Supervisor review of the dissertation thesis of Kristupas Tikuišis

„Optical and magneto-optical properties of topological and Dirac materials“

Dissertation thesis of Kristupas Tikuišis is devoted to systematic optical and magneto-optical characterizations of two representatives of topological and Dirac materials, namely PbSnSe and graphene. Due to their topologically protected physical properties these materials are suitable candidates for applications in novel electronic devices.

PbSnSe is IV-VI semiconductor, which was recently categorized as topological crystalline insulator. Such material exhibits protection by spatial symmetry transformations which act non-locally, e.g. mirror or rotational symmetries. Although the material itself is known for decades, its low frequency magneto-optical properties with emphasis to potential observations of surface states are still subject of scientific debate.
Graphene is nowadays well known material with outstanding physical properties. When prepared, this material exhibits the best properties in the form of mechanically exfoliated flake, which is not convenient for practical applications. Therefore finding the way, how to produce large scale graphene with close to exfoliated physical properties is an ultimate goal of scientific community.

The thesis itself is divided into five sections. In the first three sections the reader is introduced in detail into investigated materials in a broader context as well as into experimental methods used for their characterization. The sections are pedagogically written and in the case of the experimental part the student explain all the theoretical aspects required for better understanding of characterization technique. In my honest opinion this is a well written introductory part.
The first results section is devoted to PbSnSe and its magneto-optical characterization. A series of PbSnSe samples with different ratio of Sn to Pb was grown. IR Landau level spectroscopy in magnetic fields up to 32 T was used to characterize the investigated samples. Derivation of the correct Dirac Hamiltonian led to the identification of Landau level transitions and the bulk band-structure parameters. These depends on the composition of particular sample. As a next step an extension of the Hamiltonian to account for surface states was done. The field dependencies of surface state transitions were predicted and compared with the experimental data. This I value as a most interesting result of the thesis.
Last section of the thesis is devoted to optical characterization of quasi freestanding graphene prepared on SiC. Spectroscopic ellipsometry was employed to deduce a spectral dependence of optical parameters in broad spectral range from FIR to UV. The analysis of the experimental data was complicated due to the optical anisotropy of SiC substrate. This resulted in a interference pattern observed in the spectra. However, Kristupas successfully overcame this difficulty suggesting the correct model structure of the sample. The results demonstrated a high optical quality of the graphene layer, which had optical properties comparable with mechanically exfoliated flake.

Kristupas has attended several study stays at National laboratory of high magnetic fields in Grenoble, France were he measured infrared magneto-optical spectroscopy of PbSnSe samples. His stays were well evaluated.

During the whole study Kristupas showed significant interest in the research and full working activity. As follows from the thesis, he was involved not only in the experimental characterization, but also participated in the development of theoretical models. The thesis resulted in two impacted publications where Kristupas is first author. He is author or co-author of four impacted publications in total which were more than 50 times cited. During his Ph.D. study, he also presented his results at two international conferences.
Kristupas Tikušis has proven to be a good student and clearly showed his ability to solve complicated scientific topics in the field of magneto-optics and material physics. In my honest opinion the dissertation thesis fulfils all the formal and scientific requirements, and I am gladly recommending it for the defense.

In Prague 16.8. 2023

RNDr. Martin Veis, Ph.D.