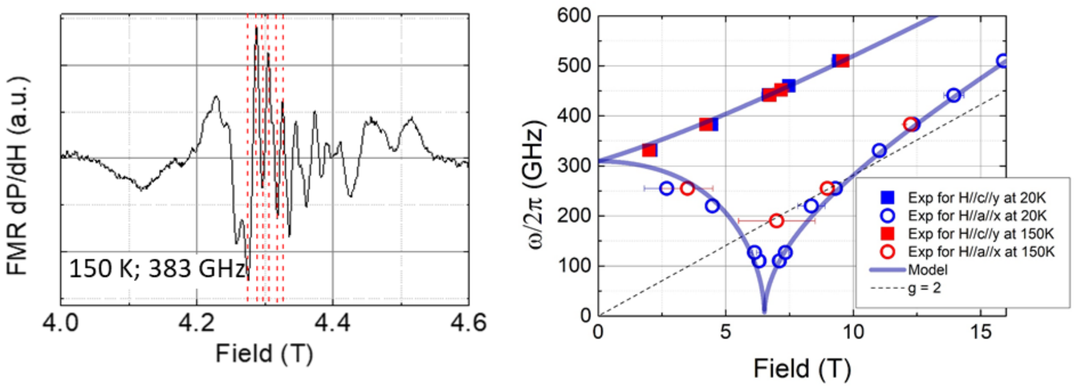
Harnessing the Thz dynamics of antiferromagnets

Context

Several applications - for health, telecommunications, and security - would use the 0.1 to 15 THz range. Spintronic devices based on the dynamics of the antiferromagnetic (AF) order parameter are adapted to handle this range. Indeed, an AF consists of sub-lattices of opposite moments [1]. The sub-THz to THz dynamics is directly related to the internal exchange interactions between the sub-lattices, which is several orders of magnitude larger than the internal fields involved in the GHz dynamics of ferromagnets. **We aim to understand: 1/ how the sub-THz to THz dynamics of AFs can promote spin current emission (spin pumping) and subsequent electric detection** and **2/ how efficiently**, with respect to the damping coefficient (α), exchange field (H_E), the anisotropy fields along the different crystallographic axis ($H_{a,b,c}$), the Dzyaloshinskii-Moriya interaction (H_{DMI}) and the transfer of angular momentum at interfaces.

This project builds on results obtained in a collaboration including **LNCMI Grenoble, CNRS/Thales Paris and SPINTEC [2,3]**. We have taken advantage of the rare capabilities of a quasi-optical bench at LNCMI [4]. It combines high-magnetic fields (0 - 16T), high-frequencies (110 GHz and multiples up to 660 GHz) and a wide temperature range (5 - 300K), thus overcoming the obstacles to study the dynamics of AFs. A mapping of the sub-THz properties (α, H_E, $H_{a,b,c}$, H_{DMI}) of selected model AFs (Fe_2O_3, $YFeO_3$) was obtained. We adapted the system to spin pumping experiments by designing a transport module. **Our objective for the present project is to investigate ways to improve the setup in terms of the input power reaching the sample with minimal losses in order to promote the larger spin pumping effect needed to study most AFs.**

[1] V. Baltz et al, Rev. Mod. Phys. 90, 015005 (2018) - [2] R. Lebrun et al, Nat. Comm. 11, 6332 (2020)- [3] S. Das et al, Nat. Comm. in press (2022) - [4] Y. Li, A.-L. Barra et al, Phys. Rev. B 92, 140413 (2015).



(Left) Typical absorption spectrum obtained for a $YFeO_3$ AF. Data analysis allowed estimating α (see text). (Right) Frequency-field dispersion curve obtained from series of absorption spectra. Data fitting returned H_E, $H_{a,b,c}$, and H_{DMI}.

Work program & Skills acquired during internship

The work will include : **1/ electromagnetic simulations and sample fabrication** for realizing planar antennas and contacts ; **2/ sub-THz AF resonance measurements** using the current design and comparison with measurements using a newly designed sample and/or sample holder, based on the simulations.

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Requested background: Master 2, solid state physics, numerical simulation, good level of English
Duration: 6 months
Start period: Feb/ March 2023
Possibility of PhD thesis : YES
Proposal number : do not fill in