Mass, charge and spin are fundamental properties of matter. For hundreds of years, mass and charge has been used by humans to transport energy and information over long distances. As for the transmission of energy high-energy carrier is the best, to send information, we would like to do it with the lowest possible cost. In order to send the information to a distance of one kilometer with the Morse code, it is better to use the vibrations of the rail by striking at it than to throw its pieces at such distance. As a rule, vibrations require using less energy than transport (for the same carriers).

Electric charge is a carrier used in electronics. For years, scientists have been working on the concept of replacing the electric charge with spin, because putting the spin into motion or vibrations, at least in theory, requires much less energy. In analogy to electronics, knowledge branches called spintronics (in relation to the transport of spins – spin currents) and magnonics (in relation to vibrations of spins - spin waves) arose.

Spin waves propagate in ferromagnetic materials. The problem with spin waves is that their amplitude decays quite quickly with the distance from the source. The solution may be to look for new materials with low damping, or to find ways to enhance spin wave amplitude. Known for more than twenty years is the interaction of a spin wave with a spin current, which can lead to its enhancement. However, an efficient spin current production is still quite challenging, because it is usually obtained from the flow of high intensity "normal" (charge) current through the ferromagnetic material.

The first goal of this project is to investigate whether a spin current can be created in a ferromagnetic metal layer by means of an alternating external electric field instead of passing through this layer electric current. In practice, the electric field around the ferromagnetic layer will be produced by a capacitor, applying voltage to its plates. The capacitor plates will be separated from the ferromagnetic metal by insulator layers. Therefore, no macroscopic electric current from the external circuit will flow through the ferromagnetic layer. The whole will be carried out at the nanometer scale. By developing and using theoretical models, the flows of charges and spins in the metal layer induced by an alternating, external electric field will be investigated.

The second goal of the project is to investigate what impact the currents generated in this way have on the spin wave properties. To achieve this goal, theoretical models describing the dynamics of spin waves and the influence of spin currents on this dynamics will be used. Also, the opposite, we will examine how the dynamics of spin waves affect these currents. The calculations will use the parameters of the real materials and the dimensions of the layers that are possible to be fabricated and other parameters that can be obtained in the experiment (e.g. the values of voltage). All this to best plan the layout for experimental implementation.

In the main experimental part, capacitors which contain a ferromagnetic layer in the middle will be made. An alternating electrical voltage will be applied to the plates of the capacitor. By means of an external, alternating magnetic field or an additional spin current, the spins in the layer will be excited to resonate vibrations (ferromagnetic resonance). The experiment aims to investigate the impact of electrical voltage on this resonant vibrations, in particular whether and how it will change the energy loss of this vibration. The experiment aimed at investigating the same phenomenon, but without resonance stimulation of spins vibrations, will be carried out by the method of inelastic light scattering (Brillouin spectroscopy). The project will be carried out in a center specialized in static and dynamic studies of thin magnetic layers and in cooperation with one of the best experimental centers in the world.