DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

The rotation of the plane of the linearly polarized electromagnetic wave (optical activity) propagating through a medium in the presence of a magnetic field is known since 1845, when Michael Faraday performed his famous experiment using a thick slab of lead glass placed in a magnetic field. Quantitatively, the effect was described by Emil Verdet who confirmed a linear dependence between the optical rotation angle θ and the magnetic field strength B. The proportionality factor called *Verdet constant* depends on the type of the material and the wavelength of light. Faraday's experiment required thick samples as the effect depends on the optical path and, in the case of glass, the Verdet constant is very small, of the order of 0.1 rad/(T*m). Recently it was discovered that the Verdet constant in polythiophenes and mesogenic molecules is several orders of magnitude greater than in typical organic materials, reaching 7000 rad/(T*m). It is even higher than for commercially used inorganic materials, with the record high Verdet constant value. For example, for the terbium gallium garnet (TGG), used for optical isolators in the visible range, the Verdet constant is at least one order of magnitude smaller. Such surprisingly large Verdet constant in organic materials enables their use for detecting very small magnetic fields, like Earth's magnetic field or even magnetic fields that are related to biological activity, e.g generated by neuron cells.

Despite scientific efforts, the mechanism of GFE in conducting polymers is still unknown. **The objective of this project is to determine the nature of the GFE for the organic conducting materials.** In the initial stage of the study the chemical structure of conductive polymers will be systematically altered. The basic physicochemical properties, i.e. phase sequence, conductivity, absorption, etc. will be measured for all synthesized materials. The properties of pure polymers will be compared with the ones doped with electron-donors/electron-acceptors. For all the materials the dependence of the optical activity on external magnetic field and temperature will be examined in detail and compared with the magnetization obtained from SQUID magnetometry. In addition, the techniques of macroscopic ordering of the polymers, e.g. by the orientation of macromolecules in the presence of external fields or laser melting zone will be used to find the role of the long-range order in GFE. The Verdet constant will be measured by several methods using state-of-the-art setups constructed by the applicant. We believe that the results collected for organic conducting polymers will help to understand the mechanism leading to high Verdet constants and allow to design new polymeric and non-polymeric materials showing GFE. The non-polymeric materials will be sought among liquid crystal materials forming column phase with high electron conductivity, e.g. porphyrin derivatives. The advantage of non-polymeric materials is much easier and cost effective synthesis and processing as well as superior chemical stability. We will propose a theoretical model explaining the large Verdet constant in conducting organic materials.

The project is related to the fundamental research, but its results might lead to important applications in the future. Currently, the primary commercial use of the high Verdet constant materials is in optical isolators. Organic materials are likely to be used in miniature optical magnetic field sensors, which could be used in geophysical surveys, astronomical devices, magnetic electroencephalography (MEG), cardiography, etc. For example, electrical activity of the heart produces a signals of approximately 60 pT (picotesla) and the brain 100 fT (femtotesla). Only the most sensitive detectors currently used - superconducting quantum interferometers SQUIDs, allow the measurement of MEG. So far, magnetometers based on the Faraday effect, working with inorganic TGG crystal, are not sensitive enough. Increasing of the Verdet constant by 2-3 orders of magnitude comparing to TGG crystal would allow the use of optical magnetometers in cardiography, but the final goal is to use optical detection of magnetic fields in brain research and bionic applications. Optical sensors using organic materials would have the several advantage over their inorganic counterparts as they are easy to build, they are flexible and lightweight, and first of all they should be many times cheaper than cryogenic superconducting quantum interferometry SQUID detectors and are resistant to electrical interference.