Layered materials that can be easily exfoliated down to single atomic layers, have attracted the interest of scientists for more than a decade due to their various extraordinary properties. In their two-dimensional form they can exhibit completely different properties as compared to the bulk form, which makes them perfect candidates for the future development of nanotechnology. Moreover, one can stack flakes of different layered crystals on top of each other in order to create so-called heterostructures. The materials interact with each other enabling the exploration of processes occurring in specially designed systems.

In our project, we join two families of layered materials: hexagonal boron nitride (h-BN) and two-dimensional magnetic materials. By performing a series of optical measurements, we study the proximity effect of two-dimensional magnets on the light emission from h-BN.

Hexagonal boron nitride is exceptionally popular among layered crystals because of its stability, durability and a large bandgap (~6 eV). It is often called “white graphene” due to its hexagonal structure although it does not contain carbon atoms as in case of graphene, but alternately arranged boron and nitrogen atoms. In heterostructures it is often used as an insulator, as well as a layer protecting other materials from environmental factors. Furthermore, h-BN can improve the optical properties of flakes of two-dimensional crystals in contact with it.
Of special interest in the context of our project is that **h-BN exhibits light emission corresponding to defect states in the energy range below the bandgap.** The material excited by e.g. laser light can emit single photons, which are fundamental for quantum technologies such as quantum repeaters, computers and communication.

The basis of our project lies in the possibility of utilizing epitaxial layers of h-BN, grown by our research group by metalorganic vapour phase epitaxy (MOVPE). This method allows to control the properties of the material such as number of layers, level of doping and concentration of desired defects responsible for the single photon emission.

The recent demonstration of the existence of magnetic ordering in ultrathin layers of various two-dimensional materials opens up new possibilities of exploring the influence of magnetic field on the properties of h-BN. Our unique approach concentrates on the preparation of heterostructures containing 2D magnets (in particular materials from the chromium trihalides family with the general formula CrX3, where X stands for Cl, Br, I). These crystals exhibit different orientation of spin ordering (spin can be understood as a magnetic moment localized on the crystal lattice nodes). Hence, it is possible to perform measurements in magnetic field oriented either perpendicular or parallel to the atomic plane. Various trihalides possess different spin configurations, which results in different type of magnetism (ferro-, or antiferromagnetism), which can be controlled by e.g. changing number of layers of chosen material or applying an external electric field.

The possibility to control the magnetic behavior, together with a wide range of magnetic properties allow for a detailed study on the influence on the light emission from h-BN of magnetic probes. Initial experiments utilizing CrBr3 demonstrate the activation of an additional emission from h-BN at temperatures below the ferromagnetic phase transition. It is a very promising result which may allow to use magnetic materials to control the properties of single single photon emitters in h-BN and to explore the properties of magnetic centers in this material.
In our experiments we mainly focus on optical spectroscopy: photoluminescence and Raman scattering. We perform measurements at low temperatures (<30 K), since only then the materials manifest their magnetic ordering.

The presented project will allow to gain a better understanding of the fundamental mechanisms behind the interaction between 2D magnets and h-BN and in the future may contribute to the development of novel quantum technologies and spintronics.