**Effective Magnetization Damping in Inhomogeneous Spin Textures: Vortices and Skyrmions**

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Recently, new inhomogeneous magnetization objects - magnetic skyrmions - vortex-like curling spin textures with a quantized topological number have been observed in chiral magnets possessing Dzyaloshinskii-Moriya exchange interaction as well as in traditional ferromagnetic materials (bubble-skyrmions). Skyrmions attracted considerable attention of researchers assuming potential applications in spintronic devices because their motion can be controlled with ultralow current density [1]. To achieve efficient manipulation of nanosized spin textures and realize skyrmion-based new brand spintronic devices, it is essential to understand skyrmion motions in confined geometries, for instance, in magnetic nanodots and stripes. The motion of skyrmions in such patterned nanostructures is essentially influenced by their energy dissipation – magnetization damping.

In this work we investigate in detail the magnetization damping of dynamical vortex and bubble-skyrmion spin textures in circular ferromagnetic dots. We use an extension of the Landau-Lifshitz-Gilbert equation of magnetization motion considering an additional damping contribution coming from the conduction electrons in the case of inhomogeneous magnetization distributions (such as vortices and skyrmions) in ferromagnetic metals. The additional magnetization damping is calculated using the *s-d* exchange model. The effect of conduction electrons on the magnetization dynamics is accounted assuming a slowly varying spin texture within an adiabatic approximation by using a coordinate transformation to the local quantization axis parallel to the magnetization vector. The additional damping appears due to spin currents generated by emergent electric fields, which are determined by the spatial and time derivatives of the moving magnetization. The moving magnetic vortex in a circular permalloy nanodot and bubble-skyrmion in a circular dot with a moderate perpendicular magnetic anisotropy [2] are considered as examples. The value of the damping and its dependence on the geometrical sizes of the dots is obtained [3]. It is found that the additional damping can reach 20% of magnitude of the phenomenological Gilbert damping for the vortex case and is comparable with the Gilbert damping for moving bubble-skyrmions. Therefore, this contribution to the magnetization damping should be taken into account for inhomogeneous spin texture dynamics in patterned films made of ferromagnetic metals.

**References**

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