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Doctoral thesis: Optical and magneto-optical properties of topological and Dirac materials

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Abstract:
Dirac materials exhibit unusual properties that attract interest both for practical applications and fundamental reseach of exotic and relativistic physics. This thesis aims to systematically study basic optical and magneto-optical properties of several members of these materials, namely the lead tin salts crystalline topological insulators and graphene. Non-destructive experimental techniques of spectroscoipic ellipsometry and FTIR magneto-optical spectroscopy were used to perform measurements from IR to UV spectral regions. A four-band Hamiltonian model was derived to describe the most important band structure features of PbSnSe system placed in a magnetic field. This allowed to extract the band structure and topological parameters of the investigated samples. Extensive modeling results based on Kubo-Greenwood formalism and ab-initio simulations are presented to help validate the measurement results and predict the appearance of the topologically protected surface states. Despite excellent quality of the samples, the surface states were not observed, and the potential reasons are discussed. The epitaxial graphene grown by intercalation of graphitized silicon carbide offers a cheap and easily mass-produced source of graphene for novel optoelectronic devices. An efficient parametrised model dielectric function over a wide spectral region from IR to UV is presented. The spectral response in terms of the sharpness of the excitonic peak suggests intercalated graphene to be optically similar to exfoliated graphene and suitable candidate for potential applications.