tunneling microscopy (SP-STM) and spectroscopy (SP-STS) [3] we have shown that magnetic skyrmions in ultrathin film systems can be as small as one nanometer in diameter [4] and that their properties can largely be tuned by the choice of the substrate and overlayer materials [5,6]. By locally injecting spin-polarized electrons from an atomically sharp SP-STM tip, we are able to write and delete individual skyrmions one-by-one, making use of spin-transfer torque exerted by the injected high-energy spin-polarized electrons [5]. Alternatively, individual skyrmions can be created and deleted by local electric fields, which can be of great advantage in view of energy-saving skyrmionic device concepts.

As second example, we will focus on interfacial superconductivity in novel types of heterostructures. Here, we present an SP-STS study of ultrathin $FeTe_{1-x}Se_x$ (x = 0, 0.5) films grown on prototypical Bi-based bulk topological insulators. We observe fully developed U-shaped superconducting gaps in $FeTe_{0.5}Se_{0.5}$ layers of one unit cell (UC) thickness with a transition temperature (Tc) of ~11 K, close to the one of the corresponding bulk system (Tc ~ 14.5 K). Surprisingly, we also find clear evidence for superconductivity up to Tc ~ 6 K for one UC thick FeTe layers grown on $Bi_2Te_3$ substrates, in contrast to the non-superconducting FeTe bulk compound which exhibits bicollinear AFM order in a wide temperature range up to 70 K. Even more surprisingly, detailed investigations of the atomic-scale spin-resolved local density of states by SP-STS reveal that superconductivity in one UC of FeTe grown on $Bi_2Te_3$ appears to spatially coexist with bi-collinear AFM order. This finding opens novel perspectives for theoretical studies of competing orders in Fe-based superconductors as well as for experimental investigations of exotic phases in heterostructures of topological insulators and superconducting layers.

**References**


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