Experimental observation of a magnetic warping transition in a topological insulator mediated by rare-earth surface dopants

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Magnetic topological insulators (MTIs) are a novel class of materials where the topologically protected band structure coexists with long-range ferromagnetic order, which can lead to the breaking of time-reversal symmetry (TRS), introducing a bandgap in the Dirac cone-shaped topological surface state (TSS) [1, 2]. Recently, the gap opening in MITs has been predicted to be accompanied by a distortion in the TSS, evolving its typically warped shape from hexagonal to trigonal [3, 4].

In this work, we demonstrate such transition by means of angle-resolved photoemission spectroscopy after the deposition of low concentrations of magnetic rare earths (RE), namely Er and Dy, on the ternary three-dimensional prototypical topological insulator Bi_2Se_2Te. Indeed, indications of the gap opening occurring as a consequence of the TRS breaking have also been observed, whose existence is supported by the observation of the aforementioned transition. Moreover, increasing Er coverage results in a tunable p-type doping of the TSS. As a consequence the Dirac point and therefore the magnetically induced bandgap can be both tuned towards the Fermi level as the RE concentration is increased, thus fulfilling the two necessary prerequisites for the realization of the quantum anomalous Hall effect (QAHE). The experimental results are rationalized by a theoretical model where a magnetic Zeeman out-of-plane term is introduced in the hamiltonian governing the TSS band dispersion. Our results offer new strategies to control magnetic interactions with TSS based on a simple approach and open up viable routes for the realization of the QAHE and their implementation in new spintronic devices.

References

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