GUIDING, SHAPING AND AMPLIFYING SIGNALS IN STRONGLY COUPLED ELECTROMAGNETIC-MAGNONIC CIRCUITS

Electromagnetic waves have revolutionized the communication systems already few times during last century. Starting from Marconi demonstration of radio-telegraph, moving to higher frequencies and providing analog radio and TV transmission, through the satellite communication systems, to fiber transmission with light waves and to digital wireless microwave transfers, dominating today long and short distance data transfers, respectively. Further research is underway to improve the efficiency of data transmission, with higher throughput, and, importantly, also with lower energy consumption. In this paradigm electromagnetic waves are harnessed to signal processing formed grounds for integrated photonics operating at infrared wavelengths. More recently microwave photonics gave solutions for increasing bandwidth and enable development of Internet of Things (IoT). To make further progress and to meet modern society demands, new ideas for miniaturization with increased bandwidth and decreased energy cost are required.

Some solutions may be offered by **magnonics**, an emerging field of physics and technology which harnesses spin waves for logic operations and signal transmission. Spin waves are low energy coherent disturbances of the magnetization that can carry information in magnetic media at broad range of frequencies ranging from GHz up to THz. As the wavelength of spin waves is few orders shorter than respective electromagnetic waves at same frequencies, spin waves are a suitable tool for developing next generation communication systems. Nevertheless, potential of magnonics is difficult to exploit fully as to meet the stringent requirements on modern technology devices. Among the challenges limiting the development of magnonics is the ineffective transduction between information coded in microwaves and spin waves. Currently, the state-of-art is to use inductive approaches based on microstripes or coplanar waveguides (CPW), whose sensitivity, scalability and energy efficiency are still far from meeting the requirements of Information and Communication technologies.

New opportunities arise, if we consider a resonant coupling between phonons and magnons. Particularly interesting and promising for the above-mentioned purposes is the combination of photons and spin waves to create electromagnetic-magnonic circuits. Such a combination could be beneficial for both, microwave technology and magnonic technology, and may offer opportunities for new research and applications, like quantum computation and metrology. Thus, ***the main objective of the project is to develop theoretical models and computational methods for describing and simulating hybrid electromagnetic-magnonic elements, and to uncover the underlying coupling principles and their utilization for next generation microwave-magnonic circuits.***

In the course of the project the framework for combining electromagnetic and spin wave simulations will be developed and implemented numerically with the aim to design functional, strongly coupled cavity magnonic systems. The scientific results will be published in high-quality journals and disseminated through conference presentations. Young researchers involved in the project realization will receive extensive training in research and exposure to multidisciplinary and international research. Thus, we will generate well qualified experts who can contribute to further development in the field of magnonics, photonics, and microwave technologies and their cross-links. It is expected, that the Project will create for both partners the ground for further grant applications at the national and EU level.

The project will be realized in international collaboration of two groups from the Institute of Physics at the Martin Luther University Halle-Wittenberg (MLU), Halle, Germany, coordinated by prof. Jamal Berakdar and from the Faculty of Physics at the Adam Mickiewicz University, Poznań, Poland, coordinated by prof. Maciej Krawczyk.