Automated FMR Measurement and Analysis

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We present a software framework developed for automated ferromagnetic resonance (FMR) measurements and data analysis, designed to operate in close integration with a lock-in–based experimental setup [1]. The software enables fully automated acquisition, processing, and interpretation of FMR spectra, significantly reducing user intervention and improving measurement reproducibility.

The measurement workflow includes automated control of microwave frequency, static magnetic field, and modulation parameters, as well as synchronized data acquisition from the lock-in amplifier and magnetic field sensors. Acquired FMR spectra are analyzed in real time using numerical fitting routines based on derivative Lorentzian line shapes, allowing for reliable extraction of resonance field and linewidth parameters.

A key feature of the developed software is adaptive measurement control, where the results of preliminary spectral analysis are used to dynamically adjust subsequent measurement parameters, such as magnetic field sweep range and frequency selection. This closed-loop approach optimizes measurement time while maintaining high accuracy, particularly in broadband FMR experiments.

The capabilities of the software are demonstrated using Co/Ni-based thin-film multilayer structures [2], for which systematic frequency-dependent FMR measurements are performed. The automated analysis enables efficient determination of effective magnetic anisotropy fields and Gilbert damping [3] parameters across multiple samples and measurement geometries [4].

References:

[1] Z. Celinski, K.B. Urquhart, B. Heinrich, Journal of Magnetism and Magnetic Materials, Volume 166, Issues 1–2, 1997, Pages 6-26

[2] C. Yan et al., Chinese Physics B, 32, 2023, 017503

[3] J. M. Shaw, H. T. Nembach, T. J. Silva, and C. T. Boone, Journal of Applied Physics 114 (2013) 243906

[4] Cierpiał, M., Maślanka, D., Gubała, K. et al. Sci Rep 15, 35227 (2025)

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