Description for the general public

Spin waves (SWs) are collective spin excitations, which can propagate in the ordered magnetic materials. Their operational frequencies cover a broad range from hundreds of megahertz (MHz) to terahertz (THz) with the wavelengths ranging from micro- to nanometers. Those dependencies are determined by SW dispersion relations, which are significantly different from the well-known dispersion of light or sound in the uniform media. They are strongly anisotropic due to the given orientation of magnetization vector and, additionally, strictly determined by the geometry of a medium. Spin waves can be used as data carriers in the next-generation devices for processing information at a micro- and nanoscopic level. The field concerning manipulating spin wave is called magnonics.

It is predicted that the magnonic devices can be applied in processing of information with several advantages in comparison to commonly used CMOS electronics. The most important advantage is the reduction of energy consumption. It is commonly known that modern computers produce a lot of heat. In contrast, processing information with SWs allows for significant reduction of the produced heat what makes it suitable for GreenIt information and communication technology devices. Other advantages are better miniaturization in comparison to photonics or higher operational frequency in comparison to electronics.

Spin waves, to be useful for data processing, should be properly excited, detected and controlled in designed ferromagnetic waveguides which allow for propagation at the distances dictated by magnetic losses. Almost a perfect medium – with the smallest known magnetic losses – for spin wave propagation is Yttrium Iron Garnet (YIG) in single crystal phase. However, up to now, it was not possible to fabricate the structures of a type: bottom electrode – YIG film – top electrode, and to prove the applicability of such system for a direct spin wave steering with the use of the electric field. We have already gained expertise in growth of ultrathin YIG films on Gadolinium Gallium Garnet. In our project however, we aim to develop techniques of YIG growth on conducting layers such as Platinum, Tantalum or Gold films, or innovatively employed lithium garnet (LLZO) exhibiting the ion conductance. This would allow us to prepare a system of electrodes enabling the control of SW propagation in the direct way: by application of a local (i.e. in properly chosen places of the waveguides) electric field. For inductive excitation and detection of SW, micro antennas will be used.

The proposed investigations – both experimental and theoretical – are of great importance to develop more efficient information processing devices and to enrich the rapidly growing field of magnonics.