

Ferromagnetic resonance VNA-FMR

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Ferromagnetic resonance (FMR) is a well-established experimental technique for magnetic sample characterization. FMR linewidth analysis in particular has considerably regained interest these days, due to the relation between the resonance peak width and the damping of magnetization motion. The standard FMR experiment uses fixed frequency by the employed microwave cavity while sweeping magnetic field. On the other hand, Vector network analyzer-FMR (VNA-FMR) can sweep frequency and measure reflected/transmitted power while the external magnet can sweep the magnetic field providing 2D scans over both quantities providing much bigger set of data. The sample is excited by passing the RF signals through a coplanar waveguide (CPW) over which the sample is positioned.

In the introductory part of the session we will discuss the working principle of the VNA in relation to the CPW exciting the samples, the signals measured by VNA and their relation to FMR.

In the experimental part we will

1. Learn how to manipulate and position microwave probes
2. Perform a calibration of vector network analyzer (VNA)
3. Measure ferromagnetic resonance of thin layers of magnetic materials
4. Evaluate magnetic parameters of samples by fitting the experimental data.

Recommended reading:

- [1] Kalarickal, S. S. *et al.* Ferromagnetic resonance linewidth in metallic thin films: Comparison of measurement methods. *Journal of Applied Physics* **99**, 093909 (2006).
- [2] Kalarickal, S. S. *et al.* Ferromagnetic resonance linewidth in metallic thin films: Comparison of measurement methods. *Journal of Applied Physics* **99**, 093909 (2006).
- [3] M. Heibel, *Fundamentals of Vector Network Analysis*, Rohde&Schwarz (2008).