

Spin waves are precessive magnetization oscillations propagating in a magnetic material. Typical spin wave frequencies (from several to several dozen GHz) correspond to relatively short wavelengths (from several to several hundred nanometers). As a result, spin waves can be processed into nanostructures and used for unconventional wave-based calculations.

The properties of spin waves can be influenced by the appropriate selection of the magnetic materials or the sizes of the nanostructure in which they propagate. However, the scope of these changes is limited to some extent. Additional possibilities of shaping the dynamics of spin waves are provided by hybrid systems, which use the interaction of spin waves with other excitations, e.g., with elastic waves or with an alternating electric current. This approach also allows the control of spin waves by external, non-magnetic stimuli (e.g., mechanical stress or electrical voltage). As part of the project, the tested hybrid systems were hybrid systems in which a magnetic system was combined with (i) elastic or (ii) superconducting system in one structure.

An important parameter directly influencing the properties of spin waves is the so-called surface anisotropy, which describes the change in spin wave energy due to the presence of the surface. This parameter, together with the magnetic dipolar effects, determines the dynamics of the spin wave on the surface of the magnetic material – observed as a so-called partial pinning a spin wave. We believe that the surface anisotropy will be of particular importance in the hybrid systems we investigate. This is due to the following reasons:

- surface anisotropy affects the boundary conditions at the interface separating the magnetic and non-magnetic components of the hybrid structure,
- change of the surface anisotropy influences directly on the spatial distribution of the spin wave amplitude, which should be important for the interaction of the spin wave with another excitation penetrating the magnetic subsystem (e.g. (i) an elastic waves or (ii) a magnetic field created by a superconducting current),
- surface magnetic anisotropy can be changed by mechanical stress or/and electric field - which may be an additional factor influencing the coupling in hybrid structures.

In the framework of the project, the numerical and theoretical research will be carried out on the dynamics of spin waves in hybrid planar nanostructures – the ferromagnetic system (i) coupled elastically with a non-magnetic system or (ii) coupled with a superconductor through the field generated by the so-called eddy currents. Numerical and theoretical research conducted by the Ph.D. student will be supported by experimental research performed by cooperating teams.