Spintronics with Antiferromagnetic Insulators

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Introduction

Present Spin-Transfer-Torque (STT) based devices rely on ferromagnetic (FM) materials as their active constituents. An alternative is to employ antiferromagnetic (AF) materials, particularly antiferromagnetic insulators. In contrast to ferromagnets, where magnetic anisotropy dominates spin dynamics, in antiferromagnets spin dynamics are governed by the interatomic exchange interaction energies which are orders of magnitude larger than the magnetic anisotropy energy, leading to the potential for ultrafast information processing and communication in the THz frequency range.[1]

Experimental

The single crystal sample MnF_2 with MBE grown MnF_2 film (10 nm) capped with Platinum (4 nm), was provided by D. Lederman (UCSC). Antiferromagnetic Resonance (AFMR) measurements and spin pumping experiments were performed at NHMFL's EMR facility utilizing the heterodyne quasi optical spectrometer and its 12.5 T SC magnet under the supervision of J. van Tol. Polarized microwaves of 120 GHz were used to excite the magnetization precession of the two sub lattice magnetizations of MnF_2 and inverse spin Hall (ISHE) voltage was measured across platinum.

Results and Discussion

Strong spectroscopic signatures were observed as shown in **Fig.1**. Due to the thickness of the sample, microwaves are very strongly absorbed in the sample. Due to misalignment of the easy axis in the sample, only one resonance mode was observed at 120GHz. Further study at higher frequencies will enable us to observe the higher field modes.

We observed electrical signal in the voltage measurements that corresponds to the resonance position observed in the AFMR (~5 T) as observed in **Fig.2**. There was significant amount of noise that can be improved upon.We are currently working on polishing the crystal samples to the right thickness for EPR and repeating the experiment at higher frequencies to advance further on this route.

Conclusions

The results of our experiment undoubtedly indicate towards a spin Hall Effect origin. We are planning to perform similar experiments on MnF_2 at higher frequencies at NHMFL, particularly around zero field where the use of polarized microwaves will allow us to explore new physics.

Acknowledgements

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References

[1] Johansen, Ø. *et al.*, Phys. Rev. B, **95**, 220408(R) (2017).

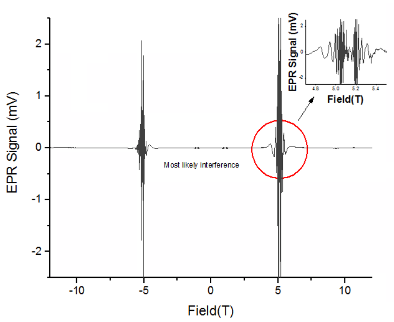

Fig.1 AFMR signal at 120GHz in MnF_2 single crystal sample.

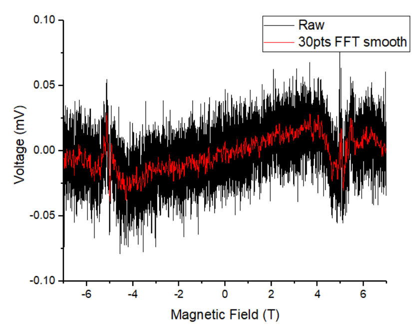

Fig.2 Voltage signal developed across platinum due to spin pumping across MnF2/Pt interface and ISHE in Pt.