



Spin-Charge Interconversion at Near-Terahertz Frequencies

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Injection of spin currents into a ferromagnetic material can induce spin dynamics that can be employed to control the magnetic state of the material, enabling spintronics operations at gigahertz frequencies. The reciprocal effect, spin pumping, converts magnetization dynamics into spin currents in an adjacent metal. Both effects have been used interchangeably to advance the field of spintronics.

This research demonstrates the dynamical generation of spin currents using an antiferromagnetic material for the first time, enabling spin pumping at near terahertz frequencies – more than two orders of magnitude faster than ferromagnetic spintronics devices. The unique spectrometers available in the Electron Magnetic Resonance facility at the National MagLab were essential for this work, because the typical spin dynamics of antiferromagnets lie in the terahertz regime, while magnetic-field-tuning of these ultrafast spin dynamics within antiferromagnetic ordered phases requires high magnetic fields.

The demonstration of coherent near-terahertz spin pumping using antiferromagnets opens the door to devices operating at frequencies that are two to three orders of magnitude faster than current spintronics technologies, with broad impacts in future applications ranging from magnetic recording to communications to medical imaging.

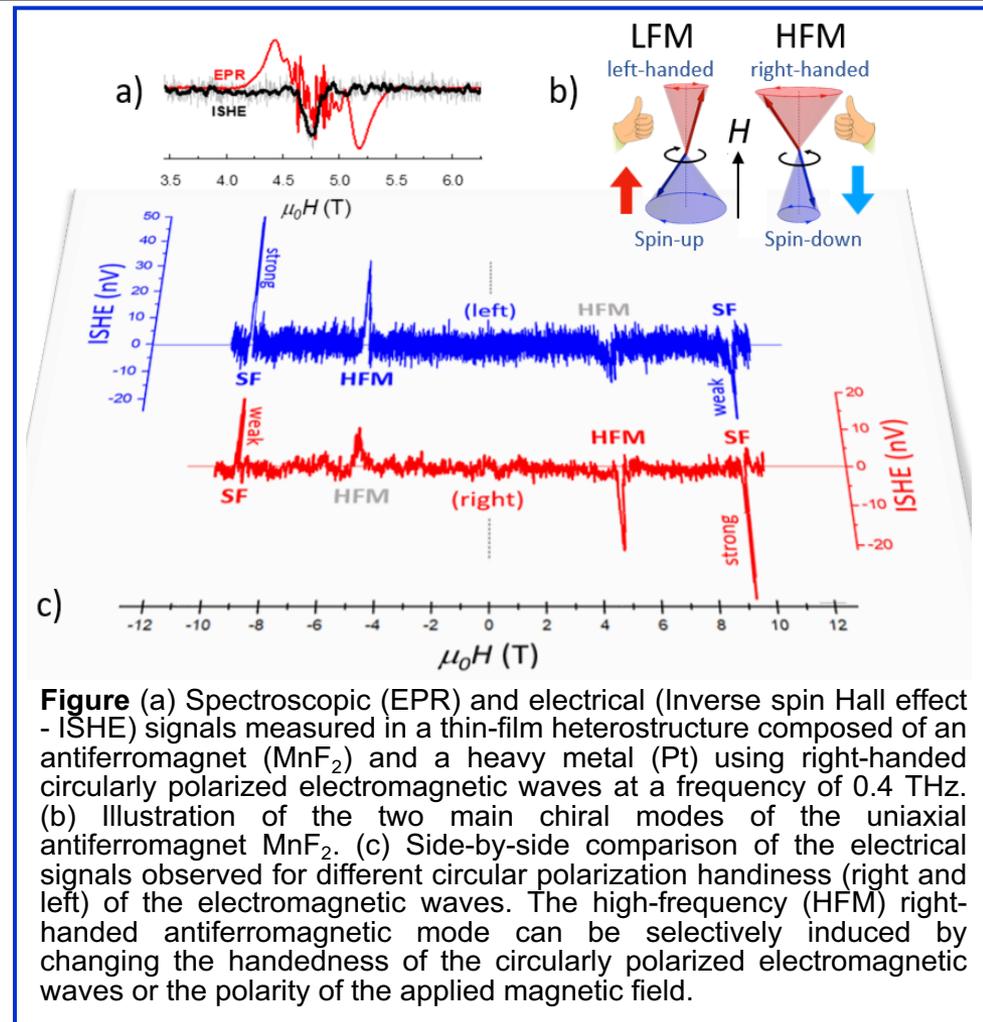


Figure (a) Spectroscopic (EPR) and electrical (Inverse spin Hall effect - ISHE) signals measured in a thin-film heterostructure composed of an antiferromagnet (MnF₂) and a heavy metal (Pt) using right-handed circularly polarized electromagnetic waves at a frequency of 0.4 THz. (b) Illustration of the two main chiral modes of the uniaxial antiferromagnet MnF₂. (c) Side-by-side comparison of the electrical signals observed for different circular polarization handedness (right and left) of the electromagnetic waves. The high-frequency (HFM) right-handed antiferromagnetic mode can be selectively induced by changing the handedness of the circularly polarized electromagnetic waves or the polarity of the applied magnetic field.

Facilities and instrumentation used: EMR program, 12.5 Tesla Pulsed EPR quasi-optic heterodyne spectrometer.

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