Spin-charge interconversion in a Dirac semimetal

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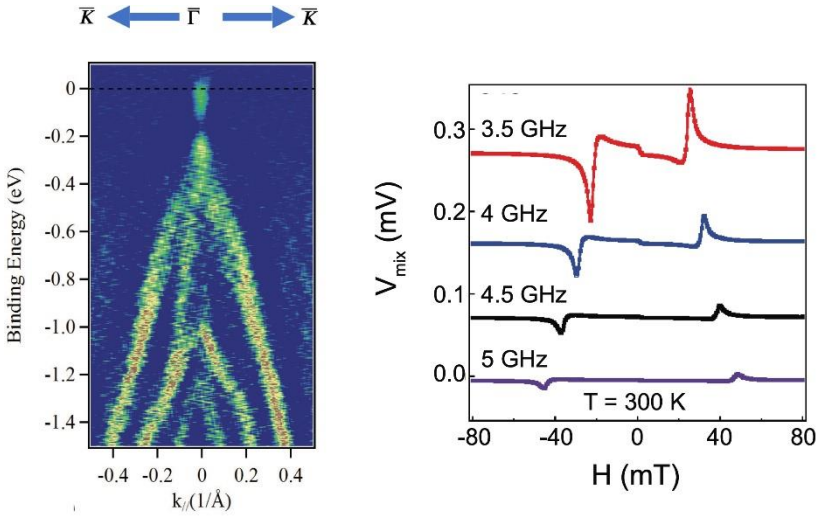
Project Summary: Contemporary approaches to non-volatile magnetic random access memory (MRAM) rely on using an electrical current (charge) to change the magnetization (spin) of a ferromagnetic material. Understanding the spin-charge interconversion (SCI) process in topological quantum materials, such as topological insulators, Dirac semimetals, and Weyl semimetals, is important in this context for developing energy-efficient MRAM architectures. This article reports room-temperature measurements of SCI at the interface between an archetypal Dirac semimetal (Cd_3As_2) and a conventional metallic ferromagnet ($Ni_{0.8}Fe_{0.2}$). We first used molecular beam epitaxy (MBE) to synthesize 12 nm - 40 nm thick Cd_3As_2 films. *In vacuo* transfer allowed angle resolved photoemission spectroscopy (ARPES) that confirmed the Dirac semimetal nature of these thin films. After depositing a metallic ferromagnet, $Ni_{0.8}Fe_{0.2}$ on top, we studied SCI in $Cd_3As_2/Ni_{0.8}Fe_{0.2}$ heterostructures using spin pumping and spin torque ferromagnetic resonance (ST-FMR). Analysis shows that Cd_3As_2 can have a SCI efficiency comparable to that of other materials that have attracted significant attention for energy efficient MRAM, namely heavy metals and topological insulators. Surprisingly, the highest efficiency is associated with extrinsic effects due to imperfect (oxidized) interfaces. These results suggest caution in attributing spin transport solely to the topological states of Cd_3As_2 as reported in several recent papers studying topological spintronics in Dirac semimetals. Published in *Physical Review Applied* **16**, 054031 (2021) as an Editor's Suggestion.

2DCC Role: The 2DCC facility was used for ARPES measurements of the Cd_3As_2 thin films via *in vacuo* transfer within the 2DCC highly integrated vacuum environment (HIVE).



(Left panel) Second-derivative ARPES spectrum from a 30 nm thick (112) oriented Cd_3As_2 film grown by MBE on GaSb/GaAs (111). (Right panel) Measurements of ST-FMR in a Cd_3As_2 (40 nm)/$Ni_{0.8}Fe_{0.2}$ (30 nm) heterostructure. All data are taken at T = 300 K.