Along with the increasing technological possibilities, the quality of the created materials and the sensitivity of measuring instruments increases. Consequently, the produced devices may be smaller and smaller, and scientists are discovering more and more subtle properties and phenomena. This leads to the construction of useful structures and devices, already used today, for example in computers, medicine or photovoltaics.

An example of such structures are magnetoelectric nanomaterials. Nanomaterials also play a large role in medicine - one of the most important fields for humans. Magnetoelectric nanomaterials in the form of nanopores support tissue growth, and magnetoelectric nanoparticles are being studied for use in cancer therapy, tissue regeneration, transport and release of drug molecules or nerve stimulation.

The principle of operation of these structures is based on the magnetoelectric effect, which is a combination of magnetostriction and the piezoelectricity. The external magnetic field changes the direction of the magnetization deforming the system by magnetostriction, and this deformation leads to the creation of an electric field through the piezoelectric effect. So we get an electric field around the structure, induced by the magnetic field. This field can be used to electrically stimulate tissues, nerves or to charge chips placed in the human body.

The magnetoelectric structure consists of two materials: magnetostrictive (ferromagnetic) and piezoelectric. However, other sources of the magnetoelectric effect are also known in physics: magnetoelectric coupling through charge effects. For these effects, no piezoelectric material is needed, only a dielectric. Therefore, the range of materials that can be used to produce, for example, a nanoparticle operating on the basis of the charge magnetoelectric effect, may be larger, which is a technological simplification due to the strong requirements for the toxicity of materials in medicine.

In this project, we will investigate whether charge-mediated magnetoelectric effects can be useful in IT and biomedicine applications in the form of nanoparticles or nanoantennas. To this end, we will run computer simulations of these effects in multilayers, checking how strong they are and how they can be maximized. Based on these simulations, we will build a system consisting of ferromagnetic and dielectric layers and conduct an experiment on them to detect the inverse charge-mediated magnetoelectric effects. In the last step, we will move from multilayers to modeling three-dimensional structures: a magnetoelectric antenna and a magnetoelectric nanoparticle.

Based on this research, we will answer the question of whether charge-mediated magnetoelectric effects can be useful in a field such as medicine? Can nanoparticles exhibiting these effects be used to stimulate nerves or tissues? Is it possible to build an antenna based on these effects and use it to charge the electrical system inside a human with an external magnetic field? Or maybe these structures will be useful for detecting small magnetic fields? In this project (1) we will deepen our knowledge of charge-mediated magnetoelectric effects, (2) we will develop numerical methods describing these effects, (3) we will check how these effects affect other physical processes in such systems, (4) we will conduct pioneering experiments to measure these effects and (5) we will check whether these effects can be useful not only in the field of IT, but also outside it.