Thin magnetic films have been the subject of study for several decades, but to this day this area of research remains highly active. Their popularity can be attributed to the presence of surfaces and material interfaces, which make the properties of magnetic films very different from their bulk forms. While bulk (i.e. of dimensions measured beyond the nanoscale) magnets have already become an inseparable part of modern-day technology, low-dimensional magnetic structures have a huge potential of widespread practical applications as well.

Magnetic recording and mass storage systems have been very popular since the very beginnings of the computer industry. However, despite numerous advantages, magnetic random access memory (MRAM) still has a long way to go before it will replace semiconductor volatile computer memories for at least two reasons. The first one is outstandingly large scale of integration needed to obtain huge memory capacity counted in GB, while the second reason is still relatively high power consumption, which decreases with the Gilbert damping factor, α, of the used conductive magnetic films. Nonetheless, bit switching time increases as $1/\alpha$. Therefore, practical MRAM designs incorporate both low- and high-damping materials and there is high demand for their better and better quality. Understanding the origin of various damping mechanisms and their relation to structural properties of such films remains one of the key challenges, which is still insufficiently understood, especially at a quantitative level needed to control the damping properties of the films.

In view of the described technological problems, the main goal of the project is to determine the fundamental correlations between different physical mechanisms responsible for magnetic losses occurring in ferromagnetic thin films at microwave and millimeter wave frequencies, contributing to the homogeneous and inhomogeneous broadening of the ferromagnetic linewidth, and structural parameters of the film, such as anisotropy, thickness, inhomogeneity, defects/doping, magnetoelasticity. As it is well known, magnetic loss mechanisms include Gilbert damping, two-magnon scattering, spin-orbital coupling, spin pumping (if non-magnetic electrically conductive layers are adjacent to the magnetic layer) or radiative damping, the contribution of which will need to be separated from each other in the course of the project. Special attention will be paid to the magnetoelastic effect, which can be usually correlated with strong spin-orbital coupling of the magnetic ions, while the latter one usually results also in strong magnetic damping, which manifests itself in the broadening of the ferromagnetic linewidth. However, the quantitative correlation between these two phenomena remains poorly understood.

In order to clarify the correlation between the magnetoelastic properties and magnetic damping in thin films, a rigorous quantitative study of various contributions to the magnetic damping occurring in thin films has to be undertaken in a broad electromagnetic spectrum. Commonly used methods, like VNA-FMR with a co-planar waveguide (CPW), suffer from low dynamics (i.e. poor accuracy) and does not allow easily de-embedding losses of the setup from the measurement in order to get a real FMR linewidth (i.e. unloaded from extrinsic losses of the measurement system). Much better performance can be achieved with resonant methods with the sample inserted in a hollow metallic cavity, as a rigorous (i.e. fully accurate) model of the electrodynamic phenomena occurring in the whole system, including the sample, can be developed. However, resonators operate at discrete frequencies (usually at just one frequency), providing substantially less information than is contained in a broad spectrum. Therefore, an auxiliary goal of the project will be to develop a rigorous broadband resonant method for FMR linewidth measurement of thin ferromagnetic films by means of a tunable cavity.

Thin films are most commonly studied with static and magnetic fields tangential its surface. However, interesting phenomena can be observed if the bias static magnetic field is normal to the film. In such a case, it is theoretically possible to excite surface modes in a thin ferromagnetic film, which may be also called magnetic plasmons in analogy to surface modes occurring in thin electrically conductive films. Such plasmons have been already discovered in spherical and cylindrical samples, however, it still lacks experimental confirmation in planar ferromagnetic structures. For those reasons, another auxiliary goal of research will be to find the necessary conditions for the excitation of a magnetic plasmon with the aid of rigorous electromagnetic modeling and, subsequently, confirm the existence of that kind of mode experimentally.