Electrodynamic theory of resonances in gyromagnetic materials: insights and applications

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Recent work on electrodynamic theory of ferromagnetic resonance in gyromagnetic materials has led to the formulation of a transcendental equation for a spherical sample. It aided in the discovery that multiple FMR modes in spheres, including the dominant one, have magnetic plasmon properties with negative effective permeabilities [1,2,3]. On the grounds of the theory, the first direct broadband measurements of the intrinsic ferromagnetic linewidth of monocrystalline garnet spheres have been reported [4]. Measuring the intrinsic linewidth vs. the internal field, as opposed to the extrinsic linewidth vs. frequency, removes inconsistencies such as negative non-physical intercepts and non-linearity [5]. In addition, the theory has been applied to extend the accuracy of resonant-cavity based methods for broad-linewidth samples, where direct broadband measurements are hindered due to low signal-to-noise ratio and the influence of metal coupling structures. The electrodynamic model has also been used for accurate measurements of saturation magnetization [3] since it allows one to consider the permittivity of the surrounding medium and the presence of surrounding metals. Moreover, an electrodynamic model of cavity-coupled films has been proposed and validated [6]. Experimentally observed higher order FMR modes can be attributed to extremely short-wavelength modes distributed across the thickness of the film. Such volume modes in the film coupled to a cavity are different than in a film open to the free space.

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