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Magnetic impurities in the bulk and on the surface of 3D topological insulators probed using soft X-ray spectroscopy

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Among the most important requirements for realization of versatile spintronic devices is a foundation of robust sources of the spin-polarized carriers. For semiconductors, this is achieved by means of an injection of spins directly from ferromagnetic material or by realizing magnetic semiconductors by means of diluted 3d transition metal (TM) impurities. The latter might also be realized in 3D-topological insulators (TI), in which the metallic surface states revealing the linear dispersion in a form of a Dirac cone, are robust against non-magnetic impurities.

In this contribution we present results of systematic investigations of electronic and magnetic properties of surface and bulk impurities into tetradymite semiconductors of $Bi_2Se_{3-x}Te_x$ family by means of soft X-ray absorption and dichroism.

We show how, depending on adatom/substrate type, different types of magnetic anisotropy – either uniaxial out-of plane or basal ion-plane easy axis – may be achieved [1-2]. Moreover, we discuss the intriguing oscillatory effects in electron yield detected XAS and its linear natural dichroism (XNLD) spectra, that are tentatively ascribed to X-ray induced plasmon excitations of well-defined frequency.

By exploring evolution of electronic and magnetic properties of impurities we aim for revealing, how robust against magnetic impurities is the metallic state at the surface of canonical topological insulators, and how the extraordinary topology of electronic structure promotes the magnetic interactions.

Based on the experience gained during realization of the project, we discuss the requirements for future undulator-based soft X-ray absorption and magnetic dichroism beamline at “Solaris”, that are essential for probing interactions and electronic structure of ultra-diluted magnetic impurities in exotic systems.

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