Information technologies (IT) are today the most important factors determining progress in such areas as automation, communication, robotics, defense, and medicine. Progress in the IT-devices (computers, operational memories, mass memories, logic devices…) is determined by new technical concepts that often use newly discovered physical phenomena. On the other hand, this progress requires the creation of new materials that can guarantee the implementation of these concepts.

The aim of our project concerns detailed research of materials that are important for the implementation of a new concept of the magnetic mass memories and logic devices in which skyrmions will be used as information carriers. Skyrmions are magnetic quasi-particles (topological objects) showing a chiral spins order. The important advantages of this concept are as follows:

- the thin films layered structures in which skyrmions occur can be produced with methods well established in industry, like sputtering,
- small sizes of skyrmions (for specific materials of the order of nanometers) allowing for high densities of information recording,
- the ability to generate, move and detect skyrmions solely by electric methods.

These features give a substantial possibility for building mass memories in the form of narrow stripes created of thin magnetic layers in which the skyrmions are propagated by flow of electric current. In such a sequential information memory the presence (absence) of skyrmion will correspond to the logical zero (one). In the last three years, nearly 150 publications were published (over 30 in 2017) concerning the skyrmions in ferromagnetic (FM) layers sandwiched between metal layers (M) or insulator (I). In these publications, it was shown that an important feature of these layered systems is the interaction known in the literature as Dzyaloshinskii-Moriya interaction (DMI), which favors the noncollinear spin configuration of the adjacent magnetic moments of the FM layer. As a result, the chiral spinmagnetic configuration may be obtained.

In ultrathin FM layers sandwiched between M or I layers, DMI plays an important role due to interafacial character. Investigating the current-induced skyrmion propagation, it was found that the skyrmion motion occurs not only in the direction of the electrical current, but also has a perpendicular component. As a result skyrmions moves along a curved trajectory (similar to the ball’s spinning motion). From the applications point of view, this is an unfavorable effect. In the last year, several theoretical works has been published indicating that this effect can be compensated by replacing a single FM layer with the DMI by a system of two such FM layers. It is important that FM layers are coupled antiferromagnetically. This means that with no external magnetic field present magnetizations of neighboring layers are oriented antiparallel to each other.

In these publications, the authors pay special attention to the fact that in systems of ultrathin layers composed of ferromagnetic and nonferromagnetic sublayers, the magnetic structure is determined by such factors as: the magnetic anisotropy of FM layers, the exchange interaction between FM layers, and the DMI. Unfortunately, so far there has been no systematic study on layered structures, in which, in addition to magnetic anisotropy, the impact of the exchange interaction and the DMI on the magnetization reversal process and the magnetic structure has been investigated. The goal of the submitted project is to fill this gap.

The implementation of this task is difficult both from the technological and experimental point of view. Layered structures should be deposited under ultrahigh vacuum conditions, and layer thicknesses must be controlled with precision comparable to the size of atoms. Investigation of the magnetic properties must be done using methods that guarantee extraordinary sensitivity and resolution. To fulfill this requirements the magnetooptical methods are ideal, in which a change in the polarization of light as a result of the interaction with magnetic material is utilized. The project will be carried out at the University of Bialystok in the Department of Physics of Magnetics, which has the the best equipment in Poland for magnetic measurements of layered nanostructures at its disposal.

Supplementary measurements will be carried out at the Leibniz Institute for Solid State and Materials Research in Dresden which is a world leader in the field of magnetic research using magnetooptical methods. Subject of studies i.e., layered films will be produced at the Institute of Molecular Physics, Polish Academy of Sciences. Many years of experience of above three teams and excellent equipment guarantee the project's successful realization.