Exploring the Optical and Magnetic Properties of a Two-Dimensional Magnetic Semiconductor - CrSBr

Konrad Widaj [1], Oliwia Janikowska [1], Michał Baranowski [1], Mateusz Dyksik [1], Maciej Śmiertka [1], Paulina Płochocka [1,2], Jakub Jasiński [1,2] and Zdeněk Sofer[3]

[1] *Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, 50-370 Wroclaw, Poland*
[2] *Laboratoire National des Champs Magnétiques Intenses, EMFL, CNRS UPR 3228, Université Toulouse, Université Toulouse 3, INSA-T, 31400 Toulouse, France*
[3] *Department of Inorganic Chemistry, University of Chemistry and Technology Prague, 160 00 Prague, Czech Republic*

Magnetic semiconductors are garnering significant interest in both technological and theoretical fields due to the interplay between their electronic structure and magnetism, which facilitates spintronic and magnetoelectric phenomena.[1] Such properties allow for applications in spin injection, the development of magneto resistive devices, and direct-read magnetic memory technologies. The rules governing optical transitions in these materials are shaped by their overall symmetry, which is a composite of the crystal lattice's symmetry, the symmetry of electronic orbitals, and the spin/magnetic order inherent in the material. Therefore, controlling the magnetic order, for instance, through temperature adjustments or external magnetic fields, could significantly affect the optical properties of a magnetic semiconductor, offering novel avenues for manipulating material characteristics and reading magnetic state.

Here we show our investigation of the optical properties of layered CrSBr. It is a two-dimensional orthorhombic layered material known for its unique electronic and magnetic properties. It features strong ferromagnetic intralayer interactions and antiferromagnetic interlayer coupling, making it an A-type antiferromagnet. CrSBr exhibits a direct band-gap of around 1.5 eV and is known for its highly anisotropic electronic and optical properties. [1] This material has shown significant potential for applications in spintronics and magnetoelectronics due to its ability to maintain magnetic properties even in monolayer form. The magnetic order in CrSBr can be controlled through temperature or external magnetic fields, impacting its optical response and offering new avenues for material control.

We will show a series of detailed photoluminescence and reflectance measurements conducted on the exfoliated crystals of different thicknesses – ranging from *quasi*-bulk – to single layers. We put a particular focus on correlating optical response with the magnetic order and layer thickness. We put particular attention to undertande excitonic properties and their variation with temperature, or high magnetic fields – far above magnetic state switching. The study also extended to evaluating the dependency of photoluminescence characteristics on the excitation power and wavelength, offering a more detailed understanding of the sample's optical response and excitonic structure of this material.

[1] Nathan P. Wilson, Engineering Interfacial Effects and Layered Behavior in 2D Materials (2020).