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# Two-magnon damping in thin films in the case of canted magnetization: Theory versus Experiment

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**Abstract** – We present results for ferromagnetic resonance measurements in ultrathin magnetic films. Our aim is to investigate quantitatively the damping of spin motions where different sources of damping are present. We investigate a polycrystalline 10 nm thick Co film grown on GaAs using microwave frequencies between 4 and 35 GHz and different orientations of the static magnetic field. We discuss the role of Gilbert and two-magnon damping (activated by defects in the film) within the theoretical framework presented some years ago by Arias and Mills [1] and its extension to the case in which the magnetization is tipped out of the film plane [2]. It is found that linewidth versus field angle data are well reproduced by the theory for several frequencies, and we obtain information about fundamental parameters as well as the role of defects in the dynamical response of the prototype Co system.

The most popular ansatz for the magnetic relaxation in metallic ferromagnetic films is given by the Landau-Lifshitz-Gilbert phenomenology. It was demonstrated, however, that besides intrinsic Gilbert damping extrinsic mechanisms like the two-magnon process, that describes the defect mediated scattering of the uniform precession mode into non-uniform ones may strongly alter the overall relaxation or play even a major role [3-4]. Using microwave frequencies of 4.06, 9.8 and 23.82 GHz for room temperature investigations on a prototype Co thin film of polycrystalline nature we have shown that the theoretical description presented earlier in [2] is capable of quantitatively describing the effect of canted magnetization on the FMR linewidth in thin magnetic films. Besides the classic Gilbert damping, two-magnon damping may influence and strongly alters the dependence. The results provide a way to predict magnetic damping for arbitrary external field direction for systems for which two-magnon scattering plays an important role. As – in contrast to Gilbert damping – two-magnon scattering is an extrinsic effect which can, in principle, be influenced by incorporating defects into the film, the result also yields a possibility to controllably tune magnetic damping, since theory is able to predict the size of defects as well as their influence on the overall magnetic relaxation.

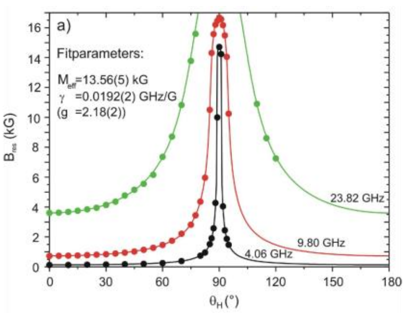


**Figure 1:** Angular dependence of the resonance field. The dots are the experimental data, whereas the lines are fits obtained with our theory.

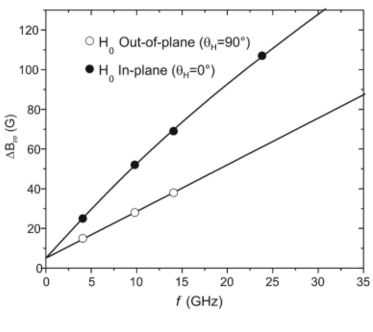


**Figure 2:** a) Peak-to-peak FMR linewidth as a function of the frequency for out-of-plane and in-plane magnetization.

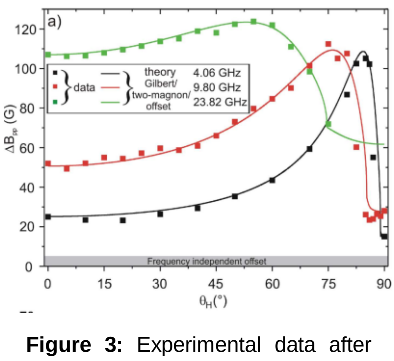


**Figure 3:** Experimental data after subtracting the angular dependent mosaicity contribution. Solid lines are the sum of Gilbert and two-magnon contributions

## References

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