THREE-DIMENSIONAL MAGNONIC STRUCTURES FOR ANALOG COMPUTING: INTERACTION ANALYSIS AND DEVICE DEVELOPMENT

Electronics has primacy in the field of computing devices. Unfortunately, we are very close to reach the limit of the size of smallest parts of computing devices – transistors, and further development of this field is open to question. The scientists are looking for alternatives which could allow for reaching comparable performances with preserving the perspectives for further development of this field and, at the same time, answering to the huge environmental problem of increasing energy consumption. **Magnonics** could be the answer to this challenges.

Every electron possesses a magnetic moment called spin which are responsible for the magnetization of matter. In ferromagnetic materials all spins are strongly interacting with each other and are aligned in one direction. When a magnetic moment is deviated from its equilibrium position, it tries to return back to the stable state in a precession motion quite like a toy spinning top. Simultaneously, because of strong interaction, all the neighboring spins are set in motion making a coherent disturbance which disperse as a wave. This disturbance is called **spin wave**. The research field focused on spin waves and developing spin-wave-based technology is called **magnonics**. Spin waves are characterized with large frequencies in range from several to several hundred gigahertz and wavelengths from dozens of nanometers to several micrometers. In comparison with electronics and photonics, the nonlinear and anisotropic effects are easily achievable and there also exists the possibility to steer the structure via control of the magnetization. It makes *the spin waves ideal for transmission and processing of information in miniaturized devices*.

A standard way to steer the wave is making a narrow channel for transmission called waveguide. To transmit the wave between the waveguides one can connect them, but in case of spin waves, it is possible to make use of magnetic field produced by the wave. Recent studies about the coupling of waveguides focus on the structures made from single layer due to easy production process. In multilevel structures there appears the problem with irregularities which occur when first layer is structured but their big advantage is that thanks to the possibility to deposit the layers of single-atom-size thickness, the distances between particular elements can be very small which significantly increases the coupling strength.

In my project I want to analyze the coupling strength in dependence on the structure geometry, materials used, and also using different interactions which could increase the strength and control of coupling. Also, I plan to use the superconducting materials which, thanks to the ability to reflect the magnetic field, can block the coupling between waveguides as well as increase the spin-wave velocity and, therefore, increase the device speed. Eventually, basing on obtained results, I aim to design the device which can be used in computers basing on spin waves. In order to perform the tasks, I will use the numerical simulations intended for studying the spin-wave dynamics.

This project is a next step to design of magnonic computers which could compete with currently-dominating electronic computers, at the same time offering the solution to problem of increasing energy consumption.