Description for general public

State the objective of the project, describe the research to be carried out, and present reasons for choosing the research topic - max. 1 standard type-written page

The magnetic materials play important role in many areas of modern technology. They are used in computer technology for data storage (due to non-volatility of magnetic configuration of ferromagnetic materials) and in telecommunication for routing of optical signal (due to non-reciprocal properties of magnetic material for electromagnetic waves). The new emerging technology called *magnonics* exploits the properties of magnetic material arising from the dynamics of the magnetic moments. Magnetic moments can rotate in precessional motion around the direction of the static magnetic field, if they are pushed out from an equilibrium position (e.g. by application of the radio frequency field, or by thermal excitation). In magnetic medium, due to the interaction between magnetic moments, the waves of coherently precessing magnetic moments can propagate. These waves (called *spin waves*) can transmit energy and information, similarly like waves of different nature (e.g. electromagnetic waves or elastic waves). The systems, which use the spin waves for processing and transmitting information, can fill the gap between electronic and photonic. Typical frequencies of spin waves (in the range from fraction of GHz to hundreds of GHz) and their wavelengths (in the range from tens to hundreds of nanometers) make possible the design of miniaturized devices (called *magnonic devices*) operating on high frequency signals. The main advantages of magnonics over the other technologies (photonics and electronics) are: (i) simplicity of inducing of nonlinear effects (useful in many tasks related to signal processing), (ii) anisotropy in propagation of waves, (iii) nonreciprocal effects for propagation of waves (making possible design of separators). The one of the main obstacles in technological application of magnonics is damping of spin waves which limits the lifetime and the propagation length of this kind of waves. A lot of scientific interest in the field of magnonics is nowadays focused on the methods of compensation of spin wave damping. The interaction of magnons (quanta of spin waves) with phonons (related to thermal excitations of the system) is almost unavoidable channel of energy dissipation for spin waves. The problem results from the universal character of elastic properties – common for any kind of solid material. However, the forced coherent elastic waves can be used to amplification of damped spin waves as well – i.e. to transfer the energy from phonons to magnons.

In the framework of this project we are going to investigate the interaction between spin waves and elastic waves in periodic nanostructures which play the role of multifunctional system being simultaneously the magnonic crystal and phononic crystal. By introducing the periodicity (e.g. by pattering of the material) we are able to shape the dispersion relation which is one of fundamental characteristics for the wave dynamics supported in the system (spin and elastic waves in our studies). The main goal of the project is to **design, fabricate and experimentally characterize the periodic nanostructure in which the interaction between magnons and phonons will be adjusted by changes of structural and material parameters.** We will look for the structures in which the interaction between spin waves and elastic waves will be enhanced. Such systems should poses two features: be composed of magnetostrictive ferromagnets, and allows to concentrate the amplitude of elastic waves in the ferromagnetic subsystem where the spin wave can propagate.

The good candidates seems to be structures in which the elastic slab/substrate is loaded by periodic pattern of elements. The pattern can be made of ferromagnetic or nonmagnetic materials. But in the latter case periodic pattern must be deposited on ferromagnetic underlayer. For such geometry surface elastic waves will be concentrated close to the face of the slab and can induce the strain to the magnetostrictive ferromagnetic pattern or the underlayer.

We will investigate experimentally the interactions of the spin waves (magnons) with elastic waves (phonons). The spin wave excitations will be detected using the light scattering techniques (Brillouin spectroscopy). The theoretical research will encompassed both the numerical solutions and the investigations of semi-analytical models. The first kind of theoretical approach is necessary do design the rear structure for the experiment. The later one is necessary for identification of physical mechanisms and interpretation of experimental outcomes.